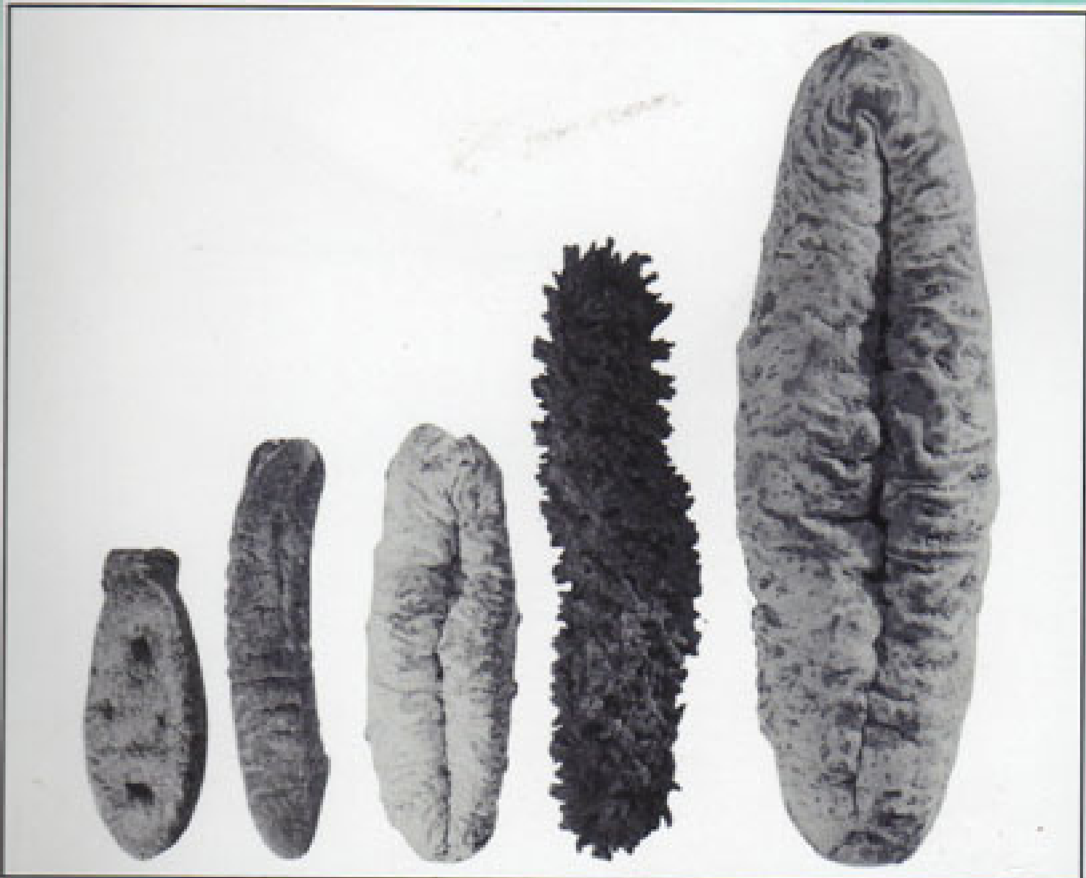
The fishery resources of Pacific island countries

Part 2. Holothurians



FAO FISHERIES TECHNICAL PAPER

272.2

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

M-43
ISBN 92-5-102508-8

PREPARATION OF THIS PAPER

The FAO Fisheries Department has undertaken a review of the fishery resources of Pacific island countries. This paper on holothurians is the second contribution to that review (Part One was published as a Fisheries Technical Paper: King M.G., 1986. The fishery resources of Pacific island countries. Part 1. Deep-water shrimps. FAO Fish.Tech.Pap. (272.1):45 p.), it summarises the available information on the main commercially valuable species and covers biology, harvesting and fishery management as well as describing processing techniques and the principal markets. It was prepared on behalf of the FAO by Mrs C. Conand in conjunction with the "Institut français de Recherche Scientifique pour le Développement en Coopération" (ORSTOM) and the "Université de Bretagne Occidentale". The chapter about the bêche-de-mer market and the appendices were prepared with the assistance of Mr Van Eys, international trade specialist with INFOFISH.

ABOUT THE TRANSLATION

This document is a translation of the original paper published in French in 1986. Research conducted since then, particularly in New Caledonia, has improved knowledge on biology and stock assessment. The results have been published in a paper entitled: "CONAND C. 1989 - Les holothuries aspidochirotes du lagon de Nouvelle-Calédonie : biologie, écologie et exploitation. Etudes et thèses, ORSTOM (Ed.), Paris, 388 p.

The translation has been made by R.M. Benyon of the Interpretation/Translation Section of the South Pacific Commission (S.P.C., B.P. D.5 - Noumea Cedex, New Caledonia). FAO wishes to gratefully acknowledge the collaboration of S.P.C. in the preparation of this document.

ACKNOWLEDGEMENTS

The author owes a special debt of thanks to ORSTOM, the "Institut français de Recherche Scientifique pour le Développement en Coopération" which made it possible for her to carry out the holothurian survey as part of a programme entitled "The lagoon and coastal zones of New Caledonia: research and development".

She also wishes to express her gratitude to her colleagues and the staff at the ORSTOM Centre in Noumea for their efficient assistance during research work carried out between 1979 and 1983, and to the Fisheries Advisers of the SPC, the South Pacific Commission, for their congenial cooperation which encouraged the circulation of information and ideas.

The author could not conclude without acknowledgements to her colleagues at the Laboratory of Animal Biology of the Faculty of Science, University of Western Britany, who gave their support during the drafting phase.

Distribution

FAO Fisheries Department
FAO Regional Fisheries Officers
Regional Projects
Authors
Pacific island countries

Conand, C.
The fishery resources of Pacific island countries.
Part 2. Holothurians.
FAO Fisheries Technical Paper, No. 272.2.
Rome, FAO. 1989. 143p.

ABSTRACT

The main species of holothurian exploited in the South Pacific are *Holothuria scabra*, *H. fuscogilva* and *H. nobilis*, which have high commercial value, *Actinopyga echinites*, *A. miliaris* and *Thelenota ananas*, of medium commercial value, and *Holothuria atra*, *H. fuscopunctata* and *H. mauritiana*, whose commercial value is low.

Knowledge of the biology of these species is reviewed in detail, as are resource assessment methods. An example of the possible use of remote sensing for estimating potential is given.

Harvesting and processing techniques and commodity grading are also discussed, while a chapter focussing on the principal markets for bêche-de-mer, Hong Kong and Singapore, concludes that an increase in exports from the countries and territories of the South Pacific is possible if they can supply a consistently good-quality product on a regular basis.

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1. INTRODUCTION

1.1 International trade in echinoderms

According to the FAO's annual statistics (1984)[1] and Conand and Sloan (in press), the world echinoderm harvest in 1983 amounted to approximately 80,000 tonnes. Echinids account for roughly two-thirds of the total, sea urchins being considered a delicacy for their genital glands. The biggest market is Japan, an avid consumer of 'uni', where the 26,800 tonne trade consists mainly of species from the family Strongylocentrotidae. Next comes Chile with an 11,800 tonne harvest of the species *Loxechinus albus*, most of which is exported to Japan. The same country is the main destination for the north-eastern Pacific coast catches of *Strongylocentrotus franciscanus*, which totalled 8 590 tonnes in 1983 (Sloan, in press). Trade in other species, such as *Paracentrotus lividus* in France, is not significant.

The other group of economic echinoderms comprises the holothurians, which are gathered either for local consumption, fresh or boiled, as in Japan and Korea (12,688 tonnes in 1983), or to be prepared as bêche-de-mer (or trepang) for export to Asian markets (around 13,000 tonnes).

1.2 History of research on holothurian fisheries

Holothurians, which have a very long history of consumption by the Chinese, are known in the western world as sea slugs or sea cucumbers; the term '*Cucumis marinus*' appeared as early as Pliny. The first scientific studies, in the late sixteenth century, dealt primarily with species taxonomy and anatomy. Knowledge of their distribution was gathered on the great voyages of discovery (Challenger, Albatros, Siboga). By the end of the nineteenth century, papers had been published on holothurian fishing for trepang production in various areas. Semper (1868) and Seale (1911) described this activity in the Philippines, Saville-Kent (1903) on the Australian Great Barrier Reef, Koningsberger (1904) in the Dutch East Indies (Indonesia) and Hornell (1917) in India.

A later work is 'l'Industria del Trepang' by Sella and Sella (1940), who studied the statistics for the main markets, described the fishing grounds of eastern Africa and recorded attempts to produce Italian trepang using Mediterranean species. Such commodities could not compete with the quality products traded on the Asian markets. Panning (1944) described the industry and the species exploited in 'Die Trepang Fischerei', while Choe (1963) carried out a detailed investigation of the main Japanese species of commercial interest, *Stichopus japonicus*. As well as addressing the morphological aspects and the biological and ecological parameters, this author gave an account of attempts to sustain and increase stocks.

In recent times, the worldwide growth of fishing activities has made fisheries management a necessity; this has become possible through the knowledge acquired about population dynamics. Small-scale artisanal fisheries are no exception to the rule, but, as with many tropical species, little is yet known about the biology and ecology of holothurians. In 1974, the South Pacific Commission (SPC), an organisation established in 1947 to promote cooperation

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1. FAO data on holothurian catches, not including Japan and Korea, have been multiplied by a factor of ten because these statistics probably relate to the dry product (cf. Chapter 6).

and regional development, and the FAO jointly produced a fishermen's handbook on bêche-de-mer, derived from a report by Sachithananthan. The SPC has since brought out a revised edition, in 1979 and, in conjunction with the Fisheries Division, conducted a survey of stocks in Fiji (Gentle, 1979). Other research has been carried out at universities in Australia and Papua New Guinea. Finally, as part of a programme of research and development focussing on the lagoon and coastal zones of New Caledonia, the "Institut français de Recherche Scientifique pour le Développement en Coopération (ORSTOM) has sponsored studies on species biology and distribution (Conand, 1979, 1981, 1982, 1983, 1985; Conand and Chardy, 1985).

1.3 Background information on the southern tropical Pacific

1.3.1 An introduction to the region

The southern tropical Pacific is a vast area of the Pacific Ocean, extending over 30 million square kilometres and corresponding to the area served by the SPC.[2] It covers approximately one hundred degrees of longitude between the tropics, from 130° East to 130° West (Figure 1). Excluding Papua New Guinea, which alone accounts for 465,000 km^2, total land area amounts to 90,000 km^2, formed by the archipelagoes of Micronesia, Melanesia and Polynesia. Their respective land areas and populations, given in Table 1, demonstrate the very uneven distribution of inhabitant densities.

The physical environment may be divided into four main structural types:

- high continental islands, of sedimentary or metamorphic origin, with varied reliefs and soils;
- high volcanic islands, where the degree of soil development depends on the age of the volcanic activity;
- elevated platform reefs;
- low islands or atolls close to sea level, composed of coral sand and debris.

Table 1 - Land area and population distributions in the South Pacific (Source - ORSTOM, 1981).

	LAND AREA Km2	%	POPULATION 1978 Estimates No.	%	DENSITY per Km2
Melanesia (archipelagoes)	78 200	87	1 060 500	59	13.6
Polynesia	8 742	10	461 800	25	52.8
Micronesia	3 115	3	286 000	16	91.8

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2. Data relating to research in Australia (Queensland) on holothurians of commercial importance have been included in this document. The history of the trade in that country is linked with other countries in the region and the same species are sometimes exploited there in similar environments.

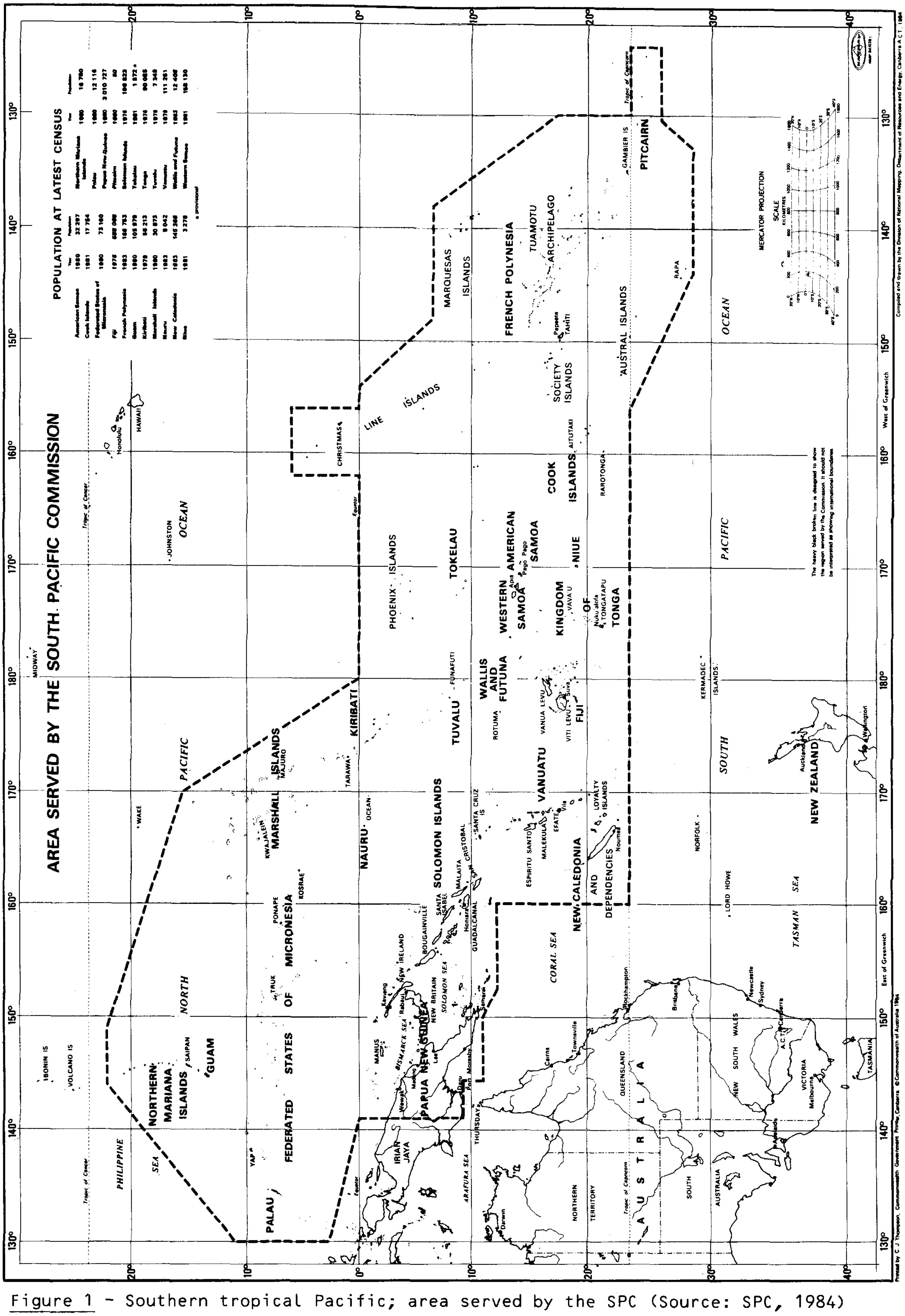


Figure 1 - Southern tropical Pacific; area served by the SPC (Source: SPC, 1984)

1.3.2 Countries and territories

This brief description of states and their populations is drawn from the Pacific Islands Yearbook (1978) and the Atlas of New Caledonia published by ORSTOM (1981).

Papua New Guinea: An independent state, comprising the eastern half of the island of New Guinea, a very complex continental island, and outlying island groups, (Bismarck, Bougainville, etc.) including continental, volcanic and low islands. The essentially Melanesian population of around 3 million is composed of many different ethnic groups. Approximately seven hundred distinct languages are spoken.

Solomon Islands: This extensive archipelago, covering 29,000 km^2, is an independent country consisting of six main high islands, as well as elevated reefs and atolls. The population of around 200,000 is Melanesian.

Vanuatu: Independent since 1980, this island group is formed of some sixty mainly volcanic islands (11,900 km^2). Melanesians account for almost the entire population of approximately 100,000.

New Caledonia: This French overseas territory consists mainly of 'Grande Terre', a long narrow continental island, and the Loyalty Islands, which are elevated reefs, 19,100 km^2 in all. New Caledonia has a multiracial population of approximately 140,000, in which Melanesians and Europeans predominate.

Fiji: This independent archipelago of 320 islands consists of high volcanic islands, the largest of which are Viti Levu and Vanua Levu, elevated reefs and atolls (10,400 km^2). The population, originally Melanesian, has undergone strong Polynesian influence; the descendants of Indian indentured labourers brought in to tend the sugar-cane crop outnumber native Fijians.

Tuvalu: A small independent state (26 km^2). Its Polynesian population, 7,300 strong, lives on atolls.

Wallis and Futuna: A French overseas territory (210 km^2). These are volcanic islands. The 10,000 inhabitants are Polynesian.

Western Samoa: An independent nation consisting of two main volcanic islands and a number of small islands (2,900 km^2). The 153,000 population is of Polynesian stock.

American Samoa: A United States territory (197 km^2) comprising, in addition to Tutuila, the main volcanic island, other small islands and atolls. The 31,000 population includes Polynesians, Europeans from America and Asians who are mainly employed in the tuna fishing industry.

Kingdom of Tonga: Tonga is made up of three main groups of numerous volcanic islands and elevated reefs (740 km^2), scattered over 560 km from north to south. The 93,000 inhabitants are Polynesian.

Tokelau: A territory administered by New Zealand, this territory consists of three atolls (10 km^2) populated by 1,600 inhabitants.

Cook Islands: This self-governing country associated with New Zealand consists of fifteen volcanic or raised islands, the biggest of which is Rarotonga (240 km^2). Polynesians account for the great majority of the 18,500 population.

Niue: Similar in status to the Cook Islands, Niue is an elevated reef (259 km^2). It sustains 3,700 Polynesian inhabitants.

French Polynesia: A French overseas territory comprising various archipelagoes (Society, Tuamotu, Gambier, Marquesas, Austral) of volcanic islands, raised reefs and atolls, representing a total land area of 4,000 km^2, scattered over four million km^2 of ocean. The population of 140,000 is essentially Polynesian or part-Polynesian and concentrated largely in Papeete.

Kiribati: An independent country comprising the many atolls of the Gilbert, Phoenix and Line islands (720 km^2). The 56,000 population is Micronesian.

Nauru: An independent micro-state consisting of an elevated reef (22 km^2). Phosphate mining has given the 7,500 inhabitants a high standard of living.

Northern Marianas: A chain of sixteen volcanic islands 480 km in length from north to south, with a land area of 471 km^2. Six islands are inhabited. Two-thirds of the 15,000-strong population are Chamorros, descendants of the indigenous population, while the remaining third are the offspring of immigrants from the Carolines.

Guam: A United States territory situated at the southern end of the Marianas, Guam is an old volcanic island, 549 km^2 in area. The population of around 100,000 has been influenced by Spanish colonisation. The economy relies on the military base and tourism.

Palau: This group of islands in the western Carolines is formed of more than 200 islands, some of which are volcanic and others elevated reefs (460 km^2). Eight of these islands are populated by a total of 14,000 Micronesians.

Federated States of Micronesia: Stretching from west to east of the Caroline Islands, the FSM comprise Yap, with its four high islands and atolls (121 km^2), Truk, made up of volcanic islands and atolls (118 km^2) enclosed by a broad reef and a lagoon, Ponape and Kosrae. The Micronesian population totals approximately 70,000.

Marshall Islands: The easternmost part of the former U.S. Trust Territory of the Pacific Islands. The 34 islands include 29 atolls (180 km^2) scattered over almost 970,000 km^2 of ocean. The Micronesian population is 29,000 in number.

The diversity of the physical environment and the peoples is matched by the great differences in political status, often a legacy of the last war. The problems of economic development are manifold, and often intractable because of the sheer smallness of the territories, their low population densities and their remoteness from world markets. Difficulties due to climatic hazards, cyclones and drought also have to be contended with.

1.3.3 Coastal zones and resources

The very vastness of the ocean leaves scope for planning greater utilisation of fisheries resources. The traditional importance of this activity has been reinforced by the establishment of two hundred nautical mile exclusive economic zones. The pelagic resources, mainly consisting of tuna, are capable of sustaining more intensive exploitation.

The coastal environments are highly diverse, as a result of various historical, climatic, physical and biological factors. The principal types of substrate are:

- coral formations developing on coasts not subject to major alluvial deposits or cold water currents;

- other rock or sedimentary substrates of beaches, estuaries and lagoons.

Historical factors such as fluctuations in sea level caused by glaciation or tectonic accidents, during the Quaternary period in particular, have influenced coastal morphology and reef building. The major reef types - fringing reefs, islet reefs, barrier reefs and atolls - feature zonation in groupings or parallel formations, as determined by the gradients of the relevant environmental factors.

The physical structure of an island has a direct impact on the composition of its substrate. Continental type islands, with varied soils and subject to orographic rain, show the greatest degree of diversity. The structure of volcanic islands and elevated platform reefs varies according to the age of the volcanic activity or the elevation. Atolls are the least diversified islands and the extent of inflow from and outflow to the ocean determines the degree of confinement of their lagoons.

Coastal resources are also very varied; they have been utilised on a small scale as a source of food since time immemorial but also as ornaments and trade items. The harvest is very varied: certain algae, molluscs (trochus, collectors' shells, giant clams, pearl-shells, oysters, cephalopods, etc.) and shellfish (prawns, crabs, spiny lobsters) being the most commonly gathered invertebrates, but corals,. sponges and echinoderms are also consumed. Among vertebrates, besides an untold number of fish species, turtles and dugongs are also exploited.

2. GENERAL INFORMATION ON HOLOTHURIANS AND THEIR EXPLOITATION

2.1 Holothurians

2.1.1 General characteristics

Holothurians, or sea cucumbers, form one of the five classes of the marine phylum of echinoderms. They possess the main characteristics of this subdivision, as described in detail by Hyman (1955), Boolootian (1966) and Meglitsh (1975). Certain aspects of their anatomy, physiology and ecology will be discussed as an introduction to this paper. Echinoderms are characterized by their lack of segmentation, an endoskeleton of calcareous ossicles and a spacious coelom with complex chambering which is the source of the haemal and water-vascular or ambulacral systems. The latter system is hydraulic, comprising ambulacral tube feet or podia, in which the functions of respiration, locomotion and sensory reception are combined. The typical pentaradial body symmetry is mirrored by secondary bilateral symmetry visible on the body surface, where five radial ambulacral tracts, which usually bear the tube feet, alternate with five intermediate trunks. The alimentary canal is complete, the nervous system is not centralized and the reproductive system is simple. Embryonic development proceeds by a series of larval stages.

2.1.2 Anatomy and biology

The Class Holothurioidea, consisting of approximately 1,200 species, features a soft, cylindrical body, elongated along an axis from mouth to anus which rests on the trivium, that is to say, the three ambulacral "ABE zones" of the Carpentier system, and a reduced endoskeleton formed of microscopic spicules embedded in the body wall. The six orders of this class, Dendrochirotida, Dactylochirotida, Aspidochirotida, Elasipodida, Apodida and Molpadiida are distinguished by the presence or absence of tube feet, the shape of the mouth tentacles and the presence or absence of oral retractor muscles, respiratory trees and cuvierian organs. Most commercial species belong to the order Aspidochirotida, whose general characteristics are described and illustrated in Figure 2.

These holothurians have many oral tentacles (multiples of five, up to thirty) of the peltate type. On the trivium, the podia are either arranged in three rows or cover the whole creeping ventral surface or sole. On the bivium, they may occur in the modified form of wart-like processes or papillae, more or less highly developed. Their generally dull, brown, grey or black colouring is occasionally relieved by bright shades such as the green of *Stichopus chloronotus*, coloured stripes, as with *Bohadschia vitiensis*, or the blotches or ocelli of *Bohadschia argus*. Some species (*Bohadschia marmorata*, *Holothuria scabra*) show a high degree of polymorphism.

The edible part is the body wall. There is no clear dividing line between the epidermis and the softer underlying dermis, while the deeper dermis is dense, consisting of fibrous connective tissue enveloping the spicules, pigments, coelomocytes and a nervous plexus. The spicules, which form the internal skeleton, are microscopic elements which are important taxonomically. They occur in a very wide variety of shapes, from tiny rods, plates, rosettes, ellipsoids or buttons to more complex forms such as tables with discs or arrow-heads. Species descriptions are based on spicule shape, distribution and abundance in the dorsal and ventral body wall, and on the papillae, the podia and the tentacles.

The internal skeleton also contains the peripharyngeal calcareous ring, an organ partly comparable to Aristotle's lantern in sea urchins. To this ring, formed of calcified plates differing in size and shape from species to species, are attached five longitudinal muscular bands, which contract to allow the oral tentacles to be retracted into the mouth under the oral membrane. Aspidochirotes are usually detritus-feeders, using their tentacles to gather food on the hard or soft substrate. This food passes through a long tubular digestive canal beginning with a muscular pharynx; through the calcareous ring passes an oesophagus, opening into a short stomach which is succeeded by an intestine with three loops, the first going backwards, the second forwards and the third backwards, terminating in a large cloaca opening outwards through an anus, which is sometimes ringed with calcified anal papillae (anal teeth). A recent review of available knowledge on the digestive system and nutrition appears in 'Echinoderm nutrition' (Jangoux and Lawrence, 1982).

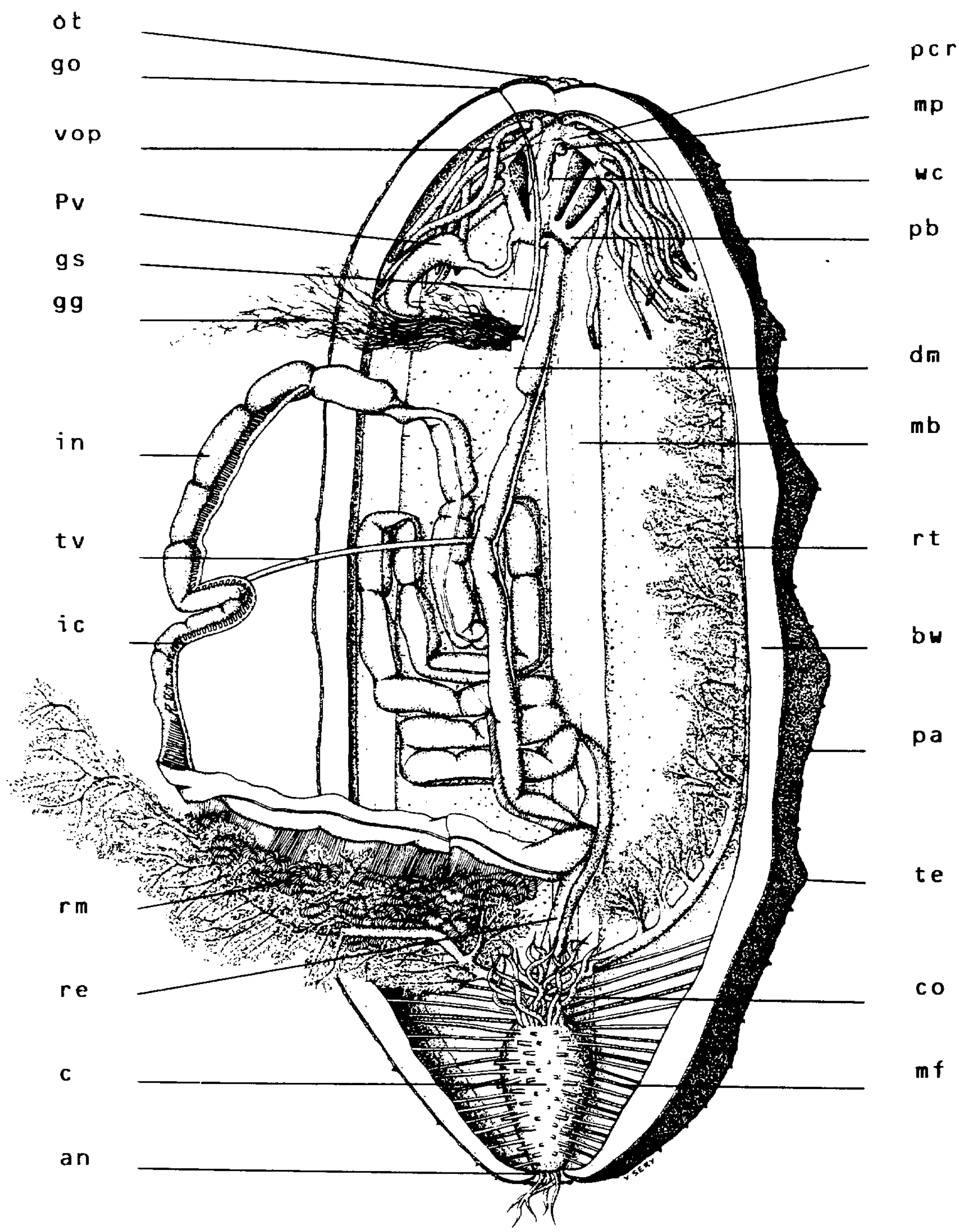
The two branched bodies of the respiratory trees terminate, either separately or jointly, in the cloaca. They pass up through the coelomic cavity; the left-hand respiratory tree is sometimes, as with *Holothuria nobilis* (Figure 2), intertwined with the haemal system *(rete mirabile)*, which is attached to the forward loop of the intestine.

Cuvierian organs are present in some species of genera *Holothuria* and *Actinopyga*, in particular abundance with *Bohadschia*. These sticky tubules, attached to the base of the respiratory trees, are expelled through the anus towards a source of irritation. They are generally considered to be a defensive organ.

The reproductive system consists of an unpaired genital gland (contrary to other echinoderms whose pentaradial symmetry is reflected in the gonads). The sexes are usually separate. The gonad consists of one or two tufts of tubules attached to the dorsal mesentery through which the gonoduct passes, terminating in a gonopore or a genital papilla. The gametes are freely released into the sea water. Some brooding takes place with certain species of dendrochirotes and apodes but aspidochirotes are oviparous.

A special kind of behaviour occurs during spawning. The male and female animals rear upright and, attached to the substrate by the posterior podia, sway back and forth while the sexual cells are released.

After radial holoblastic segmentation, development follows a series of larval stages: the first is a swimming larva with ciliate bands, *auricularia*, which evolves into *dololaria*. The *pentacula* stage, characterized by five oral tentacles and the first podia, becomes benthic. The juvenile, initially transparent, gradually acquires adult characteristics.



<u>Figure 2</u>: Anatomy of *Holothuria nobilis*

ot: oral tentacles go: genital orifice vop: vesicles of the oral podia mp: madreporite wc: water ring canal Pv: Polian vesicle pcr: peripharyngeal calcareous ring mb: radial muscular band gs : genital stolon gg: genital gland
co: cuvierian organs c : cloaca an: anus re: rectum rt: right respiratory tree pb: pharyngeal bulb rm: rete mirabile tv: transverse vessel ic: intestinal cavity dm: dorsal mesentery mf: muscle fibres bw: body wall in: intestine
pa: papillae te: teats

Asexual reproduction, by transverse binary fission, has been recorded with a number of species. In *Holothuria atra*, the incidence may be as high as 70 per cent of the population (Harriot, 1982). Evisceration and autotomy are probably processes of adaptation to unfavourable environmental conditions. These enable the individual to survive with a reduced metabolism and are followed by regeneration when normal ambient conditions are restored.

Holothurian toxicity, due to the presence of holothurin, has been tested on many organisms. The toxin is concentrated in the body wall, the viscera and particularly in the cuvierian organs. Its ecological significance is probably that it acts as a protection against predators (Bakus, 1968).

2.1.3 Distribution

Holothurians are found in many marine biotopes at all latitudes, from the foreshore to greater depths. They are usually benthic except for some pelagic Elasipodida. Although some species live on hard substrates (rocks, cavities, coral reefs) or in epibiosis on plants or invertebrates, they more regularly inhabit soft bottoms, either living on the seabed surface or, temporarily or permanently, in the sediment.

The distribution of the various groups in coastal zones shows the predominance of Aspidochirotida between the tropics and of Dendrochirotida in temperate and higher latitudes.

The greatest degree of diversity occurs in the tropical coastal areas where genus *Holothuria*, for example, comprises 114 species (Rowe, 1969). Much disparity is evident in the surveys carried out in the Indo-Pacific area, with regard both to the purpose of the study and the methods used, which makes comparisons difficult. This difficulty is exacerbated by the wide variety of biotopes. Holothurian densities, whether mean or maximum, may be as high as several hundred animals per square metre. This aspect will be investigated in more detail in Chapter 5, which deals with resources.

In deep-water zones, holothurians account for a high percentage of total biomass, where their abundance was discovered by the 'Challenger' expeditions. More recent papers have concentrated on their quantitative distribution in relation to environmental parameters (Sibuet, 1985) or to their life cycles or behaviour (Tyler, et al., 1985).

2.2 The holothurian as a commodity

2.2.1 Consumption of fresh sea cucumber

The consumption of holothurians, either raw or after very simple preparation, is common in Japan and Korea.

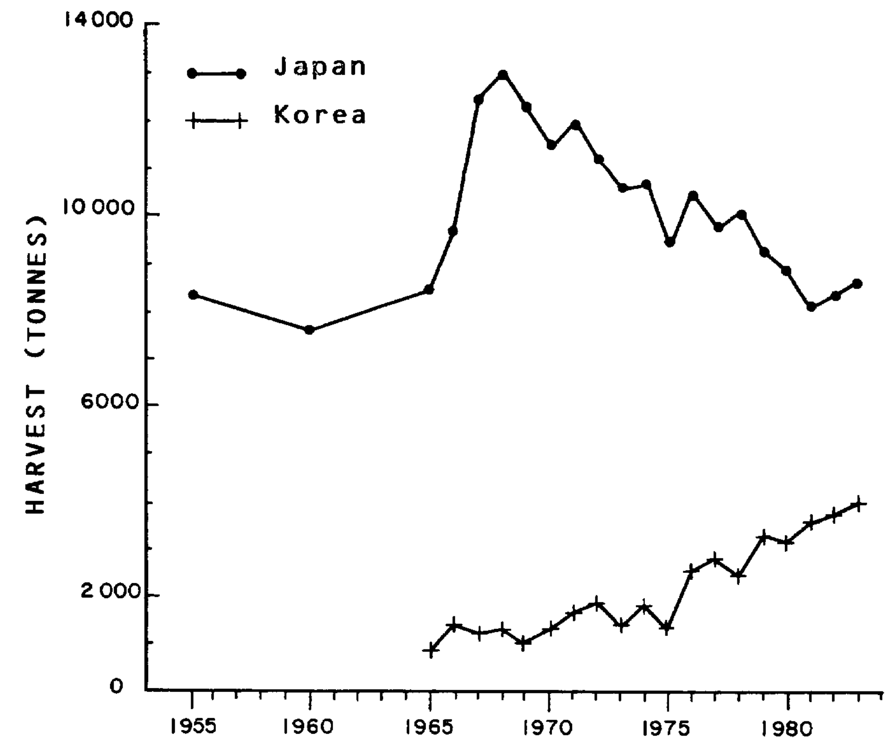


Figure 3: Evolution of the *Stichopus japonicus* fishery

Table 2: Estimates of the world harvest of holothurians for preparation as bêche-de-mer and geographical distribution, by area

AREA	1978	1979	1980	1981	1982	1983
Southern Pacific (%)	8	4	4	2	4	4
Central Pacific (%)	54	65	68	77	75	76
Northern Indian Ocean (%)	11	9	10	9	9	10
Western Indian Ocean (%)	26	21	17	11	12	8
Total (MT, fresh weight)	10 860	10 540	15 370	13 300	13 600	14 450

In Japan, the body wall, 'namako', is eaten raw, in slices soaked in a mixture of vinegar and soya sauce. Other organs are also considered delicacies: the ovaries, either dry, 'konoko', or salted and fermented; the intestines, 'konowata', and even the respiratory trees, 'minowata'. A dry product, known as 'iriko', is also traditionally produced. Choe (1963) refers to this product as an export to China along with abalones and sharks' fins, but this trade has now declined to less than ten tonnes per year. Market prices are generally much higher for the viscera than for the body wall (Mottet, 1976). According to documentation communicated by Dr Ishida, referring to two locations in Aichi prefecture in 1976, 'konowata' was fetching between 13 and 20,000 yen per kilogram, while 'namako' was priced on average at 1,000 yen per kilogram; seasonal price fluctuations were very marked, being dictated by the availability of the various organs.

In 1983, the sea cucumber harvest totalled around 8,700 tonnes, confirming a gradual downward trend since 1970, when it exceeded 12,000 tonnes (Figure 3). According to the annual statistics for 1978, the geographical distribution was very uneven; for example, the 8,970 tonnes collected in 1980 consisted of 42 per cent from the Seto Naika Sea, 16 per cent from Hokkaido, 15 per cent for the Pacific region, 18 per cent from the Sea of Japan and 9 per cent from the China seas. According to Suguri (1965) in Mottet (1976), fishing regulations were determined by the prefectural authorities and the cooperatives and were based on closed seasons and quotas. The timing of fishing bans varied from region to region; during the spawning season of *Stichopus japonicus*, fishing was forbidden for periods varying from two months, the shortest, to eight months, as at Aichi. April-to-December is the breeding and estivation season. During the summer, this species stops feeding, its intestine atrophies and the body wall loses weight; these occurrences are more pronounced with specimens aged three years or over. Attempts to increase stocks have traditionally been made either by using artificial reefs or by transplanting adults or juveniles.

The next most prolific *Stichopus japonicus* harvest is recorded in the Republic of Korea. FAO statistics for this country are shown alongside those for Japan (Figure 3).

This species is also harvested in the extreme eastern portion of the USSR, in Peter The Great Bay. In a work on the biology, fisheries and uses of *Stichopus japonicus*, Levin (1982), presented catch data since the early part of the century; these are incomplete and sometimes contradictory; approximately 6,000 tonnes had been collected by 1935. After 1970, reliable data reveal a decline in the harvest from 274 tonnes in 1970 to 33 in 1978. To this figure should be added the harvest taken by private individuals with a taste for this animal, which is probably of equivalent size. Fishing is regulated by quotas and a summer closed season. Hopes for a future production increase are being pinned on aquaculture (Mokretsova, 1978).

A dry product, 'Hai-som', is prepared from this species in China and a number of recent articles have dealt with artificial reproduction and larvae breeding (Shuxu and Gongchao, 1981; Shui Xi-Lin *et al.*, 1984). This activity is carried out by the people's communes, who sell their catch to the government. The local market absorbs the production estimated at 60-100 tonnes dry weight per year.

2.2.2 The bêche-de-mer industry - world statistics and the importance of the South Pacific

On the whole, it is difficult to find statistics on small-scale artisanal fisheries in the South Pacific region. The sea cucumber is chiefly gathered in the seas of tropical countries with limited technology and where, in some cases, part of the harvest is consumed locally, in countries with a large ethnic Chinese community. Some evaluations refer to the catch (fresh weight), and others to the processed, dry product; in the latter case, figures have to be multiplied by ten (cf. section 6.2) to obtain the approximate equivalent fresh weight.

Catch estimates were made using the results of a survey carried out by ORSTOM which consulted French embassies and local fisheries departments in countries where this activity had a long history, and the FAO's statistical yearbooks (1978 to 1983).

Holothurian fishing grounds throughout the world exploited for bêche-de-mer production can be divided into various groupings, determined by the geographical area and the species concerned (Conand and Sloan, in press), as follows:

- the western central Pacific, itself subdivided into the central Pacific and the southern tropical Pacific, where the activity is chiefly centred on Fiji, the Solomons and New Caledonia; some other islands produce small quantities or would be interested in resuming this activity (cf. section 3.5). The major bêche-de-mer producers are to be found among the states of the central Pacific area - the Philippines, Indonesia and Malaysia - but their statistics are not always accessible. Generally speaking, a number of different species are harvested in each of these countries.

- another traditional fishery area is the Indian Ocean, especially for the species *H. scabra*. This zone may be split into eastern Africa and south-west Asia, including India and Sri Lanka. The main east African countries involved are Madagascar, Mozambique, Tanzania and Kenya.

- The north-eastern Pacific, British Columbia, Washington and California have recently begun developing fisheries for two species (Sloan, 1986); these operations remain modest, representing less than one per cent of the world market and will therefore not be detailed.

The table gives a summary of the harvest, area by area, in recent years.

The total annual harvest ranges from 10 to 15,000 tonnes and would appear to be following a slight upward trend in recent years. A study of the Hong Kong and Singapore market statistics would yield a more accurate picture, but the substantial tonnages of bêche-de-mer re-exported from these centres make interpretation of these figures difficult. Indeed, the same product may crop up in a number of markets one after the other (cf. Chapter 7).

The Philippine and Indonesian fisheries are by far the biggest and the southern tropical Pacific only accounts for 10 per cent of the world catch.

3. THE INDUSTRY PAST AND PRESENT IN THE SOUTH PACIFIC

3.1 Introduction

To gauge available resources and decide how stocks can be rationally managed, it is necessary to appraise the present state of the industry. The fisheries take many forms and often represent a very small-scale activity; little information is therefore available. It would seem relevant to discuss the history of the trade in some detail. The trepang or bêche-de-mer industry developed as a result of the combined impact of historical and socio-economic factors on the biological resource. Analysis of the distinct fluctuations in these circumstances may cast light on the present position and point the way towards rationally-conceived management.

The history of fishing and trade may be divided into a number of phases. From the distant past to the 19th century, what we know is drawn from navigators' logs. During the first half of the 20th century, the earliest statistics were examined and revealed China's importance as an importer (Sella and Sella, 1940). Once the Chinese market was closed, Singapore and Hong Kong took its place as the main trading centres.

3.2 From the origins to the nineteenth century

Dried sea cucumber is a traditional Chinese delicacy, referred to in that country's early folk tales. It also appears in Japanese legends, such as the story of Princess Anna at Irako who explains the origins of sea cucumbers and the story of the race between the holothurian and the whale (Choe, 1963). For a thousand years or more, the Chinese sought this commodity in India, Indonesia and the Philippines. In conducting their fishing and trading activities, which gradually covered a wider and wider area, the Chinese taught native populations processing techniques, but kept a firm grip on the trade.

During the 18th century, traders from Makassar in the Celebes gathered and prepared bêche-de-mer on the northern coast of Australia. Each year with the November monsoon they set course for Arnhem Land aboard their proas, 10 to 25 tonne sailing boats; there they stayed several months collecting and curing holothurians before sailing home with the tradewinds. Here it was that, in 1803, Captain Flinders, on board the 'Investigator', encountered them, estimating that 60 sailing ships were carrying a cargo of six million cured holothurians. Mulvaney (1975) gave an account of early contacts with the Aborigines and their amicable relationship with the Malays. The east-African trade also commenced about the same time or possibly earlier.

At the end of the 18th century European, Australian and American traders, the latter from New England, began prospecting the South Sea islands for bêche-de-mer to trade in Manilla or Canton for tea, silk and spices to sell at home. The term 'bêche-de-mer', adopted by the English language, is a French translation of the Portuguese 'bicho-do-mar' meaning sea worm. These traders also dealt in sandalwood, pearls, pearl-shell and turtle-shell. The expansion of this trade had a significant impact on the island peoples with whom, for the first time, lasting contact was made (Ward, 1972).

3.3 Nineteenth century

The heyday of the trade probably came in the 19th century, but virtually no hard information exists. China was the main importer and Simmonds (1879) estimated that between 1868 and 1872 trade in this commodity amounted to 1,000 tonnes per year, whereas Seale (1911) put it as high as 3,000 tonnes.

Ward (1972) investigated this trade in the Pacific islands thoroughly. Its scale has varied both in space, from Australia to Guam and Fiji, and in time, influenced by prices on the Chinese market, the availability of sandalwood, and over-fishing of the reefs. From 1820, for some ten years, Spanish, Australian and New England vessels combed the reefs and loaded bêche-de-mer cargoes. After a decline in interest between 1830 and 1840, during which time Spanish ships carried cargoes from Yap and Palau, the trade flourished for a further decade. The navigators were operating in the Carolines, the Solomons and Fiji. The organisation of the trade then changed with permanent trading posts being set up to buy direct from island populations, storing their purchases until a ship arrived. Its importance then diminished with the diversification of export products. Cooktown was at that time the main centre for trade in this area. Elsewhere, merchants from Hawaii, Guam, Tahiti and Manilla bought bêche-de-mer from all the islands with abundant holothurian populations.

The strongest influence over this activity was exercised by Fiji, according to Ward (1972), whose study was based on ships' logs. Between 1830 and 1835 three to four cargoes each weighing 35 to 70 tonnes were shipped each year. In the second period, 1842 to 1850, the trade wavered, with ships taking longer to load a full cargo, apparently because the reefs had been overfished during the previous 'rush'. A decline set in after 1850; around 1865 bêche-de-mer still accounted for 6 per cent of the value of exports, as against a mere 0.13 per cent in 1869.

Saville-Kent (1903) described the exports from Australia between 1880 and 1889 during which time Queensland exported 2,724 tonnes, 607 of which had originated in New Guinea. The annual quantities varied from 162 to 259 tonnes.

In his thesis, Russell (1970) explained that in New Guinea the trade was organised around small trading posts and was dependent on Queensland. The period of prosperity only lasted from 1873 to 1885, with the decline, in terms of both tonnage and value, growing more marked after the end of the century.

Sandalwood traders began visiting New Caledonia and its dependencies, the Loyalty Islands and the Isle of Pines, in 1841, hoping to set up bêche-de-mer fisheries. The first attempts were sometimes fraught with difficulties, such as the attack on the brigantine 'Bull' reported by Cheyne and that on the 'Mary' (Douglas, 1971). Bêche-de-mer was a recurrent item in the cargoes of sandalwood ships listed by Shineberg (1973) which touched New Caledonia between 1845 and 1855. This trade was based on Sydney until 1865 and was greatly influenced by the businessman, R. Towns. With Paddon and Henry, his fellow merchants, he realised the need to found a permanent trading post on the Isle of Pines and then later others on Nou island off Port-de-France (today's Noumea), Paita and Ouvea.

After France claimed the island in 1853, bêche-de-mer, sandalwood and coconut oil became the main export commodities. Most of the production originated on concessions operated by managers working for Paddon, Henry and Higginson. The missionaries encouraged some Melanesian tribes to gather holothurians as well, which they sold to passing ships, as did some small European producers. This activity is often described in accounts of that period, such as those given by Patouillet (1873) and Garnier (1867), the engineer who discovered nickel, whose book 'Voyage à la Nouvelle-Calédonie' provided Figure 4.

To assess bêche-de-mer production at that time, the shipping movements recorded in 'Le Moniteur Imperial' a newspaper later to become 'Le Moniteur', were analysed. This publication listed sailing dates and destinations for each vessel and gave details of its cargo. Coastal trading records can be similarly informative on quantities and production areas, at least for bêche-de-mer shipped through Noumea (Table 3). The first reference appears in No. 96, July 1861, when the Australian brig 'Gazelle', was reported as carrying thirteen sacks of bêche-de-mer. A ministerial request was made the same year for specimens to be sent to the London Universal Exposition in 1862. Between 1862 and 1875, this column was published regularly and provides an indication of the size of the industry. There was substantial commerce between 1865 and 1868 and the figures for shipments arriving on coasters and departing to Sydney, the port of transshipment for China, match quite closely. After shrinking slightly, the market saw another burst of activity between 1872 and 1874, after which time cargo details ceased appearing regularly.

This journal became the 'Journal officiel' in June 1886, publishing a quarterly summary of imports and exports. Table 4 has been drawn up on the basis of this item. Changes in the Territory's activities can be inferred from the way exports developed: mining activities expanded and copra production increased, replacing coconut oil, while the agricultural and livestock sectors were developed.

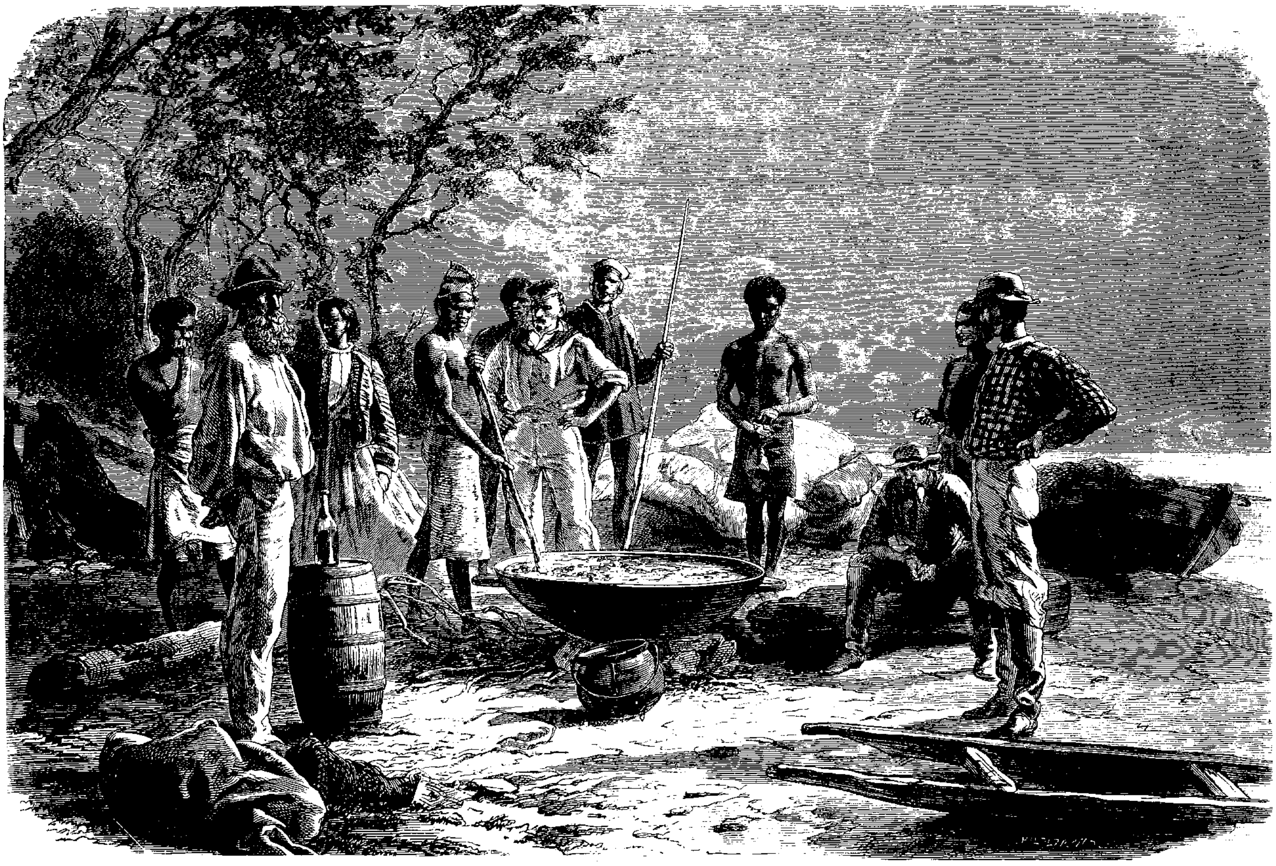
3.4 First half of the twentieth century

The many more detailed studies which emerged from this period usually included trade statistics. General works by Sella and Sella (1940) and Panning (1944) described trepang fisheries around the world, the various preparation techniques and the species utilised. Production in the Pacific islands only accounted for a small proportion of the total.

In Australia, this activity was pursued in the Torres Strait and along the eastern shore of the tropical zone. Data on export tonnages are fairly disparate: 1925, 168 tonnes; 1928, 131 tonnes; 1934, 409 tonnes; 1935, 190 tonnes; 1936, 61 tonnes.

For Papua New Guinea, Shelley (1981) quoted 83 tonnes in 1903, which ranked this product in fifth position on the list of exports. Each year on average, Papua exported 60 tonnes and the Trust Territory of New Guinea 98.

In Fiji, quantities fluctuated in relation to prices, reaching 143 tonnes in 1931.



The preparation of trepang - Drawing by A. de Neuville from a photograph

Figure 4: Boiling trepang in the 19th century (in "Voyages à la Nouvelle-Calédonie" (Journeys to New Caledonia) by Jules Garnier, Hachette, 1967-68)

In New Caledonia, the tonnages exported from 1903 to 1930 were recorded in the Noumea Chamber of Commerce's 'Bulletins'. Details of such exports also appeared in an unpublished report by the Government Secretary-General entitled 'The Economy of New Caledonia in 1954'. The results, assembled in Table 5, which quotes bêche-de-mer tonnages and their value as a proportion of total exports, excluding ore, show distinct fluctuations. The quantities rarely exceeded 50 tonnes. A boom took place between 1922 and 1924. A price rise brought on a rush of activity by European, Melanesian and even a few Japanese fishermen. Even for this period, however, bêche-de-mer only represented a small percentage of exports. Activity subsequently subsided, probably due to a fall in prices, and came to a halt during the Second World War.

The average annual import and export tonnages at Singapore and Penang were calculated by Hornell (1917) for the period from 1907 to 1916. During this decade, Singapore handled 363 tonnes from 18 countries, chiefly the Philippines, the Celebes, the Moluccas and Borneo. Australia provided a little over 8 tonnes, New Guinea (German) 2.7 tonnes and French Pacific territories 1.4 tonnes. To Penang, where imports only averaged 49 tonnes for the same period, Australia provided only around a tonne.

The statistics presented by Sella and Sella (1940) generally related to the period from 1931 to 1933. On average, over the three years, 367 tonnes per year were imported into Malaysia, mainly from the Philippines and the Dutch East Indies. Australia exported 14 tonnes on average. Statistics for the same years were also given for Hong Kong. The average was 1,315 tonnes from twenty or so different countries. Australia emerged as the main supplier with 354 tonnes. French Pacific possessions exported 1.8 tonnes, but exports from New Caledonia transited through Australia and therefore appeared in that country's statistics. The countries of the British Empire accounted for a major share but the configuration of the colonial empires makes statistical interpretation difficult. Lastly, China's imports came mainly from Hong Kong and Malaysia, revealing the complexity of the import and re-export circuits through clearing houses. Imports, which averaged around the 2,000 tonne mark between 1932 and 1934, fell away sharply in 1936 as the world-wide slump set in.

3.5 Traditional consumption and commercial trade in the South Pacific today

A number of traditional ways of consuming or using holothurians should be mentioned before going on to the subject of bêche-de-mer preparation for export. Some Polynesian peoples (particularly in Samoa and Wallis) and Micronesian populations (Palau) consume the body wall raw, sometimes seasoned with lime juice. In Fiji, *Holothuria scabra* is cooked in coconut milk (Figure 5) while in Papua New Guinea the sea cucumber is sometimes grilled. Plesis (1975) reported that a toxin from the body wall of *Holothuria atra* was sometimes used in Polynesia to stun fish in tidal ponds and in traditional medicine to soothe injuries caused by urchin spines. A small pharmaceutical activity has recently been set up on a Torres strait island, using holothurians in the production of a medicine for the relief of arthritis (Johannes, personal communication).

It is hard to put a figure on the scale of these fisheries. In Fiji, three species of holothurian appear in the market statistics under the marine products (excluding fish) category. *Holothuria scabra* or 'dairo' is the main species concerned, accounting for 7 tonnes out of a total catch of 7.8 tonnes in 1980, 5.6 out of 6.5 in 1981 and 7.8 out of 11 in 1982. Most of this trade takes place outside the commercial circuits but has social importance.

The gathering of sea cucumber to prepare bêche-de-mer was halted during the Second World War. No published data exist for the period between then and the revival of interest in the seventies when the FAO and the SPC, who were implementing a programme designed to breathe new life into this trade in the islands of the South Pacific, engaged a consultant, Mr Sachithananthan. His reports from 1971 to 1972 yielded information about the scale of production. The FAO fisheries statistics yearbooks recorded catches country by country. Lastly, a survey was carried out by ORSTOM in 1978 in countries where this activity had a long history. A form was sent out to the cultural counsellors of French Embassies, to some Chambers of Commerce and to Heads of Fisheries.[3]

These figures may be compared with the import statistics for Hong Kong and Singapore.

Although some statistics are lacking, a fairly close correlation is observed between the data from various sources. On the whole, national production figures are fairly low, usually under 50 tonnes of dry product per year (Table 6).

In Australia, interest has revived on various occasions (Anon., 1969, 1979). Despite the resulting studies on techniques and potential, fisheries did not develop. For essentially socio-economic reasons, Harriot (1985) came to the conclusion that this activity was unlikely to be viable on the Great Barrier Reef. Shelley (in press) believes that if stocks were first assessed then constantly monitored, an artisanal fishery in the Torres Strait islands would again be a proposition.

The harvest in Fiji is showing a gradual upward trend. The Fisheries Division markets a certain tonnage each year and, in cooperation with FAO/UNDP and the SPC, organises training courses and demonstrations of processing techniques, intended both for Fijians and for participants from the various South Pacific countries.

Production in the Solomon Islands is subject to marked fluctuations. James (1977) described the development of the trade: a protected industry based on the processing of fresh holothurians functioned in Honiara from 1966 to 1971, but could not survive because of difficulties associated with the storage and transport of the live animals. When the monopoly was withdrawn, production began to increase. In 1984, exports exceeded 44 tonnes, worth SI$251,000, almost 80 per cent of which went to Hong Kong.

In Papua New Guinea, on the basis of exports from Port Moresby, the harvest is quite small (Shelley, 1981).

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3. It is my pleasant duty to express my gratitude to everybody who obtained and sent me such information.

Table 3: Bêche-de-mer shipments via Noumea from 1862 to 1887 (according to "Le Moniteur" and "Le Moniteur Impérial").

x = tonnage not stated.
* = cargos arriving from various quarters:
New Hebrides (Vanuatu), Sandwich Islands (Hawaii).

YEAR	NOUMEA-SYDNEY No. of ships	NOUMEA-SYDNEY Tonnage	COASTAL TRAFFIC No. of ships	COASTAL TRAFFIC Tonnage
1862	3	3.5 t	9	2 t + x
1863	4	1.2 t + 4.5 barrels	9	0.2 t + x
1864	7	16 t + 2 barrels	16	1 barrel + x
1865	6	28.5 t	26	22.4 t + x
1866	5	35 t	38	34.4 t
1867	7	24.5 t	20	9.9 t
1868	7	36.7 t + x	10	9.9 t + x
1869	10	21.2 t	5	3.4 t
1870	5	7 t + 8 bales	9	6.8 t
1871	10	20.5 t + 54 sacks	15	14.7 t + x
1872	13	44.8 t	42	37.1 t
1873	9	28 t + 34 casks	54	57.8 t
1874	1	1.5 t	22	30.2 t
1875	1	0.8 t	17	14.4 t
1876	-	-	7	7.5 t + 50 sacks
1877	-	-	-	-
1878	-	-	1	10 t*
1879	-	-	5	7 t* + 105 sacks
1880	-	-	4	1 t* + 6 sacks
1881	-	-	-	-
1882	-	-	-	-
1883	-	-	-	-
1884	-	-	-	-
1885	-	-	4	1 t + x
1886	-	-	4	x
1887	-	-	1	x

Table 4: Bêche-de-mer and other exports from New Caledonia, 1888 to 1895 (according to "Journal Officiel")

B = Bêche-de-mer M = ore T = total

YEAR	BECHE-DE-MER Sacks	BECHE-DE-MER Tonnes	VALUE OF EXPORTS ('000 francs) B	M	T	% B/T	% B/T-M
1888	589	30			3300		
1889	957	48			5633		
1890	839	42			7374		
1891	536	27			7512		
1892		39	50	4958	7335	0.7	2.1
1893		42	50	6938	9278	0.5	2.1
1894		18	22	5506	6371	0.3	2.5
1895		13	15	5843	7779	0.2	0.7

Table 5: Bêche-de-mer and other exports from New Caledonia during the first half of the twentieth century

B = bêche-de-mer M = ore T = total

(1) After 1920, the values are provided by the report on exports and B also includes dried fish and salted fish.

(2) After 1940, tonnages also include dried or salted fish.

YEAR	B (tonnes)	VALUE OF EXPORTS B ('000 F)	M ('000,000F)	T ('000,000F)	B/T (%)	B/T-M (%)
1903	-	35	-	9	0.40	-
1904	-	3	-	11	0.07	-
1905	-	6	-	11	0.05	-
1906	-	43	7	8	0.50	-
1907	-	67	6	7	0.90	-
1908	-	45	7	9	0.50	-
1909	32.6	33	4	6	0.60	1.60
1910	32.7	35	5	8	0.40	1.20
1911	26.7	27	8	11	0.30	0.90
1912	29.3	28	8	12	0.20	0.70
1913	-	23	8	13	0.20	0.50
1914	23.1	22	9	13	0.20	0.60
1915	59.9	86	8	13	0.70	1.70
1916	36.7	41	41	10	0.30	0.80
1917	31.3	44	13	17	0.30	1.10
1918	21.1	28	11	19	0.20	0.40
1919	10.0	17	-	18	0.10	-
1920	19.3	66 (1)	20	39	0.20	0.30
1921	36.8	85	11	24	0.30	0.60
1922	91.8	173	8	18	1.00	1.70
1923	109.0	357	11	22	1.60	3.20
1924	154.3	528	14	45	1.20	1.70
1925	61.6	266	16	48	0.60	0.80
1926	49.3	136	30	63	0.20	0.40
1927	21.0	146	32	61	0.20	0.50
1928	13.4	164	43	75	0.20	0.50
1929	24.7	222	45	69	0.30	0.90
1930	42.8	123	48	67	0.20	0.70
1931	67.9	143	40	54	0.30	1.00
1932	44.7	91	23	37	0.30	0.70
1933	41.3	48	33	45	0.10	0.40
1934	3.2	24	36	46	0.05	0.20
1935	14.9	48	41	54	0.09	0.40
1936	20.2	39	39	54	0.07	0.30
1937	22.0	40	81	104	0.04	0.20
1938	39.7	93	123	146	0.06	0.40
1939	24.6	61	132	156	0.04	0.30
1940	- (2)	1	187	200	-	-
1941	1	6	218	229	-	0.05

Table 5: Bêche-de-mer and other exports from New Caledonia during the first half of the twentieth century
(Cont'd)

B = bêche-de-mer   M = ore   T = total

(1) After 1920, the values are provided by the report on exports and B also includes dried fish and salted fish.

(2) After 1940, tonnages also include dried or salted fish.

YEAR	B (tonnes)	VALUE OF EXPORTS B ('000 F)	M ('000,000 F)	T ('000,000F)	B/T (%)	B/T-M (%)
./.						
1942	-	-	163	178	-	-
1943	3	10	181	184	-	0.30
1944	-	-	222	227	-	-
1945	-	-	165	178	-	-
1946	-	-	184	238	-	-
1947	7	84	94	195	0.04	0.08
1948	15	214	208	312	0.07	0.20
1949	3	163	340	425	0.04	0.20
1950	10	288	374	519	0.06	0.20
1951	-	-	520	688	-	-
1952	-	-	957	1 100	-	-
1953	-	-	1 226	1 394	-	-
1954	-	-	1 349	1 575	-	-

Figure 5: Traditional consumption of *H. scabra* in Fiji (photo: Conand)

Table 6: Present bêche-de-mer production in the South Pacific

COUNTRY	SOURCE	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
FIJI	FAO			0	3	4	4	36	38	19	15	22	25	46	
	Fisheries Dept.								15.3	10.4	16.9	15.8	34.6	32.9	53.1
	HONG KONG					0.3	2	9	37	6				30.3	22.8
	SINGAPORE			1					-						
SOLOMONS	FAO		200	300	18	9	20	46	34	22	37	8	18	5	
	Fisheries Dept.	5.4	35	50.8	17	9	28	39	34	10	36.5	8	17.2	4.5	44.3
	HONG KONG					8.5	18	43	27.9	14.4				4.5	35.2
	SINGAPORE														7.3
PAPUA NEW GUINEA	Shelley (1981)							5.7	12.8	2.2	3.2				
	HONG KONG							5	13	1				6	1.4
	SINGAPORE			9	1		1	4	2	3	4	12	5	7	5
NEW CALEDONIA	Conand (unpublished)								4	0	0	0	0	15	149
	HONG KONG														
	SINGAPORE								8						67

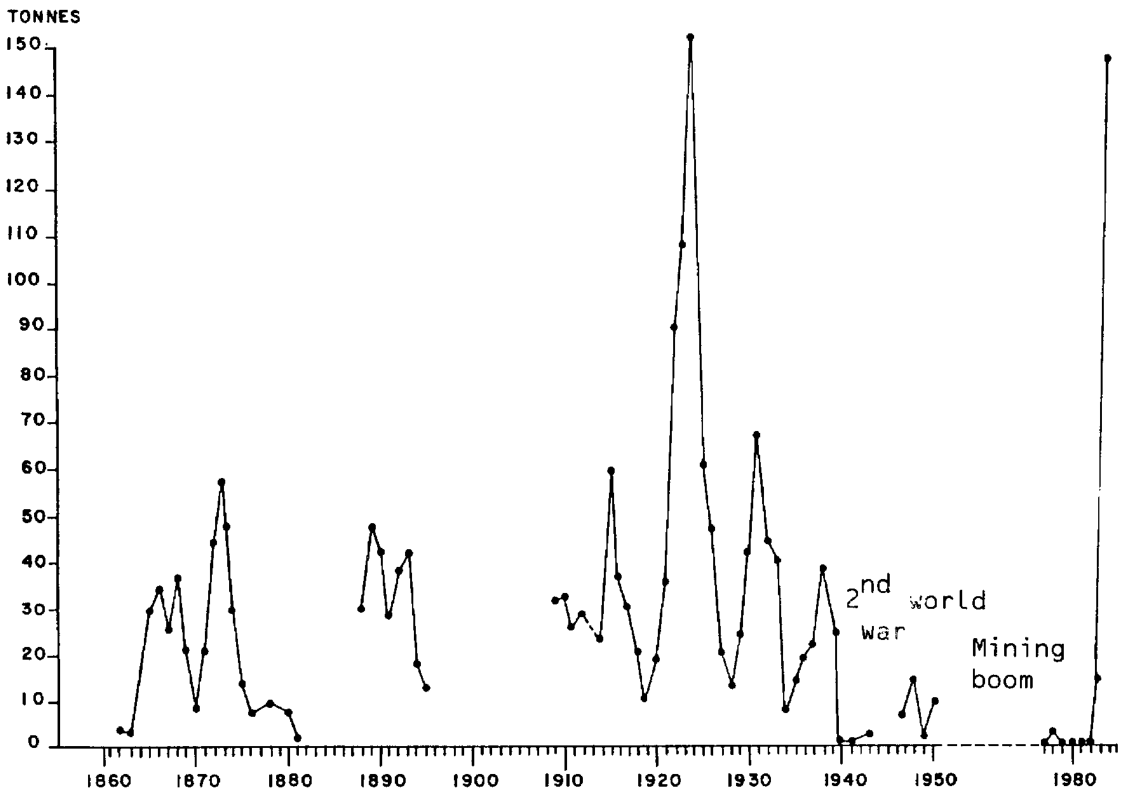


Figure 6: Bêche-de-mer exports from New Caledonia, 1862 to 1984

Table 7: Bêche-de-mer exports from New Caledonia

			DESTINATION (%)			
YEAR	TOTAL	MONTHLY TONNAGE	HONG KONG	SINGAPORE	OTHERS	NUMBER OF COMPANIES
1982	0	0	0	0	0	0
1983	15.7	2.3	88	12	-	2
1984	149.9	12.4	42	51	-	4
1985 (beginning)		6.6	-	100	-	4

This commodity has also generated a certain amount of interest in other islands and territories, for example in Truk (Howell and Henry, 1977), in Tuvalu (Pita, 1979), in French Polynesia (Yen and Neagle, 1985) and in Vanuatu.

Training courses on preparation techniques were arranged in New Caledonia in 1978 and 1979 by the territorial administration. Marketing problems, however, prevented this activity developing until 1983, when local companies, belonging to New Caledonians of Chinese origin, organised the gathering, processing and export of bêche-de-mer. Customs statistics show how this activity developed.

After a trial run early in the year, regular exports began in July 1983, mostly to Hong Kong. There was a spectacular surge in 1984, with a third company starting exports in February and a fourth in July that year. Exports were split between Hong Kong and Singapore, which came to take the larger share. The statistics for the early months of 1985 showed the average monthly tonnage dropping by 50 per cent to 6,600 kg, with all exports going to Singapore.

Figure 6, which summarises exports since 1860, shows that they have been subject to substantial fluctuations over the last century and a quarter; some of this unpredictability was due to political events, such as the Second World War, or economic circumstances, like the boom from 1922 to 1924, which was caused by a favorable price on world markets. In more recent times, this trade has been completely ignored during mining booms but has prospered during slumps, when sources of income need to be diversified. The question that now arises is whether 1984 levels of activity will be maintained and whether holothurian stocks can sustain exploitation of this kind?

4. BIOLOGY OF THE COMMERCIAL SPECIES FOUND IN THE SOUTH PACIFIC

4.1 Introduction

A knowledge of population parameters is a prerequisite for the rational management of holothurians. Published information on the various species is scarce despite their abundance and size, which qualify them as a significant component of the benthic macrofauna of lagoon and coral environments. Clark and Rowe (1971), in their monograph on shallow-water echinoderms of the Indo-Pacific area, gave a table of references to each species, by geographical area. Most of the published papers deal with the description and distribution of the various species, while some supply information on their ecology. A review by Bakus (1973) stressed the gaps in knowledge about their biology. Since then, much attention has been paid to the optimum exploitation of marine resources, the diversification of sources of income for fishermen and to gaining a better understanding of how coral reef ecosystems function. Recent research in the area, particularly that conducted by ORSTOM in New Caledonia, has enhanced available knowledge of holothurian populations (Conand, 1981, 1982, 1983).

Various species are harvested in the tropical Pacific for processing into bêche-de-mer. Common characteristics of the species concerned are their abundance in shallow water, the large size of specimens and the thickness and quality of their body wall. This should neither contain too many spicules nor deteriorate between gathering and processing; it should be borne in mind that, with some species, the body wall disintegrates rapidly (Tanikawa and Ishiko, 1955, in Mottet, 1976 and Motokawa, 1981, 1982). Using these criteria (and others imposed by the market), the species of commercial value can be subdivided into three main categories:

- species with high commercial value: *Holothuria scabra* and *Holothuria scabra* variety *versicolor*, the 'sandfish', and *Holothuria nobilis* and *Holothuria fuscogilva*, the 'teatfish';

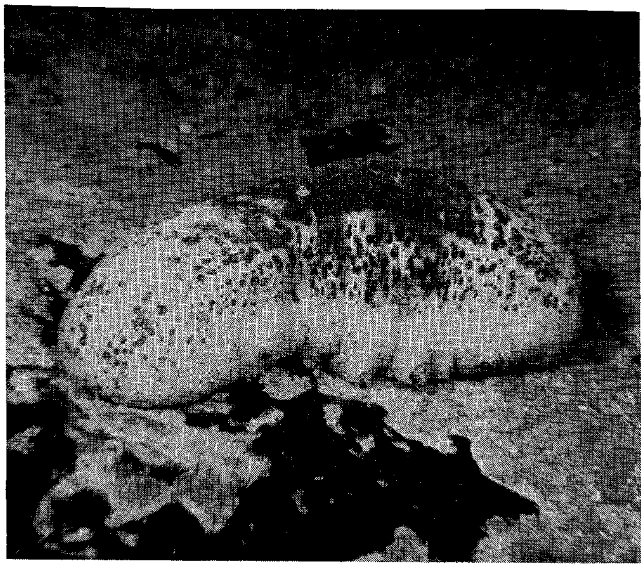
- species with medium commercial value: *Actinopyga echinites*, *Actinopyga miliaris*, *Thelenota ananas*;

- species with low commercial value: *Holothuria atra*, *Holothuria fuscopunctata*, *Actinopyga mauritiana*.

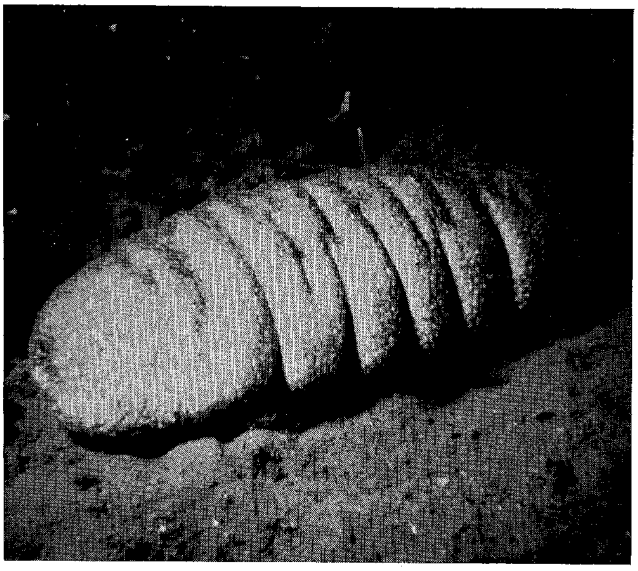
Saville-Kent (1903) and Panning (1944) refer to other species: *Bohadschia argus*, *Bohadschia marmorata*, *Holothuria edulis*, *Thelenota anax*, *Stichopus chloronotus* and *Stichopus variegatus*. These are all large species, but their harvesting was abandoned for a variety of reasons: low profit margin due to very low prices, unpleasant handling caused by the expelling of the cuvierian organs the moment *Bohadschia* is handled, the deep habitat of *Thelenota anax* and, lastly, the very rapid disintegration of the body wall with the two *Stichopus* species mentioned.

One or more species are gathered in each of the countries concerned. Present understanding of the population parameters of each species will be discussed for each commercial grade. The morphometric parameters will be given in detail because of their importance for grading processed products and for the market. One major hindrance in studying holothurians is the inaccuracy of weight and length measurements, due to the elastic consistency of the body wall, the absence of a skeleton and the variability

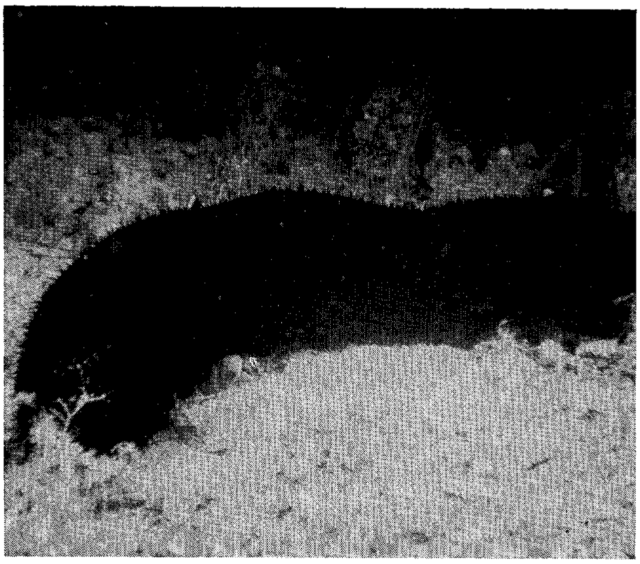
Holothuria nobilis



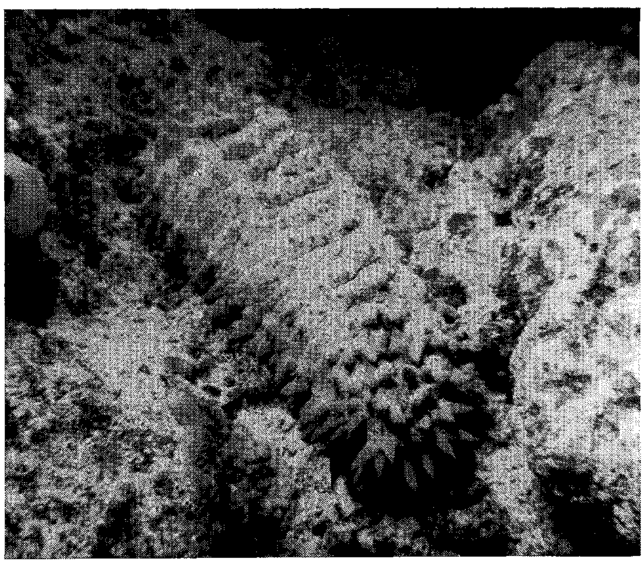
Holothuria fuscogilva



Holothuria scabra var. versicolor



Actinopyga miliaris



Thelenota ananas

Figure 7: Main commercially valuable species of holothurian (photos: ORSTOM)

of the contents of the digestive system and the coelomic fluid. The results obtained with regard to biological parameters, reproduction, growth and mobility will be discussed.

4.2 Species with high commercial value

4.2.1 Holothuria scabra (Jaeger, 1833) and H. scabra variety versicolor (Figure 7), the 'sandfish'

This species yields the second biggest catch worldwide after *Stichopus japonicus*. It accounts for the majority of bêche-de-mer exports from India, Sri Lanka and Madagascar. It is also a commodity in Indonesia, the Philippines and some tropical Pacific islands, particularly New Caledonia since 1983.

4.2.1.1 Description and distribution

Described by Jaeger in 1833, it has a wide distribution in the Indo-Pacific area; references to it may be found in a publication by Clark and Rowe (1971); Cherbonnier (1980) recorded 'its very great variability in colouring'.

From observation in New Caledonia, it would seem feasible to distinguish between *H. scabra* and *H. scabra* variety *versicolor*. Although it is not possible to describe a completely new species, in the absence of significant differences between the spicules, the calcareous ring or the anatomy, some particularities do recur regularly: the tegument colour varies with *H. scabra* from deep grey fringed with varying hues of green to very light grey on the dorsal surface. *H. scabra* shows very pronounced lateral wrinkles (Figure 7), black speckling and unpronounced papillae. Five dark lateral bands may also occur (Tan Tiu, 1981). With *H. scabra* variety *versicolor*, the colouring of the dorsal tegument is highly variable; it may be of any of the intermediate shades between light beige and unrelieved black. Some specimens show black blotches of varying size and number, but in this case the dark patches and lateral folds are absent, while the papillae and tube feet are more fully developed. The distribution of these phenotypes in New Caledonia, divided into three categories (black, speckled and beige), is given in Table 8.

The *versicolor* variety differs from *H. scabra* by its size and average weight in addition to the previous dissimilarities. It is generally (cf. Chapter 4.2.1.2) larger and heavier. There is, moreover, no difficulty whatsoever in distinguishing between a small specimen of this variety and an *H. scabra* of the same size. When specimens are being taken for monthly sampling or tagging, evisceration occurs more frequently with *H. scabra* (Table 9). Ecologically speaking, (cf. Chapter 5.2.7.2), they are characteristic of different environments. They are both absent from the barrier reef, the slopes and the outer lagoon, while remaining abundant in biotopes under terrigenous influence. *H. scabra* was gathered in sixteen locations, usually on inner reef flats, and *H. scabra* var. *versicolor* at twenty stations in the inner lagoon or in bays. Only in three places were they found together and in all such cases one or other was greatly predominant. Both burrow into the muddy or sand-and-mud sediment; this behaviour was described by Yamanouchi (1956). The maximum density for *H. scabra*, 6,000 individuals per hectare, was recorded on a beach, to seaward of a mangrove swamp, and high densities were recorded on inner reef flats

Table 8: Distribution of phenotypes of *H.* scabra var. *versicolor* in New Caledonia

n: number of animals %: percentage

STATION	HOW COLLECTED	PHENOTYPE					
		Black		Blotchy		Beige	
		n	%	n	%	n	%
1. Seagrass	Tagging	58	34	50	30	61	36
2. Outer slope	Sampling	67	26	85	33	105	40
2. Outer slope	Tagging	265	36	147	20	313	43
	TOTAL	390	34	282	24	479	42

Table 9: Evisceration by *H. scabra* and *H. scabra* var *versicolor*.

n: number collected; e: number eviscerating; %e: evisceration rate
* evisceration sometimes occurring one hour after tagging

SPECIES	TAGGING			SAMPLING		
	n	e	% e	n	e	% e
H. scabra	254	37	14.6*	365	25	6.9
H. scabra var *versicolor*	453	5	1.1	273	3	1.1

Table 10: Biometric relationships for *Holothuria scabra* and *H. scabra* var *versicolor* in New Caledonia

df: degree of freedom; r: correlation coefficient;
c: confidence interval of slope (s = 0.05)

X	Y	*Holothuria scabra* dl	r	Equation	c	*H. scabra* var *versicolor* dl	r	Equation	c
TL	TW	323	0.78	Log Y = 2.28 Log X - 6.35	2.13-2.44	268	0.76	Log Y = 2.26 Log X - 5.97	2.09-2.44
TL	DW	322	0.74	Log Y = 2.29 Log X - 6.65	2.12-2.46	270	0.63	Log Y = 2.44 Log X - 7.42	2.22-2.67
TL	GW	322	0.73	Log Y = 2.23 Log X - 6.67	2.07-2.40	270	0.64	Log Y = 2.29 Log X - 6.83	2.09-2.51
TW	DW	322	0.95	Y = 0.80 X - 7.10	0.78-0.83	268	0.84	Y = 0.68 X - 13.47	0.63-0.73
TW	GW	322	0.93	Y = 0.57 X - 4.69	0.55-0.59	268	0.75	Y = 0.44 X + 86.56	0.41-0.48
DW	GW	321	0.97	Y = 0.71 X - 0.36	0.69-0.72	270	0.93	Y = 0.66 X + 95.24	0.63-0.69

of fringing or islet reefs; the average density was 683 per hectare. Densities of *H. scabra* var. *versicolor* were generally lower, with an average of 82 per hectare. The higher densities, 450 individuals and upwards, were found in the deeper lagoon biotopes.

As well as publications on the reproductive cycle and the biochemical constituents of *H. scabra* by Krishnans and Krisnaswamy (1967, 1968, 1970, 1971), the biology of a number of populations has been studied in Moreton Bay, Australia (Harriot, 1980) in Papua New Guinea (Shelley, 1981) and in New Caledonia (Conand, unpublished).

4.2.1.2 Morphometric parameters and biometric relationships

The three studies on *H. scabra* by Harriot (1980), Shelley (1981) and Conand (unpublished) were based on monthly sampling of some twenty specimens, gathered by diving at low tide. In New Caledonia, they were taken mainly from two stations (Figure 8A) on an inner islet reef flat. The frequency distributions of total lengths (TL) were fairly similar; individuals measured from 16 to 32 centimetres, with the general average being 24 cm. In Papua New Guinea, the results obtained by Shelley from the population of an inner fringing flat south-east of Port Moresby were fairly comparable; most individuals measured between 16 and 32 cm, with a mean length of 25 cm.

Three indices were used to express fresh weight: total weight (TW), drained weight after making an incision down the inside of the back to drain the coelomic liquid (DW) and gutted weight (GW) or body wall weight. In most cases, individuals surveyed in New Caledonia (Figures 8B, C, D) weighed in at between 150 and 1,000 g, with a mean weight of 480 g; their drained weight varied from 150 to 850 g, the mean drained weight being 350 g, while the gutted weight range of 50 to 600 g gave an average of 270 g. The comparison of these figures with Shelley's shows that the weights were slightly greater at the PNG survey station, the mean values being TW: 590 g, DW: 480 g and GW: 340 g. For Moreton Bay (Harriot, 1980), the mean total weight was 440 g, not dissimilar to the average weight obtained for New Caledonia.

Most of the samples of *H. scabra* var. *versicolor* were gathered from a site in the inner lagoon, at the foot of an outer reef slope close to a lagoon islet, at a depth of between 15 and 20 m. The frequency distributions of the parameters measured (Figures 9A, B, C, D) were as follows:

TL between 24 and 48 cm	- mean:	35 cm;
TW between 600 and 2,500 g	- mean:	1,450 g ;
DW between 400 and 1,800 g	- mean:	970 g ;
GW between 300 and 1,300 g	- mean:	730 g .

This variety is therefore larger and heavier than *H. scabra*. The biometric relationships for both varieties are given in Table 10.

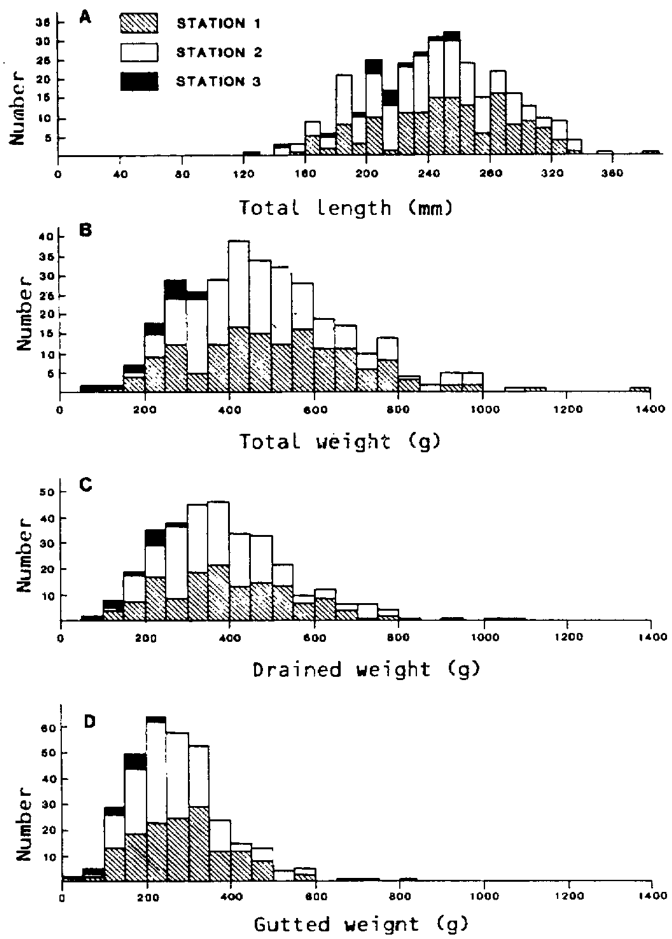


Figure 8:

Distributions of measured characters of H. scabra, New Caledonia.

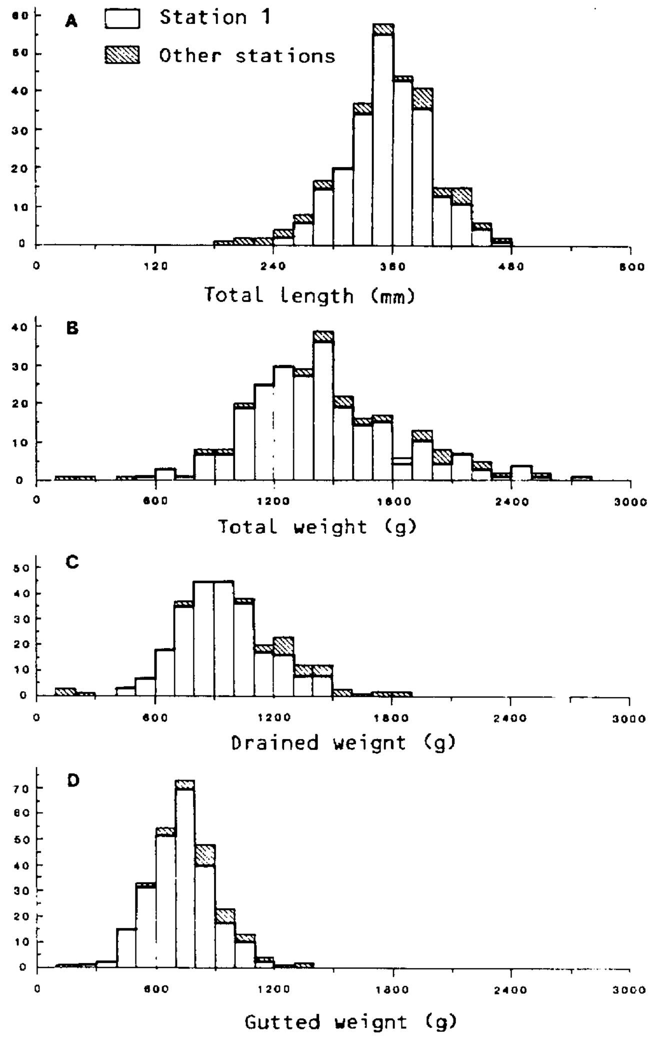


Figure 9 :

Distributions of measured characters of H. scabra var. versicolor.

4.2.1.3 Reproduction

Sexual cycle

Information on the sexual cycle of these two varieties was obtained by analysing the monthly samples. It relates to the sex-ratio, the anatomy of the genital organs and their stages of development and the evolution of the gonad index. According to the authors, this index is related either to the total weight or the drained weight, which is considered less variable (Conand, 1981). Hence the following calculation: GI = G x 100/TW and GI2 = G x 100/DW, where G is the fresh weight of the gonads.

A synopsis of the results can be made from the three studies. The sexes are separate and the sex-ratio is not significantly different from 1:1. The genital organs, ovaries and testes, consist of a tuft of tubules whose development shows cyclical variations. From the macroscopic examination of their colour, shape and consistency and the histological examination of their gametes can be defined a five-stage scale of maturity for each sex. The characteristics, broadly comparable for all species of the holothurian family, will be described using *H. nobilis* as an example (cf. Chapter 4.2.2). At maturity, the female gonads are heavier than the male ones, producing a higher gonad index (Table 11). A comparison of the two varieties showed that *H. scabra* var. *versicolor* has heavier gonads, but as the drained weight is greater, the mean GI2 is relatively lower.

The progression of the monthly percentages for each stage of maturity for male and female *H. scabra* var. *versicolor* shows a single annual cycle, confirmed by the GI2 variations (Figures 10A, B). Maturation occurs between June and September during the cold water season and as the water begins to warm up. The GI2's increase and the percentage of mature individuals is at its highest in October-November. It declines from December to February while the percentage of individuals in the post-spawning stage rises; the gradual fall in GI2 continues in April/May. In 1978, the cycle was less marked than in 1979, possibly due to the varied origins of the first samples or because of irregular variations in temperature, which did not reach a monthly maximum until March. This cycle shows that the resting period was brief and that spawning continued throughout the warm water season. Reproducing animals were photographed during the day in February 1980 (Laboute, personal communication).

The cycle of *H. scabra* in New Caledonia is more complex. Mature individuals have been found at most times of year and variations seem to occur from year to year. From observations of the progress from stage to stage of maturity (Figure 11A) and the variations in GI2 (Figure 11B), it would appear that, after the main reproduction season during the warm water period, (December-January), there is a second breeding period at the end of the cool months. The existence of a secondary reproduction season has also been shown in other areas where the species has been studied, for example in India (Krishnaswamy and Krishnan, 1967), in Australia (Harriot, 1980), and in Papua New Guinea (Shelley, 1981). Figure 12 illustrates the variations in GI1; it emerges that the main peak clearly occurs during the warm water season, whereas the timing of the secondary peak is more variable. In New Caledonia, it comes from a small fraction of the population. Comparison of three locations shows that GI1 maximums are lower in Papua New Guinea; they are comparable to those of the Mannar Gulf in

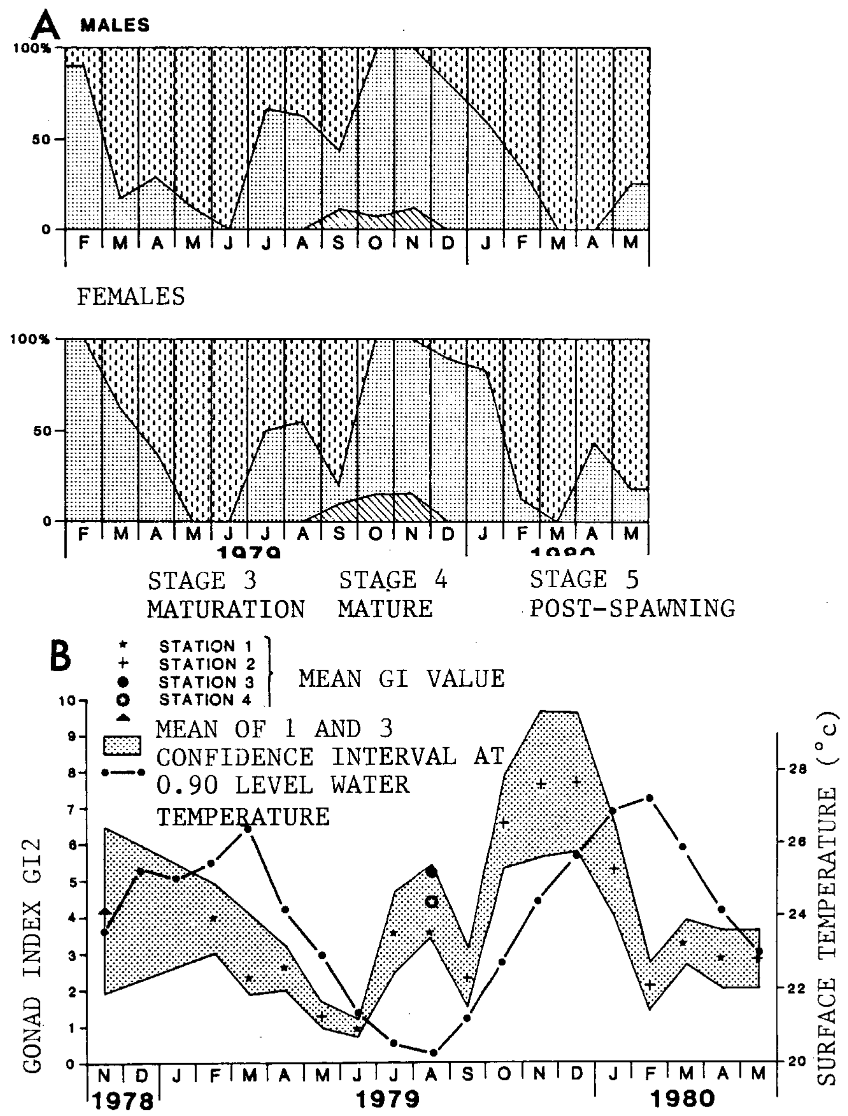


Figure 10: Sexual cycle of H. scabra, New Caledonia.
A: monthly percentages of stages of maturity.
B: monthly variations in GI2.

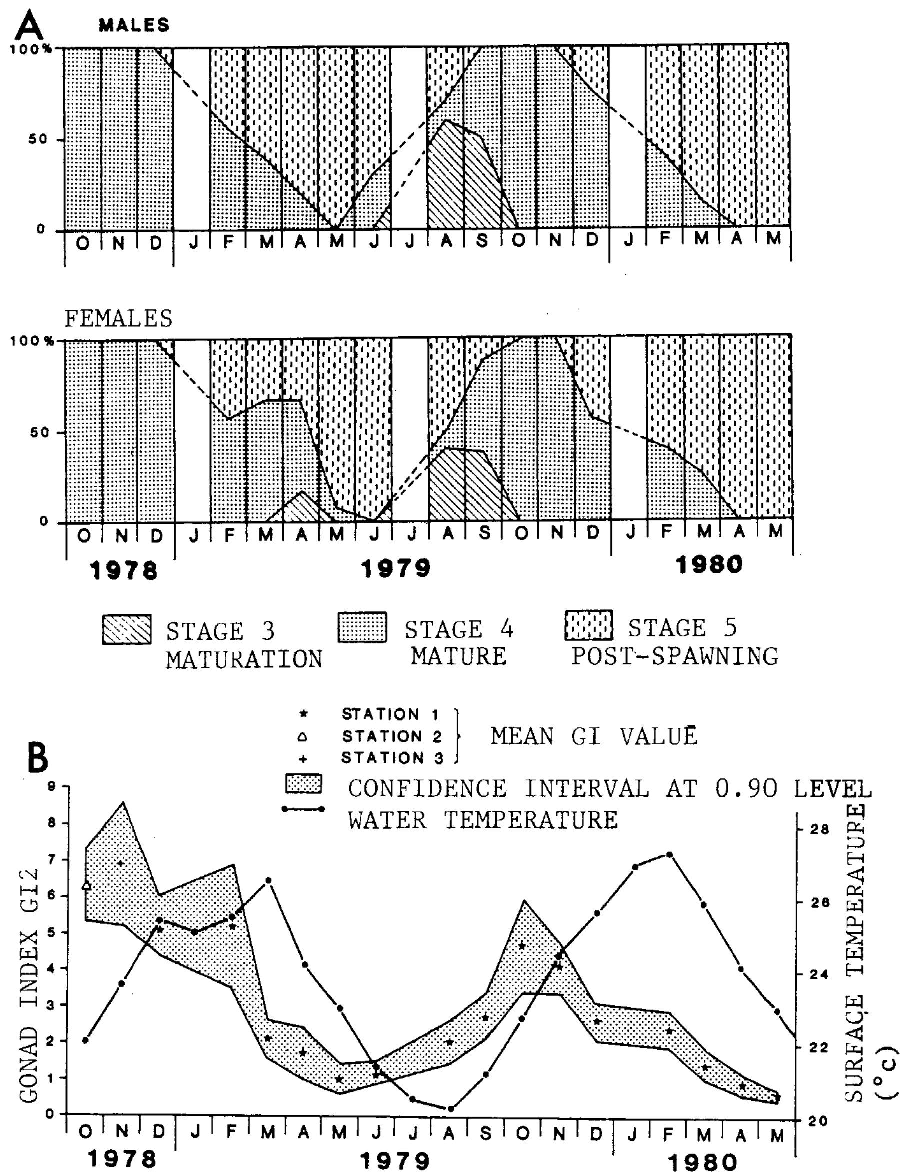
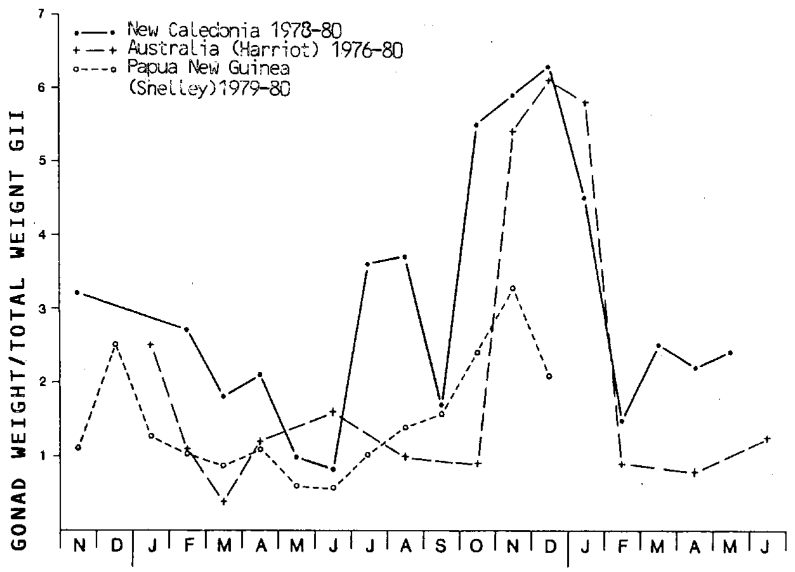
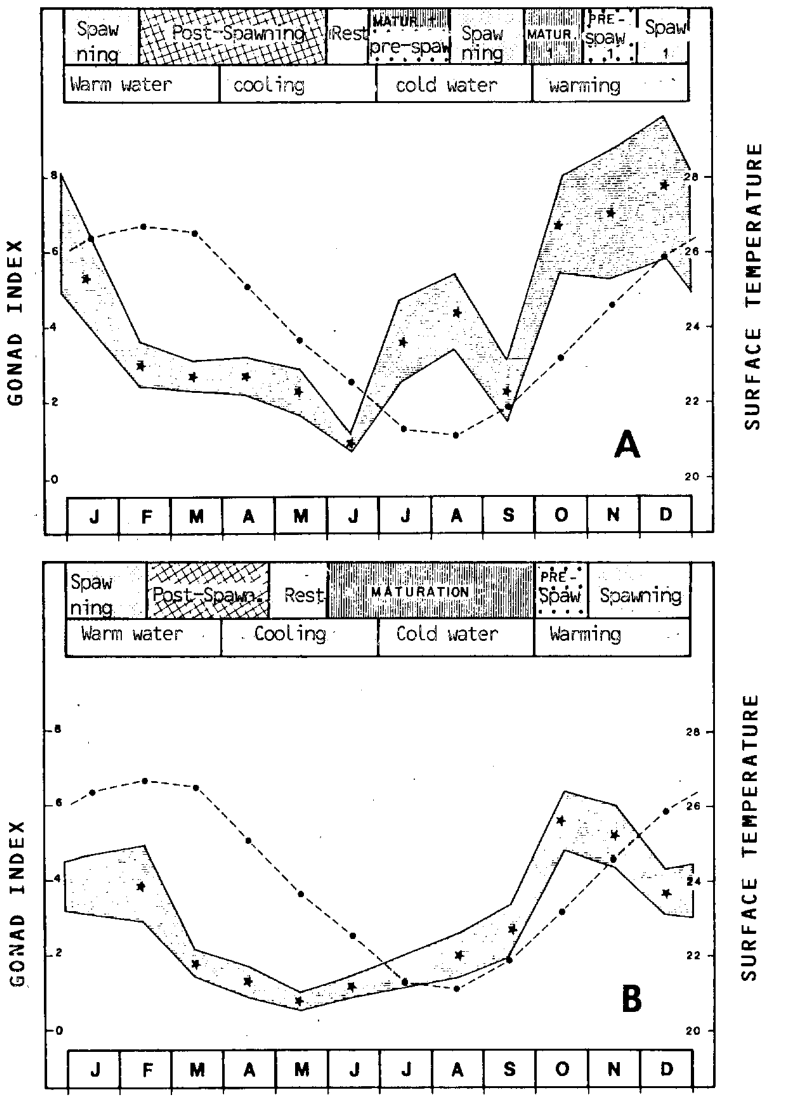


Figure 11: Sexual cycle of H. scabra var. versicolor.
A: monthly percentages of stages of maturity.
B: monthly variations in GI2.



<u>Figure 12</u>: Monthly variations in GI 1 with *H. scabra* in various localities



<u>Figure 13</u>: Reproduction of *H. scabra* (A) and *H. scabra* var. *versicolor* (B)

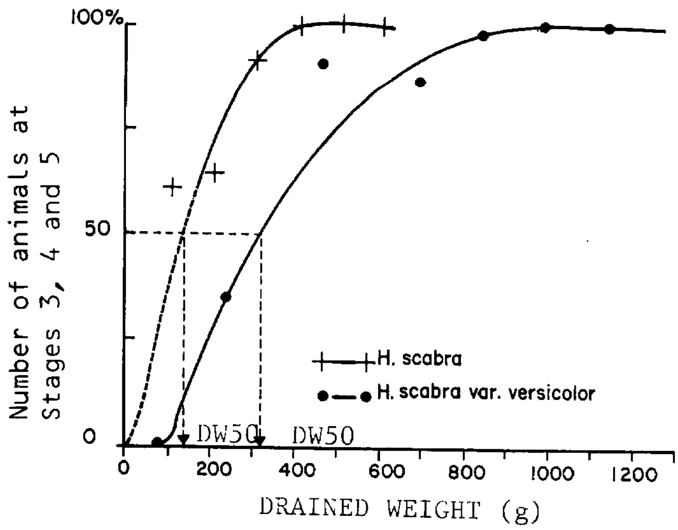


Figure 14: *H. scabra* and *H. scabra* var. *versicolor*; first sexual maturity

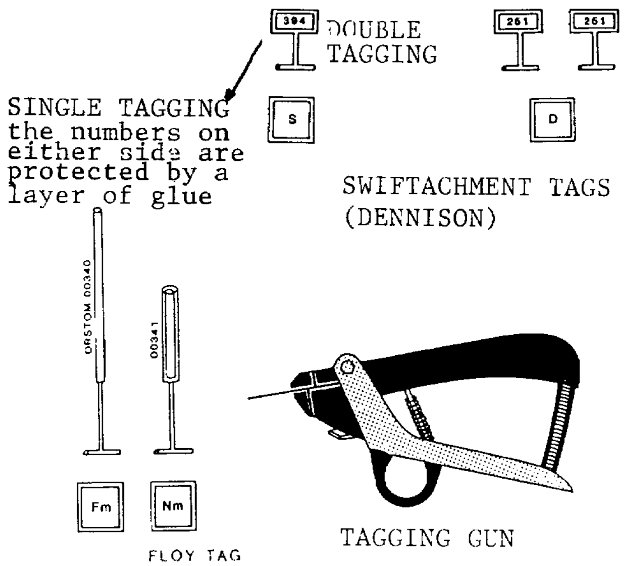


Figure 15 : Tagging method.

Table 11: Characteristics of mature gonads (stage 4) of *H. scabra* and *H. scabra* var. *versicolor* (after Shelley, 1981 and Conand, in press).
( ): number of animals in sample.

SPECIES/PLACE		SEX	G (g)	TUBULES Length (mm)	TUBULES Diameter (mm.10^{1})	GONAD INDEX GI 1	GONAD INDEX GI 2
H. scabra	PNG	M	13,6 (17)	62,9 (17)	14 (17)		
H. scabra	NC	M	23,8 (74)	81,7 (72)	10,3 (69)	4,35 (74)	5,43 (73)
H. scabra	PNG	F	19,9 (21)	75,2 (19)	15 (21)		
H. scabra	NC	F	31,2 (65)	80,5 (62)	13,2 (61)	5,85 (65)	7,21 (65)
H. scabra var. *versicolor*	NC	M	45,9 (72)	136,7 (72)	12,9 (70)	-	4,01 (72)
H. scabra var. *versicolor*	NC	F	69,7 (53)	125,6 (53)	18,6 (49)	-	5,84 (53)

Table 12: Tagging and tag returns
N°: operation no. n: number of specimens tagged
d: number of days since tagging
%r: percentage of tagged specimens recovered

Holothuria scabra

N°	n	J	% r	Place
1	100	5	13	PNG
		14	10	
		117	10	PNG
2	52	76	11	(Shelley)
1	56	90	32	NC
		190	4	
		267	9	
		356	5	
2	32	100	15	NC
		177	19	
		266	3	
3	50	77	10	NC
		166	12	
		476	2	
4	106	89	64	NC
		399	2	

H. scabra var. versicolor

N°	n	J	% r	Place
1	43	90	7	NC
		190	5	Reef flat
		267	7	
		356	5	
		664	0	
2	31	77	13	NC
		166	29	Reef flat
		476	3	
3	65	89	28	NC
		399	0	Reef flat
4	117	78	16	NC
		245	3	Out slope
		410	4	
		505	4	
5	81	167	1	NC
		332	1	Out slope

India. Figures for New Caledonia and Australia are broadly comparable. Spawning was observed by Shelley (1981) in December; all individuals showed the characteristic behaviour already described for other species such as *Bohaschia marmorata* by Mortensen (1937): the animal raises its front section upright, the genital papilla is dilated and protuberant and gametes are released, while the front portion sways slowly backwards and forwards; spawning varies in duration and probably recurs several times in a season. Figures 13A and B summarise results obtained in New Caledonia on the reproductive cycles of *H. scabra* and *H. scabra* var. versicolor in relation to the sea water seasons, which are characterised by surface water temperatures.

Fecundity

Fecundity is one population parameter with potential influence on recruitment. Research in this area is difficult to carry out because prior knowledge of the reproductive cycle is needed in order to be able to define a sampling system during the pre-spwaning stage, when the oocytes are ripe and GI values at their maximum level. The various authors have also observed a very high degree of variability between individual samples at this stage. Lastly, the relationship established between a size parameter (length or weight) and the weight of mature gonads is variable, depending on the species and the comparison method used. For *H. scabra*, for example, there is no significant correlation between weight and gonad weight (Shelley, 1981; Harriot, 1980), but there is such a correlation for the species *H. atra* and *H. edulis* (Harriot, 1980). In such a case, sampling for the purposes of a fecundity study has to cover each of the various size groups.

The fecundity of *H. scabra* in New Caledonia was determined by methods usually used for fish (Conand, 1977). Absolute individual fecundity is defined as the number of oocytes of the principal mode in the pre-spawning stage. Oocyte diameter distribution in the ovaries is variable. Whereas it is generally difficult to clearly distinguish between modes at stage 3 of maturity, these do reveal themselves individually at stage 4, making it possible to count the oocytes of the last batch. These are considered to be equivalent to the oocytes spawned in one reproduction season, because individual gonads, observed after partial spawning, still contain oocytes from this batch. Ovaries at the post-spawning stage often contain oocytes from a smaller-diameter batch, thought to be reabsorbed; sometimes oocytes from the principal mode also remain, but these small numbers will be ignored.

Samples of a mature ovary, weighing approximately 1 g, were taken from the median part of a tubule, drained, weighed (w) and placed in a gilson fixative which helps disintegrate the ovarian stroma and harden the oocytes. Before counting them, a volumetric sub-sample was prepared: after rinsing to remove fragments of ovary wall and separation of oocyte clusters with a pair of tweezers, they were placed in solution in a graduated tube. Homogenous suspension was then obtained using a cyclo-vibrator; a sub-sample was taken using a manostatic pipette. A second dilution is generally necessary before counting in a Dollfus tank. If n is the number of oxocytes counted in sample w, GW being the weight of the ovary, absolute individual fecundity is:

$$Af = n \times G/w$$

Relative fecundity is the ratio of the absolute fecundity of a specimen to the weight of the ovaries, i.e. Rfg = Af/G = n/w, expressed in terms of number of oocytes per gram of ovary, or to its gutted weight, i.e. Rfe = Af/G, expressed in terms of number of oocytes per gram of gutted weight.

The preliminary results obtained for five *H. scabra* showed an absolute fecundity ranging from 9 to 12 x 10^6 oocytes, the average Rfg being equal to 133 x 10^3 and Rfe 31 x 10^3 oocytes. For *H. scabra* var. *versicolor*, on the basis of twelve specimens, Af varies from 2 to 18 x 10^6, relative fecundities being lower, with Rfg equal to 93 x 10^3 and Rfe 11 x 10^3 oocytes.

For *H. scabra,* these values can be considered maxima, since the ovaries were chosen from the best developed specimens, but these preliminary results should be further refined by research on the evolution of relative fecundity in relation to size and an appraisal of the importance of the second surge of reproductive activity.

For *H. scabra,* the diameter of oocytes in the last batch, after fixing in formalin, varied between 150 and 230 microns, with a mode at 190 microns or thereabouts; the gilson caused the diameter to shrink by 20 to 25 per cent. This shrinkage, due to the histological fixatives, explains the lower figures recorded by Harriot (1980) for this species, from 80 to 125 microns, with a mean of 111 microns for mature ovocytes.

With *H. scabra* var. *versicolor,* mature oxocytes measured from 170 to 245 microns, with the mode falling at around 210 microns.

First sexual maturity

The size of individuals at first sexual maturity can be determined graphically, on the curve representing the percentage of individuals in the process of maturation, mature or in the post-spawning stage, by length or weight intervals. The drained weight has been used for this purpose. The number of immature individuals drops as weight increases. The point on the curve where 50 per cent of individuals are considered mature is taken as the index of first maturity. Progression from 0 to 100 per cent takes longer for some species than others.

Despite the low number of immature individuals observed, the drained weight at first maturity can be calculated as approximately 140 g for *H. scabra* and 320 g for *H. scabra* var. *versicolor* (Figure 14). The biometric relationships make it possible to calculate corresponding length and total weight, i.e. TL_{50} = 16 cm, TW_{50} =184 g for *H. scabra* and TL_{50} =22 cm, TW_{50} = 490 g for *H. scabra* var. *versicolor.*

4.2.1.4 Growth

Various standard organism growth study methods were used to try and determine the growth of holothurians, but each was difficult to apply. The results obtained are therefore restricted to a few species and generally to a limited phase of their life cycle.

With regard to tropical holothurians of commercial importance, the first publications were those by Shelley (1981, 1985) and Conand (1983) on the basis of tagging experiments, progression of the modal size of frequency distributions and monitoring of individuals in aquaria.

Tagging

Various methods have been tried, both in the aquarium and at sea, to try and distinguish individuals in a group or assign an individual number to specimens of sea cucumber. The techniques used have included gluing tags to the body wall, scratching, using colouring agents, burning, and attaching tags with wire. Most of these tags were rejected or caused necrosis to some degree. With the temperate species, *Parastichopus parvimensis*, Muscat (1983) succeeded in tagging, giving an interesting insight into the migratory habits. These tags, which remained in place for two to three years, did not seem to affect movements or mortality rates. Tags of the type used in the clothing industry, to which was stuck a small label, were attached using a pistol. This technique was also used to apply tags consisting of coloured plastic strips or Floy Tags (Figure 15). Various tagging operations have been carried out on *H. scabra* in Papua New Guinea and on *H. scabra* var. *versicolor* in New Caledonia; the results with regard to tag recovery rates are shown in Table 12. These were generally fairly high for the first three months after tagging but fell away rapidly thereafter. It is difficult to determine the main causes for this drop: migration, natural mortality or mortality due to tagging or to loss of tags. In addition, because of inaccuracies in measurements of total weight in the field (weighing problems and the state of contraction in which individuals are found), such data is not easy to interprete (Conand, in press).

Farming

Trials carried out with juvenile *H. scabra* in large aquaria were inconclusive for Shelley (1981) with regard to growth. Although the farming conditions closely resembled the natural environment, mortality was high and the juveniles probably failed to gain weight.

A transplantation experiment was carried out in the Andaman Islands of India (CMFRI Newsletter, 1978); 500 juveniles, measuring from 6.5 to 16 cm, were released in a 15,000 m^2 pond in January. By July, the recorded lengths were between 19 and 29 cm, a growth of more than 10 cm in seven months. No further information on this experiment could be secured.

Progression of modal sizes

For holothurians, it is difficult to determine weight or length intervals and monitor how these factors develop over time, because of the variability in units of measurement, the unpredictability of recruitment and the scarcity of juveniles. The growth trends of *Stichopus japonicus* (Choe, 1963), *Stichopus chloronotus* (Franklin, 1980) and *Actinopyga echinites* (Shelley, 1981) have nevertheless been determined in this way. Fish (1967), noticing the absence of any substantial change in mode with *Cucumaria elongata*, inferred that its growth was slow and subsequently proved his theory using weight distributions recorded at various stations over several consecutive years. Shelley (1985) kept track of the length distributions of some *H. scabra* specimens in one quadrat for fourteen months. There was no very obvious progression of modal values in the early months but clear trends emerge from April to December 1980, leading Shelley to conclude that mean growth was 0.5 cm per month, equivalent to 14 g of fresh weight, assuming that this trend in the modes is applicable to the growth of specimens between 10 and 25 cm in length.

To conclude, recent research has elucidated some characteristics of *H. scabra* and *H. scabra* var. *versicolor* populations, such as the reproduction season, first maturity, fecundity and biometric relationships. Further study will be required to establish parameters for growth equations and natural mortality.

4.2.2 Holothuria (Microthele) nobilis (Selenka, 1867) or 'black teatfish' and Holothuria (Microthele) fuscogilva (Cherbonnier, 1980) or 'white teatfish' (Figure 7), the 'teatfish'

4.2.2.1 Description and distribution

Holothuria nobilis and *H. fuscogilva* are large species, easy to recognise by the lateral processes from which the name, 'teatfish', is derived. Both are accurately identified by Pacific island fishermen who in Fiji, Kiribati and Papua New Guinea have baptised them with names referring to their black or white colour (SPC, 1979). There were however cases of mistaken identity in scientific publications until Cherbonnier described *H. fuscogilva* (1980). Despite their commercial promise, the only research so far made on their biology is that carried out by Gentle (1979) in Fiji and Conand (1981) in New Caledonia. Some unpublished subsequent observations should be added to these studies.

Holothuria nobilis has an unvariegated black tegument, except for smaller specimens which exhibit cream or orange blotches. It has cuvierian organs (Figure 2) but apparently expels them infrequently because this has only been observed in tanks where the temperature and water disturbance conditions were quite unusual. The anus is surrounded by five calcareous teeth and some papillae.

Holothuria fuscogilva has a fegument of varying colour, from yellowish white to grey, usually with grey-brown patches. There are no cuvierian organs. The anal teeth are rectangular. The fegument of juveniles also has an orangey-brown pigmentation and often possesses dorsal processes or tubercles, as well as the many well-developed lateral ones, terminating in a dark patch which gives them the general quadrangular shape already observed by Clark (1925).

A synopsis of the evisceration observations made in New Caledonia is given in Table 13.

The distribution of these species varies considerably in New Caledonia. *H. nobilis*, the most frequently encountered one, was observed at 57 lagoon stations with a mean density of 13 animals per hectare and a maximum of 84. It most frequently occurred on inner and outer slopes of barrier and islet reefs, in shallow water. *H. fuscogilva*, a less frequent find, was gathered from 21 locations, with a mean density of 11 per hectare and a maximum of 43. It can be found on flagstones covered with a thin layer of coral sand, near passes or at the foot of inner reef slopes, in deeper water than *H. nobilis*.

Its distribution in Fiji is quite different. On Suva reef, Gentle (1979) observed fairly dense populations of this species in seagrass beds of *Syringodium isoetifolium* and *Halophila ovalis*, at a depth of under 10 m, in a zone subject to terrigenous influence as well as salinity variations due to the Rewa river outflow. This species can also be found at deeper stations whereas *H. nobilis* is restricted to shallow water.

Depth is also the distinguishing factor for the preferred biotopes of these species in Papua New Guinea, where *H. nobilis* often lives among the living corals of reef slopes (Shelley, 1981).

In Australia, the relatively high densities of *H. nobilis* (over twenty per hectare) were found on outer reef slopes (Harriot, 1985).

4.2.2.2 Morphometric parameters and biometric relationships

Sampling of *H. nobilis* in New Caledonia was carried out at various stations including reef flats and slopes, fringing reefs and islet and barrier reefs. *H. fuscogilva* sampling was restricted to one pass station.

Length and weight-frequency distributions for *H. nobilis* samples as a whole are given in Figure 16. The characteristic parameters, assembled in Table 14, show the large size of these species.

The frequency distributions are plurimodal, although there are never very many small specimens.

The distributions of gutted weight for *H. nobilis* vary from station to station (Figure 18) and suggest the formation of three groupings which, generally speaking, equate to different biotopes:

- a first group (stations 3, 4, 7 and 8) corresponding to reef flat and barrier reef inner slope locations; the gutted weight for such specimens is between 900 and 1,900 g;

- a second group (stations 1 and 5) comprising lagoon islet slope locations; specimens here have a more variable gutted weight of between 400 and 1,500 g approximately;

- a third group (stations 2 and 6) from shallow reef flat, islet or fringing reef locations, whose smaller inhabitants generally weigh under 1,300 g (eviscerated weight).

These three biotope-based distributions would appear to be confirmed by observations made during tagging and stock assessment work (Conand, in press). It is hard to explain the origin of these differences. A number of theories have been expounded, assuming either variable growth and mortality rates, or differing recruitment seasons or migrations, which would appear unlikely in the light of tagging results which pointed to low mobility.

The parameters of the sampled *H. fuscogilva* population are shown in Figure 17 and Table 14. There is a distinct absence of small individuals. In Fiji, Gentle (1979) studied a colony living in a thick sea grass bed at a depth of around 5-10 m, whose weight distribution was very close to that recorded in New Caledonia, with weights ranging from 1 to 3 kg; the mode was approximately 2 kg. On the same reef, however, in a shallower area, the individuals were smaller, weighing 500 g on average. Lastly, juveniles

Table 13: Evisceration with teatfish
n: number sampled e: number eviscerated
%e: evisceration ratio

SPECIES	TAGGING			SAMPLING		
	n	e	% e	n	e	% e
H. nobilis	570	2	0.4	518	6	1.2
H. fuscogilva				125	11	8.8

Table 14: Morphometric characters of New Caledonia teatfish
n: number rv: range of values
m: mean s: standard deviation

	Holothuria nobilis				*Holothuria fuscogilva*			
	n	rv	m	s	n	rv	m	n
TL (mm)	518	180-560	370	57	125	230-570	401	46
TW (g)	509	300-4300	1829	644	108	1005-3600	2111	530
DW (g)	507	250-2450	1238	398	120	685-2590	1463	308
GW (g)	516	200-1900	938	283	124	320-2000	1209	253

Table 15: Biometric relationships of New Caledonia teatifsh
i: confidence interval of slope (p = 0.05)

X	Y	*Holothuria nobilis* dl	r	Equation	i	*Holothuria fuscogilva* dl	r	Equation	i
TL	TW	506	0.80	Log Y = -6.39 + 2.34 Log X	2.22-2.46	106	0.70	Y = -2712 + 11.94 X	10.42-13.68
TL	DW	504	0.65	Log Y = -5.80 + 2.18 Log X	2.04-2.33	117	0.68	Y = -1458 + 7.21 X	6.31-8.23
TL	GW	513	0.61	Log Y = -4.97 + 1.99 Log X	1.86-2.13	121	0.73	Y = -1049 + 5.61 X	4.96-6.34
TW	DW	497	0.82	Y = 104,44 + 0.62 X	0.59-0.65	105	0.80	Y = 217.7 + 0.58 X	0.52-0.65
TW	GW	505	0.77	Y = 132.04 + 0.44 X	0.42-0.46	104	0.78	Y = 292.7 + 0.43 X	0.38-0.49
DW	GW	504	0.96	Y = 56.71 + 0.71 X	0.69-0.73	119	0.97	Y = 75.54 + 0.78 X	0.75-0.81

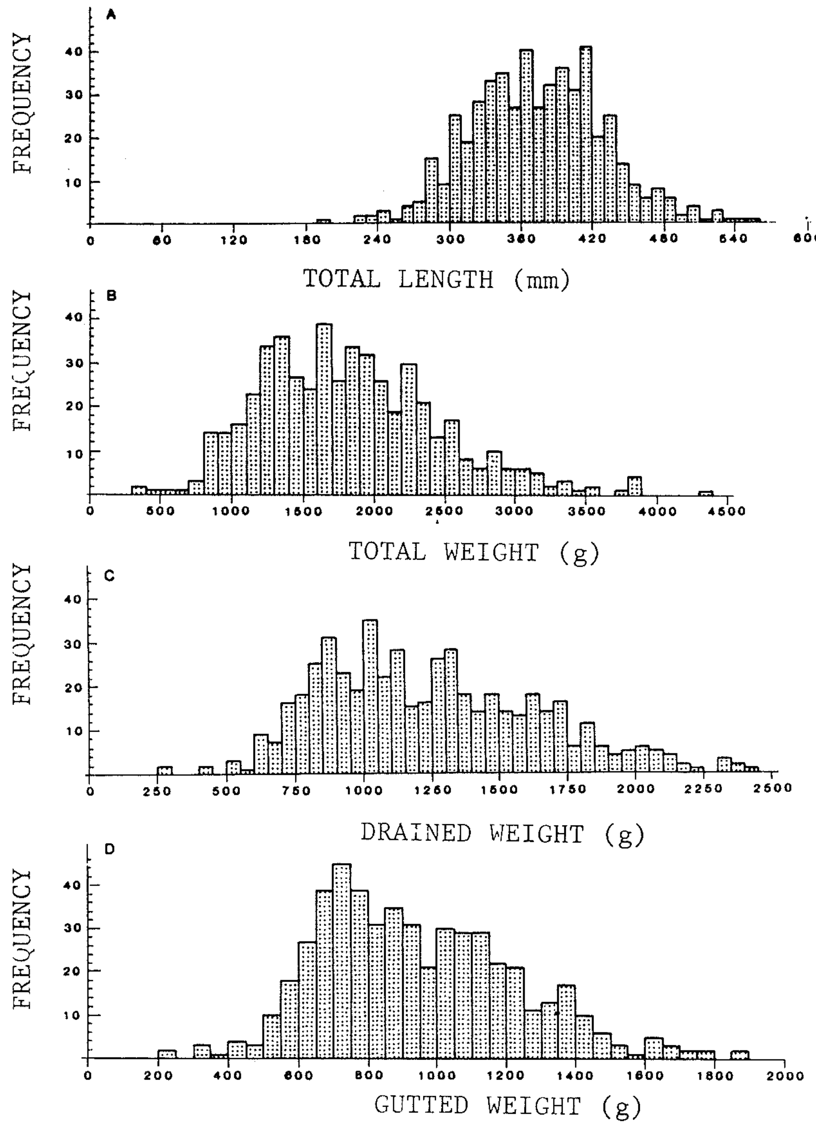


Figure 16: Distribution of measured characters of *H. nobilis*, New Caledonia.

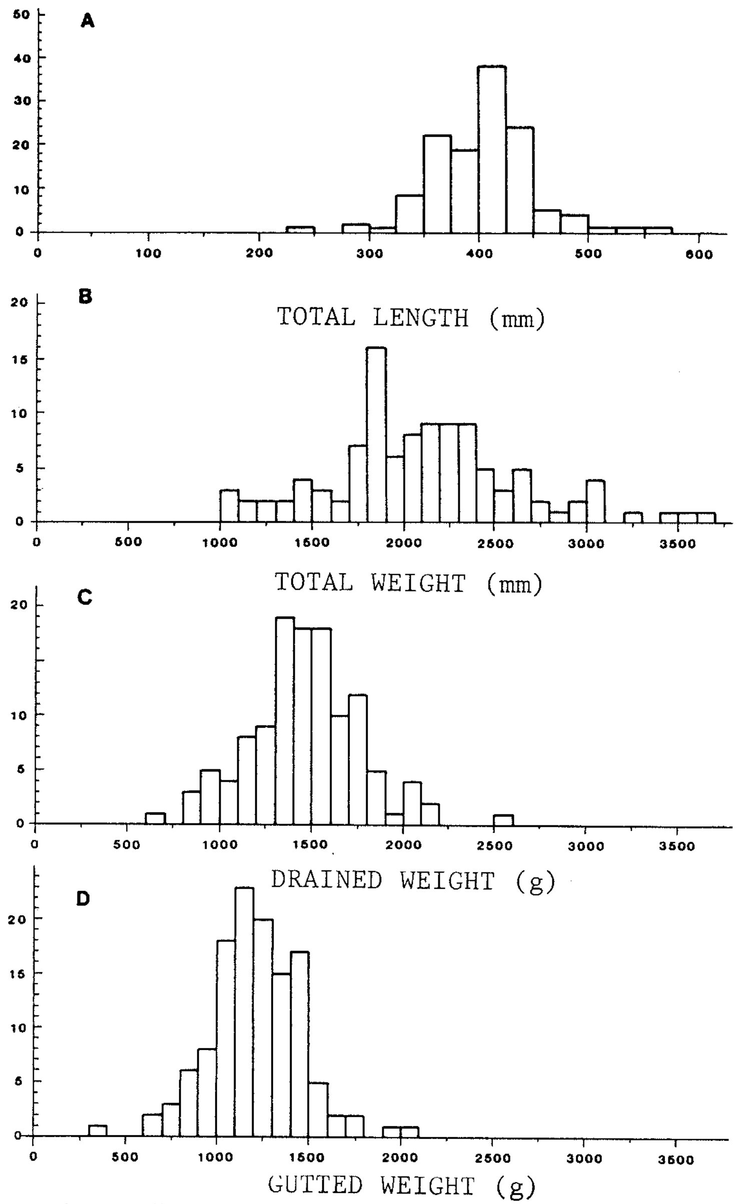


Figure 17: Distributions of measured characters of *H. fuscogilva*.

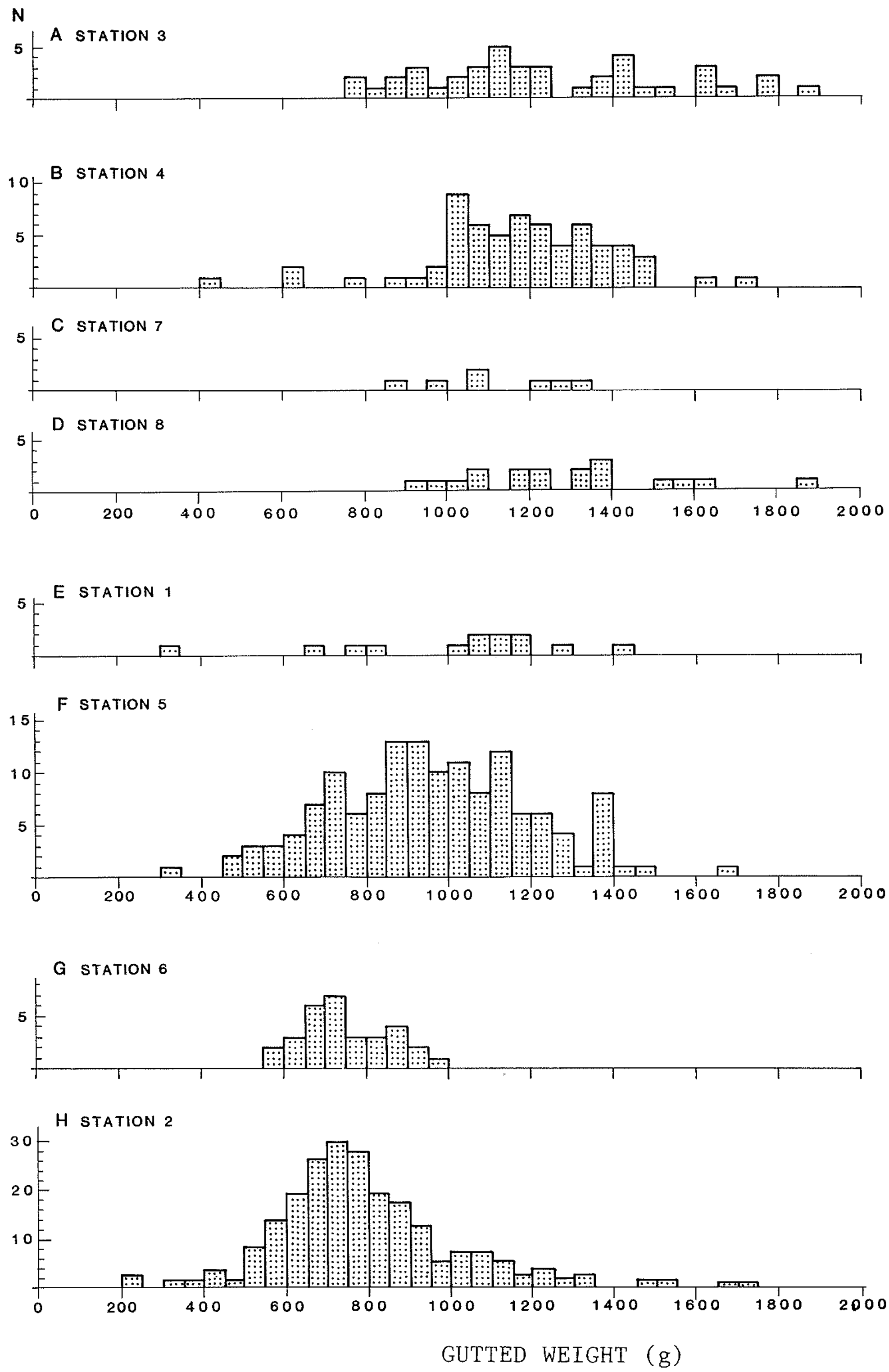


Figure 18: Distributions of gutted weight frequencies for *H. nobilis* at various stations in New Caledonia

Table 16: Main characteristics of the various stages on the scale of maturity of Holothuroidea gonads

STAGE-SEX	MORPHOLOGY	MICROSCOPIC FEATURES
Undetermined Stage 1 Immature Stage 2 Resting	Few transparent tubules with little branching; short and thin; distal end of tubules club-shaped	Spherical germinal cells with diameter less than 20 microns
Stage 3 Growing		
Male	More whitish tubes, branching; length and diameter grow.	Development of some spertids and a few spermatozoa
Female		Opaque spherical oocytes 20 to 120 microns approx. (diameter varies according to species)
Stage 4 Mature		
Male	Tubules of maximum volume, white with swellings. Sperm may be present in genoduct.	Numerous spermatozoa, swimming from a tubule section.
Female	Swollen, translucid or pink tubules; transparent, ripe oocytes.	Polymodal distribution of oocyte diameters; principal mode approx.150-200 microns (variable depending on species). Oocytes free or attached to the follicular membrane by a "micropylar appendage"
Stage 5 Post-spawning		
Male		Some spermatozoa remaining: atresic aggregations or spherales.
Female	Some tubules as in Stage 4, others more limp, others shorter, showing atresia; yellow or brown in colour.	A few ripe oocytes scattered around the tubule, stages of resorption and atresia; empty follicular membranes.

under one centimetre in length and weighing only a few grams were observed in February at the base of *Syringodium* leaves. With this species therefore, the various size groupings have different depth distributions; also, the sampling stations are close enough for migration to be possible during growth.

Biometric relationships have been established for these two species in New Caledonia (Table 15). Linear relationships can be established in the gaps between values recorded for *H. fuscogilva*. For *H. nobilis*, the lack of any significant difference between the various stations meant that all the results could be processed in a single group.

4.2.2.3 Reproduction

The sexes are separate, the sex-ratio does not diverge from 1:1 and no evidence of asexual reproduction has been recorded. The gonad, an ovary or a testicle, consists of a single tuft of many tubules each branching into 2 or 3 ramifications.

Stages of maturity

Macroscopic observation is concerned with colour, consistency and measurement of the length and average diameter of tubules. Microscopic observation of a tubule fragment enables the sex to be determined and female oocytes or the maturity of spermatozoa to be measured. A five-stage maturity scale has been identified without recourse to the histological techniques which are often used (cf. recent publications by Costelloe, 1985; Harriot, 1985; Tyler, *et al.*, 1985). The main features of these stages (Table 16) are also valid for other species of the family Holothuriidae. Where sex is not determined, the distinction between stage 1 (truly immature) and stage 2 (resting) is made restrospectively after determining size at first sexual maturity. Figure 19 illustrates the macroscopic characteristics of the stages of maturity of *H. nobilis*, Figure 20 their microscopic aspects and Table 17 the parameters of the two species' gonads at maturity.

Sexual cycle

The reproductive cycle of *H. nobilis* (Figures 21A and B) and *H. fuscogilva* (Figures 22A and B) may be determined by comparing the variations in monthly percentages of maturity stages and in the gonad indices. It is evident that males and females develop synchronously. With *H. nobilis*, although mature individuals were found in each sample, stage 4 predominates from May to July, when the lagoon waters cool. Slight variations occur from year to year and station to station but the cycle can be summarised by Figure 23A, produced by collating the monthly averages for successive years.

The cycle of *H. fuscogilva* (Figure 23B) bears a close resemblance to that of *H. scabra* var. *versicolor*, with the reproductive season coinciding with the warm waters. Sexual resting occurs during the cool water season; the uniform GI stages shown during this phase should be noted. The cycles begin and end at different times for these two species and the spawning periods do not overlap.

Fecundity

The results were obtained from 24 specimens of *H. nobilis* revealing that absolute fecundity was between 13 and 78 million oocytes, Rfg being equal to 208 x 10^3 and Rfe to 28 x 10^3 oocytes. Despite the small size, five individuals, of the *H. fuscogilva* sample, fecundity was apparently lower with this species, being between 8 and 14 million oocytes; Rfg and Rfe were equal to 128 and 7 x 10^3 oocytes respectively.

The mean diameter of ripe oocytes, fixed in Formalin, was 150 microns for *H. nobilis* and a little larger, about 170 microns for *H. fuscogilva*, with the oocytes of the most advanced batch falling between 120 and 200 microns for the former and 150 and 220 microns for the latter species.

First sexual maturity

The presence of immature individuals in the samples made it possible to calculate the size at first maturity, using the data available but excluding the sexual resting period which also included individuals at stage 2. For *H. nobilis* (Figure 24B), for example, 50 per cent of specimens matured when their total weight was 800 g since DW_{50} = 580 g, TL_{50} = 26 cm. Specimens whose tegument showed cream-coloured patches were usually immature. Figure 24B shows that patches disappear and sexual maturity is reached at the same time.

Where *H. fuscogilva* is concerned, the infrequency of small-sized specimens may have led to a slight overestimation in determining that DW_{50} = 900 g, from DW_{50} = 1,175 g and TL_{50} = 32 cm (Figure 25).

4.2.2.4 Growth

The preliminary results of tagging operations at four reef flat and reef slope stations in New Caledonia show a rapid decline in recovery rates for *H. nobilis* (Table 18) due at least partially to the rejection of the tags (Conand, 1983).

Colonies of *H. fuscogilva* on the Suva reef could provide very good material for studying growth because of the proximity of high density populations of different and widely varying sizes and the presence of juveniles. It is likely that monitoring of the weight and length distributions would provide a very valuable insight into the biology of this species.

4.3 Species of medium commercial value

A few species, such as *Actinopyga echinites*, *A. miliaris* and *Thelenota ananas*, are being traded at the present time, but the price they attract is always lower than for top-grade species.

4.3.1 Actinopyga echinites (Jaeger, 1833) 'deepwater redfish'

4.3.1.1 Description and distribution

Actinopyga echinites is a medium sized species whose tegument, brown to orange in colour, bears many small papillae and is usually covered in sand over its dorsal surface. The anus is ringed by five beige coloured anal teeth. The pinkish cuvierian organs, few in number, are only expelled in the rare event of evisceration. In fact, during tagging operations in New Caledonia, only one individual, or 0.5 per cent of the sample, eviscerated; the same rate was observed during sampling and only a single specimen showed an alimentary canal in the process of regeneration. This species occurs in the tropical Indo-Pacific (Clark and Rowe, 1971). It is a common shallow-dwelling species, inhabiting reef flats and the upper portion of fringing reef and lagoon islet slopes (Rowe and Doty, 1977; Intes and Menou, 1978; SPC, 1979; Levin, 1979; Shelley, 1981; Conand, 1982). It is apparently absent from barrier reefs where the biotope is occupied by *Actinopyga mauritiana*. At the 18 stations where it was found in New Caledonia, its mean density was 847 per hectare, with a maximum of 9,000.

4.3.1.2 Morphometric parameters and biometric relationships

Preliminary information on its biology (Conand, 1982) has been augmented by continued sampling in New Caledonia and by studies carried out in Papua New Guinea (Shelley, 1981 and 1985).

The length and weight-frequency distributions at one of the main stations (1), in the upper windward portion of an islet reef slope, and on the outer reef flat of a fringing reef (2), in New Caledonia, demonstrate the characteristics of this species (Figures 26A, B, C, D). These parameters may be compared with those of the population of a Papua New Guinea fringing reef (Table 19). They emerge as not dissimilar, except at station 2 in New Caledonia, consisting of specimens covering a very wide size range, including small ones.

The biometric relationships (Table 20) were calculated from the data for New Caledonia as a whole.

4.3.1.3 Reproduction

This investigation, carried out in the same way as for the other species, showed that the sexes were separate and the sex-ratio not different from 1:1. The characteristics of the gonads at maturity, on the basis of the sampling carried out in the two areas, are assembled in Table 21.

The progression of stages of maturity and gonad indices was monitored from 1978 to 1982 (Figures 27A and B). The annual cycles show regularity, making it possible to group the monthly values and present a synopsis of the reproduction of this species (Figure 28). This shows that spawning takes place in January-February, during the warm water season; the post-spawning period, followed by a long phase of sexual resting, continues during the cold water season; maturation and pre-spawning take place when the water warms up.

The cycle observed by Shelley (1981) in Papua New Guinea was less clear (Figure 29), with the drop in GI 2 corresponding to spawning apparently taking place in October in 1980, as against February in 1979. Such irregularity may however be due to the small size of some samples or the presence, as in March 1980, of a specimen whose gonads recorded a weight diverging greatly from the mean. Observations of spontaneous spawning, in February 1979 (Conand) and December 1980 (Shelley), confirmed that it did indeed take place in the hot season. The various stages of the cycle are perhaps more clearly defined in habitats further from the equator.

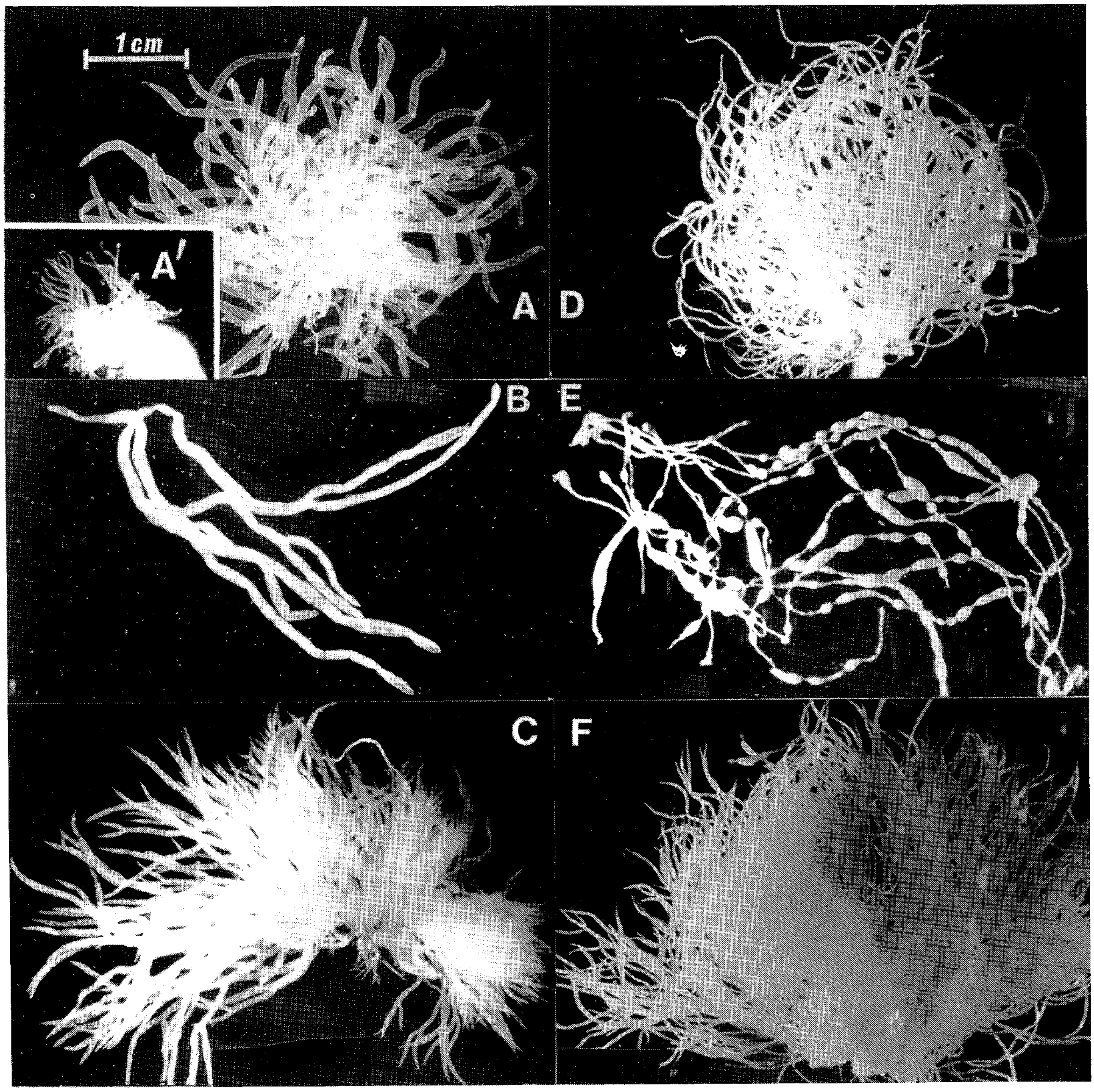


Figure 19: Macroscopic features of Holothuroidea gonads (*H. nobilis*)
A: female, stage 3 - A: undetermined - B; female, stage 4
C: female, stage 5 - D: male stage 3 - E: male, stage 4
F: male, stage 5 (Conand, 1981, Bull.mar.Sci.)

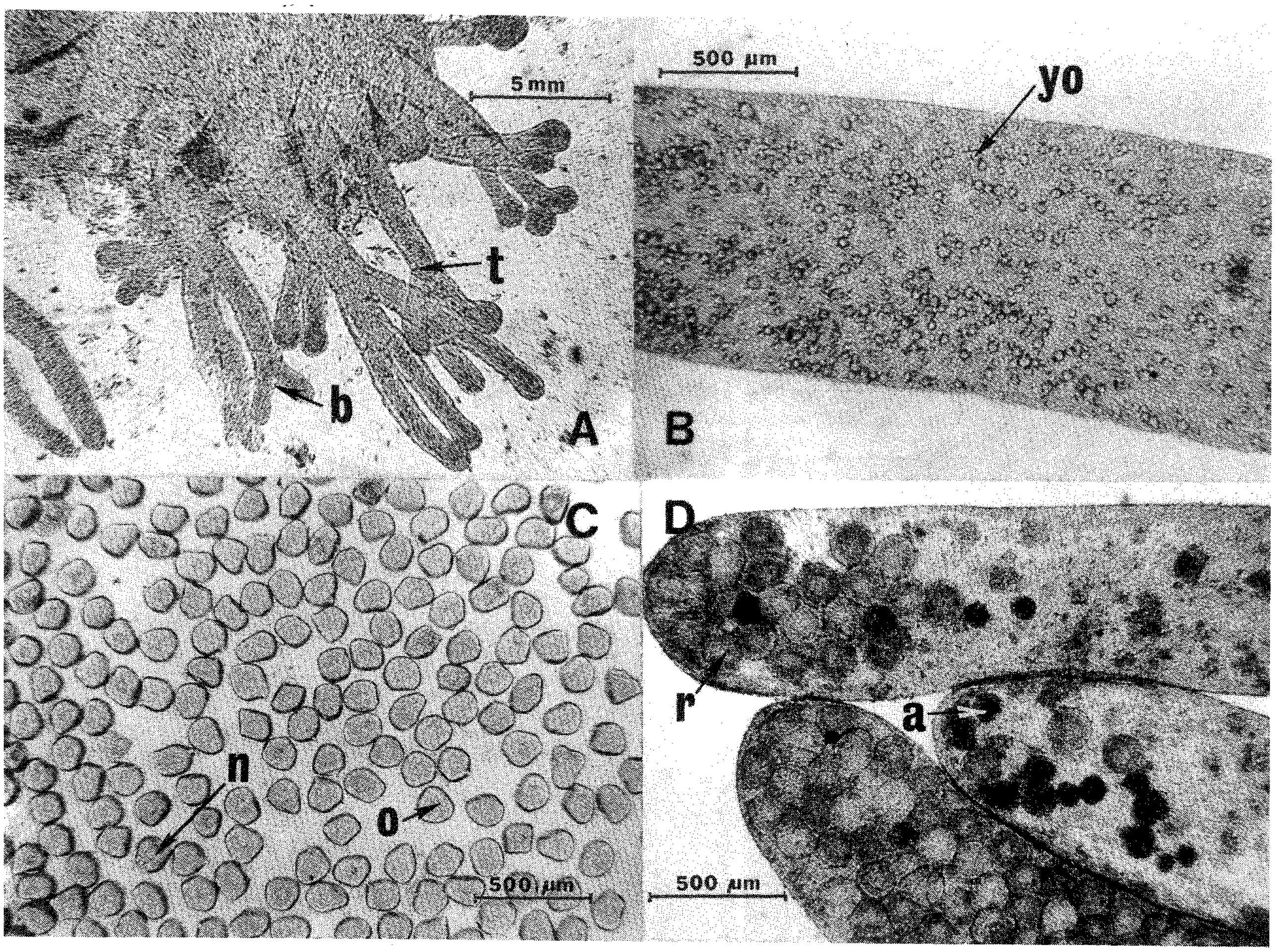


Figure 20: Microscopic aspects of Holothuroidea gonads (*H. nobilis*)
A: undertermined sex - B: female, stage 3 - C: female, stage 4
D: female, stage 5 a: atresic follicle - b: tubule branching
n: oocyte nucleus o: residual oocyte t: tubule
yo: young oocyte (Conand, 1981, Bull.mar.Sci.)

Table 17: Characteristics of mature gonads of teatfish
( ): number of fish in samples

SPECIES	SEX	G (g)	TUBULES Length (mm)	TUBULES Diameter ($mm.10^1$)	GONAD INDEX GI1	GONAD INDEX GI2
H. nobilis	M	50.6 (83)	123 (80)	11 (80)	2.5 (83)	3.5 (82)
	F	77.7 (109)	103 (109)	20 (107)	3.8 (108)	5.3 (109)
H. fuscogilva	M	13.8 (27)	88 (27)	9 (27)		0.8 (27)
	F	36.0 (21)	79 (21)	16 (21)		2.2 (20)

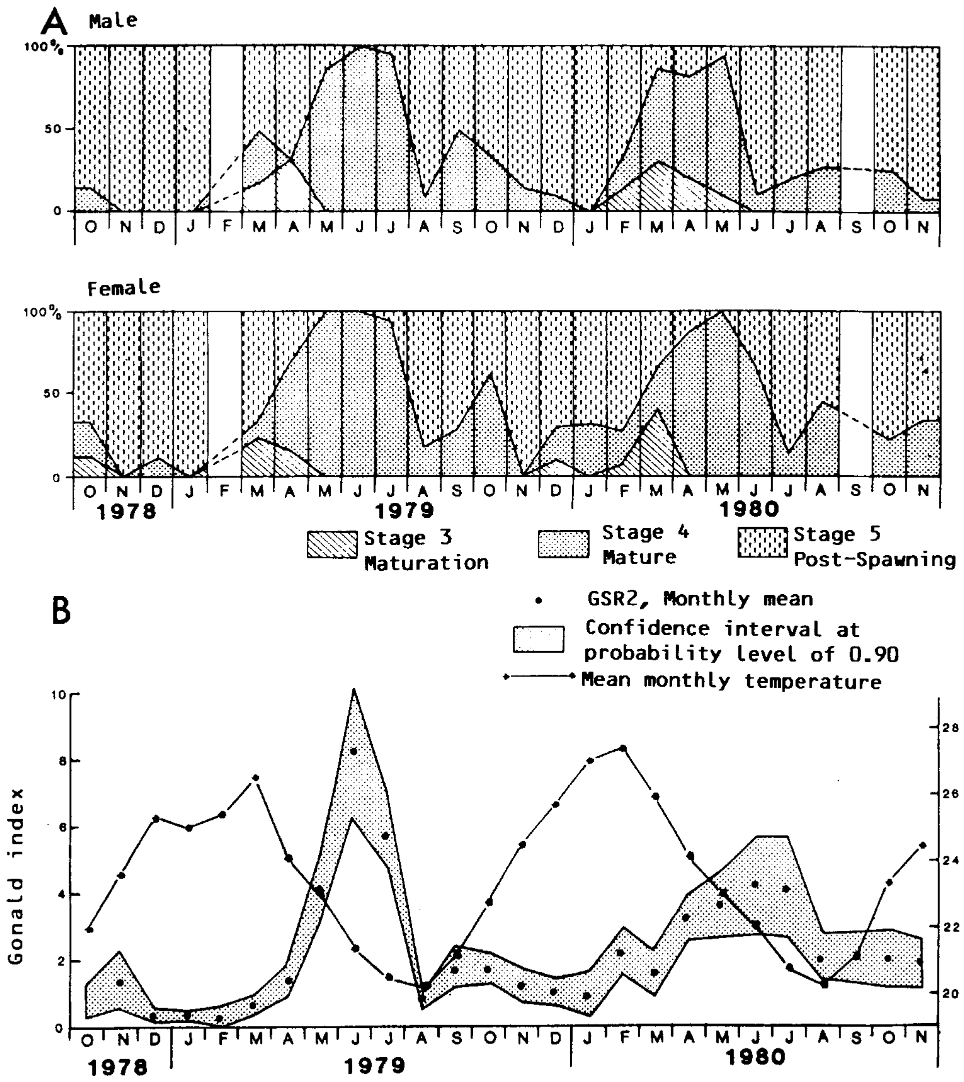


Figure 21 : Sexual cycle of H. nobilis, New Caledonia.
A: monthly percentages of stages of maturity.
B: monthly variations in GI2

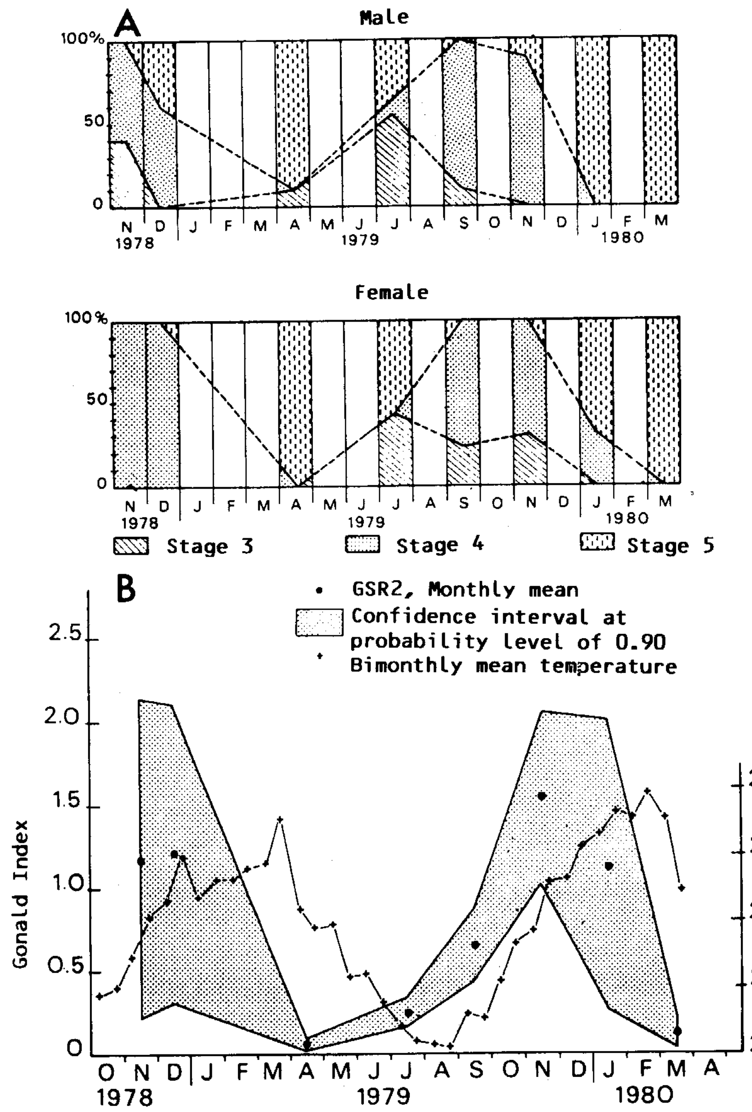


Figure 22 : Sexual cycle of H. fuscogilva, New Caledonia.
A: montly percentages of stages of manturity.
B: monthly variations in GI2.

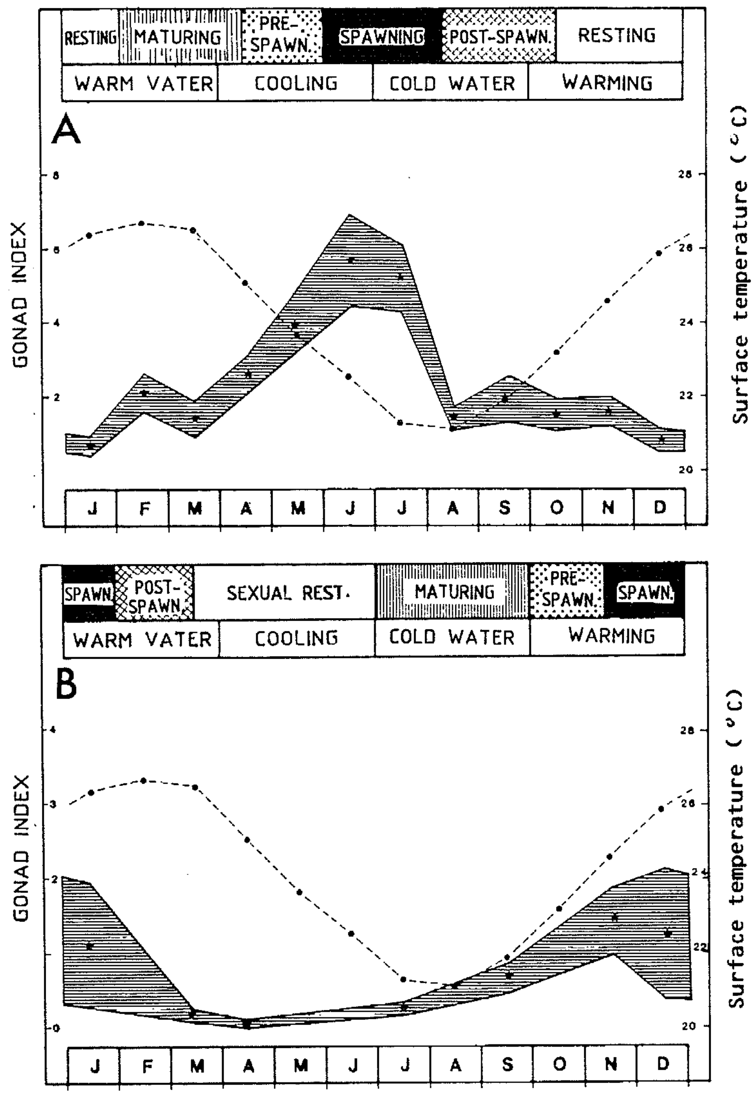


Figure 23 : Reproduction of H. nobilis (A) and H. fuscogilva (B).

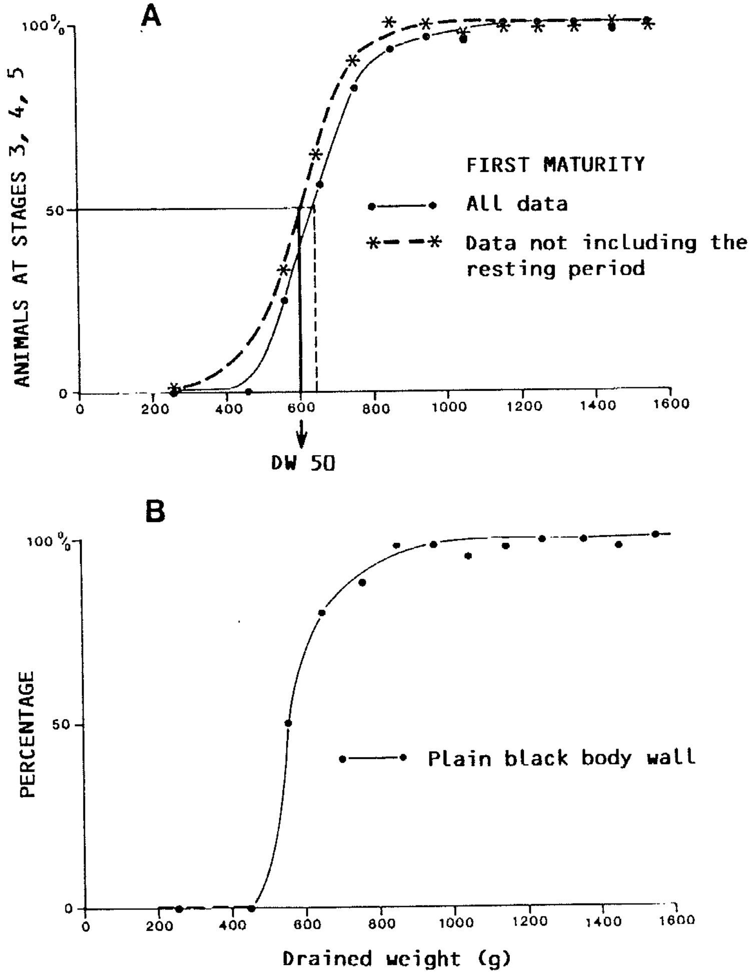


Figure 24 : First sexual maturity of H. nobilis.
A: drained weight at first maturity.
B: change in body wall colour.

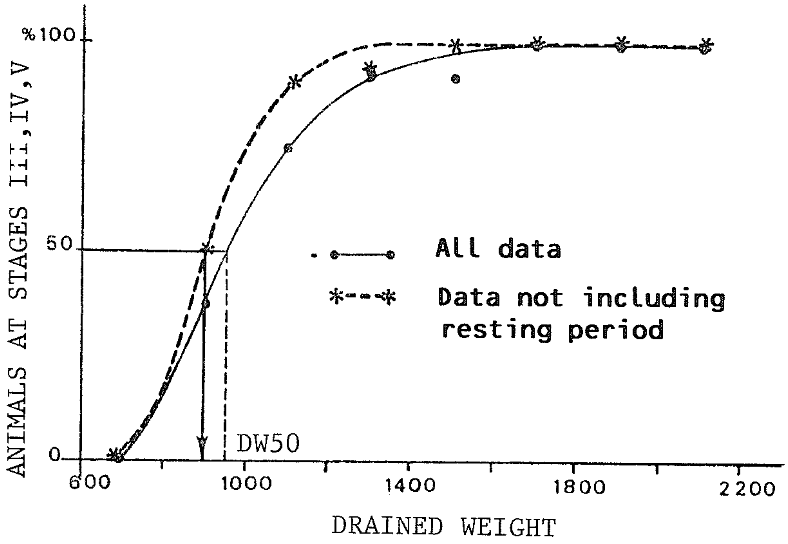


Figure 25: First sexual maturity of *H. fuscogilva*

Table 18: Tagging and recapture of *H. nobilis*
N°: operation no. n: number of specimens tagged
d: number of days since tagging
%r: percentage of tagged specimens recovered

STATION 1				STATION 2			
N°	n	d	% r	N°	n	d	% r
1	40	97	15	1	60	97	15
		190	5			190	13
		357	0			357	0
2	35	92	28	2	49	92	46
		259	6			259	2
		442	3			442	2
3	31	167	9	3	51	166	4
		350	0			350	2
4	36	183	3	4	25	184	4

STATION 3				STATION 4			
N°	n	d	% r	N°	n	d	% r
1	31	98	45	1	56	92	5
		192	30			258	0
		358	3			442	0
		541	3				
2	14	92	7	2	50	166	2
		440	0			235	0
3	20	168	15	3	55	184	0
		351	10				
4	18	183	0				

Table 19: Morphometric characters of *Actinopyga echinites*
PNG: after Shelley (1981)
NC: Conand (unpublished).

		n	I	$\bar{m}$	s
TL (mm)					
PNG		302	100-320	217	33
	t	602	40-380	207	51
NC	1	486	40-380	217	44
	2	79	40-280	151	52
TW (g)					
PNG		300	0-780	339	126
	t	599	0-1410	396	208
NC	1	483	0-1410	437	189
	2	79	0-630	168	143
DW (g)					
PNG		298	0-540	256	79
	t	595	0-600	260	99
NC	1	480	0-600	283	75
	2	78	0-450	120	94
GW (g)					
PNG		302	0-390	176	66
	t	600	0-420	188	69
NC	1	484	0-420	205	54
	2	79	0-390	96	79

Table 20: Biometric relationships of *Actinopyga echinites* (New Caledonia) i: confidence interval of slope (p = 0.95).

X	Y	dl	r	Equation	i
TL	TW	597	0.89	Log Y = -7.98 + 2.60 Log X	2.51-2.70
TL	DW	593	0.84	Log Y + -6.74 + 2.30 Log X	2.20-2.40
TL	GW	598	0.83	Log Y = -6.61 + 2.21 Log X	2.11-2.31
TW	DW	590	0.94	Log Y = 0.32 + 0.88 Log X	0.86-0.90
TW	GW	595	0.93	Log Y = 0.18 + 0.85 Log X	0.83-0.87
DW	GW	591	0.96	Y = 5.30 + 0.70 X	0.69 -0.71

Table 21: Characteristics of gonads of mature *Actinopyga echinites* (stage 4), after Shelley (1981) and Conand (in press) (J: number of specimens sampled)

PLACE - AUTHOR	SEX	G (g)	TUBULES		GONAD INDEX	
			Length (mm)	Diameter (mm.10^{-1})	GI 1	GI2
PNG Shelley	M	25.9 (33)	109 (22)	14 (33)		
	F	38.5 (33)	119 (21)	18 (33)		
NC Conand	M	20.9 (96)	115 (43)	8.0 (43)	4.9 (96)	9.9 (94)
	F	28.2 (80)	106 (60)	12.2 (60)	6.5 (79)	9.0 (78)

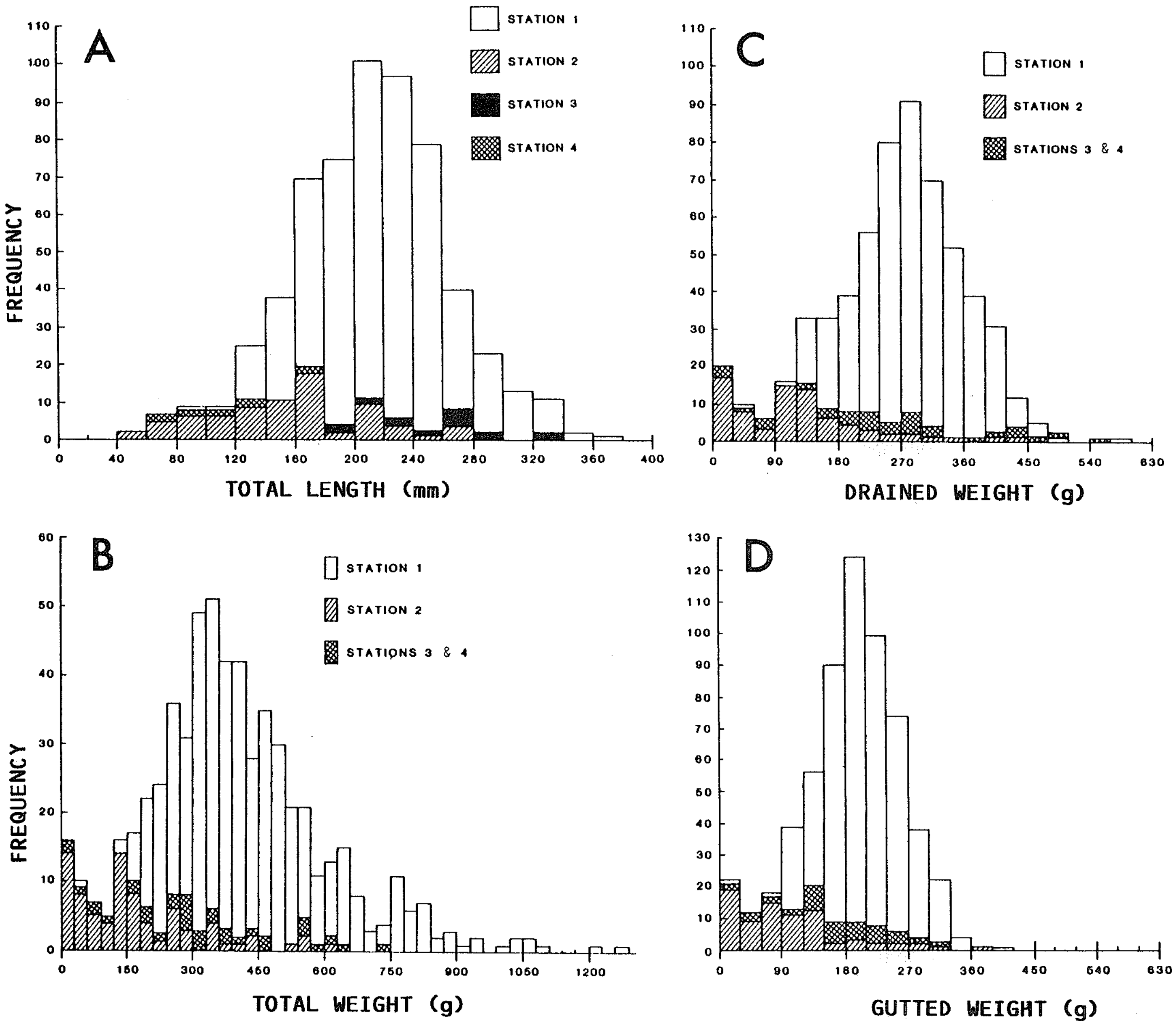


Figure 26: Distributions of measured characters of *A. echinites*, New Caledonia.

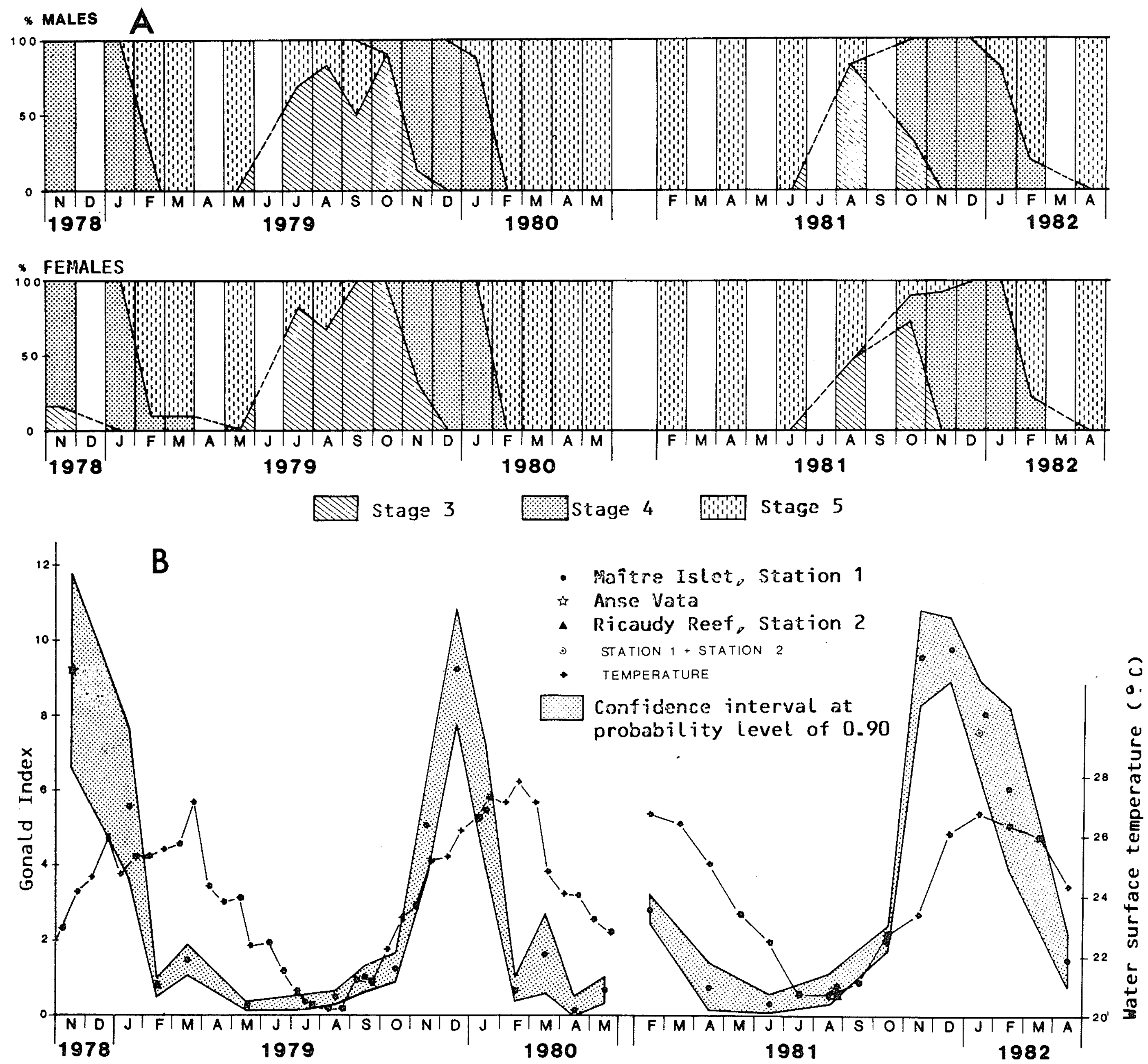


Figure 27: Sexual cycle of *A. echinites*, New Caledonia
A: monthly percentages of stages of maturity
B: monthly variations in GI2.

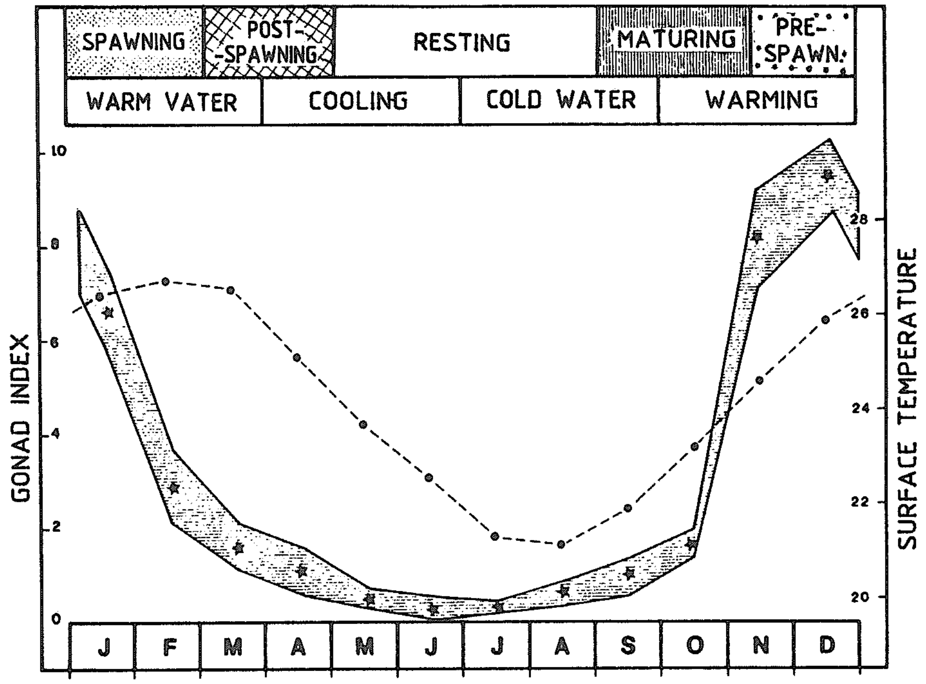


Figure 28 : Reproduction of *A. echinites*

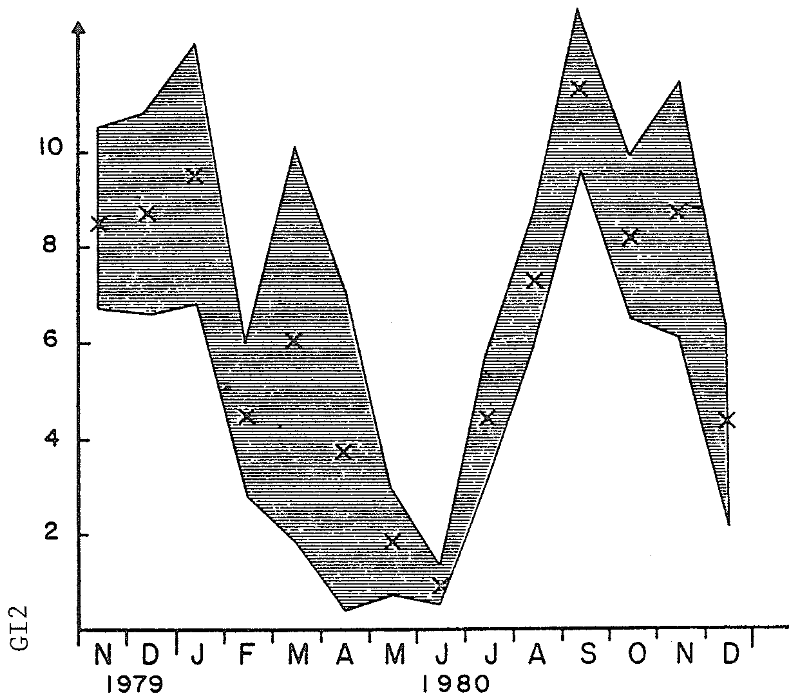


Figure 29 : Sexual cycle of A. echinites, Papua New Guinea. Monthly variations in GI2 (after Shelley, 1981).

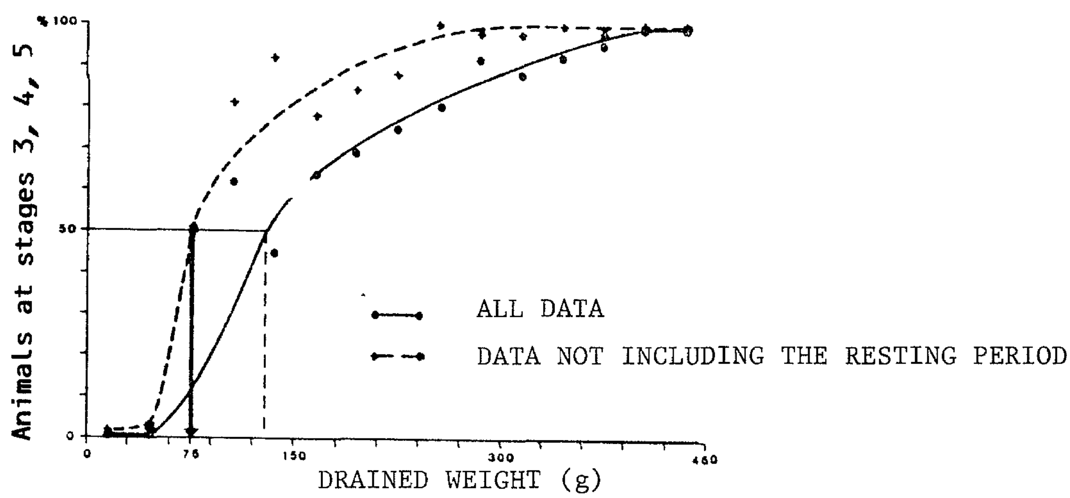


Figure 30 : First sexual maturity of A. echinites.

Table 22: Tagging and recapture of *A. echinites*.
No.: operation no. n: nmber of specimens tagged
d: number of days since tagging
%r: percentage of tagged individuals recovered

N°	n	d	% r	N°	n	d	% r
1	93	73	64	4	114	195	13
		225	30			269	14
		309	33			353	16
2	89	114	17	5	112	61	27
		192	11			117	8
3	116	49	64			205	1
		131	55				
		329	16				
		459	16				
		551	7				

The size of mature oocytes is approximately 165 microns, the range for the latter mode being 140 to 200 microns.

Fecundity

Fecundity has been studied in some detail for this species, with ovary sampling on individuals of various sizes. Absolute fecundity ranges from 4 to 25 x 10^6 oocytes, while relative fecundity is reasonably stable, at around 333 x 10^3 per gram of ovary and approximately 59 per gram of gutted weight.

First sexual maturity

The length and weight parameters at first maturity calculated without including the data relating to the period of sexual resting are: DW_{50} = 75 g, TW_{50} = 90 g, TL_{50} = 12 cm. This stage is therefore attained by small-sized specimens (Figure 30).

4.3.1.4 Growth

Tagging

Experiments on the effects of tagging were conducted on this species in the aquarium and in the natural environment (Conand, 1983). It was observed that small individuals lost their tags more readily than large ones. In the aquarium, the specimens lost weight when they stayed more than a few months, and necrosis of the body wall, sometimes leading to death, occasionally occurred.

Some specimens tagged on a reef flat (Table 22) were recaptured more than a year and a half after tagging.

Progression of modal sizes

Using a monthly sampling schedule, Shelley (1985) monitored the progression of total-length distribution modes. These were not always easy to identify. Throughout the year, the occurrence or disappearance of some of these raised problems which are difficult to resolve in the light of presently available knowledge on the biology of the species. It was, however, possible to estimate growth parameters (L = 23 cm and k = 0.78) and to infer therefrom a monthly length increase of 0.6 to 0.9 cm, or 19 to 29 g. These initial results enabled Shelley (1985) to assess the annual yield of this species on the reef flat. With a density of 1,800 per hectare, this amounted to 497 kg of fresh weight.

Small specimens, observed on a reef flat near Noumea in May 1982, measured between 6 and 11 cm and weighed 10 to 60 g, the mean figures being 8.5 cm and 50 g. Assuming these specimens had been spawned in the previous reproduction season, they would have been five months old and their average growth would have been 1.7 cm and 10 g per month.

Further research is still needed to compare these values with other biotopes and investigate mortality problems.

4.3.2 Actinopyga miliaris (Quoy and Gaimard, 1833) 'blackfish' (Figure 7)

Three of the black coloured species of *Actinopyga* are common in New Caledonia: *A. miliaris, A. palauensis, and A. spinea.* These are medium-sized species, roughly cylindrical in shape, with an anus ringed by strong calcareous teeth. On being handled, they contract to the shape of a rugby ball. Their distribution varies quite considerably. *A. miliaris* occurs in abundance on inner reef flats in seagrass beds, while *A. spinea* sinks into the muddy sand of inner lagoons and *A. palauensis* is located in areas swept by strong waves and currents, on flagstones covered in coral sand situated on the slopes and in the passes of the barrier reef.

A. miliaris is probably the only trade species, but it would be difficult to distinguish between the three as far as the processed product is concerned.

Its importance emerges from a number of publications. On the Great Barrier Reef, for example, Pearson (in press) reported a density of ten specimens per hectare on Michaelmas Reef and a usually lower density on the other reefs investigated. It is also common in Fiji, inhabiting the sea grass beds with *H. fuscogilva* (Gentle, 1979). In New Caledonia it was gathered at 39 stations with an average density of 512 per hectare and a maximum of 5,970. It was present in 50 per cent of the islet inner reef flat locations and 80 per cent of the fringing reef stations investigated. No population study on this species has yet been published. The relationship between total length and total weight was calculated from 120 specimens gathered in New Caledonia, $TW = 0.824 \times 10^{-3}, TL^{2.441}$ with $r = 0.96$ where TL is between 9 and 36 cm and TW between 60 and 1,500 g.

Various observations on spawning carried out in the natural environment suggest that reproduction takes place in the hot season. In February 1979, *A. miliaris* and *Bohadschia similis* specimens were releasing their gametes on a fringing reef and, at the beginning of March 1983, eight individuals of the fifteen to be seen were in an upright position and released their genital emissions during the thirty minutes of observation, as did the two specimens of species *H. flavomaculata*.

Some small specimens were observed in July 1982, measuring from 3 to 9 cm and weighing from 5 to 30 g, giving a modal value of TL = 6 cm and TW = 15 g. Assuming they were spawned in February 1982, their growth for the first six months would be approximately 1 cm and 5 g per month.

4.3.3 Thelenota ananas (Jaeger, 1833) or 'prickly redfish' (Figure 7)

This is the only species of family Stichopodidae currently exploited in the tropical Indo-Pacific, whereas *Stichopus japonicus, Parastichopus californicus* and *P. parvimensis* account for a large share of the harvest taken in the temperate Pacific.

4.3.3.1 Description and distribution

Many descriptions have been made of this species (Cherbonnier and Féral, 1984), which is widely distributed throughout the Indo-Pacific (Clark and Rowe, 1971), from Japan to the Great Barrier Reef and from the Mascarenes and Madagascar to the Marshall Islands and the Society Islands. The most thorough examination of its biology is to be found in a study of a population in New Caledonia (Conand, 1981). Its bright, often orange-tinged colouring and its highly developed papillae make it a spectacular species. It may reach up to 120 cm in length (Saville-Kent, 1893). In New Caledonia, the record was a 98 cm specimen weighing over 8 kg inside which was found a large commensal fish, *Carapus parvipinnis* (Olney, personal communication).

It was harvested at 40 stations in New Caledonia with a low mean density of 17.9 per hectare and a maximum of 141. It occurred frequently on outer barrier reef slopes (83% of stations surveyed), passes (100% of stations) and outer islet slopes (50% of stations). Although usually restricted to the upper portion of slopes and to a depth not exceeding approximately 20 m, it gave way to *T. anax* in areas where the substrate was covered with coral sand. Its distribution would appear to be similar elsewhere, in Australia (cf. Chapter 5.2.6), Papua New Guinea and Guam (Row and Doty, 1977), for example.

4.3.3.2 Biometrics and reproduction

The main results have already been published (Conand, 1981). The biometric characteristics and relationships are illustrated by Figure 31 and Tables 23 and 24. Evisceration, which occurs frequently when specimens are caught for sampling (80% of cases) meant individual plastic bags had to be used for collection, whereas this occurrence was infrequent in tagging (0.9%). Many individuals displayed large scars, which can probably be ascribed to attacks by predators.

For both sexes, the gonads are formed by two tufts of tubules, on which saccules develop. The gonads turn a very vivid purple colour on maturity. The testicles of males weighed 26 g on average, with a low GI 2 of 1.1; with females, the ovaries weighed 38 g and the GI 2 was equal to 1.6.

The reproductive cycle may be summarised by Figure 32, with spawning occurring during the warm water season, probably from January to March. Resting continues until the waters warm again in October, when maturation begins.

Fecundity, calculated for five specimens, was not very high; the oocytes were fairly large, around 200 um, and the wall of the saccules was fairly thick. Af varied from 2 to 7 million oocytes, Rfg being equal to 74×10^3 and Rfe 2.3×10^3 oocytes. The parameters at first sexual maturity were: TL_{50} = 30 cm, TW_{50} = 1,230 g and DW_{50} = 1,150 g. This stage is therefore reached when individuals are relatively large.

4.3.3.3 Growth

A tagging-recapture trial (Table 25) was carried out at the sampling station. A number of individuals were found complete with tags after 22 months but recapture rates in general fell below 5 per cent after one year. It is still impossible to know to what extent this is due to tag loss, emigration and mortality respectively.

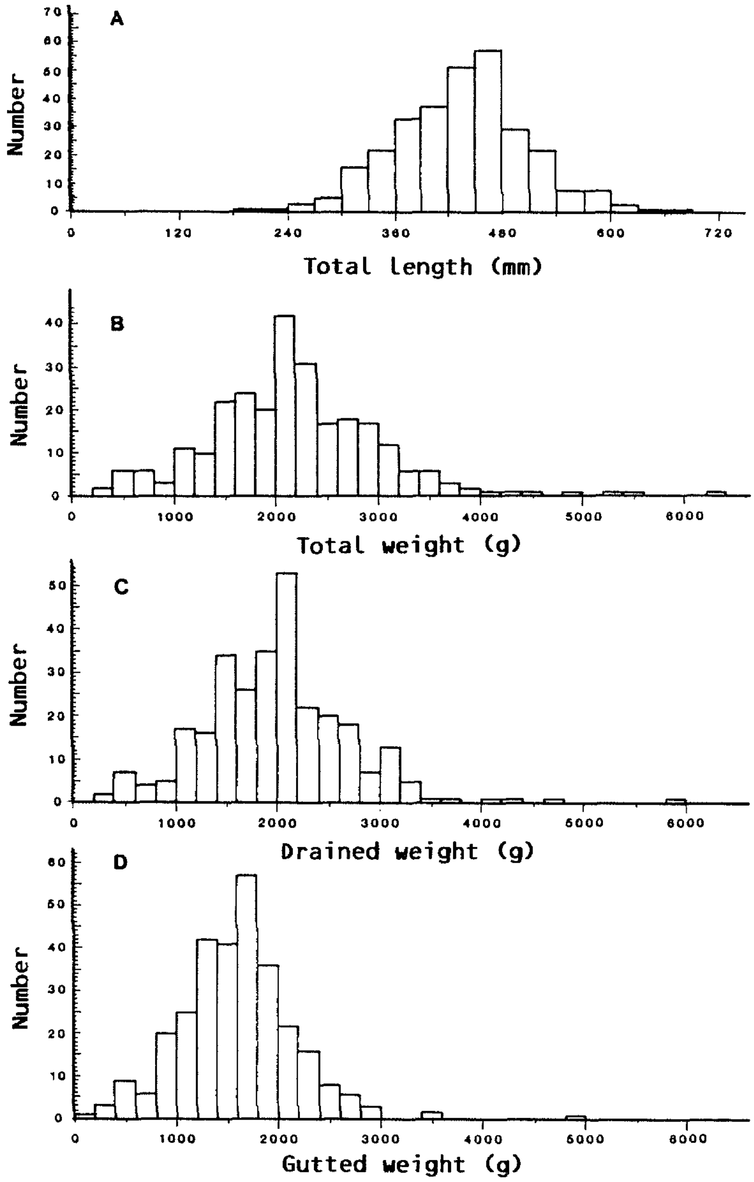


Figure 31 : Distributions of measured characters of T. ananas, New Caledonia.

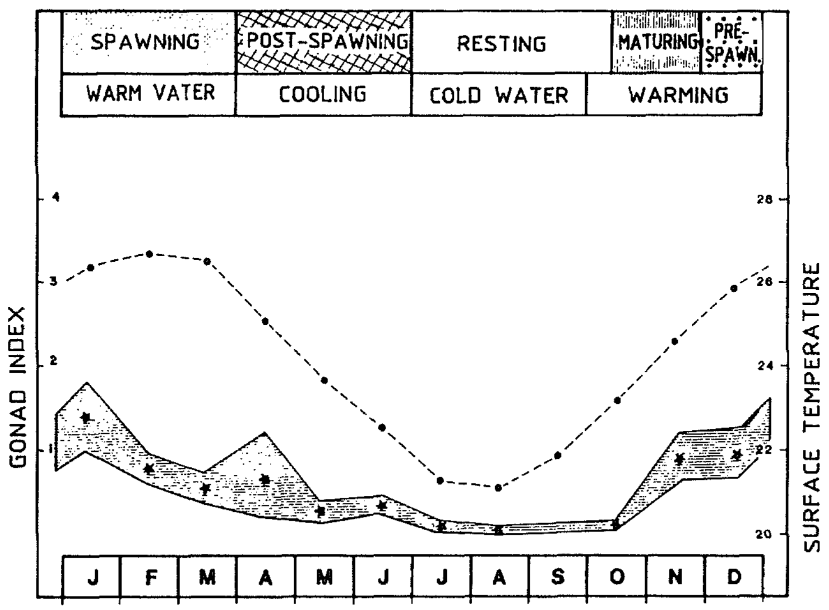


Figure 32 : Reproduction of T. ananas.

Table 23: Morphometric characters of *Thelenota ananas*, (New Caledonia).

	n	I	m	s
TL (mm)	298	180-670	430	75
TW (g)	265	220-6250	2180	854
DW (g)	290	205-5850	1979	723
GW (g)	298	175-4800	1600	656

Table 24: Biometric relationships of *Thelenota ananas*, (New Caledonia).

X	Y	dl	r	Equation	i
TL	TW	263	0.89	Log Y = -6.67 + 2.36 Log X	2.23-2.49
TL	DW	288	0.87	Log Y = -6.51 + 2.32 Log X	2.19-2.45
TL	GW	296	0.86	Log Y = -6.28 + 2.25 Log X	2.12-2.38
TW	DW	259	0.97	Y = 92.78 + 0.86 X	0.83-0.89
TW	GW	263	0.94	Y = 117.76 + 0.68 X	0.65-0.71
DW	GW	288	0.98	Y = 58.12 + 0.78 X	0.76-0.80

Table 25: Tagging and recapture of *T. ananas*
N°: operation no n: number of specimens tagged
d: number of days since tagging
%: percentage of specimens recaptured.

N°	n	d	% r	N°	n	d	% r
1	68	56	34	3	45	99	13
		139	13			191	9
		238	18			358	4
		330	10			542	2
		468	4	4	92	92	25
		651	3			259	3
2	66	83	9			443	0
		182	5	5	71	167	4
		274	5			351	0
		441	5	6	49	184	6
		625	1				

4.4 Species with low commercial value

Some low-value species are collected, incidentally to the main catch, such as *Holothuria atra*, *Actinopyga mauritiana*, *A. fusca*, which is probably a variety of *A. miliaris* with a light-coloured tegument (Cherbonnier, 1980, 1984), and *H. fuscopunctata*. Other species quoted in the literature were not found for sale on the market; *Bohadschia argus*, *B. marmorata*, *H. edulis*, *Thelenota anax*, *Stichopus variegatus* and *S. chloronotus*, for example, are probably no longer gathered. The reasons for this were explained in the introduction and these species' biology will not be discussed in this article.

4.4.1 Holothuria atra (Jaeger, 1833), 'lollyfish'

This black cylindrical species, whose body is often covered by a fine layer of sand, except in some circular areas (SPC, 1979), is the most common and abundant species encountered on the tropical shore. Long lists of its descriptions are given in Mitsukuri (1912), Clark and Rowe (1971) and Cherbonnier (1980). Many publications exist on its biology and physiology, relating in particular to its distribution and abundance (Baker, 1929; Bakus, 1968; Bonham and Held, 1963; Yamanouchi, 1939; Salvat, 1971, 1973; Roberts, 1979, 1982; Lawrence, 1979), its nutrition (Trefz, 1958; Lawrence, 1972; Webb, Dupaul and d'Elia, 1977; Renaud-Mornand and Helleouet, 1977; Moriarty, 1982), to its growth (Ebert, 1978) and to its sexual and asexual reproduction (Pearse, 1968; Doty, 1977; Harriot, 1982, 1985).

In New Caledonia, it was gathered at 45 per cent of all stations; it was the most frequent species, with a mean density of 545 specimens per hectare and a maximum of 7,270. It would appear that a distinction can be made between sparse populations of large specimens, with a tegument covered in warts, occurring on reef flats subject to strong waves and currents, and populations inhabiting inner reef flats, consisting of smaller individuals (TL under 30 cm), sometimes having a high fission (asexual reproduction) rate.

4.4.2 Holothuria fuscopunctata (Jaeger, 1833) or 'elephant's trunk fish'

This species, sometimes referred to as *H. axiologa* (Clark, 1921; Liao, 1984; SPC, 1979), is large in size, sometimes over 60 cm in length, and bright yellow to brown in colour (Rowe and Doty, 1977; Intes and Menou, 1978; Cherbonnier, 1980). It is sometimes processed in the Philippines (Gentle, personal communication), but its market value is very low. It is fairly common on the coral sands of inner slopes, barrier reefs, outer lagoons and islet slopes in New Caledonia, where the biology of a population has been studied (Conand, in press).

4.4.3 Actinopyga mauritiana (Quoy and Gaimard, 1833), or 'surf redfish'

Widespread in the tropical Indo-Pacific (Clark and Rowe, 1971), this species' habitat is restricted to outer reef flats subject to strong waves and currents. Sand accounts for only a small part of its diet, which consists mainly of plant debris. Brown algae are very common in this biotope. In size, shape and colour it resembles *A. echinites*, from which it may be distinguished by the presence of white patches of varying size and extent. Two populations have been researched in New Caledonia (Conand, in press).

Results on the parameters of populations of species with commercial importance have been dealt with in detail throughout this chapter. It may be concluded that the knowledge available is apparently very incomplete.

For the commercially very valuable species, the sandfish (*H. scabra* and *H. scabra* var. *versicolor*) and the teatfish (*H. nobilis* and *H. fuscogilva*), some parameters have been established, such as the weight and length distributions, and the characteristics of the biometric relationships and reproductive cycles. These are rather variable, with either one or two spawning seasons. The extremely high fecundity varies from species to species. Growth parameters are as yet unknown and will require further research, the results of which are necessary to assess the potential yield of the various species.

Of the species of the second group, of medium commercial value, *A. echinites* and *T. ananas* have been the subject of similar research and growth evaluations are still at a preliminary stage, but *A. miliaris*, despite its importance, has not yet been investigated.

5. HOLOTHURIAN RESOURCES

The exploitation of marine resources in the South Pacific was traditionally a subsistence activity. The arrival of the explorers led to an expansion in fishing for various species to be traded on outside markets. The tonnages yielded by these artisanal activities were however very irregular, being dependent on political, social and economic factors such as wars, mining booms and recessions. Some countries have recently expressed the wish to develop this traditional artisanal sector, but their isolation often hinders the development of a fishery because of the complications raised by commodity storage and transport. After processing, bêche-de-mer can however withstand a long storage period if it is kept in a dry place. This renewed interest has led to a demand for estimates of available resources and their renewal rate.

5.1 Resource assessment methods

The holothurians which are of commercial interest are sedentary mega- or macro-benthic organisms. Some species live on hard substrates, others on soft ones. These general characteristics are conducive to the use of certain quantitative sampling techniques, as described in detail in articles by Reys and Salvat (1971), Plante et Le Loeuff (1983) and in 'Coral reefs research methods' by Stoddart and Johannes (1978). Choice of technique and of a sampling strategy is at once governed by the relevant scientific aims, population parameters and material constraints (technical possibilities, cost, manpower). Although present knowledge of holothurians of reef and lagoon systems is not very thorough, various techniques have been used to assess either the size of populations or the wealth of the reef environments. Some of the methods described have already been used, while others could be adapted to this kind of research.

5.1.1 Estimation of species abundance

5.1.1.1 Utilisation of fishery statistics; catch per unit effort (CPUE)

Used in fishery population dynamics, this indirect method is based on fisheries data. Where certain factors are known, such as the number of divers working on a boat, their respective diving times, the number of specimens of each species and the tonnage harvested, it is possible to calculate 'catch per unit effort', in which the unit will be the number or fresh weight of holothurians per diving hour. The very nature of these fisheries, however, both temporary and scattered, makes data collection very difficult. CPUE can also be calculated by scientific observers.

The CPUE only provides a rough guide to the natural abundance, because its values are not related to a surface area. The main factors responsible for its variation are the following:

- harvesting method: walking at low water on a reef flat or skin diving by fishermen, to which should be added scuba-diving, a method available to scientists. In each case the following need also to be considered:

- the type of observation made; this may consist solely of counting or gathering one or more species, or both counting and harvest, or lastly an *in situ* length measurement of specimens whether or not they are subsequently harvested;

- environmental conditions, especially visibility; this is excellent at barrier reef stations but is reduced as the coast is approached, because of terrigenous influences. Hydrodynamic factors (waves and currents) may affect the harvest, as can the nature of the substrate. Specimens are clearly visible on bare sediment bottoms but are camouflaged on sediments where epibionts abound;

- the observer's experience and ability to detect specimens;

- population distribution factor: the risk of error in enumeration is greater with high-density colonies;

- species morphology: individuals of large or brightly-coloured species are easier to inventory.

To make comparisons, the exact conditions affecting the survey carried out to assess CPUE should be stated where possible. This method remains the simplest to apply and the least costly, and can be used in most biotopes including both hard and soft substrates.

5.1.1.2 Use of fishing gear

In marine ecology, qualitative studies generally use samples obtained by trawling or dragnetting while quantitative surveys employ dredge-buckets or suction dredgers. Such gear would however appear unsuitable for sampling widely-dispersed large specimens. It is ill-suited to rocky or coral bottoms and is therefore of limited use for fisheries resource assessment in coral environments.

5.1.1.3 Direct visual assessment of densities

Skin or scuba-diving, which is compatible with the various substrates encountered, is the method conventionally used in coral ecology and is efficient for the direct enumeration of specimens of the epifauna. Techniques vary according to the size of the area to be sampled:

- quadrats are areas that can be marked out by ropes or frameworks; they are sometimes drawn along radials, and may be continuous or at intervals, regular or random;

- transects are lines, often laid out according to an ecological gradient, along which enumeration is carried out. Their principal use is for coral colonies;

- measurement of distances between specimens is a method based on the linear measurement of distances between points where individuals are gathered at random.

For assessments covering wide areas or widely-scattered populations, other direct visual methods are used, particularly for enumerating large invertebrates such as giant clams, crown-of-thorns starfish (*Acanthaster* spp) or holothurians. Kenchington (1978) has summarised the survey techniques as follows:

- diving along a straight line, making an assessment comparable to CPUE;

- the 'spot check', a rapid sub-sampling technique, very useful in shark-infested waters; the observer simply leans overboard and submerges his head at regular intervals;

- the 'manta tow', where the observer, a diver, is towed behind the boat and can adjust his position in the water using a 'manta board'. In conjunction with a calibrated flow-meter, this method makes it possible to work out the distance travelled. In depths under 10 m, estimation of the density over large areas is possible with minimum fatigue for the diver. The towing speed, however, leads to under-estimation of densities by a factor of 2 to 4 (Harriot, 1985);

- diving, without a tow, remains the most widely used technique for qualitative and semi-quantitative evaluations. The introduction of a low speed flow-meter (General Oceanics) mounted beneath the board (Conand, 1985) has brought about a great improvement in quantitative assessments. Large quadrats were surveyed in this fashion in New Caledonia by two observers swimming alongside one another. The width of the quadrat, approximately 2 m. is estimated by the observer, visibility permitting. A third diver collects a sample of each species of holothurian which, after weighing, will give the mean fresh weight at the station and the biomass.

5.1.1.4 Indirect visual assessment

In order to minimise the time and energy required by dive-sampling and to attain greater accuracy than that given by blind harvesting using fishing gear, indirect visual methods were developed from around 1960. These techniques utilise underwater imagery either from photography or from an underwater cine camera mounted on a towed framework. These methods yield interesting results for shallow-water macrofauna, but their costliness and the very nature of coral environment topography seem, so far, to have restricted their use in such zones.

5.1.2 Biotope definition and mapping

5.1.2.1 Definition of biotopes

Irrespective of the area over which a benthic resource is to be surveyed, it is necessary to define and demarcate the biotopes to be mapped in the area concerned. The various coastal environments were briefly described in Chapter 1. In accordance with reef terminology (Battistini *et al.*, 1975; Thomassin, 1984), 16 main biotopes may be distinguished for high islands, which form the most diverse type of coastal environment. These are illustrated in Figure 33 and may be broken down into various <u>geo-morphological types</u>: reef structures associated with barrier reefs, islet reefs or fringing reefs and non-reef structures, subdivided into outer and inner lagoon and coastal categories. They may also be grouped as structural formations or features on the basis of their functional morphology: outer slope, outer reef flat, inner reef flat, inner slope, lagoon. Each biotope may be described (Conand and Chardy, 1985) by a number of general parameters: distance from the shore, depth, gradient, hydrodynamics (currents, exposure to swell and waves, exundation). Grain-size estimation enables 9 principal classes of substrate to be distinguished, from coral flagstones to rock or mud. The accompanying flora and fauna, consisting of coral formations and the dominant macro-benthic groups, complete the description. Their respective abundance and the degree of coverage of the varying types of substrate, may be coded from 0 to 5 on the simple scale recommended by Dahl (1981).

5.1.2.2 Mapping

The environmental data used in describing stations for mapping purposes may be obtained *in situ* by diving, by dredging or by underwater imagery. For shallow zones, aerial imagery is extremely useful in defining biotopes. Aerial photography is often used, with a varying degree of subjectivity, and can be automatically analysed by computer-assisted techniques. Lastly, recent developments in remote-sensing have greatly improved resolution; the use of satellite imagery is proving applicable for coral environments and an example will be given in Chapter 5.3.

In conclusion, it would appear that each of these methods suits specific objectives and has its own constraints and inadequacies. A general sampling plan therefore has to be outlined and the size and number of samples determined. Without going into the details of these options, which can advantageously be considered and appraised in the light of the study by Frontier (1983), it is advisable to state which choices have been made so as to enable comparisons to be made and to secure a return on the human and financial investment in data collection.

5.2 Holothurian resource survey results

The results obtained by the author from fisheries departments and environmental surveys will be reviewed. The level of knowledge about these resources varies considerably between countries, but the data collected in some areas (New Caledonia, Papua New Guinea, Queensland) should facilitate subsequent assessments.

5.2.1 Papua New Guinea (after Shelley, 1981)

This survey was conducted from 1979 to 1981, south-east of Port Moresby, at a bay in Papua New Guinea's coastal lagoon bounded to seaward by a barrier reef and by a coast lined with mangrove in places, in front of which seagrass beds were developing. There were fringing reefs in the areas exposed to the prevailing winds. Using quadrat, transect and CPUE methods, the distribution and abundance of the species *Thelenota ananas*, *Holothuria nobilis*, *H. fuscogilva*, *H. scabra* and *Actinopyga echinites* were determined, the research effort focussing particularly on the last two species. The habitats surveyed (28 stations) were mainly the slopes and flats of the fringing reefs and islet reefs; a few stations were located on the barrier reef. Results were expressed as catch per diving hour. Distribution of most of the species was characterized by the presence of aggregations where densities are fairly high (Figure 34). A more detailed survey of the aggregations of *Holothuria scabra* enabled the relation between effort and area covered to be estimated (1 diving hour = 1000 m^2 approximately) and, on this basis, the mean density was found to be 0.37 individuals per m^2, on the inner fringing reef flats. Over a 800 m^2 quadrat, sampled monthly for 13 months, the mean density fluctuated slightly around 0.29 individuals per square metre for this species; it was only 0.18 specimens/m^2 for *Actinopyga echinites*. From these values and from growth estimates, the maximum annual production was estimated at 487 kg/ha/year for

H. scabra and 497 kg for *A. echinites*. These figures must be regarded as approximations, in the absence of more detailed knowledge of the environmental parameters and those relating to the population considered.

5.2.2 Solomon Islands

The reports prepared by Crean (1977) for the Fisheries Division of the Ministry for Natural Resources provide some information, based on a one-week bêche-de-mer survey conducted on the atoll of Ontong-Java, one of the largest in the Pacific. Of the fifteen-odd species identified by McElroy (1978) in the five major biotopes, only *Holothuria nobilis* and *Actinopyga miliaris* were regularly harvested. Average CPUE, calculated for *H. nobilis* from the catches of about twenty fishermen over a period of 9 days, was 11 specimens.

5.2.3 Fiji

Assessments made by Gentle (1979) on the Suva and Levuka reefs by skin diving, concerned mainly teatfish. The white *H. fuscogilva* was abundant on these reefs, in *Syringodium isoetifolium* seagrass beds; average CPUE was 12 to 20 specimens.

5.2.4 Tuvalu

A survey by the Fisheries Division (Pita, 1979) reported an average harvest of 20 to 50 teatfish per trip, over a period of 12 weeks, which was considered insufficient for a viable fishery.

5.2.5 Truk

A report by Howell and Henry (1977) presented the results of teatfish harvests made in October 1976 and February 1977. It did not give enough information to enable CPUE to be calculated. On the basis of the distribution of individuals on the inner reef slopes near the passes, the species concerned appears to be *H. fuscogilva*. A diver's one-day harvest, which varied considerably, only rarely exceeded 30 specimens.

5.2.6 Australia

Evaluations of the potential bêche-de-mer resource were carried out by the Queensland Fisheries Department on the reefs of the central zone of the Great Barrier Reef (Harriot, 1985) and on the reefs between Cairns and Lizard Island (Pearson, in press). The method used in both cases was counting by a diver holding a board with a flow-meter and towed by a boat. The surveyed sites were zones less than 10 metres deep. Pearson's counts (226 tows), which included giant clams and *Acanthaster* in addition to holothurians, gave average values of 16.3 *Holothuria nobilis* per hectare, 15.5 *H. atra* and only 3.6 for the 3 species *Thelenota ananas*, *Actinopyga miliaris* and *A. mauritiana* combined. In the permanent 2.7 ha quadrat which he set up on Michaelmas reef, holothurian density was 108 per hectare, mainly made up of *H. nobilis* (63/ha), *Actinopyga lecanora* (13.3/ha), *A. miliaris* (10/ha) and *T. ananas* (4.1/ha). Harriot's estimations (Table 26) are more detailed. Values are presented by reef structure for each group. Among the species counted, the commercially valuable ones are shown separately: *H. nobilis*, *T. ananas*, *T. anax*, *A. miliaris*, *A. mauritiana* and *H. axiologa (= fuscopuntata)*. The author feels that these estimations should probably be multiplied by three to approach the real density. On the basis of the densities calculated for the commercially important species, she considers that 20 specimens per hectare corresponds to a relatively high abundance. These high-density stations are usually located on outer and inner reef slope biotopes where the species *H. nobilis* and *T. ananas* are predominant.

5.2.7 New Caledonia

5.2.7.1 Calculation of CPUE

In the course of a study on the biology of holothurians, the results of which were presented in Chapter 4, the abundance of certain species was calculated by CPUE: the data for certain species are given in Figure 34; for *Holothuria fuscogilva*, data obtained from a survey conducted in Suva, Fiji are also shown. This information permits comparison with Papua New Guinea. For the three species *Thelenota ananas*, *Holothuria nobilis* and *H. fuscogilva*, the CPUE, generally low, very occasionally reaches 100 per diver per hour. *Actinopyga echinites* and *H. scabra* have more variable CPUE's that may approach 1000.

At three stations in New Caledonia, during counts of a single species, a flow-meter enabled the area surveyed to be evaluated and the relationship between area and effort values to be calculated simultaneously (Table 27).

The surface area surveyed at the three stations was nearly 5 times as large as the one covered by Shelley (1981). CPUE is thus a simple method, but it remains to be standardized, to enable comparisons and stock-size assessments to be made.

5.2.7.2 Distribution and abundance of the various species

To determine the distribution of *Aspidochirota* holothurians more precisely, 216 stations were surveyed, at different times, in various parts of the New Caledonian lagoon. Direct visual evaluation of species density (counts made by diving with a flow-meter or walking over the quadrats at low tide), sampling to obtain biomass values and description of environmental parameters yielded estimations of biotope richness, the biotopes being classified by reef type, as well as by structural formation, faunal composition and abundance of the main species.

- <u>Biotope richness</u>. Although the method was imprecise, the populations highly dispersed and the biotopes variable in area, the results obtained depict an extensive and varied reef and lagoon complex. Figure 35 shows mean densities and biomasses, expressed per hectare, for the three categories of holothurian in the 16 biotopes of the reef complex. The first grouping contains the 5 high-commercial-value species. *Holothuria scabra*, *H. scabra* var. *versicolor*, *H. nobilis*, *H. fuscogilva*, *Thelenota ananas*, *Actinopyga echinites*, and *A. miliaris*. The second category comprises the species of little value, or of historical value only (cf. Chapter 4): *H. atra*, *H. edulis*, *H. fuscopuntata*, *Actinopyga mauritiana*, *Bohadschia argus*, *B. vitiensis*, *Strichopus chloronctus*, *S. variegatus*, and *Thelenota anax*. The third category consists of the 30 other species of *Aspidochirota* holothurians that were inventoried in these surveys.

Both density and biomass values were found to rise with the gradient from the open sea to the coast, as far as the classification by type of reef was concerned and from outer slopes to inner reef flats with regard to structural formation. The slopes and outer lagoon were less rich than the reef flats. The inner reef flats, in particular, and coastal zones (bays, estuaries) were the richest environments. From the point of view of densities, first-category species were least abundant on the barrier reefs, outer reef slopes and outer lagoons. They were however predominant on the inner reef flats and in the coastal zones. Biomass distribution had comparable characteristics, except for the barrier reefs and outer lagoons where the respective proportion of commercially valuable species was slightly higher; this was because of the large size of these species.

Composition of the fauna (after Conand and Chardy, 1985). Population units were determined by an inertia analysis performed on the basis of the density values for the different species of holothurians at the survey stations. The stations or "observations" and the species or "variables" were used to produce a two-dimensional table. The analysis deals with the distance between observations. Among the inertia analyses possible, analysis of correspondences was chosen because it gave a simultaneous representation of observation groupings and variables. Introduction of additional variables of "zero mass" and projection to control-points of the biotope barycentres assisted in interpreting the structures obtained. The results shown in Figure 36A correspond to the configuration obtained in the plane defined by the first 2 axes of the analysis; they allow discrimination between reef systems (flats, slopes, passes) and non-reef systems (lagoons and bays). Within the reef system, two types of organisation (by structural formation and type of reef) are distinguished. Along axis 1, corresponding to the offshore-inshore gradient, are located, firstly, the barycentres: barrier reef, island, fringing reef; secondly, the barycentres of the reef formations: slope, outer flats, inner flats. The non-reef system is well defined, except for the outer lagoon which is in an intermediate position, thus proving its affinity with the reef system. The passes, located at the tip of the V whose "branches" are the reef and lagoon biotopes, belong to both systems. The configuration of the species projection enables three main groupings to be defined:

. pass and slope species, including *Holothuria nobilis, Thelenota ananas* and *H. fuscogilva*, which are the commercially valuable species;

. inner reef-flat species, with *Holothuria scabra, Actinopyga miliaris* and *A. echinites;*

. lagoon species, with *H. scabra* var *versicolor*. The outer reef-flat species are less concentrated; while others show a twofold affinity: "lagoon-slope" or "inner reef-flat bay". Species of commercial interest can be seen to exist in very different biotopes, which explains how varied the possible exploitations are.

Table 26: Holothurian densities on 9 reefs of the Great Barrier Reef, in terms of numbers of animals per ha, from data in Harriot (1985). Number of transects at each station in brackets; C: commercial species; Hn: *Holothuria nobilise*: Ta: *Thelenota ananas*; T: total of large-sized species.

		BIOTOPES			
REEF	TYPE	Outer slope	Reef flat	Lagoon	Inner slope
John Brewer	C	27.6	15.2	7.6	
	Hn	2.0			
	Ta	18.8			
	T	(2) 32.0	(7) 44.0	(10) 32.0	
Outer Sand Cay	C	54.0	7.2		52.4
	Hn	2.0			0
	Ta	23.2			42.4
	T	(3) 106.8	(2) 22.4		(4) 74.4
Ellison	C	6.0	1.6	0.4	
	T	(2) 22.0	(5) 4.0	(2) 2.8	
Feather	C	5.2	2.0	2.0	
	T	(3) 92.0	(2) 4.8	(2) 6.0	
Peart	C	27.6	0		
	Hn	5.2			
	Ta	12.4			
	T	(4) 242.8	(2) 2.0		
Mc Culloch	C	20.0		8.4	24.0
	Hn	1.2			4.0
	Ta	10.8			
	T	(3) 107.2		(4) 70.8	(2) 80.0
Sudbury	C	22.8	2.0	9.6	
	Hn	0			
	Ta	16.8			
	T	(3) 143.6	(4) 10.0	(7) 45.2	
Briggs	C	8.0	5.2		76.0
	Hn				0
	Ta				48.0
	T	(5) 34.4	(4) 65.6		(2) 434.0
Michaelmas	C	7.6	0	8.8	
	T	(18) 127.2	(2) 10.0	(6) 41.2	

Table 27: Relationship between effort and area sampled, at 3 New Caledonia lagoon stations.

BIOTOPE	SPECIES	DENSITY n/ha	CPUE n/hr	AREA/hr ha/hr
Passage	*T. ananas*	42	26.4	0.63
Inner reef flat (islet)	*H. nobilis*	59	26.2	0.44
Outer slope (islet)	*A. echinites*	462	270	0.58

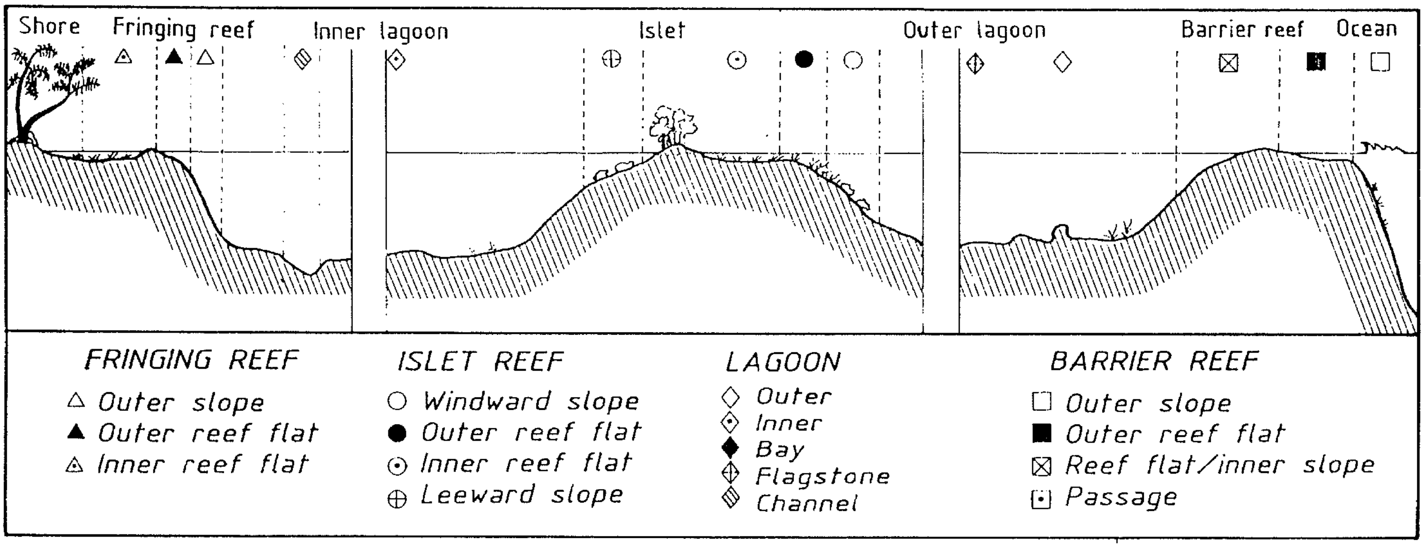


Figure 33: Principal biotopes of the reef and lagoon complexes of a continental island: New Caledonia (Conand and Chardy, 1985)

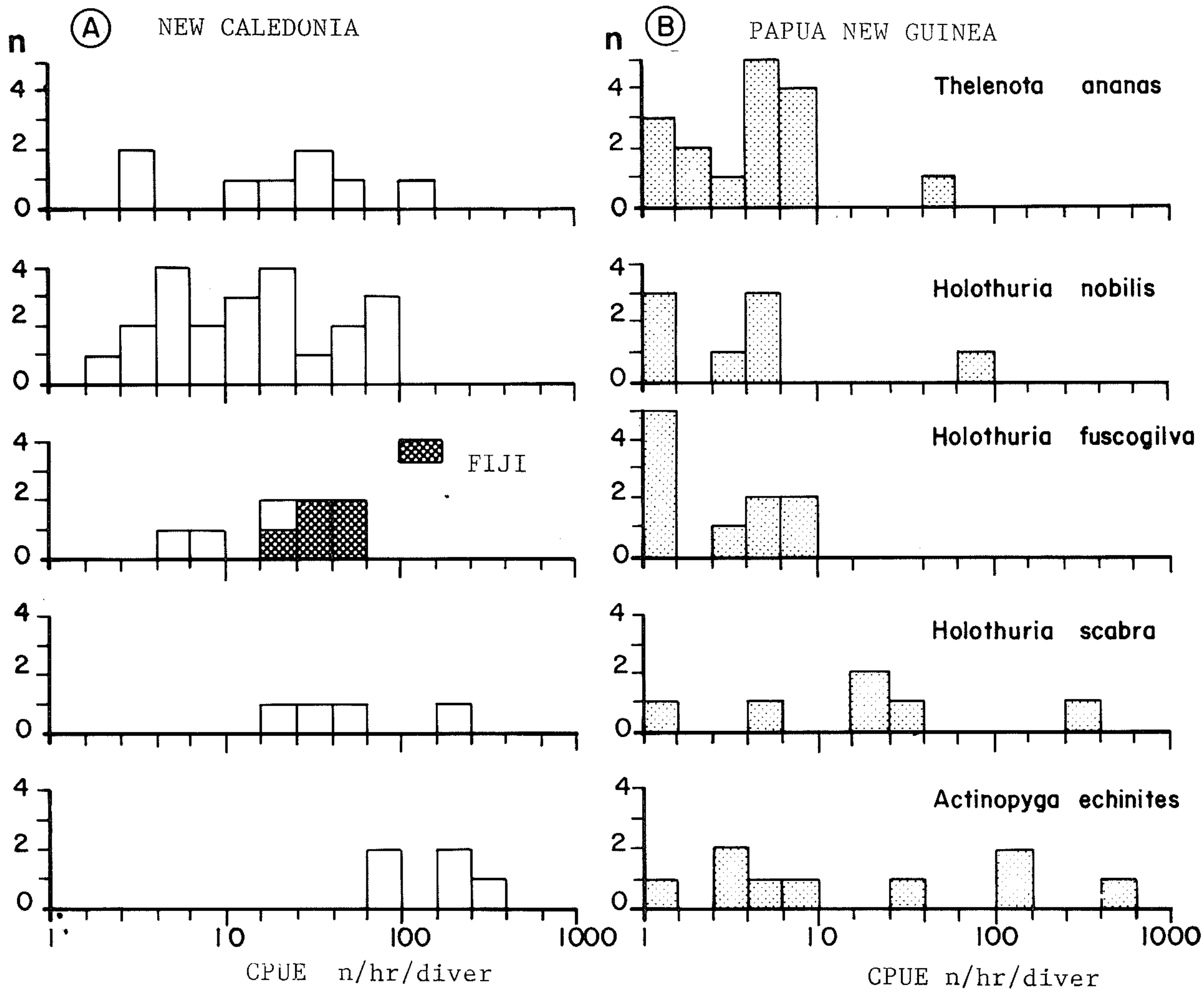


Figure 34: Distribution of catch per unit effort for the main holothurian species. A: New Caledonia (Conand) B: Papua New Guinea (after Shelley, 1981).

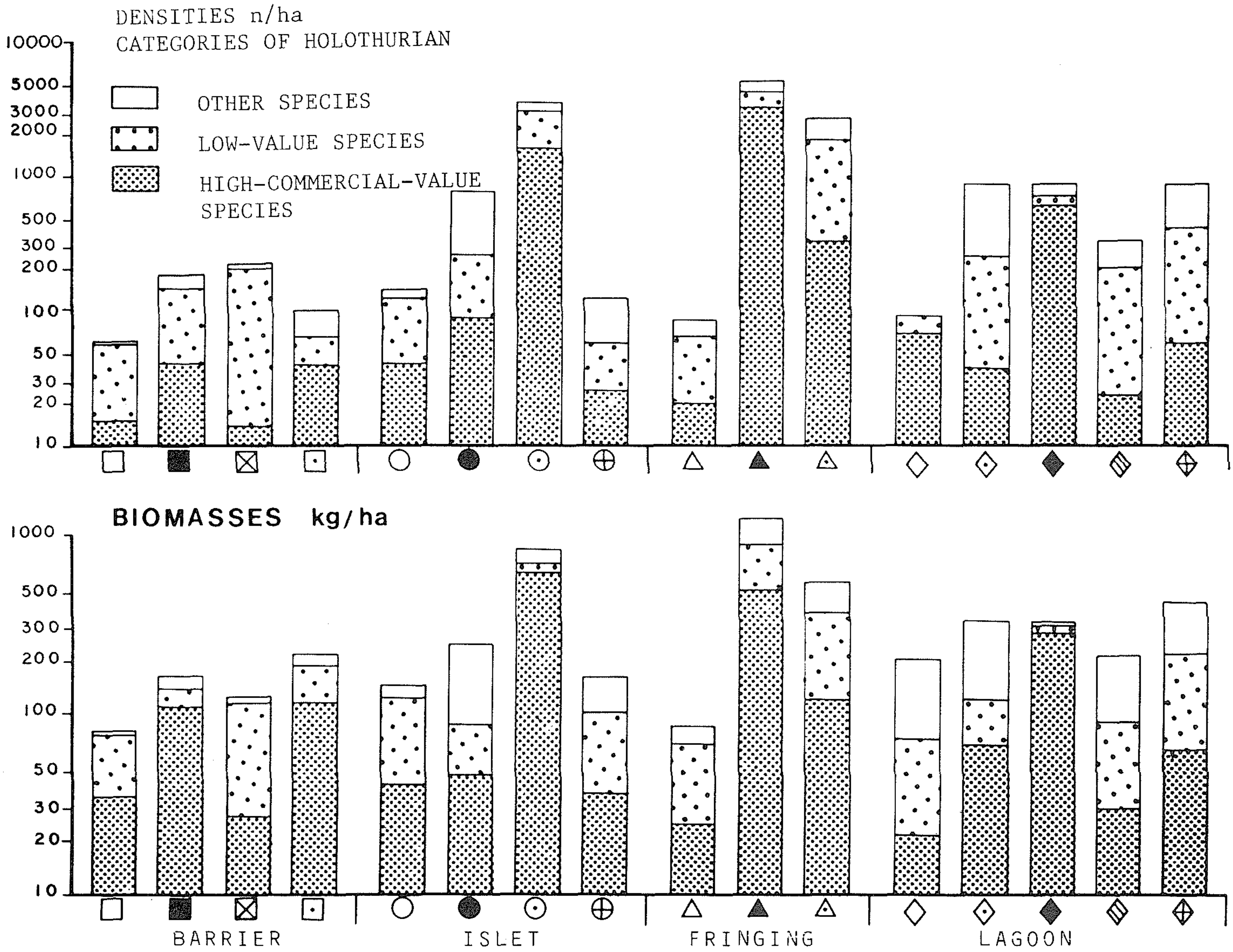


Figure 35: Abundance distribution of the various categories of holothurian in New Caledonia lagoon biotopes. For key to biotope symbols, see Fig. 33.

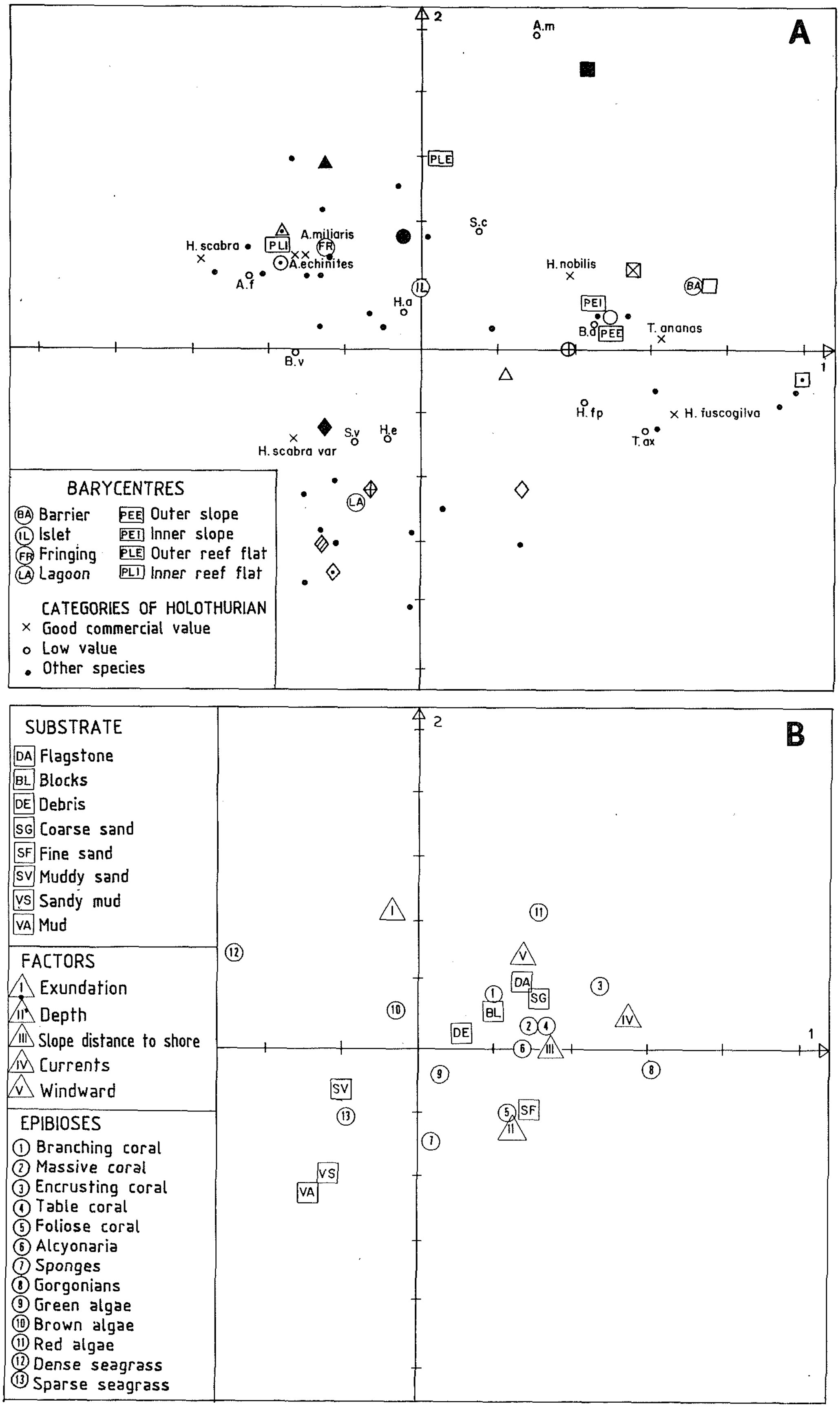


Figure 36: Faunal composition determined by analysis of correspondences.
A: projections of barycentres of stations and species. For key to biotope symbols, See Fig. 33.
B: Projection of extra variables.

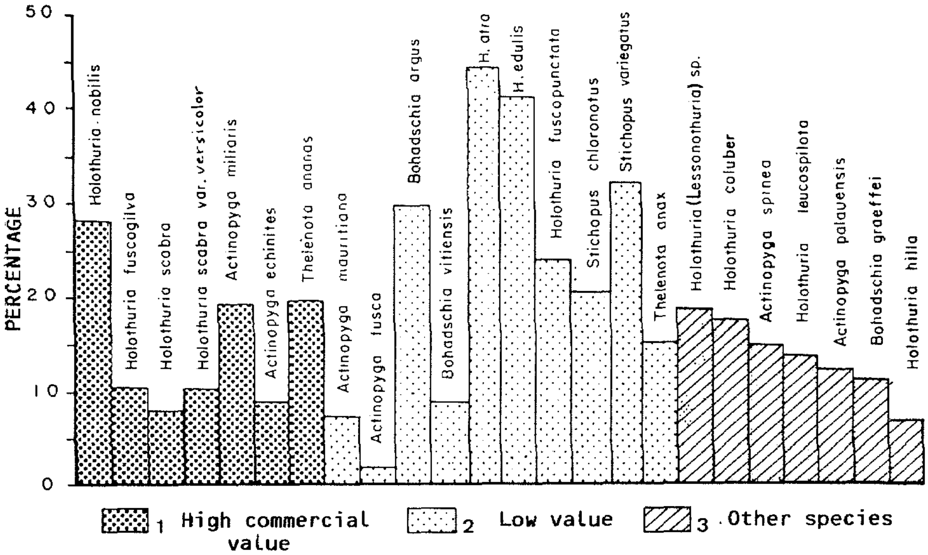


Figure 37: Percentage occurrence of the main species.

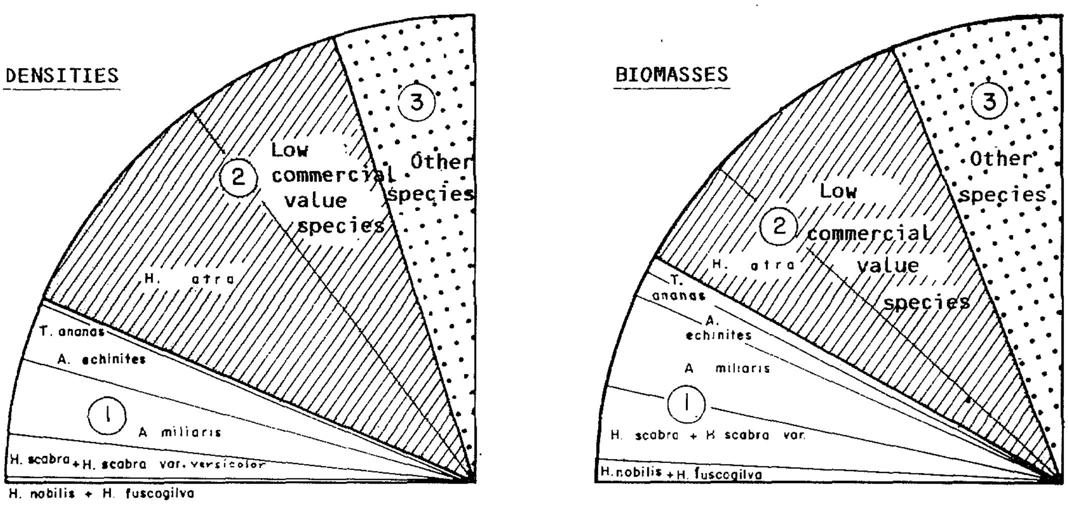


Figure 38: Relative densities and biomasses of the various species found in the lagoon in New Caledonia.

1: good commercial value **2**: low value **3**: no value

The position of the additional variables (Figure 36B) in the plane of the first two axes enables their significance to be clarified. The depth and emersion factors, on either side of axis 2 discriminate the reef flats from the submerged areas. Distance from the coast, presence of currents and slope of the biotope are grouped on the same side of axis 1, with the passes and slopes. The main substrates and the epibioses characterise the different biotopes.

- Distribution and abundance of main species. An ecological study, based on our observations during the assessment surveys, gave incidences of the major species in per cent (Figure 37). Assuming the sample to be representative of the populations of the biotopes in the reef and lagoon areas considered, the most frequently encountered species were *Holothuria atra, H. edulis, Stichopus variegatus* and *Bohadschia argus* which are of no (or very little) commercial value. In the first commercial category, *H. nobilis* and *Thelenota ananas* were encountered in over 20 per cent of the stations. In this category, the other species were also fairly frequent, 8 to 19 per cent. These values are, on the whole, lower than those for second-category species. For the other species, only the most frequent have been shown.

  Overall abundance of the three categories of species is illustrated in Figure 38. From the point of view of density, first-category species account for 25 per cent of the total and are dominated by *Actinopyga miliaris;* second-category species account for 56 per cent, dominated by *H. atra* (33%), while third-category species are less abundant. From the point of view of biomass, expressed as total live weight, the relative proportions for the three categories are as follows: 32 per cent for the first (a higher percentage due to the high weight of these large-sized species), 44 per cent for the second *(H. atra* - 16%) and 24 per cent for the third. Frequency distributions of the densities and biomasses of the first-category species are shown in Figures 39A and B. Densities vary very widely, from one per hectare to several thousand per hectare. However, two main types of density distribution can however be seen to occur:

  . densities of the populations of *H. nobilis, H. fuscogilva, T. ananas, T. anax* and *B. argus* were relatively uniform and usually below 50 specimens per hectare;

  . densities of the populations of *A. echnites, A. miliaris* and *H. scabra* var. *versicolor* were more variable, ranging from just a few individuals to aggregations of more than 1,000 per hectare.

  Biomass distributions were also extremely scattered, ranging from less than 1 kg to several tonnes per hectare where aggregations existed. From the commercial point of view, these high values can be regarded as a favourable factor. From the ecological point of view, they can be used to compare the potential richness of environments or the energy value of the species (Lawrence, 1979), which is the basic factor in the functioning of ecosystems: these maximum numerical or energy values indicate the maximum capacity of a biotope.

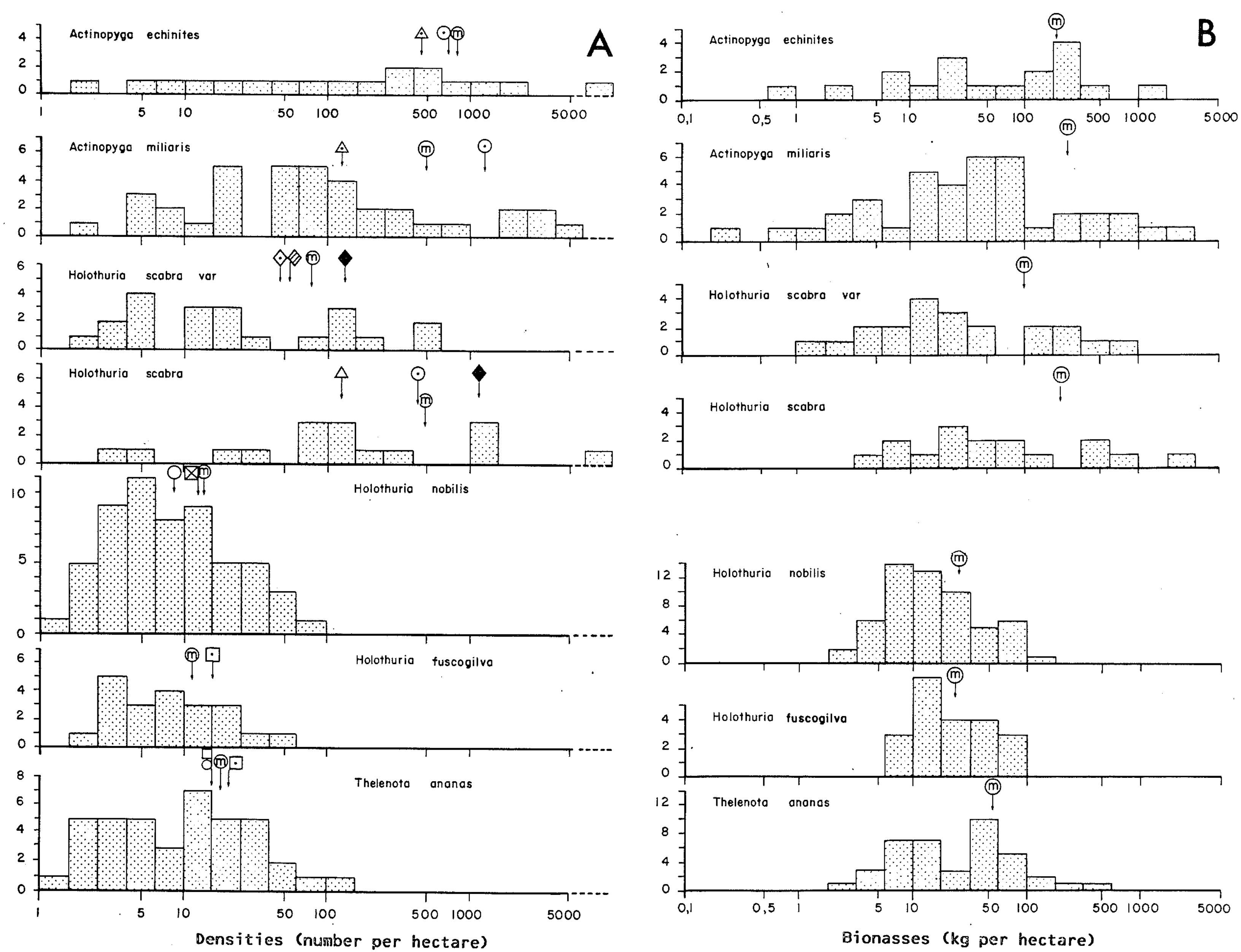


Figure 39 : Density and biomass frequency distributions of commercially important species - m: mean value.

In conclusion, among the first category species, *A. miliaris* was dominant both in density and in biomass. The sandfish, *H. scabra* and *H. scabra* variety *versicolor* came next and *A. echinites* in third position. The large species *H. nobilis*, *H. fuscogilva* and *T. ananas* only accounted for a very small portion of the total density, but a larger portion of the biomass. These species were characteristic of different biotopes.

5.2.8 Other areas

Some consultancies have also been carried out in other countries, but the data contained in the resulting unpublished reports are not precise enough to be used. From ecological studies giving data on distribution and abundance of holothurians have been selected those concerning species of commercial value. Baker (1929) for example describes the different zones of a fringing reef on Gaua Island in Vanuatu, where a density of 0.48/m^2 was recorded for *Actinopyga mauritiana*. This species reached high densities (12/m^2 maximum) on a windward reef flat of Eniwetok atoll (Lawrence, 1979). On a reef flat in Guam, Rowe and Doty (1977) found a population of *Actinopyga echinites* with a density of 0.8/m^2 located behind a population of *A. mauritiana* which had a higher density (1.2 to 1.5 specimens/m^2) but over a smaller area. In French Polynesia, available data mainly concern species *Holothuria atra* (Salvat, 1975) which is a predominant species in these ecosystems, with a mean density of 2 to 8/m^2 and a maximum density that can reach 43/m^2. In Yap lagoon, Grosenbaugh (1981) found high densities of *A. echinites* (5 to 15 specimens/m^2) in a *Thalassia* bed on the inner reef flat. Densities of other commercially important species were generally low.

5.3 Examples of the use of remote sensing for resource assessment

5.3.1 Introduction

The first photographs of the earth, taken from space during the Gemini missions in 1965, picked out coral reefs and some topographical detail. The use of remote sensing techniques for surveying coastal zones, however, requires much higher resolution. After a comparative appraisal of the performances of various sensors fitted on aircraft or satellites, Loubersac (1983, 1983a) demonstrated the value of the LANDSAT TM and SPOT high resolution satellites in studying coastal environments featuring high spatial and temporal variability. The use of LANDSAT MSS data on certain reefs has enabled bathymetric mapping to be carried out in Polynesia (Pirazzoli, 1982), and populations to be mapped in New Ireland (Quinn and Dalzell, 1985).

The SPOT program (CNES, 1982) consists of an earth observation satellite, which will be launched into orbit in 1986, and a number of receiving stations. It will yield multispectral imagery (3 channels), with a ground resolution of 20 x 20 m and panchromatic black and white images, with 10 x 10 m resolution. During simulations carried out before launching, data were obtained through an airborne Daedalus radiometer. These have been reformatted to give SPOT images, the wavelength ranges being XSI (0.50-0.59 microns), XS2 (0.61-0.69 microns) and XS3 (0.79-0.89 microns), in the multispectral mode and XP (0.51-0.73 microns) in the panchromatic mode. In December 1983, a simulation programme was carried out in New Caledonia by the 'Groupement pour le developpement de la teledetection' (Remote Sensing Development Group) with the support of a number of bodies.

5.3.2 Thematic mapping and resource estimation

5.3.2.1 Methods

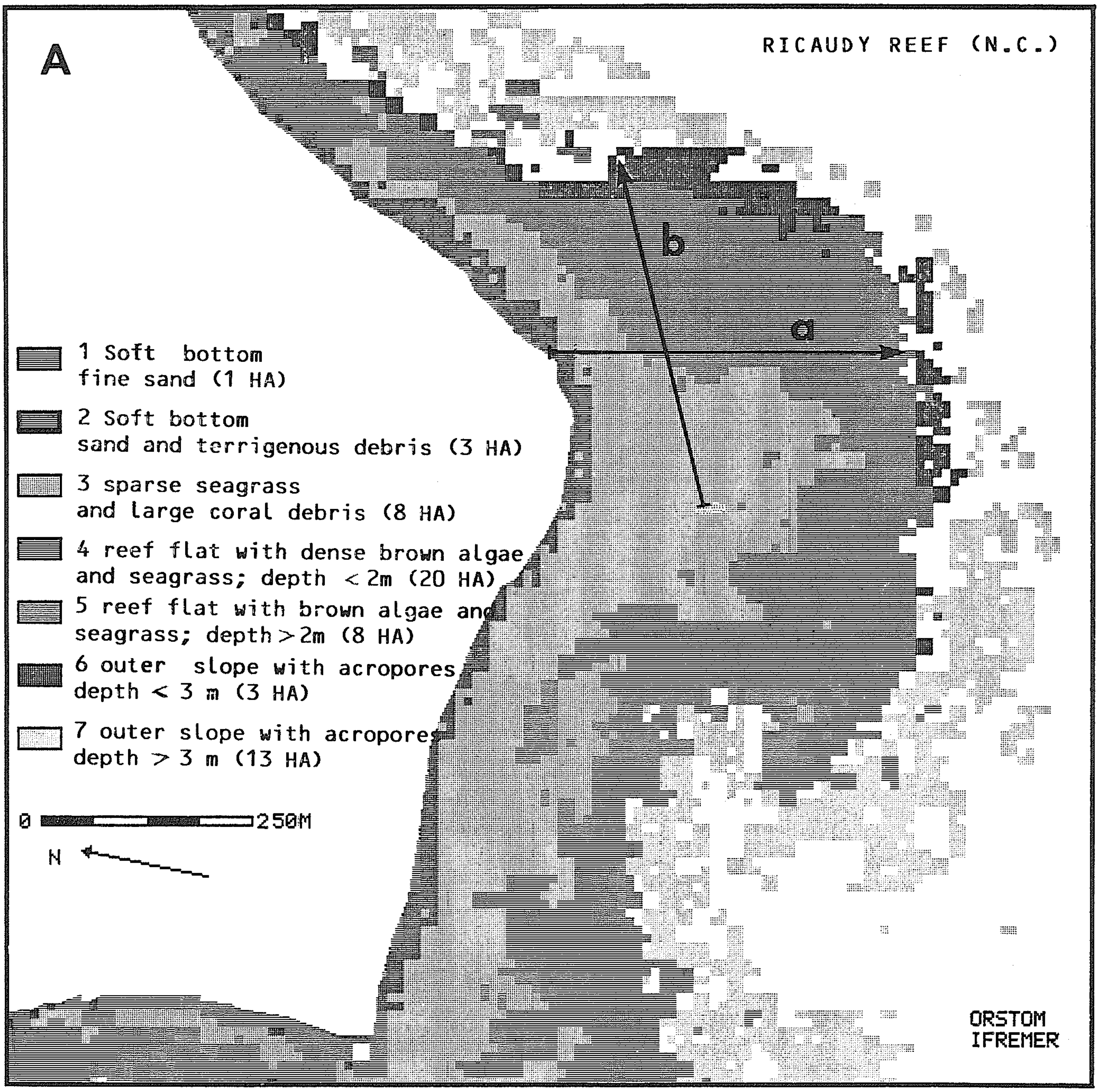
Image processing was carried out, in conjunction with IFREMER and ORSTOM, using the 'Gipsy' software (Belbeoch, 1982). The processing methodology (Loubersac, 1983) comprised the following stages: elimination of the terrestrial areas by stretching on channel XS3 (near infra-red), elimination of areas over approximately ten metres in depth by stretching on channel XS1, classification of the values by stretching on the two-dimensional channel histogram (or if their correlation is very close, on pseudo-channels) obtained by converting the Cartesian coordinates of the histogram pixels into polar coordinates (Bour *et al.*, 1985). The area for each class or theme was expressed in terms of number of pixels. The themes were confirmed by examining aerial photographs and carrying out a field check. Two of the selected reefs in the south-western lagoon of New Caledonia, a fringing reef and an islet reef, were also holothurian biomass and density survey locations. Examination of the imagery resulted in the classification of seven principal themes for each reef, ranging from bare sandy beach bottoms to outer reef slopes.

5.3.2.2 Example of a fringing reef

Abutting the end of the Noumea peninsula, Ricaudy reef runs parallel to the shore over a width of approximately 300 meters. The themes obtained by image processing cover an area of approximately 64 hectares (Figure 40A). Two series of 10 x 2 meter quadrats were studied along radials A and B; every holothurian was identified, measured and weighed. The distribution of the three clearly dominant species *Actinopyga echinites*, *Holothuria leucospilota* and *H. atra* (Figure 40B) showed that only the third variety is present, although only in small numbers, in theme 2, soft debris-covered bottoms. Higher densities were recorded for theme 3, inner reef flat with sparse seagrass beds and debris. Theme 4 consisted of a reef flat flagstone, covered in a thick brown algae (Sargassum and *Turbinaria*) on the outer portion, with sandy channels sustaining fairly dense seagrass beds of *Cymodocea* and *Halodule* on the inner part. These two surfaces were not differentiated in the analysis. On the other hand, holothurian distribution was different on them; the density of *A. echinites* increased on the outer reef flat as the outer slope was approached, whereas the frequency of *H. atra* fell. *H. leucospilota* was quite abundant in this area, but showed wide variations in biomass, due to the presence of specimens of different sizes. From the observations made along the two radials, mean density and biomass per 100 m^2 were calculated for each species, followed by total numbers and biomass for each theme (Table 28 and Figure 41). The most densely populated area was the reef flat with thick vegetation. The richness of the edge of the windward reef slope was due to the abundance of *A. echinites*.

5.3.2.3 Example of an islet reef

The reef complex surrounding Maître islet is roughly triangular in shape. The simulation image only covers part of this complex, comprising a windward reef slope, located along a channel subject to strong tidal currents, a reef flat and the leeward outer reef slope of the cay as well as the emerged, tree-covered cay itself. The three holothurian survey radials were divided between different themes (Figure 42). Radial A extended over 300 metres (quadrats of 10 x 1 m) on the inner reef flat,



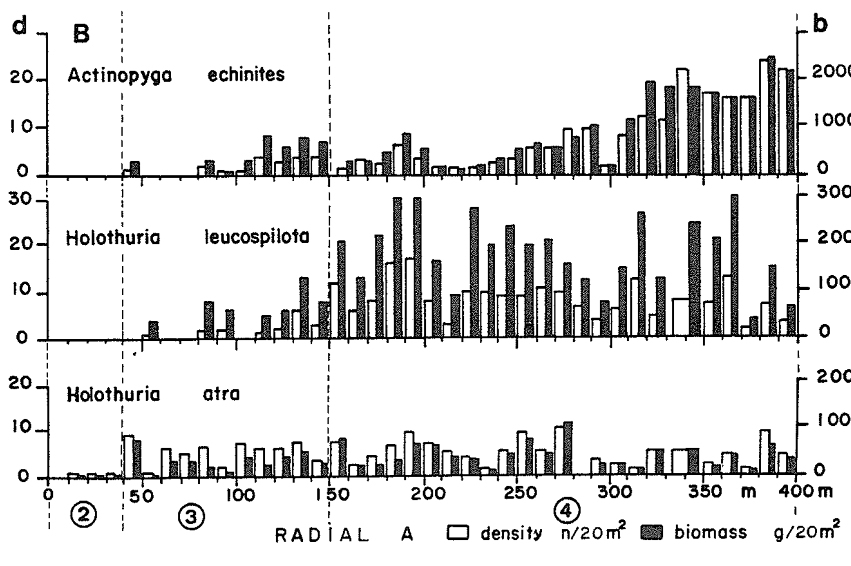


Figure 40 :

Thematic mapping of fringing reef (Ricaudy reef, New Caledonia), (A) and sampling of holothurians (B).
a and b: sampling radials.

including a zone of sand-banks (theme 2) and a zone of sparse seagrass beds (theme 3). Radial B (100 x 2 m) ran through the thick seagrass (theme 5). Radial C (750 x 3 m) was drawn by skin-diving parallel to the edge of the windward outer reef slope in an area densely populated by the starfish *Acanthaster planci* (Conand, 1985); the holothurians were located in hollows covered in sand and coral debris, between the clumps and tables of *Acropora*. Table 29 and Figure 43 show the specific composition of holothurians and their abundance in terms of numbers and weight. A dense colony of *H. atra* had congregated in the sandy inner reef flat. Much diversity was evident in the thick seagrass bed; the high biomass was shared between the different species. On the windward outer reef slope, as on Ricaudy reef, *A. echinites* was predominant.

5.3.3 Discussion

This assessment of the holothurian stocks of two reefs is based on the simultaneous use of thematic mapping from satellite data and field sampling; it is one example of the possible uses of high-resolution remote sensing. It is, however, as yet, subject to a high degree of uncertainty and the results obtained, although they cannot be considered absolute values, do give an indicative value for stock sizes. The sources of variation with each method aggregate. The uncertainties of quantitative sampling have already being explained (cf. Chapter 5.1.1). The analysis of satellite imagery has up to now often related to foreshore areas with the ensuing effect of eliminating the influence of bathymetry and the transparency of the water. In coral areas, however, the waters are clear enough for the upper part of the sub-littoral area to be analysed, as by Jupps *et al.* (1984) in mapping the Great Barrier Reef, and Bour *et al.* (1985) in mapping New Caledonia's barrier reef. These recent surveys showed that the biotopes are usually clearly differentiated. Wider application will depend on better knowledge of the spectral responses of the identified themes. Among the plant populations of the reef flats of the fringing reef and the islet reef, it was not possible to distinguish the brown algae from the seagrass beds, which have a similar profile in the SPOT spectral bands, even though they represent different biotopes. On the outer reef slopes, the effect of bathymetry swiftly became predominant in this type of biotope. Some zones were highly heterogeneous; their study will require the use of more complex methods of analysis, concerning texture for example. *Another source of inaccuracy was the positioning of sampling radials.* This was carried out in the field, assisted by topographical features, as identified on the image provided by the panchromatic channel whose high resolution, 10 m, proved very useful.

Despite these various difficulties, which will gradually be overcome, it would appear that thematic mapping of shallow zones is feasible using SPOT satellite imagery and can be used to assess benthic resources by sampling species, in the field, within the various themes defined.It will then become necessary to assess the margins of error inherent to each of these methods.

Table 28: Densities, numbers and biomasses of holothurians in four Ricaudy Reef biotopes. (A) and (B): radials, (Th): theme (see figure 40)
A - Densities, d per 100 m^2 and numbers, N = '000 specimens.

Theme		Acinopyga echinites	Holothuria leucospilota	Holothuria atra	Other species	Total
2	(A) d	-	-	4	6	10
	(Th) M	-	-	1.2	1.8	3.0
3	(A) d	9	8	26	6	49
	(B) d	2	2	24	0.3	28.3
	(Th) M	8.6	7.3	45.3	4.3	65.5
4	(A) d	40	43	23	1.2	107.2
	(B) d	33	39	29	3.6	104.6
	(Th) M	74.1	81.9	52.2	4.5	212.7
6	(B) d	113	38	10	-	161
	(Th) M	33.9	11.5	3.0	-	48.4

B - Biomasses, b in g per 100 m^2 and B in kg.

Theme		Acinopyga echinites	Holothuria leucospilota	Holothuria atra	Other species	Total
2	(A) d	-	-	231	2575	2806
	(Th) M	-	-	69	772	841
3	(A) d	1795	2366	1590	1927	7678
	(B) d	618	790	1831	34	3273
	(Th) M	1976	2578	3120	1450	9124
4	(A) d	5703	9731	1887	134	17455
	(B) d	5664	8152	2458	850	17124
	(Th) M	11371	18020	4295	922	34608
6	(B) d	9733	8775	700	-	19208
	(Th) M	2919	2632	210	-	5761

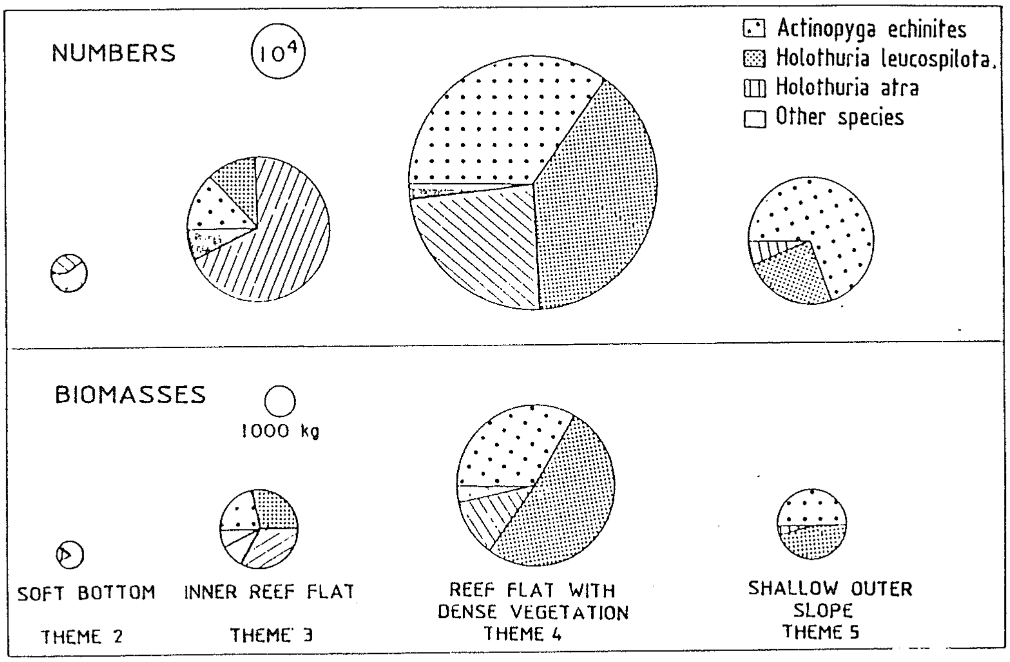


Figure 41: Assessment of holothurian abundance in various Ricaudy Reef biotopes

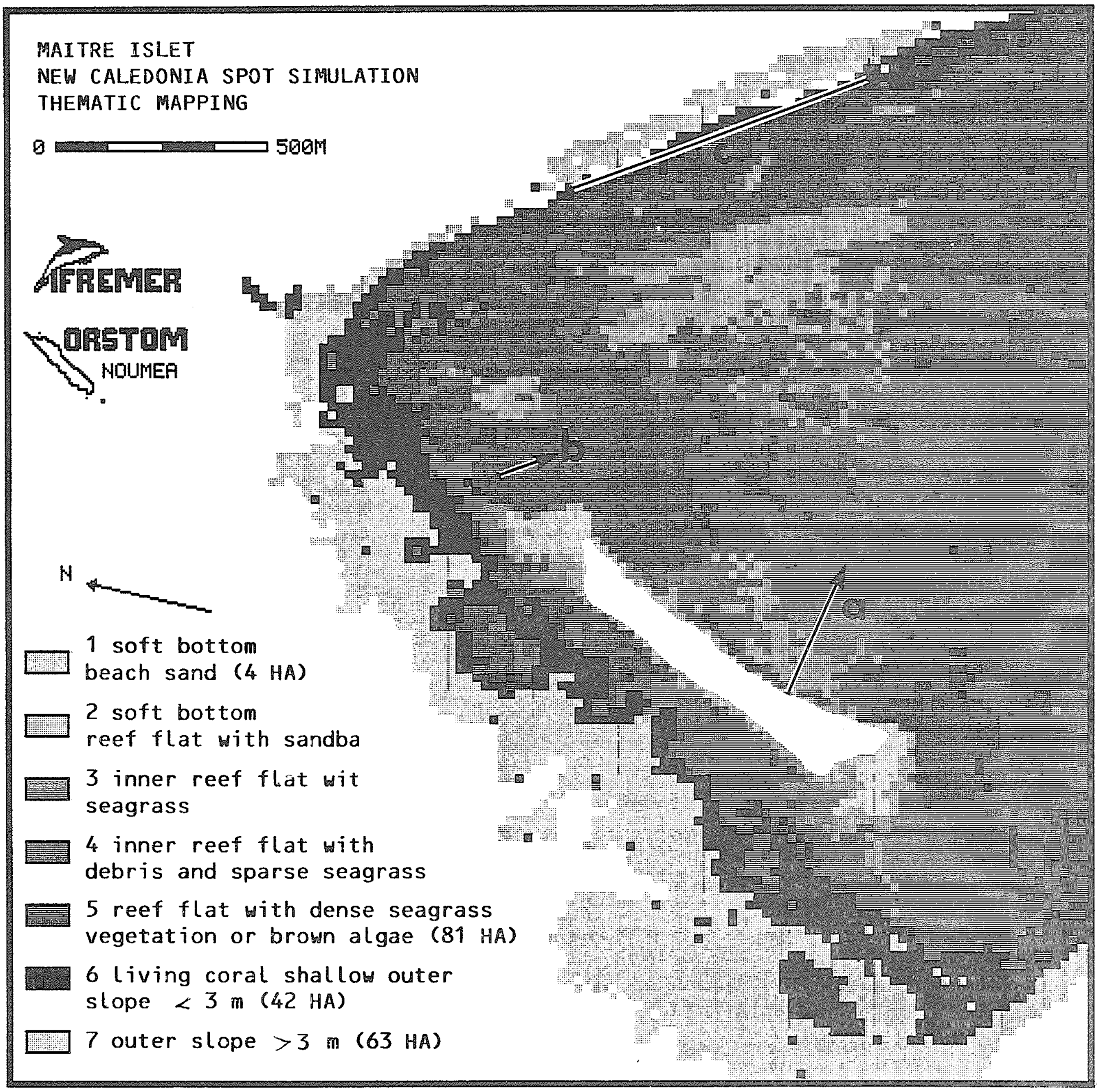


Figure 42 : Thematic mapping of a lagoon reef, Maître islet, New Caledonia. a, b and c: sampling radials.

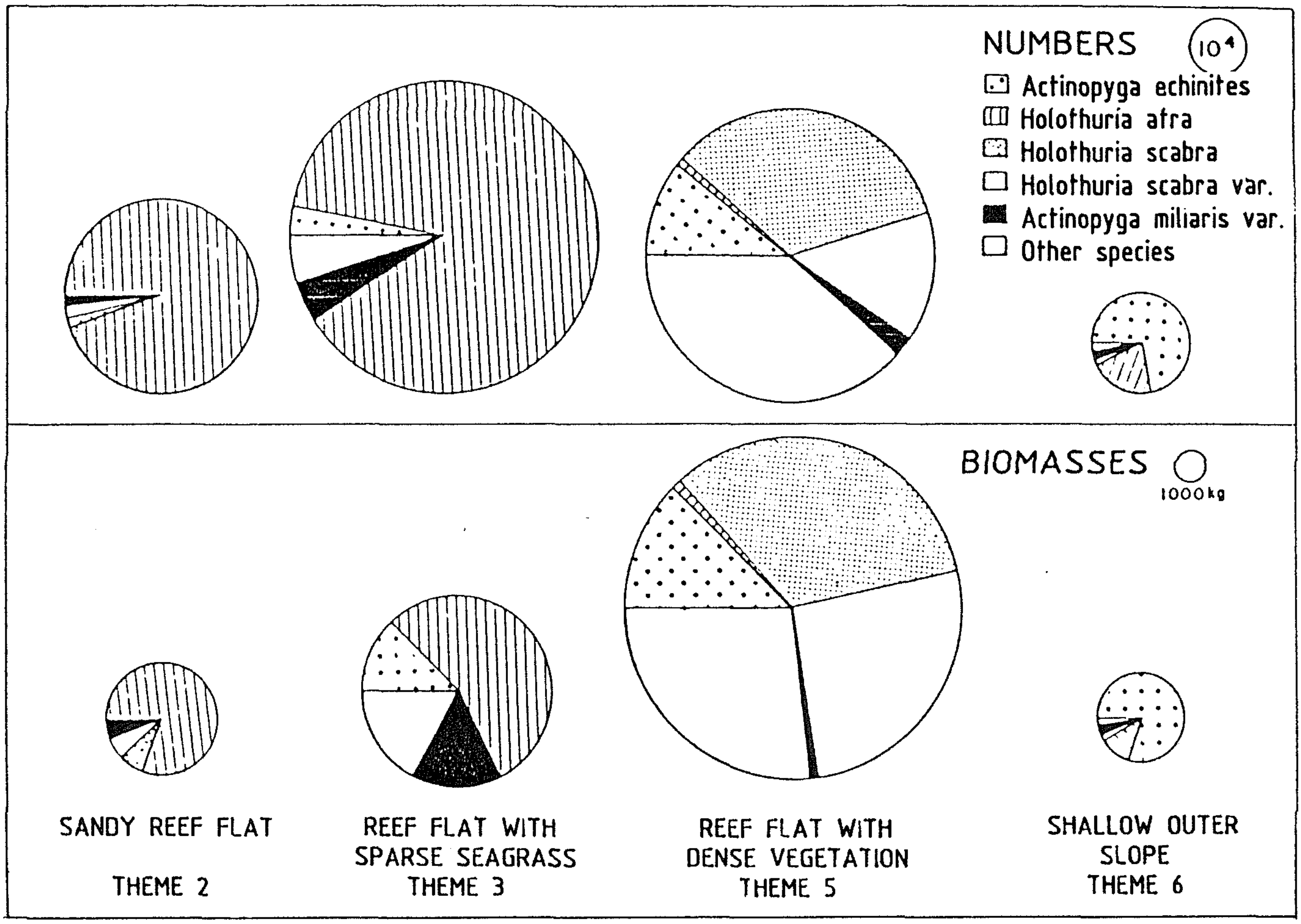


Figure 43: Assessment of holothurian abundance in various Maître islet biotopes

Table 29: Dentities, numbers and biomasses of holothurians in certain Maître islet biotopes.
(A), (B), (C): radials; Th: theme (cf. figure 42).

Theme	Actinopyga echinites	Holothuria atra	Holothuria scabra	Holothuria scabra var.	Actinopyga miliaris	Other species	Total
(A) d	1.0	46	0.3	0.3	1.7	1.3	50.6
2+3 (Th) N	8	368	2.4	2.4	13.6	10.4	405
(B) d	3.5	0.5	10.5	4.5	0.5	11.5	31
5 (Th) M	28.4	4.0	85.0	36.4	4.0	93.1	251
(C) d	4.6	1.3	-	0.1	0.2	0.1	6.3
6 (Th) N	19.3	5.3	-	0.4	0.8	0.4	26

B - Biomasses, b in g. per 100 m^2 and B in kg.

Theme	Actinopyga echinites	Holothuria atra	Holothuria scabra	Holothuria scabra var.	Actinopyga miliaris	Other species	Total
(A) d	570	4126	139	134	770	755	6494
2+3 (Th) N	4560	33008	1112	1072	6160	6040	51952
(B) d	2248	49	5574	4494	131	4654	17150
5 (Th) M	18209	397	45149	36401	1061	37697	138914
(C) d	1594	232	-	16	101	41	1984
6 (Th) N	6695	9743	-	67	424	172	8332

5.4 Conclusions

In conclusion, research on holothurian resource assessments has recently been conducted in New Caledonia, Papua New Guinea and Australia, in locations diverse enough to permit the definition of three main distribution patterns for the species of commercial importance.

- The first comprises coral areas, inner and outer reef slopes and passes in particular. These biotopes, bathed by clear waters and often strong waves and currents, undergo little in the way of terrigenous influence; sloping substrates include flagstones which may sustain corals, with coral debris and sand in the cavities. Species typically found here are *Holothuria nobilis*, *H. fuscogilva* and *Thelenota ananas*. The populations of each of these species are not very dense, usually under 50 specimens per hectare; animals are large in size on average and the biomass is around 50 kg per hectare. Most of the Great Barrier Reef locations surveyed belong to this type of environment.

- The second type of distribution corresponds to inner reef flats. These biotopes are particularly well developed on islet reefs and fringing reefs subject to terrigenous influence. Currents and waves are not strong. The various substrates range from sands to sandy mud; they are often covered in seagrass beds or dense algae populations. Species typically found here are *Actinopyga miliaris*, *A. echinites* and *H. scabra*. Their populations vary in density and may exceed 1,000 per hectare; despite the smaller size of specimens in this group, biomasses may be high, exceeding 200 kg per hectare. The Papua New Guinea study was carried out in such an environment.

- The third type covers inner lagoons, bays and estuaries. Here, the biotopes, usually deeper than those of the second type, are also subject to terrigenous influence. The substrate is often sandy and muddy and may sustain sparse seagrass beds or fields of green algae. *H. scabra* var. *versicolor* and *Stichopus variegatus*, the characteristic species here, have no commercial value. Densities lie midway between those of the two other types, 80 specimens or so per hectare; since the size of these species is also intermediate, the biomasses are usually under 100 kg per hectare.

Other biotopes, such as outer lagoons or outer reef flats, particularly those not subject to terrigenous influence, also offer holothurian habitats but the species present here, *H. fuscopunctata* in the outer lagoons and *Actinopyga mauritiana* and *Stichopus chloronotus* on the outer reef flats, are of little commercial importance. Consequently, it is necessary for future studies to clearly define the environments studied and the techniques used. The simultaneous use of remote sensing for the thematic mapping of the survey area and quantitative sampling of holothurians in the field should make it possible to estimate stocks in shallow waters.

6. HARVESTING - PROCESSING - PRODUCT GRADING

6.1 Harvesting holothurians

While *Stichopus japonicus* in Japan and *S. parvimensis* in the United States can be harvested by trawling, the tropical species of sea cucumber are generally hand-gathered. Divers go out to the fishing grounds in small motorboats, or in some places still in sailing canoes, and collect the holothurians by skin diving. Scuba-diving equipment is too expensive and the constraints involved too great for it to be a viable method of hand collection. In the Solomon Islands, a weighted hook is sometimes used (Crean, 1977) to reach animals in deep waters with good visibility. A 2.5 kg weight attached to the end of a line bears a 32 mm hook which enables the catch to be brought up from depths of up to 30 m. However, these hooks are probably not to be recommended because of the wounds they cause to the body wall which detract from the quality of the processed product. Some species, such as *H. scabra*, can be harvested by hand at low tide on the reef flats.

The sea cucumber must be kept alive in sea water until processing, to prevent evisceration which tends to occur when they are handled or confined in tanks where the temperature rises rapidly.

6.2 Processing methods

Most processing methods were introduced into the Pacific islands by the Chinese who, in many islands, still run bêche-de-mer processing and trade.

The conventional method has not changed much over the years and many descriptions of it have been given : Saville-Kent (1893), Sella and Sella (1940), SPC (1979) and in booklets issued by fisheries departments in various countries.

6.2.1 General procedure

The processing stages are as follows, for all species except sandfish *H. scabra* and *H. scabra* var. *versicolor*.

- <u>First boiling</u> (Figure 44A)
  This is done in boiling sea water, using large cast-iron pots or 200 litre drums, cut lengthwise. The holothurians are first cleaned and sorted by species and by size, then immersed in the boiling water, either directly or in wire-mesh baskets which make it easier to take them out when they are ready. They must be kept boiling for several minutes, and stirred continuously with a long flat utensil. Cooking time depends on the species and the size of the animals, which tend to swell up.

- <u>Slitting</u> (Figure 44B)
  After they have been taken out and cooled off in sea water, the bodies are placed on a board belly-side down and cut down the middle of the back with a sharp knife. The cut must be clean and leave intact the last 3 cm to the mouth and the anus.

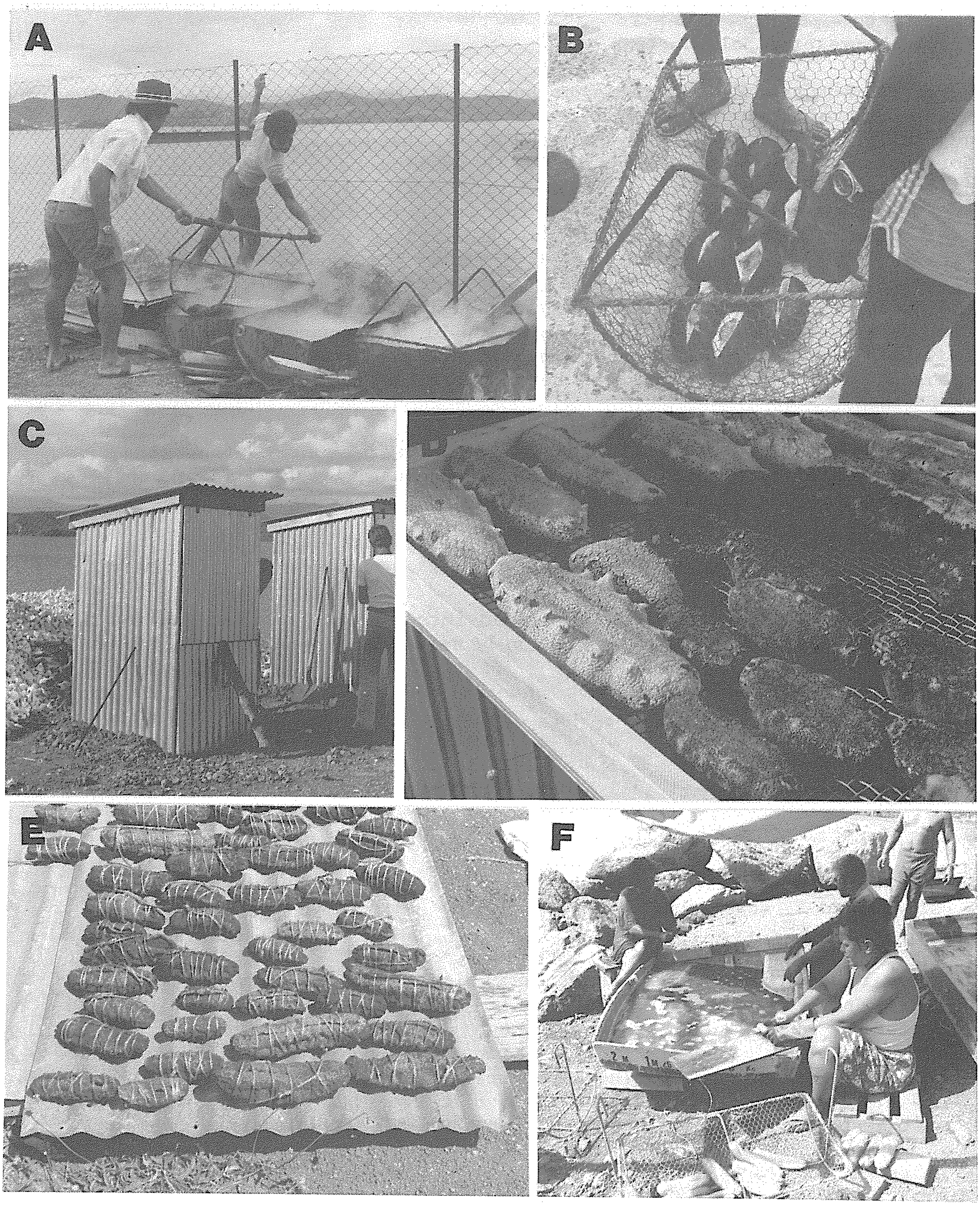


Figure 44: Processing sea cucumber. A: first boiling - B: mid-dorsal incision on *H. nobilis* - C: smokehouse - D: smoking trays containing teatfish - E: sun-drying - F: processing *H. scabra* var. *versicolor*; cleaning before second boiling (photos Conand)

- Second boiling
  During the second boiling the body hardens slightly, taking on a rubbery consistency. After boiling for a few minutes, the animals are removed and put into sea water to cool off.

- Gutting
  Depending on the method, gutting can be done either before or after the second boiling. All the internal organs must be removed and the body cavity is carefuly rinsed to remove any debris or sand. Only the longitudinal muscles remain.

- Smoke drying (Figures 44C and D)
  A bêche-de-mer dryer is similar to a copra dryer. A small but steady fire is maintained under the smoking trays. Mangrove leaves may be put on the fire to make more smoke. For teatfish, a small stick is sometimes inserted across the cut to keep the sides apart. The bêche-de-mer are arranged on the trays with the cut turned towards the heat source. The tray positions must be permutated regularly every few hours. The smoke-drying process may take several days. The sticks must be removed and the sides pressed together to close the cut; sometimes the whole body is tied closed with string to restore its uniform cylindrical shape.

- Sun drying (Figure 44E)
  The bêche-de-mer are brushed to remove any ash, then put out in the sun and wind for a few days to dry out completely. The finished product must be as hard as wood. Should the bêche-de-mer become damp, the smoking and drying process has to be repeated. Once dry, the bêche-de-mer are sorted by species and size and stored in a dry, well-ventilated place until shipment. Depending on the market for which they are intended, there may be slight variations in procedure: e.g. length and position of the cut or omission of the second boiling or the smoking process. The procedure described is very suitable for teatfish and is used in Fiji and in many other countries of the region.

6.2.2 Processing of sandfish *H. scabra* and *H. scabra* var. *versicolor*

Processing of sandfish is slightly different because of the calcareous spicules contained in the body wall. The procedure described here was developed by Adithiya (1969) from the method traditionally used in India (Hornell, 1917).

- Gutting
  Evisceration occurs spontaneously in this species (cf. Chapter 4.2.1) and the animals have usually already ejected their guts by the time they are landed. Evisceration can be hastened by pressing firmly on the body wall or by making little slits at the front and rear ends of the body or a small cut along the middle of the underside.

- First boiling
  As for the other species, boiling time varies, according to country, from a few minutes, which seems sufficient, to over an hour. They are then cooled off.

- Burying
  The sandfish are buried for about 18 hours in a pit of moist sand; this aids decomposition of the outer tegument, which contains many spicules.

- Cleaning (Figure 44F)
  After being dug up and rinsed, the sandfish are cleaned either by brushing or by being trampled on in coconut baskets, or by means of a machine, the "descummer" (Sachithananthan, 1972).

- Second boiling
  After being rinsed once more, the sandfish are thrown into boiling sea water a second time and cooked for about three-quarters of an hour.

- Smoke drying
  This is sometimes done before sun drying, but is often omitted because not all markets appreciate the smoky taste.

- Sun drying
  This is done on wire-mesh trays to allow good air circulation.

Processing must be carried out with the utmost care at every stage, so as to yield a product of consistently good quality. The defects that most commonly lead to down-grading of the product are an incorrect cut, body wall injuries, inadequate cleaning and cooking time unsuited to the size of the animal. If insufficient time was allowed for drying, or if the product absorbed moisture at a later stage, smoking and drying can always be repeated.

Sea cucumber collection and processing require very little equipment but a great deal of manpower. It is therefore rarely undertaken by individuals. Fishermen will find it profitable to pool their efforts either on a community basis or within a village cooperative. In New Caledonia, for example, holothurian fishermen sell their catch to traders who take care of processing and export. In the Solomon Islands, a Chinese-owned company was protected between 1966 and 1971. Established in Honiara and supplied with live holothurians by village fishermen, it encountered serious storage and transport problems. When the company lost its monopoly, bêche-de-mer production was gradually taken over at the village level, with the assistance of fisheries department officers.

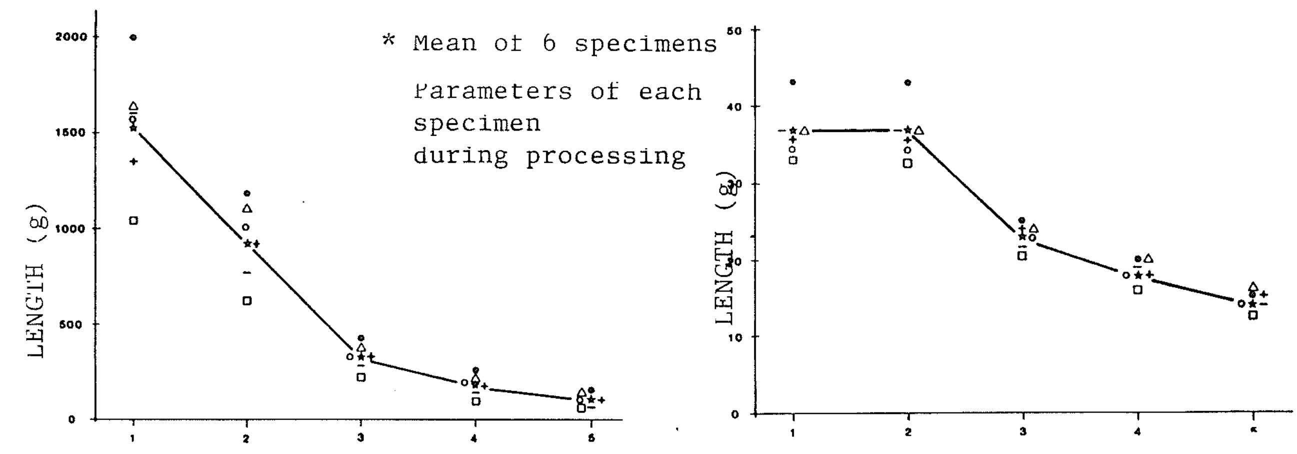
6.2.3 Changes in size and weight during processing of the major species

Processing considerably reduces holothurian length and weight. It is important to know these parameters, since sampling of the processed product is one possible technique for monitoring bêche-de-mer operations and achieving rational management of the resource. Shrinking is mainly due to dehydration during smoking and drying. Loss of weight results from removal of guts as well as dehydration. These two parameters are related to the size of the specimens, the shape of the species and the thickness of the body wall.

Table 30 sums up the results obtained for the major species of commercial value during processing trials, and Figure 45 shows results for the species *H. scabra* var. *versicolor*.

Table 30: Changes in weight and length parameters of the various species during processing.
1: initial condition - 2: after boiling - 3: smoking
4: dried product - $\bar{m}$: mean value of parameter
Percentages are expressed as a proportion of the parameter applicable to the species in its initial condition.

Species / Author		LENGTH (cm) 1	2	3	4	WEIGHT (g) 1	2	3	4
Microthele fuscogilva	m	52	33	24	23	4220	1230	340	320
Conand (1979) (n = 13)	%	100	63	46	44	100	29	8	8
Microthele nobilis	m	37	20	19	19	1730	223	170	150
Conand (1979) (n = 70)	%	100	54	51	51	100	13	10	9
Crean (1977) (n = 5)	m					1276	404	176	87
	%	100	66	59	52	100	31	14	7
Parrish (1978)(n = 8)	m					1520			632
	%					100			41
Harriot (1985) (n = 18)	m					1900			163
	%					100			9
Thelenota ananas	m	58	24	22	22	4000	290	186	184
Conand (1979) (n = 13)	%	100	41	38	38	100	7	5	5
Parrish (1978) (n = 48)	m					2850			238
	%					100			8
Harriot (1985) (n = 17)	m					4300			128
	%					100			3
Actinopyga echinites	m	19			9	330			37
Conand (1979) (n = 40)	%	100			47	100			11
Shelley (1981) (n = 100)	m					470	111	74	75
	%					100	24	16	3
Actinopyga miliaris	m					2500			76
Harriot (1985) (N = 8)	%					100			3
Holothuria scabra	m					366	312	185	20
Shelley (1985) (n = 42)	%					100	85	51	5
H. scabra var. *versicolor*	m	37	23	18	14	1530	325	182	98
Conand (unpubl.) (n = 6)	%	100	62	49	38	100	21	12	6



1. Initial condition
2. Evisceration
3. Boiling
4. Smoking
5. Drying

Figure 45: Changes in length and weight parameters during processing of *H. scabra* var. *versicolor*.

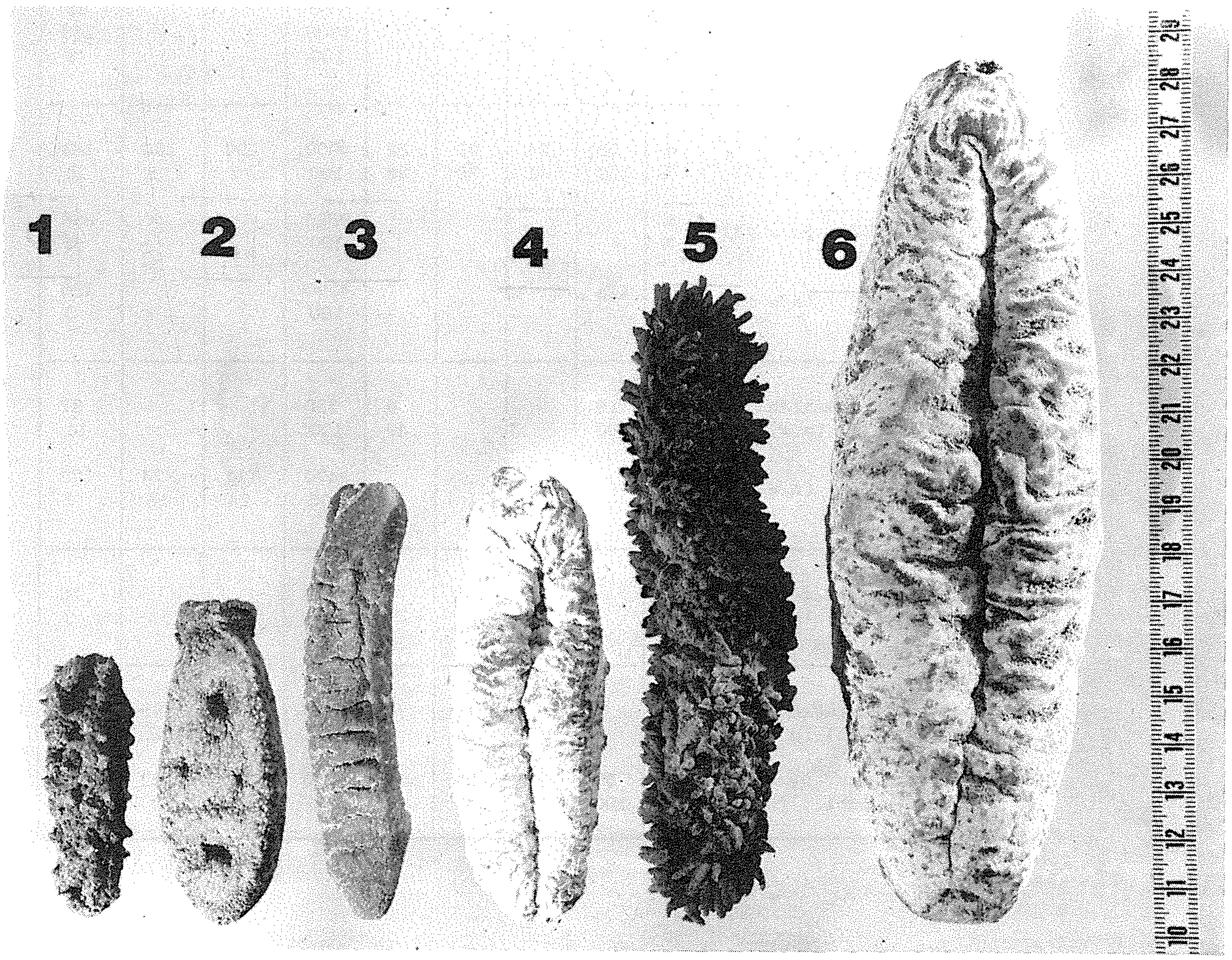


Figure 46: Bêche-de-mer samples from the Hong Kong and Singapore markets. 1: *Stichopus japonicus*; 2: *Actinopyga echinites*, redfish; 3: *Holothuria scabra*, sandfish; 4: *H. nobilis*, cat.4, teatfish; 5: *Thelenota ananas*, prickly redfish; 6: *H. nobilis*, cat. 2 (Photos Conand).

The final result depends on the moisture content of the processed product, which accounts for the slight differences in the figures given by the various authors. The length of a processed bêche-de-mer is about half that of the live animal. Its weight after processing varies between 3 and 10 per cent of the fresh weight depending on the species. Parrish gives different figures, but they were obtained after only 48 hours of drying.

6.3 Product Grading

6.3.1 Quality rating

A number of criteria are used to grade processed bêche-de-mer into various commercial categories. Three major grades were defined in Chapter 4.1: high value, medium value and low value species. However, no standard species grading procedure exists (Van Eys, 1986) and the value assigned to a species can vary with the market considered and even sometimes, on the same market, from importer to importer.

If production involves several species, the products are first sorted by species.

Figure 46 shows samples of the species sold on the Hong Kong and Singapore markets. Only the first specimen, a processed *Stichopus japonicus,* is not from the tropical Indo-Pacific area.

The second grading criterion is size. Some markets grade by length, others by weight. Depending on the species, there may be from 2 to up to 7 size grades often defined as extra-large (XL), large (L), medium (M), small (S) and extra-small (XS). Each grade corresponds to a length or weight interval, and is expressed as number of animals per kilogram.

Other grading criteria are appearance, odour, colour and moisture content. Indeed, the product's general appearance also affects the grade and depends on the care that was taken in the various stages of processing. Bêche-de-mer that have been carelessly gutted, still contain sand, are over-cooked, not properly cut or not smoked and dried for long enough, or that have been stored in a damp place, are down-graded.

This variability in the grades can be illustrated by the following examples. In its early stages, bêche-de-mer production in New Caledonia (cf. Chapter 3, Table 7), involving mainly sandfish *H. scabra* and *H. scabra* var. *versicolor,* was monitored in two trading companies. The processed animals for export, to both Hong Kong and Singapore, were graded into six categories according to number of specimens per unit weight. The corresponding weight and length classes were calculated (Table 31). The data published regularly by INFOFISH (1985) generally concern the Singapore market for species from various origins. The commercial grades for the species *H. scabra,* as well as average prices per kilo in November 1985, are shown in Table 31.

The teatfish *H. nobilis* and *H. fuscogilva* are graded as "black stone" and "white stone" in Hong-Kong (Sachithananthan, 1972) depending on whether they are black or white. Grading according to length, in inches, is usually as shown in Table 32.

Despite the lower prices paid in recent years, demand for these species, generally from the Pacific islands, remains high.

6.3.2 Weight-length relationships in bêche-de-mer

In producing countries, statistics generally refer to exports of processed bêche-de-mer. Sea cucumber harvest data are in fact very difficult to obtain because the activity is often organised in a rudimentary way and its intensity varies greatly in both space and time. It thus seems easier to sample bêche-de-mer after processing. Because of the great variability of the grading criteria applied on the markets, it is necessary to know the weight-length relationships for the processed product from the different species concerned, in order to be able to make comparisons. These ratios were worked out for the species most commonly gathered at the present time (Figure 47) and enabled us to find the lengths corresponding to the weights of the various commercial grades (Table 31). They will be useful for deducing the approximate length (or weight) distributions of freshly-gathered holothurians, from samples ready for export, by applying available knowledge on how the parameters change in the course of processing (cf. Chapter 6.2.3).

7. BECHE DE MER MARKETS[4]

7.1 General

The bêche-de-mer market is largely controlled by Chinese traders and has been ever since man first developed a taste for sea cucumber in the distant past. The world market is a complex affair; some producing countries are solely exporters whereas in others a resident ethnic Chinese minority consumes part of the harvest. Other countries are basically importers, whether or not holothurians are exploited there. It should also be noted that the same bêche-de-mer may crop up in several markets one after the other, which complicates any analysis of the statistics. An examination of export statistics from producing countries shows that bêche-de-mer may be sent to one or more of the three main markets of Hong Kong, Singapore and Taiwan. Recent trade statistics from these three centres may be used to analyse the present state of the world market and its trends.

As far back as 1917, Hornell based his survey of Indian holothurian fisheries on the Singapore and Penang statistics, providing data on the period from 1907 to 1916. To this information were added statistics from British Malaya, Hong Kong and China by Sella and Sella (1940) for the 1931 to 1933 period. These authors observed the confusion caused by re-exports from one market to another. More recently, Sachithanantan (1972) has analysed Singapore's statistics from 1962 to 1970 and Hong Kong's 1970 statistics. Lastly, some data appeared in an article in 'Australian Fisheries' (1979) for 1978.

This historical data has been supplemented by recent statistics from the Hong Kong, Singapore and Taiwan markets.[5] They include both import statistics by country of origin, in terms of tonnage and value and re-export statistics broken down by country of destination, also in tonnage and value. As these are not producing countries, their exports are negligible. Despite the inaccuracy these figures may sometimes suffer from, they are at present the best available indicators for attempting to assess the world harvest and monitor its development trends.

7.2 Hong Kong market

7.2.1 History

Hong Kong is today the largest bêche-de-mer market in the world. The way it has developed (Figure 48) can be followed from 1931-33 onwards, for which period Sella and Sella (1940) recorded the average annual import tonnage, approximately 1,315 tonnes, originating in some ten countries, the main ones being Australia, first, followed by the Dutch East Indies and a number of British Empire countries. A small percentage, 10 per cent,

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4. This chapter was prepared with the assistance of Mr Van Eys, an international trade analyst with INFOFISH.

5. Sincere thanks are expressed to the people and organisations supplying these statistics.

<u>Table 31</u>: Examples of commercial grading of *Scabra*.
n: number of specimens per kg-w: relevant weight classification - l: length classification; price indications per kg from Infofish 15/11/85, in USD (Us dollars), SGD (Singapore dollars), INR (Indian rupees).

PLACE SOURCE ORIGIN		NEW CALEDONIA Exporters NEW CALEDONIA			SRI LANKA				SINGAPORE Infofish		
	Grade	n	P(g)	L(cm)	n	w	USD	SGD	L(cm)	INR	USD
Category	A = XL	7-11	140-90	> 13							
	B = L	12-15	85-65	13 - 11.5							
	C = L	16-20	60-50	11.5-10.5	16	62	15.15	32			
	D = S	21-30	45-30	10 - 9	20	50	13.30	28	> 10	141	11.90
	E = ES	31-40	25-20	9 - 7.5	35	28	11.85	25	9.5-7	113	9.50
	F = off	> 40	< 20	< 7	50	20	10.40	22			
					80	12	8.55	18			
					120	8	6.15	13			
					160	6	3.80	8			

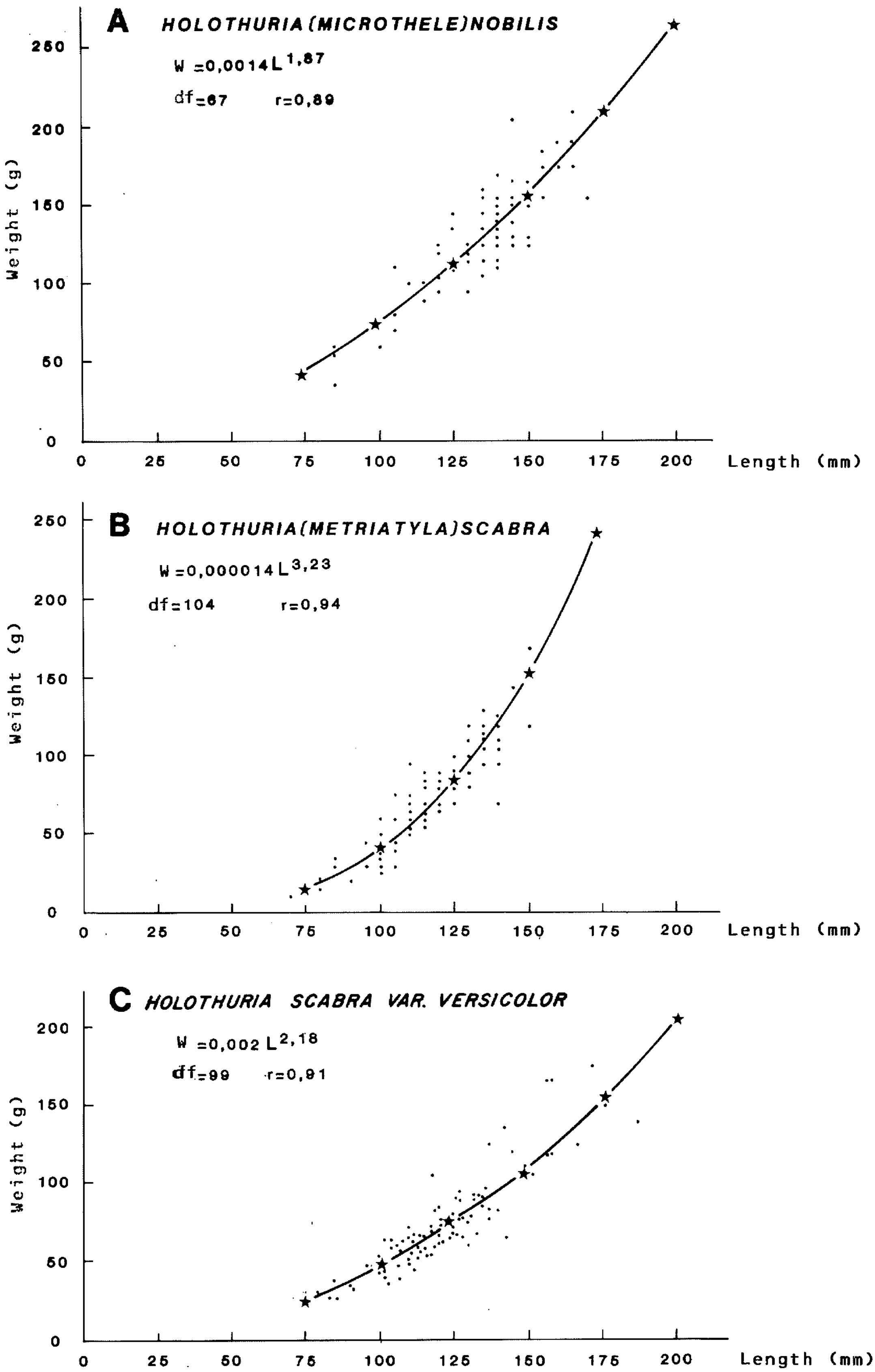


Figure 47: Length-weight relationships of bêche-de-mer processed in New Caledonia. A: *H. nobilis* B: *H. scabra*; C: *H. scabra* var. *versicolor*

Table 32: Commercial grades of teatfish in Singapore (Source: Van Eys, 1986).

GRADE	MEAN LENGTH (inches)	(cm)	MEAN WEIGHT (g)
1	9	22	250
2	7	18	180
3	5	13	100
4	4	10	70
5	3	8	50

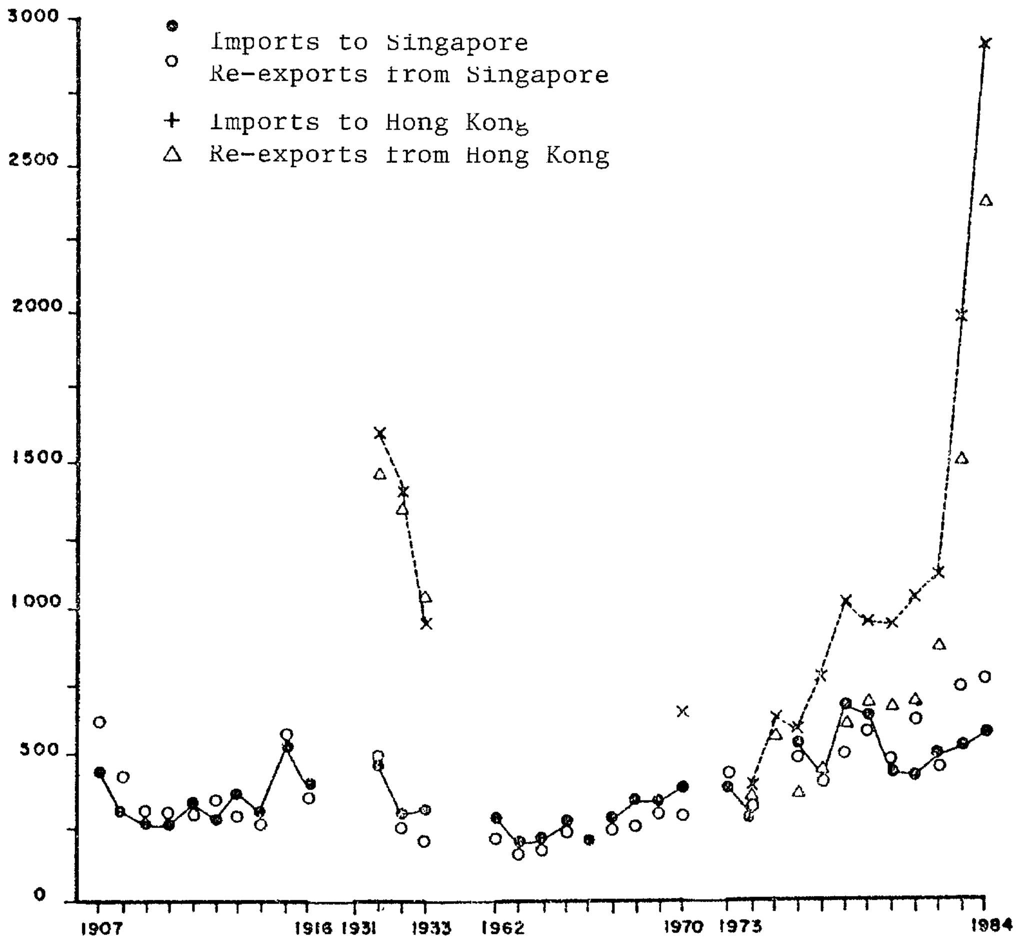


Figure 48: Fluctuations in the Hong Kong and Singapore bêche-de-mer market tonnages.

was accounted for by re-exports from British Malaya (Singapore). During this period, annual imports fell away slightly. Most re-exports, approximately 1,260 tonnes, went to China.

For 1970, only export statistics were reported by Sachithananthan (1972), by which time they were much lower, amounting to only 650 tonnes from various sources. The percentages for the various countries were 43 per cent from Mozambique, 14 per cent from Singapore and 11 per cent from Indonesia. Their total value, US$656,000, gives an average value of US$1/kg. These figures varied from country to country; small tonnages from Korea and the USSR, relating therefore to species *S. japonicus*, had a significant influence on the overall value, whereas commodities from the Philippines and East Africa were priced very low.

7.2.2 Recent developments

The available statistics for the last decade were analysed and the main results are recorded in Tables 33 and 34 for exports and re-exports respectively. These relate to tonnages, values in Hong Kong dollars and average value per kilogram, as well as the number of countries of origin or destination with tonnages over 1 tonne, to illustrate the diversity of trading patterns, and over 50 tonnes to highlight the most important countries. For these countries and the grouped countries of the tropical Pacific, the statistics are quoted year by year and expressed in terms of percentages of the annual tonnage and value; the average value per kilogram is also shown.

Historical trends in imports (Table 33) show very clearly that the tonnages, which were very low in 1974 with 405 tonnes, then increased greatly, for the first time in 1978 when they rose to approximately one thousand tonnes. They remained at this level until 1982, when a further very marked increase occurred, tripling tonnages which reached 2,900 tonnes in 1984. This vigorous growth appeared to be continuing in 1985 with more than 3,400 tonnes imported during the first ten months of the year. Values have however apparently not followed the same pattern; the value per kilogram reached its highest level in 1982, at more than HK$25, but has fallen back over the last two years under the influence of the economic recession. During this period, imports continued to come from diverse origins, some 20 countries altogether, but their respective importance changed. In 1983-84, the Philippines were top of the list, followed closely by Indonesia. These two countries together accounted for over 80 per cent of import tonnages, while tonnages from Singapore diminished. From the value point of view, the Philippines and Indonesia accounted for less than half the total, and the contribution of the Pacific islands was significant because their product is quite a high quality one. The volume of imports increases in December and January, as demand rises with preparations for Chinese New Year celebrations.

Less information is available on re-exports (Table 34). According to the overall annual statistics, these followed import trends, rising to 2,404 tonnes in 1984, worth more than HK$42 million. The average price was slightly higher for re-exports; reaching a maximum of HK$28.7/kg in 1980, it dropped to around HK$18/kg in 1984.

Table 33: Bêche-de-mer imported to Hong Kong. 1974 to 1984

YEAR	TONNAGE T (t)	VALUE v(HKD) 10^{-3}	VALUE/KG v(HKD)	NUMBER OF COUNTRIES		MAIN COUNTRIES OF ORIGIN												
						Philippines			Indonesia			Pacific Islands			Other			
				> 1t	> 50 t	%T	%v	$\bar{v}$	%T	%v	$\bar{v}$	%T	%v	$\bar{v}$		%T	%v	$\bar{v}$
1974	405	4 229	10,4															
1975	637	7 352	11,5	18	4	10	6	6,9	21	18	5,0	1	2	17,3	Mozambique	15	10	7,98
1976	570	7 915	13,8	18	5	15	6		19	20		4	7	27,1	Kenya	11	11	
1977	770	10 269	13,3	22	5	21	9	5,5	21	19	19,7	8	14	24,0	North Korea	8	15	
1978	1 027	11 684	11,3	21	3	27	14	6,0	23	28	13,7	8	9	10,9				
1979	971	15 380	15,8	16	5	31	19	9,9	23	18	11,8	2	3	19,7	Madagascar	21	17	13,0
1980	962	20 683	21,5															
1981	1 055	24 868	22,1			37	23	14,7	28	17	14,4	4	7	44,8	Singapore	5	7	31,3
1982	1 124	28 464	25,3			25	14	13,8	35	19	13,5	5	6	30,2	Singapore	5	6	31,1
1983	1 998	43 180	21,6	18	3	43	24	12,5	30	25	14,0	3	4	33,6	Singapore	2	4	36,8
1984	2 905	50 557	17,4	23	4	47	21	7,8	36	26	12,2	5	14	50,2	Singapore	3	9	60,5

Table 34: Bêche-de-mer re-exported from Hong Kong. 1974 to 1984

YEAR	TONNAGE T(t)	VALUE v(HKD 10-3)	VALUE/KG v(HKD)	NUMBER OF COUNTRIES		MAIN COUNTRIES OF DESTINATION											
				>1 t	>50t	China			Republic of Korea			Taiwan			Singapore		
						% T	% $\bar{v}$	$\bar{v}$	% T	% $\bar{v}$	$\bar{v}$	% T	% $\bar{v}$	$\bar{v}$	% T	% $\bar{v}$	$\bar{v}$
1974	305	3 500	11,8														
1975	468	7 743	16,5														
1976	372	7 005	18,8														
1977	444	9 590	21,5														
1978	621	12 205	19,6														
1979	693	16 911	24,4														
1980	680	19 546	28,7														
1981	693	19 179	27,6	7	4	8	4	12,2	24	9	10,8	28	32	31,0	26	33	35,4
1982	873	24 119	27,6	8	4	23	12	14,4	19	9	13,6	33	40	32,9	14	20	30,9
1983	1 517	31 817	21,0	12	5	61	32	10,6	9	24	16,4	16	7	30,2	8	22	52,6
1984	2 404	42 678	17,8	11	5	68	35	9,0	16	15	16,2	8	14	33,6	5	19	73,6

The role of re-exportation is not solely restricted to commodity shipment. A grading process is often carried out, giving some added value to the products.

Re-export recipients in 1983-84 included a dozen countries, especially China, Taiwan, the Republic of Korea and Singapore. China took over 60 per cent of these tonnages and Singapore ranked fourth, whereas in value terms it lies second after China.

Recent growth in the Hong Kong market has occurred to a background of increased re-exports to China since 1981. For the early months of 1985, these represented 86 per cent of total re-exports. This market consumes a rather low quality product, which could particularly concern the species *Thelenota ananas*.

The difference between imports and re-exports should largely be accounted for by local consumption, which therefore amounts to around 500 tonnes. The fluctuations in monthly tonnages show that re-exports fairly accurately reflect imports, implying a swift turnover.

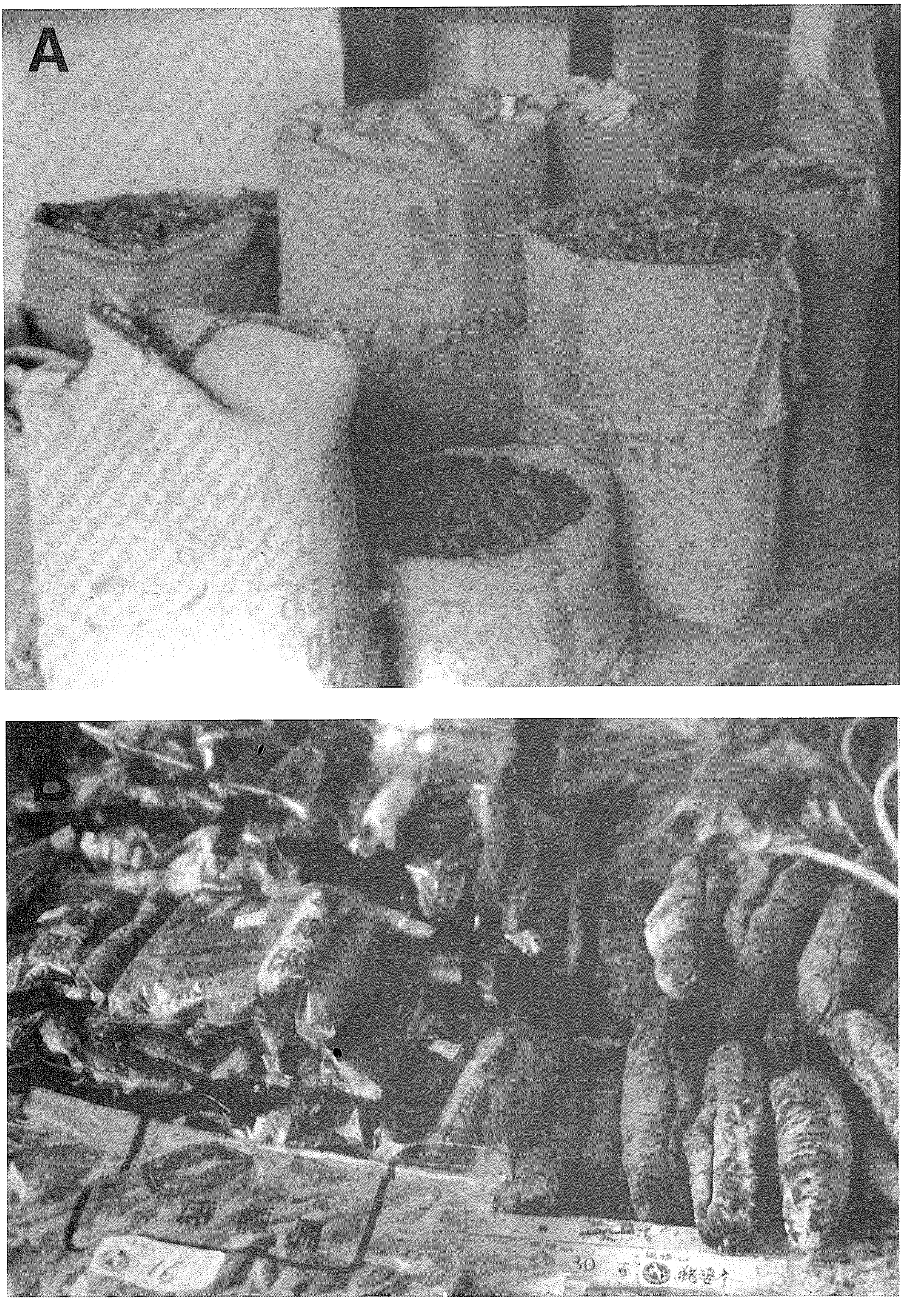
7.3 Singapore market

The Singapore market is the second biggest in the world for imports and re-exports, but the local retail market is also important. Shops also selling shark fins, birds' nests, air bladders, etc., jostle each other in some Singapore streets, offering bulk or packaged bêche-de-mer (Figure 49). The retailers purchase batches of bêche-de-mer from the importers at auction, with importers reserving the right not to sell if the bidding is too low.

7.3.1 History

The development of the market may be traced back to the beginning of the century (Figure 48). For the period from 1907 to 1916 (Hornell, 1917), annual imports fluctuated around an average of 360 tonnes, mainly from the Dutch East Indies, British possessions and the Philippines. Exports were consigned, in almost equal halves, to China and Hong Kong. 1907 and 1915 recorded tonnages well over the average. From 1931 to 1933, tonnages declined slightly and re-exports went primarily to China (55%) and Hong Kong (33%).

The 1962 to 1970 period was reviewed by Sachithananthan (1972). There was little in the way of imports, less than 400 tonnes; these came from many countries, those of the Indian ocean in particular, but also from Indonesia and territories of the tropical Pacific. Most re-exports went to Malaysia (80%).



<u>Figure 49</u>: Singapore market. A: sacks of bêche-de-mer at a wholesalers; B: teatfish and sandfish at a retailer's (Photos Conand).

7.3.2 Recent developments

Recent statistics, from 1973 to 1984, are shown in tables 35 for imports and 36 for re-exports respectively. A degree of inaccuracy in the import statistics, which sometimes paradoxically appear to be lower than re-exports, may be due to the fact that bêche-de-mer does not attract customs import duty; it is sometimes classified under the heading 'dry seafood'.

Imports were generally following an upward movement during this period despite the slump which followed the particularly busy years of 1978 and 1979. This increase was however much less marked than in Hong Kong, where the average value per kilogram quadrupled and the total annual value multiplied by a factor of five. These imports continued to be of various origins, since in 1983 and 1984, six countries sent tonnages over 50 tonnes to Singapore. Despite variations in countries' relative importance, the Philippines were usually in the top position and countries of the Indian ocean, Sri Lanka and India in particular, provided a substantial proportion of the tonnages imported. The ranking order of the African countries, Kenya, Mozambique and Tanzania, and of Sabah, were highly variable. The countries of the South Pacific exported products of high commercial value. Their market share increased substantially in 1984 with the resumption of bêche-de-mer production in New Caledonia. Philippines' trepang has always attracted a lower price than its Sri Lankan or Indian equivalent.

The volume and value of re-exports (Table 35) have evolved similarly to imports. Three-quarters of the tonnages concerned are, however, destined for one country: Malaysia. Taiwan and Hong Kong are important because their demand is for a high quality product. Small quantities are also sent to Sarawak, the Republic of Korea and Thailand.

Trade between Hong Kong and Singapore consists therefore of an exchange of products by twinned companies for speculative purposes.

7.4 Conclusions

It therefore emerges from the trade statistics that Hong Kong is currently the principal bêche-de-mer market and is showing an upward trend in imported tonnages. These amounted to approximately 3,000 tonnes in 1984 and to 3,500 tonnes for the first ten months of 1985, chiefly from the Philippines and Indonesia. Re-exports were mainly headed for the People's Republic of China and the Republic of Korea.

The Singapore market is not growing so quickly. Its imports, almost 600 tonnes in 1984, originated in various Indian ocean countries but also in the Philippines. Malaysia was the main destination for its re-exports.

A considerable proportion of bêche-de-mer production transits successively through a number of markets, making any evaluation of production a complicated task.

The other main importing countries are therefore the People's Republic of China, peninsular Malaysia and Taiwan.

Table 35: Bêche-de-mer imported to Singapore, 1973 to 1984.

YEAR	TONNAGE T(t)	VALUE v(SD. 10^{-3})	VALUE/KG v(SD)	NUMBER OF COUNTRIES		MAIN COUNTRIES OF ORIGIN												
						Sri Lanka			India			Other				Pacific Islands		
				>1 t	>50 t	% T	% $\bar{v}$	$\bar{v}$	% T	% $\bar{v}$	$\bar{v}$		%T	% $\bar{v}$	$\bar{v}$	% T	% $\bar{v}$	$\bar{v}$
1973	397	1 324	3,3	15	3	32	54	5,6	16	16	3,4	Sabah	25	5	0,7	3	7	6,6
1974	319	1 595	5,0	11	2	50	66	6,6	28	21	3,7					1	1	4,6
1976	556	2 497	4,5	12	3	20	43	9,9	15	28	8,5	Sabah	47	14	1,3			
1977	428	2 956	6,9	13	4	22	33	10,3	18	25	9,5	Sabah	28	6	1,4	1	3	13,0
1978	670	3 797	5,7	13	3	25	34	7,8	5	9	9,8	Philippines	25	28	6,3	2	3	8,3
1979	639	4 985	7,8	11	4	29	40	10,9	10	17	13,4	Philippines	19	20	8,1			
1980	467	4 896	10,5	10	4	21	35	17,7	13	18	13,8	Philippines	15	17	12,4	2	4	20,0
1981	446	5 655	12,7	13	4	18	32	22,6	20	24	15,8	Philippines	22	20	11,6	3	3	11,2
1982	506	6 239	12,3	15	5	13	26	23,9	19	19	12,6	Philippines	15	14	11,6	1	1	11,8
1983	533	7 129	13,3	15	6	10	20	27,0	18	22	16,4	Philippines	18	15	11,1	2	2	12,0
1984	500	7 055	12,0	15	6	6	13	24,7	10	13	15,8	Philippines	24	15	7,2	13	17	15,1

Table 36: Bêche-de-mer re-exported from Singapore, 1973 to 1984

YEAR	TONNAGE T (t)	VALUE v(SD. 10^{-3})	VALUE/KG v(SD)	NUMBER OF COUNTRIES		MAIN COUNTRIES OF DESTINATION												
						Malaysia			Taiwan			Hong Kong			Other			
				> 1 t	> 50 t	% T	% $\bar{v}$	$\bar{v}$	% T	% $\bar{v}$	$\bar{v}$	% T	% $\bar{v}$	$\bar{v}$		% T	% $\bar{v}$	$\bar{v}$
1973	437	603	1,4	6	1	80	47	0,8	3	2	1,2	3	7	4,1	Thailand	8	22	4,1
1974	324	658	2,0	6	2	69	35	1,0	15	22	2,9	6	21	7,5	Sarawak	6	12	4,4
1976	501	908	1,8	6	2	78	38	0,9	12	17	2,6	5	23	8,6	Sarawak	3	15	8,4
1977	465	1 121	2,4	6	2	62	29	1,1	25	32	3,0	5	8	3,8	Sarawak	4	15	9,9
1978	515	1 672	3,2	7	2	65	30	1,5	25	41	5,4	1	2	4,7	Sarawak	4	14	11,7
1979	608	3 272	5,4	6	4	52	17	1,7	23	37	8,5	10	29	14,8	Rep. of Korea	10	9	4,9
1980	489	2 185	4,5	5	1	69	28	1,8	10	28	13,7	4	16	15,5	Rep. of Korea	13	14	4,9
1981	630	4 032	6,4	5	2	68	37	3,5	21	42	13,1	7	11	11,1	Sarawak	3	7	15,3
1982	485	3 727	7,7	5	2	64	40	4,8	20	35	13,6	10	15	11,6	Sarawak	3	7	15,0
1983	758	3 488	4,6	7	3	68	50	3,3	15	23	7,3	7	9	6,2	Sarawak	2	9	17,8
1984	779	4 040	5,2	8	3	75	47	3,3	8	16	10,0	10	24	12,2	Sarawak	2	6	15,4

Malaysia's imports are on the increase. Those of Taiwan come from a dozen countries, led by Indonesia, and are falling, perhaps because of the stiff customs duty applicable (Table 37).

The countries and territories of the South Pacific export small tonnages to Hong Kong and Singapore. Their share in either of these markets is usually less than 10 per cent of the annual tonnages concerned, except for Singapore in 1984. Because of the fairly high price which their high quality product attracts, however, their contribution to the total values of imports was 14% in Hong Kong and 17% in Singapore in 1984. It is certainly possible for these products to take a bigger stake in the market, provided that they can supply a consistently high quality product on a regular basis.

A list of importers is given in Appendix III. Advertisements placed by traders seeking bêche-de-mer also appear in the SPC Fisheries Newsletter and in INFOFISH Trade News.

Table 37: Bêche-de-mer imported to Malaysia and Taiwan

YEAR	1978	1979	1980	1981	1982	1983
MALAYSIA	472	317	376	509	752	1083
TAIWAN	722	597			463	421

8. RATIONAL STOCK MANAGEMENT

8.1 Introduction

The intensified exploitation of fishery resources has created a need for their rational management, even where small-scale activities are concerned.

In countries such as Japan and China, where the bêche-de-mer industry started long ago, management is exercised by the cooperatives on the basis of regulated fishing seasons and grounds, and bans on fishing specimens below a certain size.

In the countries of the tropical Pacific, holothurian fishing did not start until the eighteenth century and activity fluctuated greatly (cf. Chapter 3). Very little official control was exercised over this sector. Referring to the nineteenth century, however, scientists Saville-Kent (1903) and Koningsberger (1904) raised the problem of overfishing, but thought that legislation was unnecessary or would be too difficult to enforce, reasoning that the species gathered occurred in very varied sizes and that the fishing grounds were recolonised by individuals migrating upwards from deeper waters. It should be borne in mind that only easily accessible animals in shallow water are harvested and that in coral environments many individuals remain hidden. Also, weather conditions often restrict the fishing seasons. Clark (1921), on the other hand, recommended government involvement to set up a research body for these fisheries.

In the more recent past, the fisheries divisions of the international organisations, FAO and SPC, as well as the countries and territories of the South Pacific and their research laboratories have turned their attention to the management of this resource (Sachithananthan, 1972; Conand, 1979; Gentle, 1979; Harriot, 1985; Shelley, 1985).

The management of a fishery generally consists of designing production models which combine the population dynamics of the species exploited, the fishing activity itself and the economic aspects at each stage, from harvest to consumption. In some cases, particularly in the countries of the tropical Pacific, social factors may also have an important part to play.

The mathematical models belong to either of two main groups (Laurec and Le Guen, 1981). The comprehensive models, whose approach is synoptic, describe how catches and yields fluctuate in relation to the fishing effort and determine maximum production. With fisheries that fluctuate so widely, however, it would appear difficult to assess effort and catch per unit effort consistently and accurately. The analytical models seek to identify and integrate the elementary factors affecting stocks: recruitment, growth, natural mortality and mortality due to fishing.

Knowledge presently available on holothurians is insufficient to develop models for their rational management. This chapter, which reports progress on research into populations and fisheries, outlines the main difficulties to be resolved to carry out sampling and appraises the prospects for management, concludes the present survey.

8.2 Sampling holothurian fisheries

In developed countries, fisheries administrations generally have available regularly-compiled statistics, although these may not always be totally accurate for small artisanal fisheries. In the tropical Pacific, however, such information is non-existent or almost so due to the small size of countries and the proliferation of small-scale activities. Statistics should be assembled both on the intensity of fishing activity and on its spatial distribution. For holothurian fisheries, these could also extend to processing and the final product.

8.2.1 Harvest statistics

What little information is available on catch and fishing effort values was given in Chapter 5. Most of these data come from one-off evaluations by scientists for the purpose of assessing resources.

With the kind cooperation of a trader who buys sea cucumber from fishermen for processing, a survey made it possible to monitor his first year of activities in New Caledonia. From small boats, divers also gathered reef fish, trochus, etc. Monthly fishing logs (Table 38) totalled daily catches per boat as well as the effort involved, in terms of the number of divers and their diving times. Information relating to the geographical location of the fishery and the circumstances of the dive, weather conditions in particular, which would have been useful, could not be gathered on a regular basis. The results are given in Table 39. A distinct increase in the fishing effort emerges, as witnessed by both an expansion in the flotilla and an increase in the number of days devoted to fishing. Since the survey established that each boat carried two or three divers, each of whom spent four to five hours diving, a boat's fishing effort was between 8 and 15 hours per day. CPUE was computed using an average value of 12 hours. The species fished changed after a number of months; *H. scabra* succeeded *H. scabra* var. *versicolor* because of prevailing market prices and the fact it was easier to gather. Whereas catch data for the latter related to eviscerated weights, they usually corresponded to total, fresh weights for the former. CPUE values, expressed in terms of fresh weight (cf. Figure 45) therefore varied from 83 to 230 kg per diver per hour for *H. scabra;* for *H. scabra* var. *versicolor* they were lower, ranging from 47 to 77 kg.

No such summary of statistics could be carried out with the other traders, possibly because of the competition which swiftly sprang up in this sector. It would however be desirable to start collecting these data on a regular basis. They would provide the required information to monitor developments in the region's fisheries.

8.2.2 Bêche-de-mer production statistics

Statistical information about the processed product is easier to come by. Sampling should apply to each of the different species, which are sometimes already graded. Length, or preferably weight distributions should be calculated. These may then be used, by applying the calculated (cf. Chapter 6) fresh/processed weight ratio, to obtain the weight frequency distribution for the specimens harvested. Some difficulty may arise in trying to determine sampling methods. The product is sampled in a warehouse where the bêche-de-mer is stored prior to packaging and shipping.

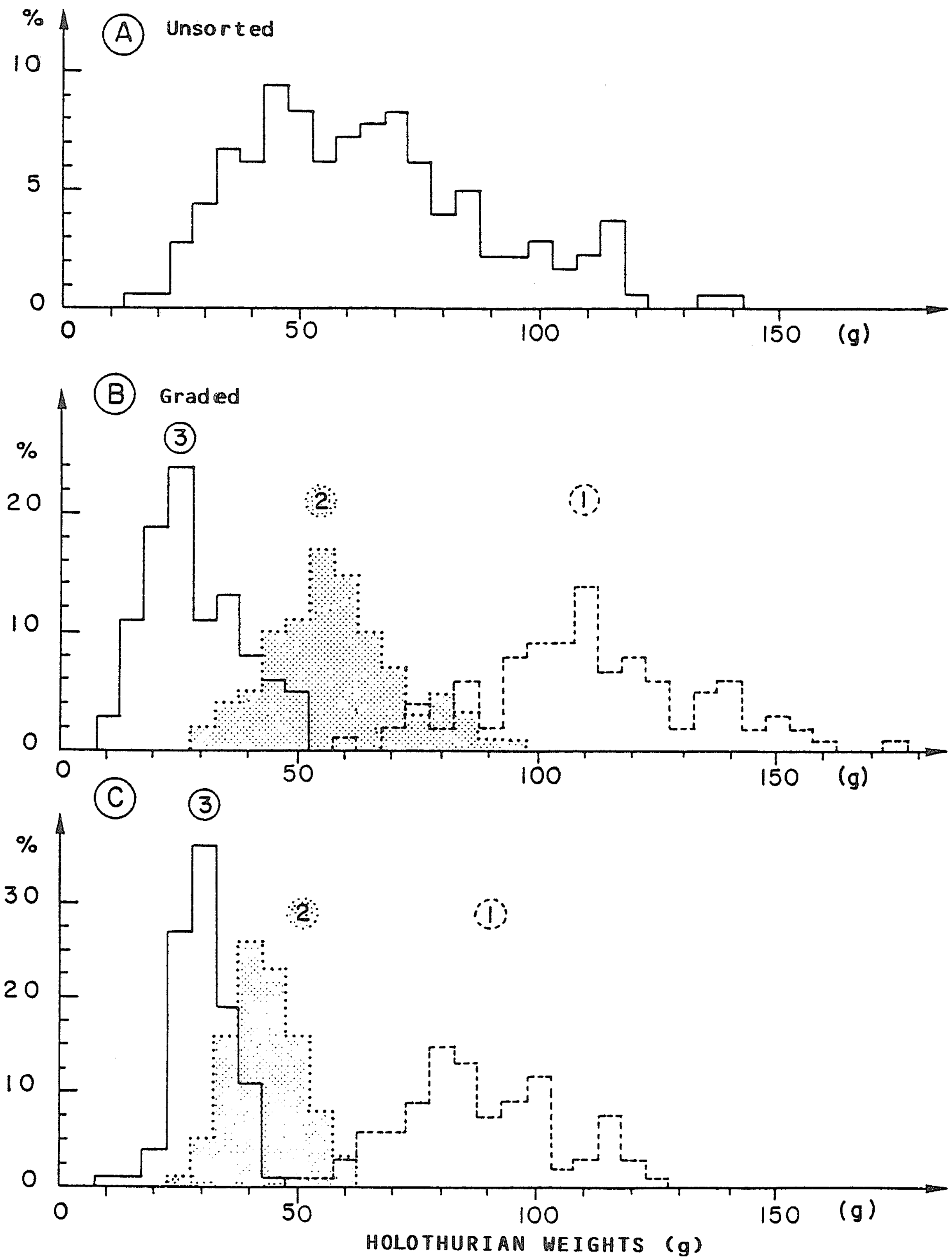


Figure 50: Sampling results of bêche-de-mer *Holothuria scabra* in New Caledonia.

As shipments are irregular, stocks build up between each one; consequently, it is not easy to determine the times at which sampling should be carried out. The time lag of several weeks which occurs during the drying period also needs to be taken into consideration, if these results are to be read together with those from the sampling of the harvest.

Measurements should ideally be taken just before shipment, but this requirement has proved practically impossible to meet and sampling was done on a monthly basis. During the early months of the activity, storage techniques also varied. Initial sorting into three grades, often carried out after drying, made it necessary to stratify the sampling process.

Figure 50 shows some examples of dry weight distributions for *H. scabra,* firstly without sorting, from which direct calculations can be made of the weights of holothurians fished (A) and also the size category (B and C). In these cases (B and C), 100 specimens of each category were weighed and had to be related to their relative proportion in order to obtain the distribution by weight group for that catch. It was shown that groups slightly overlap and that modes may vary slightly from one trip to another. There were also differences between exporters.

These difficulties demonstrate that close cooperation is needed between the operator, the fisheries administration and scientists if an attempt is to be made to standardise methods.

8.2.3 Bêche-de-mer export statistics

As the production of tropical Pacific bêche-de-mer is export oriented, trade statistics are another way of monitoring the activity. Country statistics are normally compiled from these figures as are the FAO's world statistics. Their advantage is to yield annual values, which can be used to follow long-term developments (cf. Chapter 3). Were they more detailed, they could be used to assess the demographic structure of the harvest. In New Caledonia, for example, monthly tonnages by species and by size group were recorded. Analysis of these statistics, for species *H. scabra* especially, showed that grades varied slightly from exporter to exporter, ranging from the six categories described in Chapter 6 (Table 40) to only three. Using the results of dry product sampling, it was possible to group the data into three categories: large (1) corresponding to categories A and B on the market, medium (2) or categories C and D, and smal' categories E and F. Table 40 presents total exports and exports per trader, in 1983 and 1984, for the various grades of *H. scabra*. The distribution pattern is very close to that obtained by sampling processed but unsorted products (Figure 50A). The second category, bêche-de-mer weighing from 30 to 65 g, accounts for over half of all exports. Making allowances for weight reduction during processing, this group includes individuals whose fresh weight must have been between 600 and 1,500 g. The care taken in processing and sorting into grades and the way such grades are defined are, however, so many factors contributing to the inaccuracy of these first estimates.

Simultaneous preparation of fishing, processing and trade statistics, using a standardised grading system, should nevertheless remove the barriers to establishing the demographic structure of the harvest.

8.3 Survey of commercial holothurian stocks

8.3.1 Assessment of abundance of stocks

Coral ecosystems, which predominate in shallow tropical waters, cover a total of approximately 600,000 km^2, of which around 13 per cent is located in the South Pacific (Smith, 1978). Many species are fished, most of which only account for a small percentage of the total catch. Most scientific research relates to fish and, up to the present time, very few surveys of commercial holothurian stocks have been carried out (cf. Chapter 5). Recent research conducted in Australia (Harriot, 1985) identified the main features of species distribution on the Great Barrier Reef. In New Caledonia, Conand and Chardy (1985) revealed three main species groupings, as determined by the lagoon biotopes. The densities and biomasses of commercially important species were also worked out. Stock assessment in relation to the surface area of the various biotopes has not however yet been possible for more than a few reefs, using remote-sensing data. This technique should make it possible to undertake thematic mapping of shallow coral areas to a sufficient degree of accuracy, with the assistance of appropriate sampling of holothurian species, to appraise the order of magnitude of resources. The results obtained in New Caledonia therefore relate to a continental-type high island of the western Pacific region, where the most highly diversified fauna is concentrated. A survey of holothurian stocks in atolls should therefore be carried out to give fuller scope to the results on the distribution and abundance of the main species in their principal coral habitats.

8.3.2 Study of population parameters

Available information about the biology of commercial holothurians has been given in detail for each species (cf. Chapter 4). Recent research in Australia, Papua New Guinea, Fiji and New Caledonia has led to an understanding of some parameters, but others have as yet barely been touched upon.

The main references to publications relating to holothurian population parameters in the tropical Pacific are given in Table 41.

Table 38 : Sample catch record card used in New Caledonia.

CONFIDENTIAL

HOLOTHURIAN CATCH RECORD CARD

ORSTOM BP A5 NOUMEA

DATA	NUMBER OF DIVERS	DIVING TIME	NAME OF BOAT	WEIGHT OF SPECIES (x if gutted)					OBSERVATIONS	
				TEATFISH	SANDFISH 1	SANDFISH 3	OTHER	TOTAL	PLACE	PREVAILING WEATER CONDITIONS

Table 39: Results of sampling of the holothurian fishery in New Caledonia over one year.
Species exploited: 1: *H. scabra* - 2: *H. scabra* var. *versicolor*
*: eviscerated weight

MONTH	NUMBER OF BOATS	NUMBER OF DAYS FISHING Total	m per boat	SPECIES	TOTAL CATCH (kg)	CATCH per day (kg)	C.P.U.E. kg/diver /hr
1	2	12	6	2	5 440*	454*	38* = 63
2	2	12	6	2	4 070*	339*	28* = 47
3	2	14	7	2	7 020*	500*	42* = 70
4	3	11	4	2	4 090*	408*	34* = 57
5	4	15	4	2 + 1	8 345*	556*	46* = 77
6	3	26	9	2 + 1	12 900*	496*	41* = 68
7	2	18	9	2	6 715*	373*	31* = 52
8	3	12	4	1	15 333	1 277	106
9	2	8	4	1	15 900	1 988	165
10	2	5	3	1	13 883	2 776	230
11	4	26	6	1	38 842	1 494	124
12	6	52	9	1	52 145	1 002	83

Table 40: Exports of *Holothoria scabra* by grade and by trader.

GRADE (%)	A	B	C	D	E	F
	1		2		3	
YEAR EXPORTER	140 to 65 g		65 to 30 g		30 to 10 g	
1983	28.7		42.9		28.4	
1984	27.9		56.7		15.4	
Exp. 1	6.4	17.6	37.8	21.0	13.3	4.0
Exp. 2	28.3		34.3	24.6	7.4	5.4
Exp. 3	4.9	24.7	26.9	26.5	16.6	
Exp. 4	57.0		43.0		-	

Table 41: Parameters of holothurian populations exploited in the tropical Pacific. *: this report

SPECIES	BIOMETRICS	GROWTH	REPRODUCTION				
			Annual cycle	First maturity	Fecundity	Recruitment	Mortality
H. scabra	Harriot, 1980 Shelley, 1981 Conand*	Shelley, 1985	Krishaswamy & Krishnan, 1967 Harriot, 1980 Shelley, 1981 Conand*	Conand*			
H. scabra var. *versicolor*	Conand*		Conand*	Conand*	Conand*		
H. nobilis	Conand, 1981		Conand, 1981	Conand, 1981	Conand*		
H. fuscogilva	Gentle, 1979 Conand, 1981		Conand, 1981	Conand, 1981	Conand*	Gentle, 1979	
A. echinites	Shelley, 1981 Conand, 1982	Shelley, 1985 Conand, 1983	Shelley, 1981 Conand, 1982	Conand, 1982	Conand*		
A. miliaris	Conand*						
T. ananas	Conand, 1981		Conand, 1981	Conand, 1981	Conand*		

The biometry and annual reproductive cycles are fairly well known for the principal species, except *A. miliaris*. The relevant research was carried out by means of monthly sampling at stations where the populations were fairly dense. These species do not usually show any asexual reproduction or hermaphrodism. Their sex-ratio does not differ from 1:1 in the populations surveyed and the same biometric relationships can be applied to males as to females. Apart from *H. scabra*, whose reproductive cycle includes two spawning seasons, the second being shorter, the other species have a single reproductive season which varies in length and takes place during the warm season, except in the case of *H. nobilis*. Absolute fecundity, which is variable according to species, is very high, sometimes reaching several million ovocytes. The size at first sexual maturity has not often been determined; it would however appear that small-sized species reach this stage relatively early.

Little is yet known about growth for most species, because the variability in weight and length measurements make it difficult to follow the evolution of modal values in the frequency distributions of these parameters. Shelley (1985) was, however, able to estimate average monthly growth, in terms of both length and weight, for *A. echinites* and *H. scabra*. Knowing the average density of these species, he computed annual production and potential bêche-de-mer production, the values for which amounted respectively to 497 kg/ha/yr and 15 kg/ha/yr for *A. echinites*. The values for *H. scabra* are very similar: 487 kg/ha/yr and 24 kg/ha/yr. These calculations are based on populations with assumed zero recruitment, mortality and migration.

The few observations made on juveniles only usually concern isolated specimens and recruitment remains an unknown factor for most species.

Not much knowledge is available about natural mortality. Isolated cases of predation on adults have been reported (Bakus, 1973). The most common predators are thought to be fish, gastropods and starfish. During research in New Caledonia, observations of predation only related to species of family Stichopodidae: *T ananas* and *S. variegatus* often had very marked scarring on the body wall, *S. horrens* was photographed while being eaten at night by *Tora perdix* and *Bohadschia argus* by *Charonia tritonis* (Laboute, personal communication).

No investigation has yet been made of the impact of the many potential symbiotic or parasitic species on the biology of the host holothurian.

The need therefore remains to continue research on various aspects of the biology, especially growth, recruitment and mortality, before considering rational management, because available data are either inadequate or insufficiently accurate to envisage the use of mathematical models.

8.4 Economic and social aspects

8.4.1 Economic aspects

The history of the trade (cf. Chapter 3) and the market survey (cf. Chapter 7) showed that holothurian fishing operations varied greatly in intensity and distribution. The world market is a complex one. There are many intermediate stages between fisherman and consumer: processing, transport and storage, export, import to the world market, packaging, wholesale and then retail market. The market is ultimately dependent on the demand from Chinese communities. If demand increases, there is a corresponding surge in fishing, processing and trading. The decline which is often observed after a period of prosperity may be due to a number of reasons: overfishing reducing stocks and therefore the profitability of the operation, drop in demand due to a fall in the standard of processing or a drop in prices on the Hong Kong and Singapore markets. The general economic context plays a prominent part in the way these fisheries fluctuate. In recent years, a relevant example is the opening up of the Chinese market, which increased demand for bêche-de-mer in Hong Kong and made it easier to start up a fishery in New Caledonia. This new demand, however, only concerns low quality products and has therefore led to a drop in the average value of imports and exports to and from Hong Kong.

The pricing structure has to take into account fishing, processing and transport costs. These are fairly high for the countries of the tropical Pacific, despite the fact that trade has been facilitated in recent years.

It would appear that the present price structure allows for a reasonable profit to be taken at each of the various stages. There can be no doubt that the profits accruing to Pacific islands (fishing, processing, export) could be increased, if the following suggestions from Singapore wholesalers were acted upon:

- species should be harvested as determined by specific market requirements;

- processing should be in line with importers' requirements, in particular where smoking is concerned;

- processed products should be sorted into commercial grades before export;

- supply should be regular in terms of both quantity and quality;

- packing should be more appropriate for lengthy transport. Bêche-de-mer shipped in wooden crates or cardboard boxes lined with plastic would be more effectively sheltered from risks of damage than they are in the jute sacks currently used.

To prepare <u>economic models</u> for these fisheries, comparable to the production models, statistics are required on the value of the harvest (or of the processed product in the case of holothurians) and on production costs. On the basis of the value of the fishing effort, curves for total value, gross economic return in terms of gross value of the production per unit of cost, gross economic gain and net total economic profit can be drawn (Troadec, 1982). This index shows a maximum representing the management objective. As for stocks, however, these models cannot be produced until a statistics collection system has been set up.

8.4.2 Social aspects

The way the three closely-interested sectors of harvesting, processing and trade are organised has a social impact. In the Pacific islands, the participation of fishermen in modern economic life is a factor to be considered alongside their employment and the raising of their income. Employment and income enhancement for traders processing this product are also important factors.

The countries concerned traditionally have a wide variety of social organisations and ways of sharing reef resources. These traditions are, however, tending to die out near urban areas (Munroe, 1985). Competition may then break out between different communities for access to the fishing grounds.

The organisation of holothurian fishing varies from country to country. Only rarely does a fisherman work alone with just the assistance of his family, because although the capital outlay for equipment is limited to a small boat and a dryer, processing requires more labour. Fishermen therefore form either groups at the village level or cooperatives. These cooperatives may then federate to organise marketing (Sachithananthan, 1972).

Fisheries administrations also often play an important role, as in Fiji for example, by organising training courses on bêche-de-mer processing, assisting in the setting up of cooperatives or dealing with marketing.

Elsewhere, in New Caledonia for example, the fishermen form groups around the traders, who handle processing and marketing.

However this activity is organised, the fishing and processing of holothurians are rarely sole activities; the fishermen diversify their catch and the traders their commodities under the influence of local and general economic circumstances.

8.5 Regulating the industry

This can be done by setting a limit on total effort by means of quotas or bans on fishing at particular times or in particular areas, or by changing the distribution of effort over the age groups of the resource by setting size limits on individual animals or on the processed product.

Little official control is exercised over holothurian fisheries in countries of the South Pacific. The low returns obtained on small-sized products usually spontaneously restricts fishing to large specimens, which are in fact more widely available.

In Australia however, the Queensland Fisheries Department, pending the results of their resource assessment, took interim control measures in 1976 (Curtis, 1980). These restrictions ban all fishing except pilot operations, for which licenses are issued.

In some Indian Ocean countries, the sizes of export products are regulated. This applies to species *H. scabra* in Madagascar, Sri Lanka and India. In India, for example, the export of specimens under 75 mm in length (approximately 16 g) is prohibited, which even prompted an exporters' association to petition for this minimum size to be reduced to 50 mm (INFOFISH, 1985). The regulations do not generally appear to be based on scientific results and vary from country to country for the various species.

In countries where this activity is an ancient one, such as China and Japan, the rules vary from region to region. In Japan, for example, they are applied by the cooperatives to areas and times when fishing is closed (Suguri, in Mottet, 1976). In China, the fishing activity exercised by the people's communes is regulated by restrictions on seasons and the size (or weight) of the processed product.[6]

In the countries of the tropical Pacific, each of the possible methods of regulation, if based on scientific results, could have advantages and disadvantages, but it would be necessary to be able to check that the rules are actually complied with. Annual quotas can, for example, be checked through the custom statistics, but their distribution between fishermen and traders can be hard to determine. The seasonal fishing ban can hinder exports, since the buyers on the Hong Kong and Singapore markets have always insisted that supplies should be regular. A longer closed season can be considered where yields drop drastically. It is difficult to enforce closures of fishing zones and their boundaries must respect local customs, when these non-mobile resources are exploited under a system of traditional reef ownership. Limiting fishable sizes tends to favour recruitment. When applied to catches, such restrictions are hard to verify but when applied to the processed product, they are realistic and can be checked through exports. The limits should be set on the basis of scientific results relating to size at first sexual maturity. The values presented in Table 42, for example, are obtained by multiplying L_{50} and W_{50}, the length and weight at first sexual maturity, by the factor for shrinkage due to processing. These values could be used as a basis for setting legal size limits, not forgetting that they are minima and that better knowledge about growth remains essential so as to be able to leave individuals undisturbed for one or more breeding seasons before harvesting them.

Table 42: Length and weight values for processed bêche-de-mer, corresponding to L50 and W50, parameters relating to holothurians at first sexual maturity.
%: parameter measured in dry rather than fresh condition (cf. table 30).

SPECIES	LENGTH (mm) W_{50}	%	Processed	WEIGHT (g) P_{50}	%	Processed
H. scabra	160	38	60	184	5	10
H. scabra var *versicolor*	220	38	85	490	6	30
H. nobilis	260	51	130	800	9	70
H. fuscogilva	320	44	140	1175	8	95
T. ananas	300	38	115	1230	5	60
A. echinites	120	47	55	90	11	10

6. Gratitude is due to the scientific department of the French Embassy in China, who supplied this information.

8.6 Stock improvement methods and aquaculture

Bearing in mind their long-standing taste for holothurians, it is not surprising that it should have been the Japanese who first attempted to increase the natural stocks. Mitsukuri (1912) was an early proponent of the construction of artificial reefs in coastal zones to improve the recruitment of juveniles and make the summer dormancy period easier for adults of *S. japonicus*. Choe (1963) reported that this practice was already traditionally widespread in the nineteenth century, with young individuals being transplantated to increase stocks or adults to favour spawning. Many projects were also implemented by the prefectures in areas where this activity was carried on, but only rarely were the results evaluated. Larva rearing produced much research, from Inaba (1937) and Imai *et al.* (1950) to more recent investigations attributable to Ishida (1979) and Anon. (1983). Other references are quoted by Mottet (1976). The aquaculture of *S. japonicus* has also been the subject of research in China, with the following articles describing these experiments: Anonymous (1976, 1977), Shuxu and Gonchao (1981), Shui Xi-Lin *et al.* (1984, 1985). Some Russian investigations, particularly those by Mokretsova (1978) and Levin (1982), confirmed that these techniques were likely to develop in the future. It would however be premature, in view of the knowledge presently available on these species, to consider applying these techniques to the species of the tropical Pacific. Even if the techniques were mastered, there would be no guarantee of economic viability.

8.7 Conclusion

The main characteristics of these small artisanal fisheries have been described in this chapter; the methods for sampling catches and populations have been defined. At present, the lack of statistical catch data and the absence of more thorough knowledge about the biology of the species concerned restrict the scope for developing mathematical models for the purpose of planning rational stock utilisation. Figure 51 summarises the main factors involved in achieving rational management of these fisheries in the future.

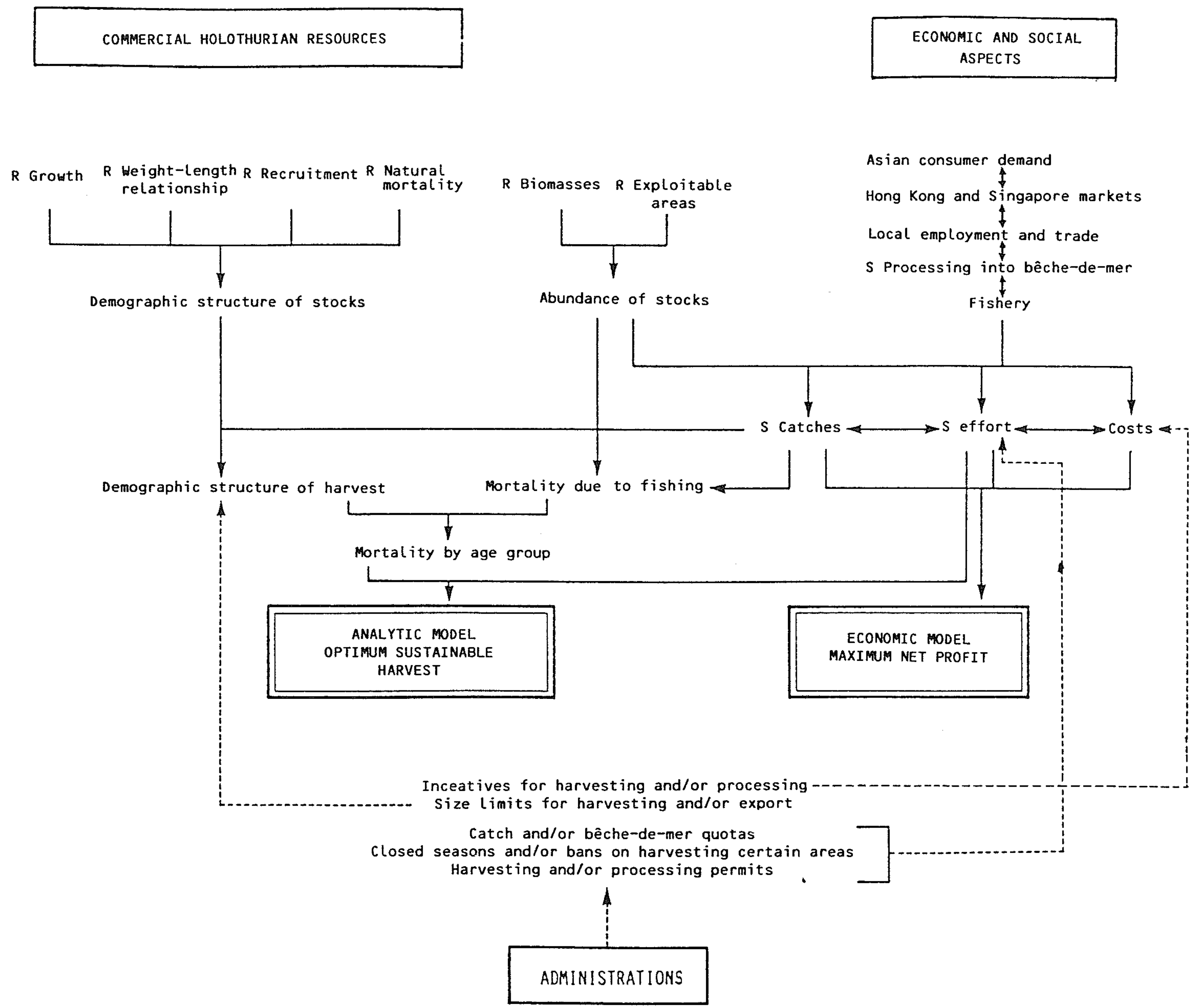


Figure 51 : Factors affecting the rational management of holoturian fisheries in the tropical Pacific.
S : sampling R : research

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APPENDIX I : HONG KONG BECHE-DE-MER MARKET (1983-1985)

A - IMPORT VOLUMES BY COUNTRY OF ORIGIN, IN KILOGRAMS

Country	Jan 83	Feb 83	Mar 83	Apr 83	May 83	Jun 83	Jul 83	Aug 83	Sep 83	Oct 83	Nov 83	Dec 83	Total	%
Indonesia	66146	50165	52738	59848	62989	62303	136527	49244	69787	32917	69555	124426	836645	39.4
Philippines	43380	28305	67195	68816	94196	85473	110946	50420	109310	44772	73970	141289	918072	43.2
Japan	3440	975	2746	420	360	6050	8000	6000	3390	6597	10420	0	48398	2.3
Korea, DPR	0	550	2080	3100	0	1822	8484	3915	9064	2560	2641	2610	36826	1.7
Sri Lanka	0	1300	0	0	0	0	0	0	0	0	0	0	1300	0.1
Singapore	9249	1004	2315	777	2319	3120	8272	7665	6119	3100	7085	900	51925	2.4
India	0	0	0	0	0	0	0	280	0	0	0	0	280	0
Africa	375	27794	17801	5750	15804	13696	5790	1350	8180	25181	16230	7475	145426	6.8
Oceania	4306	1085	5059	235	5965	0	11818	8714	7298	2871	8737	3189	59277	2.8
Total	130124	111470	150116	139127	181633	172464	290781	127618	213572	138814	189462	280244	2125425	

	Jan 84	Feb 84	Mar 84	Apr 84	May 84	Jun 84	Jul 84	Aug 84	Sep 84	Oct 84	Nov 84	Dec 84	Total	%
Indonesia	137826	96621	68926	130198	38885	149823	107419	72607	40063	103561	76890	37210	1060029	36.5
Philippines	226593	109358	191291	111584	149315	71177	54264	78802	58262	96928	98748	124151	1370473	47.2
Japan	0	2120	375	312	1757	1980	2000	135	1680	1057	1530	4870	17816	0.6
Korea, DPR	1155	1704	4810	431	2940	1659	8093	270	3614	1237	1600	3268	30781	1.1
Sri Lanka	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Singapore	8998	2419	3148	5776	7167	11423	7347	5107	6161	814	8384	10829	77573	2.7
India	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Africa	3150	22092	25210	18520	8379	0	17205	22120	0	14275	6840	13560	151351	5.2
Oceania	18453	20464	14248	10138	7200	4991	12407	8128	4804	12363	6314	21194	140724	4.8
Total	403389	254838	300048	280870	227504	251715	208696	193189	127774	231038	209196	216850	2905107	

	Jan 85	Feb 85	Mar 85	Apr 85	May 85	Jun 85	Jul 85	Aug 85	Sep 85	Oct 85	Nov 85	Dec 85	Total Jan-Oct	%
Indonesia	108865	45435	61689	58810	31750	77555	125482	134129	134839	331817			1110371	32.0
Philippines	73687	32692	48635	123114	115509	172908	151137	190153	321590	579851			1809276	52.2
Japan	0	2840	2950	890	210	220	942	1243	3612	2407			15314	0.4
Korea, DPR	1516	5585	1605	1104	280	3242	5320	3630	1190	520			23992	0.7
Sri Lanka	0	0	0	0	0	0	0	0	0	0			0	0
Singapore	16190	3355	11346	3680	5460	20980	15822	20632	25975	28271			151711	4.3
India	0	0	0	0	0	0	0	0	0	0			0	0
Africa	47810	0	18445	5250	31337	3200	17370	23025	15115	24682			185234	5.4
Oceania	15829	0	8842	1264	3500	8857	4250	1118	10100	13808			67568	1.9
Total	315733	90197	153512	194134	191846	299360	325119	384862	522551	991954			3469268	

NOTE: AFRICA IS MADE UP OF S AFRICA, MOZAMBIQUE, KENYA, TANZANIA & ZANZIBAR
OCEANIA IS MADE UP OF US OCEANIA, OCEANIA NES, AUSTRALIA, TONGA, FIJI & P N GUINEA

APPENDIX I : HONG KONG BECHE-DE-MER MARKET (1983-1985)

B - IMPORT VALUES BY COUNTRY OF ORIGIN IN HONG KONG DOLLARS

Country	Jan 83	Feb 83	Mar 83	Apr 83	May 83	Jun 83	Jul 83	Aug 83	Sep 83	Oct 83	Nov 83	Dec 83	Value Total	Volume Total/kg	Value per kg
Indonesia	877471	682270	606376	945855	960717	896460	2188048	965816	808535	496513	916141	1374195	11718397	836645	14.01
Philippines	483740	397190	674636	922932	1153253	1090527	1474337	797728	1331728	814442	743421	1615349	11499283	918072	12.53
Japan	792021	174242	559347	72000	90000	1233540	1964422	1498357	826500	1670470	2851011	0	11731910	48398	242.40
Korea, DPR	0	46075	167970	267454	0	154090	773856	361216	765021	226200	236342	229428	3227652	36826	87.65
Sri Lanka	0	59617	0	0	0	0	0	0	0	0	0	0	59617	1300	45.86
Singapore	148378	6570	91234	31176	77518	74861	239261	224855	86160	126910	665842	87480	1860245	51925	35.83
India	0	0	0	0	0	0	0	24500	0	0	0	0	24500	280	87.50
Africa	16335	1032724	570974	185245	464895	315779	180311	58000	131630	736432	700475	186751	4579551	145426	31.49
Oceania	168918	36701	158307	9562	212628	0	360635	317235	160000	144436	316791	99348	1984561	59277	33.48
T Value	2553433	2444368	2836756	2444884	2959011	3765257	7233259	4250507	4141744	4715055	6454555	3631783	47430612	2125425	22.32
T Volume	130124	111470	150116	139127	181633	172464	290781	127618	213572	138814	189462	280244	2125425		
Value/kg	19.62	21.93	18.90	17.57	16.29	21.83	24.88	33.31	19.39	33.97	34.07	12.96	22.32		

	Jan 84	Feb 84	Mar 84	Apr 84	May 84	Jun 84	Jul 84	Aug 84	Sep 84	Oct 84	Nov 84	Dec 84	Value Total	Volume Total/kg	Value per kg
Indonesia	1501408	933773	642783	1614600	222751	2519035	1516732	794855	501919	1319825	934371	449188	12951240	1060029	12.22
Philippines	1766855	837716	946923	609938	1224236	634604	668573	946403	358667	997659	511688	1187363	10690625	1370473	7.80
Japan	0	500516	80920	83593	489662	590656	493827	25255	540837	257665	450306	1295397	4808634	17816	269.91
Korea, DPR	121160	164840	456849	38575	311641	201468	950385	33137	375792	166760	213000	436440	3470047	30781	112.73
Sri Lanka	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Singapore	424489	101031	257019	460667	623581	581545	373803	299711	281425	57715	474183	757619	4692788	77573	60.50
India	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Africa	148253	865270	1249800	391896	274492	0	512758	635812	0	437102	154244	211496	4881123	151351	32.25
Oceania	936375	911593	672626	700546	285580	203422	490897	446834	173029	826364	307284	1106511	7061061	140724	50.18
T Value	5118463	4322739	4309320	4155736	3859779	5083938	5010932	3501706	2354583	4123157	3191136	5525589	50557078	2905107	17.40
T Volume	403389	254838	300048	280870	227504	251715	208696	193189	127774	231038	209196	216850	2905107		
Value/kg	12.69	16.96	14.36	14.80	16.97	20.20	24.01	18.13	18.43	17.85	15.25	25.48	17.40		

	Jan 85	Feb 85	Mar 85	Apr 85	May 85	Jun 85	Jul 85	Aug 85	Sep 85	Oct 85	Nov 85	Dec 85	Value Total Jan-Oct	Volume Total/kg Jan-Oct	Value per kg
Indonesia	639691	295291	1026746	437448	501299	1115361	1291839	1613401	1826498	3258694			12006268	1110371	10.81
Philippines	1078864	410612	513644	1541345	1286103	2116074	1778425	1849791	3330427	5871196			19776481	1809276	10.93
Japan	0	673409	703971	216970	63627	60764	299260	377727	1015401	865790			4276919	15314	279.28
Korea, DPR	194619	896250	229260	144250	41234	484847	798446	523375	171755	70296			3554332	23992	148.15
Sri Lanka	0	0	0	0	0	0	0	0	0	0			0	0	0.00
Singapore	1037908	256965	778264	126612	324547	1071790	386289	1066819	1193469	624313			6868976	151711	45.28
India	0	0	0	0	0	0	0	0	0	0			0	0	0.00
Africa	1441206	0	275320	94770	1506923	50000	280948	798643	504367	343038			5295215	186234	28.43
Oceania	414867	0	255923	98512	82582	237830	80556	94219	352530	446022			2063041	67568	30.53
T Value	5780615	2542967	3983128	2663205	3856315	5341550	5350563	6577611	8980405	11581767			56658126	3469268	16.33
T Volume	315733	90197	153512	194134	191846	299360	325119	384862	522551	991954			3469268		
Value/kg	18.31	28.19	25.95	13.72	20.10	17.84	16.46	17.09	17.19	11.68			16.33		

APPENDIX I : HONG KONG BECHE-DE-MER MARKET (1983-1985)

C - RE-EXPORT VOLUMES BY COUNTRY OF DESTINATION IN KILOGRAMS

Country	Jan 83	Feb 83	Mar 83	Apr 83	May 83	Jun 83	Jul 83	Aug 83	Sep 83	Oct 83	Nov 83	Dec 83	Volume Total	%
USA	5758	2666	722	4424	1028	4649	12822	8375	4570	2326	5276	1113	53729	32.0
Canada	0	144	349	957	441	134	834	653	138	1405	825	2422	8302	0.5
Europe	0	20	422	52	0	150	47	22	0	260	128	181	1282	0.1
Taiwan	23066	3700	8183	21453	32361	28786	42765	21468	21420	16714	26360	20605	266881	16.3
Rep of Korea	19650	21593	16560	20439	13257	3000	3665	0	13498	190	24100	10959	146911	9.0
China	51786	11086	41879	65672	50602	205892	167254	70319	67510	111814	92530	66511	1002855	61.2
Singapore	9667	1049	3055	12987	4813	12785	32718	20473	7284	5245	10007	18142	138225	8.4
Australia	120	521	300	0	405	407	674	125	113	600	0	13	3278	0.2
Total	110807	42779	72446	126370	103317	255803	261498	122154	114533	139564	160018	128628	1637917	

	Jan 84	Feb 84	Mar 84	Apr 84	May 84	Jun 84	Jul 84	Aug 84	Sep 84	Oct 84	Nov 84	Dec 84	Volume Total	%
USA	3289	445	2875	5157	2412	6140	5319	8101	7384	4605	4596	9411	59734	2.5
Canada	23	0	225	135	199	1393	902	49	0	233	1392	500	5051	0.2
Europe	479	84	54	45	56	149	95	267	142	579	459	133	2542	0.1
Taiwan	16462	14391	29878	15600	17859	19113	5462	16877	15689	12301	9166	7949	180747	7.5
Rep of Korea	15375	19430	30252	12125	19890	28688	26960	27417	24710	45593	37421	99524	387385	16.1
China	307305	157605	56570	90753	219345	156451	81574	52941	64280	204843	106112	144034	1641813	68.3
Singapore	7843	12924	7940	8755	9626	5617	12714	4248	12552	12974	3940	4599	103732	4.3
Australia	233	15	103	327	600	625	106	90	626	295	152	471	3643	0.2
Total	351449	205162	130157	132910	270739	218387	134001	110431	125677	282455	176194	266995	2404557	

	Jan 85	Feb 85	Mar 85	Apr 85	May 85	Jun 85	Jul 85	Aug 85	Sep 85	Oct 85	Nov 85	Dec 85	Volume Total Jan-Oct	%
USA	3681	2926	2975	5248	5791	1647	2122	2608	2460	1611			31069	1.1
Canada	4290	161	277	139	60	404	807	412	1573	248			8371	0.3
Europe	42	22	170	153	359	204	57	135	287	218			1647	0.1
Taiwan	8258	55369	13824	25901	12242	19100	29029	24920	27417	18633			234693	8.5
Rep of Korea	15100	8404	626	0	0	0	0	0	0	0			24130	0.9
China	239771	104115	66917	99527	220470	153295	173364	265129	447471	590817			2360876	85.9
Singapore	7387	803	1037	0	7074	13863	5103	14418	8987	6224			64896	2.4
Australia	855	27	0	68	226	333	309	250	0	1818			3886	0.1
Total	280344	171897	86954	131036	248530	189608	220937	310133	488615	620837			2748891	

NOTE: EUROPE IS MADE UP OF FR GERMANY, HOLLAND, BELGIUM, FRANCE AND UK

APPENDIX I : HONG KONG BECHE-DE-MER MARKET (1983-1985)

D - RE-EXPORT VALUES BY COUNTRY OF DESTIMATION IN HONG KONG DOLLARS

Country	Jan 83	Feb 83	Mar 83	Apr 83	May 83	Jun 83	Jul 83	Aug 83	Sep 83	Oct 83	Nov 83	Dec 83	Value Total	Volume Total/kg	Value per kg
USA	362114	199276	43113	235860	122990	185149	1158090	786087	269643	237037	298762	134767	4032888	53729	75.06
Canada	0	3601	25250	27420	10142	10425	132066	121378	15260	100490	49184	72000	567216	8302	68.32
Europe	0	865	31700	5225	0	14017	5650	2650	0	14353	16550	25841	116851	1282	91.15
Taiwan	684865	55500	364843	734971	1156514	622717	880005	471834	1402584	329780	879882	468738	8052233	266881	30.17
Rep of Korea	291050	325204	281166	325355	221749	56100	51705	0	242043	27000	389684	197558	2408614	146911	16.40
China	670461	141726	541581	601897	617936	1186177	1741772	874063	840956	880642	1379228	1148376	10624815	1002855	10.59
Singapore	572428	97390	186989	1032060	232259	856714	1606971	1053840	318340	320936	996778	0	7274705	138225	52.63
Australia	6680	44499	26200	0	14460	22460	58804	17528	7000	25200	0	0	222831	3278	67.98
T Value	2624102	912941	1593330	2985483	2407850	2953759	5696932	3389249	3095826	1976438	4086192	1208953	32931055	1637917	20.11
T Volume	110807	42779	72446	126370	103317	255803	261498	122154	114533	139564	160018	128628			
Value/kg	23.68	21.34	21.99	23.62	23.31	11.55	21.79	27.75	27.03	14.16	25.54	9.40			

	Jan 84	Feb 84	Mar 84	Apr 84	May 84	Jun 84	Jul 84	Aug 84	Sep 84	Oct 84	Nov 84	Dec 84	Value Total	Volume Total/kg	Value per kg
USA	400469	64604	324264	329325	228926	430075	492578	911930	766548	556349	580095	1023058	6108221	59734	102.26
Canada	1500	0	28995	29250	46400	101090	14883	5674	0	26159	31995	51550	337496	5051	66.82
Europe	48899	13611	3530	4120	10014	20813	15100	30395	14050	49582	32262	15950	258326	2542	101.86
Taiwan	426234	445121	1667519	428400	779548	400486	160907	356296	688866	286474	228596	208014	6076461	180747	33.62
Rep of Korea	292661	397956	554411	226643	336671	489027	557782	486227	314343	673605	486730	1446067	6262123	387385	16.17
China	2864631	1456606	705506	690659	2025213	1026346	618845	818255	764377	1273927	788916	1699496	14732777	1641813	8.97
Singapore	556702	1172088	755400	430712	757173	341556	965736	333057	1114799	510798	259847	434622	7632490	103732	73.58
Australia	24441	4053	9304	39192	28800	92349	11575	13000	85884	23680	20730	65092	418100	3643	114.77
T Value	4654617	3575604	4256929	2180791	4307002	2920144	2882966	3018134	3830884	3458606	2612098	4981085	42678860	2404557	17.75
T Volume	351449	205162	130157	132910	270739	218387	134001	110431	125677	282455	176194	266995			
Value/kg	13.24	17.43	32.71	16.41	15.91	13.37	21.51	27.33	30.48	12.24	14.83	18.66			

	Jan 85	Feb 85	Mar 85	Apr 85	May 85	Jun 85	Jul 85	Aug 85	Sep 85	Oct 85	Nov 85	Dec 85	Value Total Jan-Oct	Volume Total/kg Jan-Oct	Value per kg
USA	331288	278742	368290	492800	568344	189861	158757	188357	159622	150356			2886417	31069	92.90
Canada	214640	22930	29011	9377	6600	24150	41745	25775	76248	20365			470841	8371	56.25
Europe	4320	2192	25976	21990	39443	19697	8508	16149	36939	28699			203913	1647	123.81
Taiwan	290987	1963274	532760	815037	268930	575340	951250	1275496	1364692	650786			8688552	234693	37.02
Rep of Korea	283397	105056	42923	0	0	0	0	0	0	0			431376	24130	17.88
China	1804278	1243560	695518	1216541	2503141	2259306	2311051	4019609	7653352	7198262			30895618	2360876	13.09
Singapore	626391	16060	70242	0	625882	839526	390094	812780	356102	704209			4441286	64896	68.44
Australia	92634	2925	0	4260	14371	37060	22590	16240	0	161020			351100	3886	90.35
T Value	3712235	3644399	1828156	2558005	4161518	3999393	4000723	6420706	9698915	8930073			48954123	2748891	17.81
T Volume	280344	171897	86954	131036	248530	189608	220937	310133	488615	620837					
Value/kg	13.24	21.20	21.02	19.52	16.74	21.09	18.11	20.70	19.85	14.38					

NOTE: EUROPE IS MADE UP OF FR GERMANY, HOLLAND, BELGIUM, FRANCE & UK

APPENDIX II: SINGAPORE BECHE-DE-MER MARKET (1983-1985)

A - Imports: volume in metric tonnes, value in terms of '000 Singapore dollars.

		Volume	Value
1983	Australia	5	79
	Hong Kong	50	654
	India	95	1 560
	Japan	15	875
	Kenya	50	516
	Rep. of Madagascar	2	27
	Peninsular Malaysia	4	49
	Mozambique	22	322
	Papua N.Guinea	7	61
	Philippines	98	1 075
	Sabah	77	184
	Sri Lanka	52	1 407
	Taiwan	3	24
	Tanzania	43	190
	Oceania	2	26
	Other countries	7	76
	TOTAL	533	7 129
1984	Hong Kong	27	615
	India	59	933
	Japan	11	676
	Kenya	65	685
	Peninsular Malaysia	10	64
	Mozambique	21	336
	New Caledonia	67	1 030
	Papua N.Guinea	5	52
	Philippines	145	1 049
	Sabah	64	201
	Sri Lanka	36	890
	Tanzania	66	293
	Yemen Arab Rep.	2	30
	Other African Coun.	3	30
	Oceania	5	110
	Other countries	4	59
	TOTAL	590	7 055
1985 (January to August)	Hong Kong	19	402
	India	13	248
	Japan	2	190
	Kenya	38	411
	Rep. of Madagascar	4	40
	Pen.Malaysia	7	47
	New Caledonia	93	1 217
	Papua N.Guinea	8	85
	Philippines	55	447
	Sabah	37	174
	Sri Lanka	28	518
	Tanzania	81	561
	Yemen Arab Rep.	2	46
	Oceania	2	50
	TOTAL	388	4 447

B - Re-exports: volume in metric tonnes, value in terms of '000 Singapore dollars.

		Volume	Value
1983	Brunei	5	30
	Hong Kong	51	317
	Rep. of Korea	14	78
	Peninsular Malaysia	516	1 731
	Sabah	3	76
	Sarawak	18	321
	Taiwan	110	807
	Thailand	44	82
	Other countries	2	45
	TOTAL	758	3 488
1984	Brunei	2	39
	Hong Kong	78	957
	Rep. of Korea	5	29
	Penins. Malaysia	583	1 913
	Sabah	5	45
	Sarawak	15	231
	Taiwan	66	666
	Thailand	22	57
	Other countries	2	53
	TOTAL	779	4 040
1985 (January to August)	Brunei	1	38
	Burma	6	28
	France	1	40
	Hong Kong	103	1 327
	Pen. Malaysia	599	1 360
	Sabah	3	92
	Sarawak	10	176
	Taiwan	55	487
	Thailand	5	63
	Other countries	1	20
	TOTAL	784	3 631

APPENDIX III – LIST OF BECHE-DE-MER IMPORTED

HONG-KONG

NAM KWONG CO
P.O. Box 3042
Hong-kong

Telex: 75371 NKCHK HX

TAI HING INTERNATIONAL LIMITED
GPD Box 5690
308-309 International Building
141 Des Voeux Road
Central Hong-kong

SEA SOURCES CO
2nd Floor, General Building
6-14 Centre Street
Saiyingpun
Hong-kong

WINSON TRADERS (HK) LTD
501 Wong House
26/30 Des Voeux Road
West Hong-kong
Hong-kong

Telex: 85005 WTGRP
Tel.: 5-406706, 406484
Cable: WINFIRM

KIT HENG CHUNG (HK) LTD COMPANY
1st Floor
155 Des Voeux Road
West Hong-kong
Hong-kong

Telex: 65520 CCPHK
Tel.: 473560
Cable: BEST BEACH

EUROSIA HOLDING LTD
Millwood Mansion, 9/F, Block C
Tsimshatsui
Kowloon
Hong-kong

Telex: 37598 EUHOL HX
Tel.: 3-669309-0
Cable: EUHOLIMIT, HONG-KONG

UNIQUE DISTRIBUTORS LIMITED
GPO Box 293
Hong-kong

Telex: 61497 UNIWA HX
Tel.: 5-278331
Cable: SYSTEMS

SUMMER TRADING COMPANY
808-809 Wing Tuck Comm. Centre
177-183 Wing Lok Street
West Hong-kong
Hong-kong

Telex: 65362 SUTCO HX
Tel.: 5-411689, 456035/6
Cable: EAERY

ORIENTAL MARINE PRODUCT GROUP
GPO Box 251
Hong-kong

Telex; 38179 OMPG HX
Tel.: 3-7790021
Cable: GREATWHITE HONG-KONG

FULL SUCCESS TRADING CO
19-25 Des Voeux Road W
Room 402
Hong-kong

Telex: 38247 FOWIL HX
Tel.: 3-687851, 689808
Cable: FOWSILAR HX

EASTERN PEARL INTERNATIONAL CO
Room 1101-2, Seaview Comm. Bldg.
21-24 Connaught Road
West GPO 5409
Hong-kong

Telex: 74279 SHARK HX
Tel.: 5-408184
Cable: PEARLATION

HEEP TUNG LONG
GPO Box 407
Hong-kong

Telex: 60195 HEEP HX
Tel.: 5-468313, 467005
Cable: TIBURON, HONG-KONG

KWONG HING HONG
3 Wilmer Street
1st Floor
Hong-kong

Telex: 61649 PATHK HX
Tel.: 5-478443, 490054

NAM YUEN HONG
10 Eastern Street
Ground Floor
Hong-kong

Tel.: 5-467404

SINGAPORE

SARIANO CO
40 Wilkinson Road
Singapore 1543

Telex: RS 25283

SEAKING TRADING CO
45 A Jalan Membina
Singapore 0316

Tel: 271 72 30

ENG THONG CO
74 South Bridge Road
Singapore 0105

Tel: 222 0701

YONG THAI TRADING CO
65 Telok Ayer Street
Singapore 0104

Tel: 222 7192

CHOON HONG MARINE PRODUCTS
51 North Canal Road
Singapore 1

Tel: 43 4073

A.M. ABDULLAH SAHIB and CO
Maxwell Post Office No. 19
Singapore 9000
Singapore

Telex: RS 20847 AMAH
Tel: 5334553, 5344074
Cable: AMAH

ASIA SEAFOOD COMPANY
353-A Circuit Road
Block 64
Singapore 2337
Singapore

Telex: RS 24200 TMSR
Tel: 7 384077
Cable: ASIATONGA, SINGAPORE

WEISOON MARKETING PTE LIMITED
Block 1057
Eunos Ave. 3, 04-69
Singapore 1440
Singapore

Telex: RS 38103 WECO
Tel: 7457432, 7473902
Cable: WEISOON

HIAP HENG CHNG (S) PTE LTD
5-6 North Canal Road
Singapore 0104
Singapore

Telex: RS 25106 FIBEACH
Tel: 911888
Cable: FINEBEACH

TAIWAN

TRANSWORLD ENTERPRISES CO
4A, No1 Alley 6, Lane 303
Nanking East Road, section 3
Taipei, Taiwan

Cable: TWENTER

MALAYSIA

ENG WAN TRADING CO
P.O. Box 554
57 Leboh Pantai
10770 Penang
Malaysia

Telex: MA 40688
Tel: 04 63811
Cable: PRECIOUS PENANG

M-43/T0293E/1/2.90/2300
ISBN 92-5-102508-8