

# A Review of Recent Developments in the World Sea Cucumber Fisheries

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## Introduction

The commercial exploitation of marine invertebrates has received increased attention during recent years, and progress has been made in the knowledge of stock dynamics and fisheries management, particularly for crustaceans and mollusks. Although invertebrates yield lower landing weights in comparison with finfishes, their high economic value compensates for this difference, with invertebrates accounting for nearly 40% of the value of the world fishery trade (Caddy, 1989). Invertebrates also play an important role in the structure and function of marine communities. On coral reefs, for example, echinoderms are main compo-

nents in the food chain at various trophic levels and play an important role through grazing, predation, or bioturbation (Birkeland, 1989).

Echinoderm fisheries are generally small in scale. Sea urchins are exploited for the roe, and sea cucumbers are harvested for the body wall, longitudinal muscles, and viscera. World statistics from these fisheries have been reviewed for the years 1978–86 (Conand, 1989a; Conand and Sloan, 1989). The recent growth of the North American red sea urchin fishery has raised the question of the feasibility of stock enhancement to maintain the fishery (Tegner, 1989).

Holothurian fisheries are based on a few deposit-feeding species belonging to two families and five genera: *Actinopyga* and *Holothuria* (Holothuridae) and *Parastichopus*, *Stichopus*, and *Thelenota* (Stichopodidae). The few species exploited amount to about a dozen amongst the thousand existing.

Sea cucumbers are eaten either raw, boiled, or pickled. In Japan and Korea the body wall and viscera of sea cucumbers are eaten raw or pickled (Mottet, 1976; Conand, 1986). The most important sea cucumber product, however, is the dried body wall which is marketed as *bêche-de-mer* (Fig. 1), also called *tre pang* or *hai-som*, throughout the tropical Indo-Pacific (Conand, 1989a).

Processing methods for *bêche-de-mer*, believed to have been introduced by Chinese traders, include six stages: Boiling, slitting the dorsal side, second boiling, gutting, smoke drying, and sun drying (Conand, 1986). These procedures vary according to the species processed. Processing considerably reduces the length and weight of the sea cucumber, and the final product weight is about 10% of the original weight (Conand, 1979; Vuki and Viala, 1990). This factor must be considered when comparing landings data with *bêche-de-mer* production.

*Bêche-de-mer* is exported from the producer countries to a central market such as Hong Kong or Singapore, and then is re-exported to Chinese consumers. These fisheries are of economic significance, particularly in developing countries. *Bêche-de-mer* as an export product can fetch high prices (US\$25/kg for first grade products). The *bêche-de-mer* harvest is therefore an important source of activity and income for fishermen from developing countries.

*Bêche-de-mer* fisheries have a long history, as the Chinese have sought sea cucumbers for a thousand years or more in India, Indonesia, and the Philippines (Conand, 1986, 1989a, 1990). During the 18th and 19th centuries, traders gathered them in a wider area. A lithograph from the d'Urville Expedition of

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**ABSTRACT**—*Sea cucumbers (Holothuriidae and Stichopodidae) have been harvested commercially for at least 1,000 years. The world fisheries for sea cucumbers, however, are not well documented and in general are poorly managed. Depending upon the species exploited, there are two processing procedures for the sea cucumber product. Some species are eaten raw, while most commercial species are processed into a dry product called bêche-de-mer or tre pang. This dry product is exported to a central market such as Hong Kong and then re-exported to the consumers. In this review, recent statistics on the world sea cucumber fisheries, collected from different services, are detailed for each major fishing area. Case studies for each fishing area are also presented. Recent major changes in the Indo-Pacific fishery include the participation of new producer countries, the shift in the species being exploited, and an increase in the Chinese*

*market. The expansion of the largely monospecific temperate North Pacific fisheries is also described. Statistics from Hong Kong, Singapore, Taiwan, and the Food and Agriculture Organization provide valuable information on the producer and importer countries. Particular attention is paid to the reciprocal trade of bêche-de-mer between Hong Kong and Singapore. An evaluation of the world sea cucumber landings and bêche-de-mer production is presented. Recent developments include an expansion of the Hong Kong market due to increased demand by China, the importance of Indonesia as a major world producer, and an increase in the fisheries of Tropical Pacific nations. This increase is best documented for New Caledonia and Fiji. Ways to improve the access and the reliability of the statistics for the sea cucumber fishery are discussed, as is the potential for management of artisanal fisheries.*

1839 (Fig. 2) shows a trader's shore plant in the Northern Territory of Australia, complete with boiling and smoking equipment. Conand (1986, 1989a, 1990) also described the temporal and spatial variability in the harvest of sea cucumbers. These fisheries are still poorly documented and, in many cases, may not be well managed.

In this review, recent trends in the world holothurian fisheries are analyzed for 1986–90. Regional fisheries are di-

vided according to geographical area and the species harvested. Tropical fisheries tend to be multispecific, whereas temperate fisheries are monospecific. Tropical fisheries in the Pacific and Indian Oceans produce the dry product and are divided into four regions: Tropical South Pacific Islands, Western Central Pacific countries, Eastern Indian Ocean, and Western Indian Ocean. Temperate fisheries for fresh or frozen product are limited to the North Pacific

Ocean and are subdivided into Western and Eastern Pacific regions. The description of each fishery is based on available statistics and personal observations.

The world bêche-de-mer market is largely controlled by Chinese traders, and historical data from 1917 to 1986 were reviewed by Conand (1986, 1989a, 1990). Recent statistics are presented here for the two main market centers, Hong Kong and Singapore. These markets are also the major re-exporting centers. Taiwanese statistics are analyzed here for the first time. Evaluation of the sea cucumber landings and bêche-de-mer production is presented for 1986–90. This information is useful in documenting the main characteristics of the sea cucumber fishery and prospects for its development and management.

### Collection of Fishery and Trade Statistics

In most developing countries little official control is exercised on the artisanal sea cucumber fisheries. Consequently, relevant information and statistics are not always available. The complexity of market routes, from the fisherman to the consumer, has been shown by several studies (Sachithanathan, 1972; Conand, 1990). This makes it difficult to obtain statistics on the stages of the market, from the different sources outlined in Figure 3. Information sources include stock assessments and capture, processing, export, import, and international trade statistics.

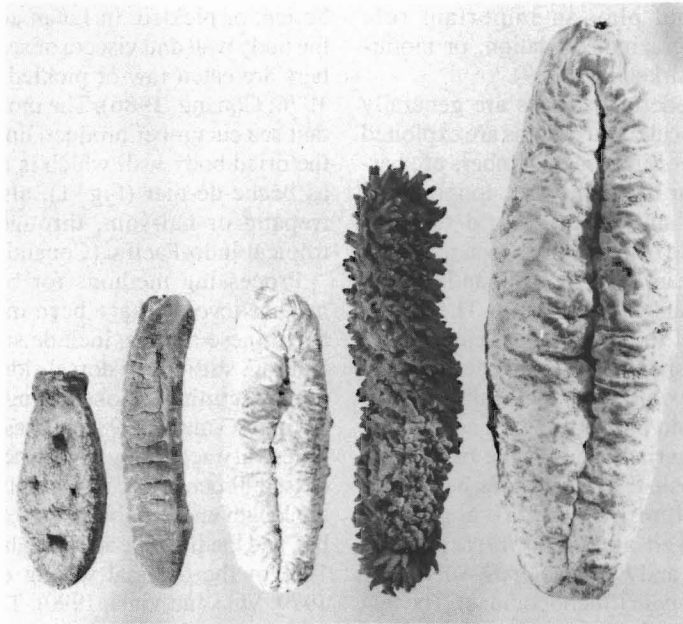


Figure 1.—Bêche-de-mer samples from several tropical holothurians: From right to left are *H. nobilis*, *T. ananas*, *H. nobilis* (lower grade), *H. scabra*, and *Actinopyga* sp. Photo by C. Conand.



Figure 2.—An 1830's sea cucumber processing plant in Northern Australia (from a lithograph drawn by L. LeBreton in 1839) made on the d'Urville Expedition and courtesy of the State Library of the Northern Territory of Australia, Darwin).

## Stock Assessments

Exploratory scientific surveys are conducted by various countries. Scientific divers give estimates of abundance, in terms of densities or sometimes in catch per unit effort (CPUE) (Conand, 1986). The data, however, are limited by the diversity of techniques used and species surveyed. One exception is evident in the regular surveys conducted by the Washington State Department of Fisheries which document the effects of regulation on this monospecific fishery.

## Capture Statistics

Little information is available on catch (live weight), catch effort (number of fishermen and harvest time), and CPUE, as fishermen generally do not use logbooks. Estimates have occasionally been made by scientists. In the State of Washington (U.S.A.), catches are recorded from fishing logs.

## Processing Statistics

Holothurian catches are often bought by processors who also export bêche-de-mer. During the different stages of the processing (boiling, gutting, drying), the length and weight of the holo-

thurians are greatly reduced, resulting in the final product weighing about 10% of the original weight and measuring 50% or less of the original length. This difference has to be taken into account when using statistics, due to inconsistencies between catches in fresh weight and the processed product.

## Export Statistics

National statistics from customs agencies or fisheries departments are useful for estimating catch levels in producer countries which, for the most part, are not consumer countries.

## International Trade Statistics

Analyses of Hong Kong and Singapore imports from producer countries and subsequent re-export of bêche-de-mer to consumer countries are important in understanding world trade. FAO yearbooks of fishery statistics (catches and commodities) also provide international trade data for the main countries.

## Import Statistics

A comparison of national import statistics from the major consumer countries with data from international trade

statistics is a source of complementary information.

## Tropical Fisheries

Tropical fisheries are traditionally based on several holothurians (Fig. 1). The species may be classified into three categories of commercial importance based on: Abundance in shallow waters, size, thickness and quality of the body wall, and main market demand and value. The species of highest commercial value (Conand, 1986) in category one are the black teat fish, *Holothuria nobilis*; the white teat fish, *H. fuscogilva*; the sand fish, *H. scabra*, and the recently described (Conand, 1986) white sand fish, *H. scabra versicolor*. The second category (medium value) includes the brown fish, *Actinopyga echinites*; the black fish, *A. miliaris*; and the prickly red fish, *Thelenota ananas*. Finally, the third category (low commercial value) includes *H. atra*, *H. fuscopunctata*, *Stichopus chloronotus*, and *S. variegatus*.

Although no standard procedure exists, processed bêche-de-mer grading depends on three main criteria: Commercial category of the species, size of the product (in length or weight), and the quality of the processing.

Although the commercial species are Indo-Pacific in their distribution, the Indian Ocean fisheries are traditionally based on the sand fish, *H. scabra*, while the Western Pacific fisheries use several species. The reproductive biology is now well known for many species, but growth and mortality need more study (Shelley, 1985; Conand, 1989a, b). The biology of the medium-valued *Actinopyga miliaris* is unknown.

## Tropical Pacific Islands

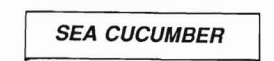
Sea cucumbers are harvested on many South Pacific islands. Fisheries data for New Caledonia, Fiji, Papua New Guinea, and the Solomon Islands were analyzed up to 1986 by Conand (1986, 1989a, 1990).

### New Caledonia

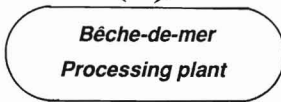
The history of the sea cucumber fishery in New Caledonia, traced back to the nineteenth century, has shown wide fluctuations in connection with politi-

### FROM SEA-BED TO CONSUMER

1 Natural resource in its environment

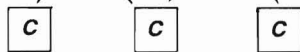


2 Capture by fisherman



3 Processor exporter customs

4 International trader



5 Consumer

### SAMPLING AND STATISTICS

Scientific surveys 1

Sampling the catch 2

Sampling processed products national export statistics 3

International trade statistics (import, re-exports) 4

National import statistics 5

Figure 3. — The holothurian fishery, from the sea-bed to the consumer and the levels for collecting statistics.

cal and socioeconomic events, as well as with the state of the stocks (Conand, 1986, 1989a). The recent revival of the bêche-de-mer fishery started in 1983, when New Caledonians of Chinese origin started to organize the fishing, processing, and trade. As all the catches in New Caledonia are exported, the export statistics provide accurate and easily obtainable data. Table 1 shows the fluctuations in recent annual landings, with a mean annual export of 103 metric tons (t). Annual production alternates from high years (1984, 1986, 1988, 1990) to low (1985, 1987, 1989). The overall trend, however, appears to be generally downward. The number of export companies also fluctuates. Although up to twelve different companies have ex-

ported bêche-de-mer from New Caledonia, only three of them share the major part of the market. Their respective importance also fluctuates (Fig. 4). The exports of the first company fell to 200 kg in 1990. The third company has increased in importance and now handles most of the exports of bêche-de-mer from New Caledonia, while the fourth, which started in 1990, handles 20% of the exports (Fig. 4). The major destinations were Hong Kong and Singapore. In 1987 and 1988, the tonnages exported to Singapore declined, and, since 1989, Singapore has disappeared from the statistics. In 1989 and 1990, exports were mostly destined for Hong Kong, with 3.7 t sent to Taiwan in 1990 (Fig. 4). The other sources of

variability that cause annual production to fluctuate include the species collected, the fishing grounds, and the organization of fishing and processing.

About 100 fishermen are now involved in the sea cucumber fishery. Most are grouped at the tribal level or in cooperatives located primarily on the northeast coast of New Caledonia. On the west coast, a few individual fishermen sell their catch to the processors or exporters. Harvesting takes place at low tide on the reef flats (Fig. 5). Each fisherman collects sea cucumbers in a small area, filling up sacks which are then left on the reef flat until the tide is high. The catch is traditionally processed to bêche-de-mer and sold to the exporter at prices according to their grade.

There have been recent changes in the species harvested. At present, more than 75% of production is from a category-two species, the black fish, which occurs in dense populations on reef flats of the northeast coast. This species is prone to eviscerate, a behavior that results in autotomy of the internal organs and their expulsion through the anus. The catch of black fish is processed the day after harvest, by which time, most have expelled their gut. As a result, the traditional stages of slitting and gutting are not necessary (Fig. 5). Among the category-one species, the sand fish and the white sand fish are still fished in some localities, but exploitation of black teat fish and white teat fish have

Table 1. — Recent bêche-de-mer production (t) from the Tropical Pacific Islands. Sources: National statistics, Asian market imports (Hong Kong, Singapore, Taiwan), FAO statistics.

Islands and data sources	Production (t)				
	1986	1987	1988	1989	1990
<b>New Caledonia</b>					
National statistics	180	77	135	55	126
Asian market imports <sup>1</sup>	100	34	28		
FAO catch	2,520	2,240	1,350	548	
FAO exports					
<b>Fiji</b>					
National statistics	230	670	665	360	323
Asian market imports	155	712	1,295	251	
FAO catch	416	1,026	761	998	
FAO exports	229	640	717	365	
<b>Papua New Guinea</b>					
National statistics	106	192	203	195	
Asian market imports	97	152	327	226	
FAO catch					
FAO exports	85	120	229	157	

<sup>1</sup> Singapore only.

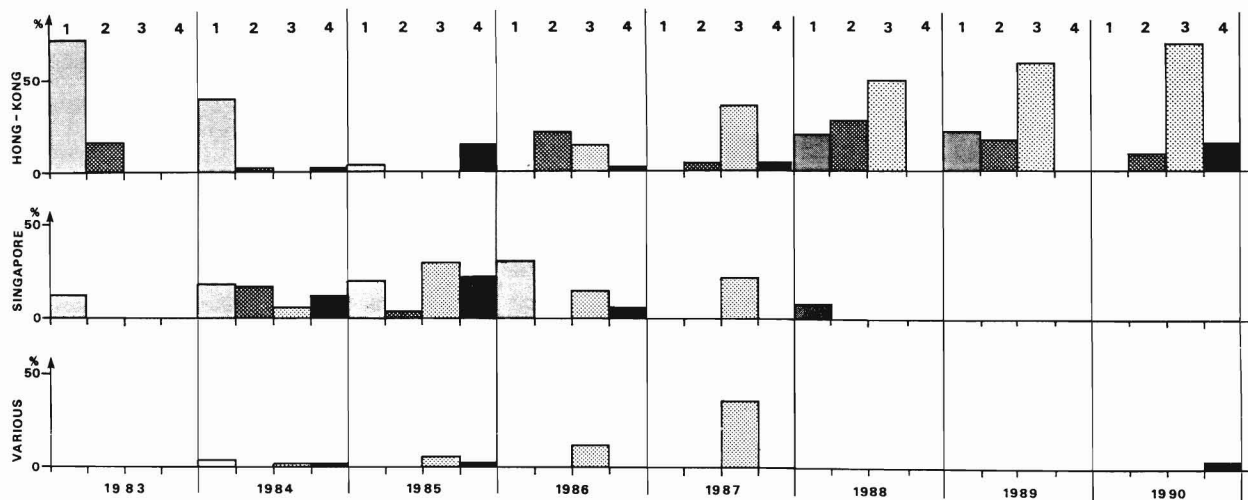


Figure 4. — Exports of bêche-de-mer from New Caledonia, in percentage of annual tonnage, by company and by destination. The numbers 1, 2, and 3 represent main companies; 4 is "other" companies.

markedly decreased. This change is probably related to the trade with The People's Republic of China which now accepts less valuable products.

#### Fiji

In Fiji, *H. scabra* is locally used as a foodstuff, while the bêche-de-mer fish-

ery is traditionally multispecific. The bêche-de-mer industry has undergone a recent major expansion as shown by several sources (Table 1). From a small industry producing some 20–30 t of dried product in 1983, annual production rose to over 700 t in 1988 (Preston, 1990). The major destinations of the

Fijian product are Hong Kong, Singapore, and Taiwan. Although the data varies, export statistics from the Fishery Department, import statistics from Fiji into the Asian markets, and FAO yearbook statistics on nominal catches and exports show correlations. Maximum landings were recorded in

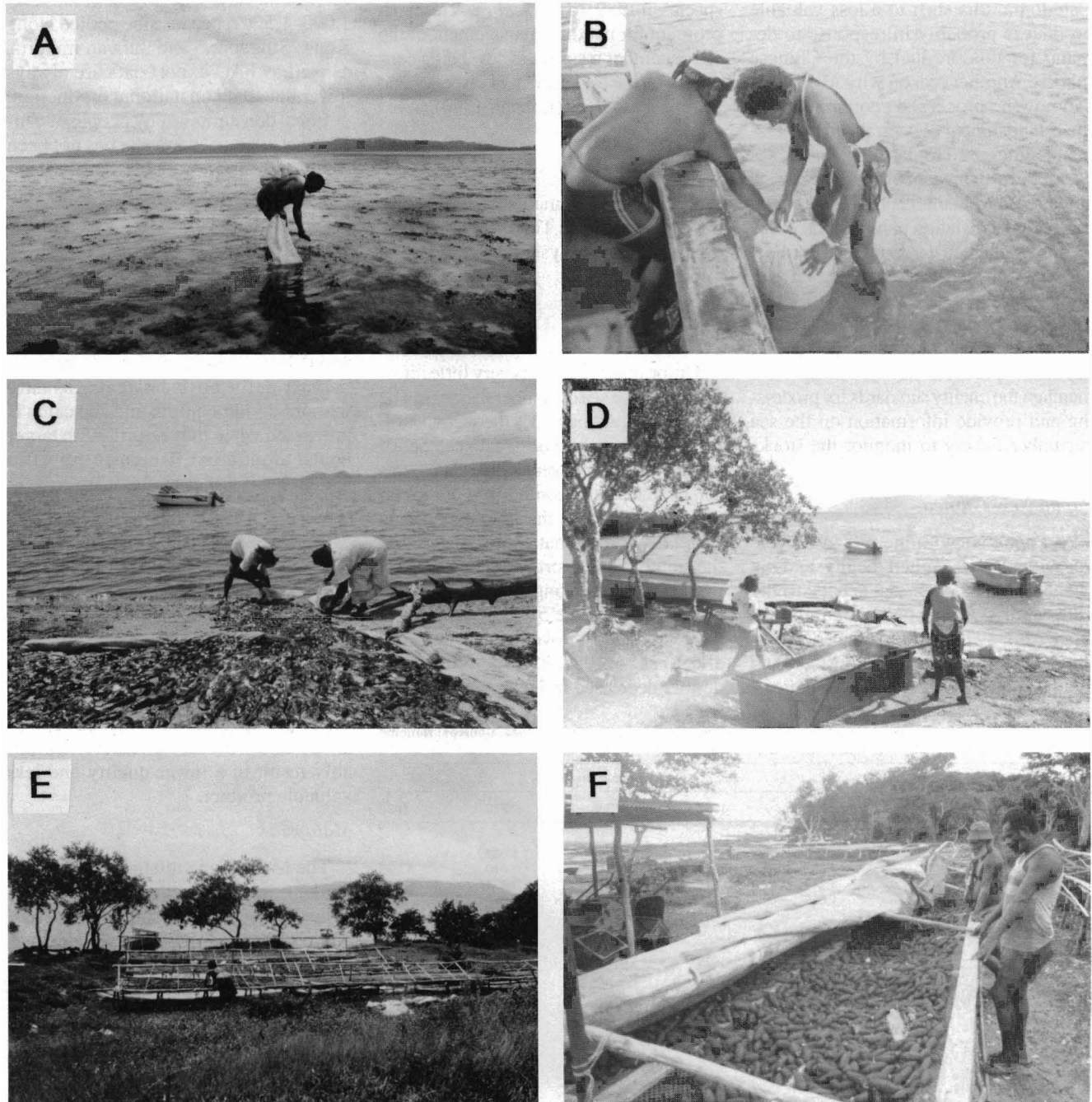


Figure 5. — Harvesting and processing of the blackfish *A. miliaris* in New Caledonia. A) Harvesting on the reef. B) The sacks full of sea cucumbers are shipped. C) Sorting out by size. D) Boiling. E and F) Sun drying. (Photos by C. Hoffschir.)

1987 and 1988 (Table 1). In 1989–90, the sea cucumber harvests appear to have decreased. The expansion of the fishery was accompanied by several structural changes, primarily in the shift from *H. nobilis* and *H. fuscogilva* toward a less valuable species, *Actinopyga miliaris*, which now makes up 95% of Fijian exports. As noted for New Caledonia, this shift to a less valuable product is probably in response to demand for this product by the Chinese market. Another reason why *A. miliaris* can now be processed economically is the establishment of centralized processing facilities used for large batches of sea cucumbers. To prevent overfishing, which could result from this centralized processing, recent legislation bans exports of the locally consumed *H. scabra*. To protect small specimens, the minimal legal length of the processed product is now 7.6 cm. The Fijian Government is also encouraging the development of an association of licensed exporters, who will establish and maintain the quality standards for processing and provide information on the sea cucumber fishery to monitor the stocks (Preston, 1990).

#### Papua New Guinea

In Papua New Guinea, *H. scabra* is occasionally consumed locally, and the bêche-de-mer fishery dates back to the 18th century. After a period of unimportance from 1977 to 1985, the fishery has played an increasingly important role as an income earning activity for inhabit-

ants of coastal communities (Conand, 1989a). This has been of local significance due to the recent depression in copra prices. Statistics from different sources are presented (Table 1). Data for 1990 are needed to determine if the bêche-de-mer fishery declined in that year, as in New Caledonia and Fiji. Unlike other Pacific Islands, in Papua New Guinea the target species in 1989 was *H. scabra*. A research program for national management of the sea cucumber resource is now being conducted by the Department of Fisheries and Marine Resources (Lokani, 1990).

#### Western Central Pacific Countries

Recent developments of the bêche-de-mer fisheries in The Philippines, Indonesia, and Malaysia are presented in Table 2.

##### The Philippines

Unfortunately, there is very little information on the sea cucumber fishery in The Philippines, although it is the second largest producer in the world, with catches of around 20,000 t per year. Three statements can be made from comparison of the statistics (Table 2): 1) the FAO export data correlate with the national statistics and the sum of the imports of the three main markets, Hong Kong being the major importer (see Table 5), 2) F.A.O. nominal catches appear overestimated, and 3) after a peak in 1987–88, exports of bêche-de-mer decreased in 1989.

Table 2. — Recent bêche-de-mer production (t) from the Western Central Pacific countries. Sources: National statistics, Asian market imports (Hong Kong, Singapore, Taiwan), FAO statistics.

Nations and data sources	Production (t)				
	1986	1987	1988	1989	1990
<b>Philippines</b>					
National statistics		2,195	2,062	1,032	
Asian market imports	1,662	2,014	1,815	670	1,218
FAO catch	3,367	3,612	3,193	3,534	
FAO exports	1,659	2,195	2,062	1,022	
<b>Indonesia</b>					
National statistics					
Production	3,670	4,605	4,755	4,888	4,679
Exports <sup>1</sup>	2,342	2,877	3,644	3,040	3,438
Asian market imports	2,820	2,678	3,633	1,987	
FAO catch	478	512	590	590	
FAO exports	2,362	2,517	3,480		
<b>Malaysia</b>					
National statistics					
Asian market imports	138	148	114	74	
FAO catch	500	800			
FAO exports	252	266	135	317	

<sup>1</sup> To Hong Kong, Singapore, and Taiwan.

#### Indonesia

Detailed bêche-de-mer export statistics from several sources have been analyzed (Table 2). Indonesia is now the major world producer and exporter of bêche-de-mer product. From the national statistics, production has been around 4,700 t/year since 1987. The catch data might be overestimated by 1,000–1,500 t, because the pooled Hong Kong, Singapore, and Taiwan imports, as well as FAO export data are always lower than data on national production.

Local consumption by people of Chinese heritage in Indonesia has not been evaluated, but it probably does not exceed a few hundred metric tons. From FAO export data, as well as from the pooled market imports, production appears to have peaked in 1988, as in other countries. In the Indonesian fishery, two types of fishing practices are undertaken according to the size of the boat.<sup>1</sup> With small boats, three or four fishermen harvest daily on local reefs, usually without diving equipment. The catch is processed when they return. With larger boats, around ten fishermen travel to distant reefs for periods of up to several months, often with their families. They use diving gear (compressed air) and sell the processed product in the nearby towns. Approximately ten species of sea cucumbers are processed by traditional Indonesian methods which may include two unusual features: Soaking in salt before boiling and incising the body wall of larger species. These practices give an unusual appearance to the processed product and probably result in a lower quality and less valuable product.

#### Malaysia

The Malaysian situation is complex, as the country appears to be simultaneously a producer, exporter, importer, and consumer. From the available statistics, the products are preferentially exported to Singapore. There is a paucity of data on the Malaysian fishery, and more information is needed to understand its organization.

<sup>1</sup>A. Tuwo, Laboratoire d'Océanographie biologique, UBO, Brest, France. Personal commun., 1992.

**Table 3. — Recent bêche-de-mer production (t) from the Indian Ocean countries. Sources: Asian market imports (Hong Kong, Singapore, Taiwan), FAO statistics.**

Nations and data sources	Production (t)				
	1986	1987	1988	1989	1990
<b>India</b>					
Asian market imports	67	79	33	94	
FAO catch					
FAO exports	33	56	34		
<b>Sri Lanka</b>					
Asian market imports	78	47	72	52	43
FAO catch					
FAO exports	54	45	61	32	
<b>Maldives</b>					
Asian market imports	3	19	347	367	551
FAO catch	3	33	553	553	
FAO exports	3	33	553	500	
<b>Western Indian Ocean countries</b>					
Asian market imports	382	535	620	470	912
FAO catch	250	315	273	227	
FAO exports	188	191	433	114	

### Eastern Indian Ocean Countries

India and Sri Lanka are traditional producers in the northeastern Indian Ocean, and the Maldives are an important newcomer (Table 3). These countries do not have domestic bêche-de-mer markets.

#### India and Sri Lanka

In India, the industry is restricted to the Gulf of Mannar and Palk Bay, although sea cucumber resources are found in many islands. In Sri Lanka, the fishery is established in the Northern Cape. The fishery research institutes of India (Central Marine Fisheries Research Institute) and Sri Lanka (National Aquatic Research Agency) have been conducting studies on the biology of several commercial holothurians and have evaluated the resources for many years. They recently organized a bêche-de-mer workshop which brought together persons involved in the biology, fishery, and trade of commercial species (James, 1989a, b). Overfishing has been reported for both countries. This indicates that the fishery needs to be regulated by size limit on the processed products and by regulation of exports. From the recent statistics presented in Table 3, it appears that the exports are regular and <100 t/year from each country. India exports largely to Singapore, whereas destinations of the Sri Lankan product are more diverse.

#### The Maldives

The Maldives (Table 3) initiated bêche-de-mer production around 1986, at first with very low quantities. A huge increase has brought exports to over 300 t/year since 1988. It is desirable to gain information on this recently expanding fishery to prevent overfishing.

### Western Indian Ocean Countries

Along the western coasts of the Indian Ocean, many African and Arabic countries produce bêche-de-mer. The Republic of South Africa, Mozambique, Tanzania, Kenya, Yemen, United Arab Emirates, and Madagascar all export on a regular basis. The data for these countries have been summarized (Table 3) to give an overview of the regional fisheries. When the total imports by Hong Kong, Singapore, and Taiwan is considered, the data show peaks in 1988 and 1990. This value is always higher than FAO data. Singapore appears to have been the major destination for bêche-de-mer produced in this region until 1989. Other countries, including Sudan and Mauritius, which produce smaller quantities of bêche-de-mer, occasionally appear in the statistics. Comparative examination of the producers in this region shows that Tanzania was the dominant producer until 1989, exporting around 200 t/year. When combined, Kenya and Madagascar exported over 300 t in 1990. The other countries ex-

ported around 50 t/year each, or less until 1989, with an increase of their exports in 1990.

### Temperate Fisheries

Temperate fisheries are divided into the Western and Eastern Pacific regions. The Western Pacific region includes the Japanese and Korean fisheries, which are largely for fresh product, and the smaller Russian and New Zealand bêche-de-mer fisheries. In the Eastern Pacific, the start of small but growing fisheries in Canada and the United States was described by Sloan (1985, 1986). This fishery is for fresh-frozen and bêche-de-mer product. These temperate fisheries are more or less monospecific, based essentially on *Stichopus japonicus* in the Western Pacific and on *Parastichopus californicus* in the Eastern Pacific.

### Western Pacific Ocean

The Japanese and Korean fisheries are mostly for fresh product and have been summarized up to 1983 (Conand, 1990). Recent information is based on FAO data, as most of the national literature is published in Japanese. Figure 6 shows a slight, but consistent decrease in landings from 1983 to 1989.

Japanese fisheries, although widely distributed along the coasts, are particularly important in Hokkaido. A small part of the catch is processed as bêche-de-mer, as illustrated in the recent Japanese best-seller "The eyes of the sea cucumber" (Tsurumi, 1990). Mariculture of *Stichopus japonicus* has started in Hokkaido and involves hatchery pro-

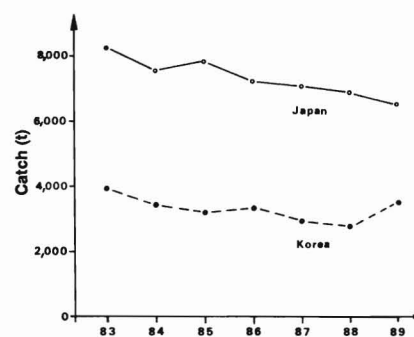


Figure 6. — Catches of *Stichopus japonicus* in Japan and Korea (from FAO data).

duction of juveniles which are transplanted to fishing grounds. From the 1990 statistics, Japanese imports of holothurians are low, with frozen products at 115 t and dried products at 18 t.

The Russian fishery in Peter The Great Bay has declined in recent times, probably due to pollution, but maricultural research continues.<sup>2</sup>

New Zealand's interest in a potential fishery for *Stichopus mollis* has recently increased. The fishery started in 1990 with a special permit granted to one company to collect *S. mollis* from the southwestern fjords. The permit was linked to the collection of information in collaboration with marine scientists to assess the viability and impact of the fishery (Mladenov and Gerring, 1991). The ecology and reproductive biology of *S. mollis* has been documented (Sewell, 1990; Sewell and Bergquist, 1990).

### Eastern Pacific Ocean

A small fishery for *Parastichopus californicus*, utilizing scuba, started around 1970 in the State of Washington. Since that time, catches of this species have been reported from British Columbia (Can.) and the State of California (U.S.A.). In California, a smaller species, *P. parvimensis*, also forms part of the catch (Sloan, 1985; 1986). The Washington and the Canadian fisheries have a unique feature in that the five longitudinal muscles are stripped from the body wall and frozen for export to Japan and Taiwan. The body wall is then processed into *bêche-de-mer* for export. Sloan's (1985, 1986) reviews stated that the fishery is characterized by incomplete market development which imparts instability and causes non-stock-related fluctuations in landings.

Several recent studies have contributed to our knowledge of the biology of *P. californicus*, including studies of its reproductive cycle and spawning behavior (Cameron and Fankboner, 1986; McEuen, 1988; Smiley, 1988a). There are also studies detailing ovulation, the maturation hormone, and meta-

morphosis of this species (Smiley and Cloney, 1985; Smiley, 1986, 1988a, b). Recently, Cameron and Fankboner (1989) described the development, recruitment and juvenile ecology of *P. californicus*, aspects of which are poorly documented for other sea cucumbers.

The Washington dive fishery is controlled by the Department of Fisheries (Bradbury, 1990; Bradbury<sup>3</sup>). Up to 1987, the fishery was assessed through mandatory logbooks filled out by licensed divers, and there were no seasonal or harvest area restrictions. Following signs of overfishing, the Washington Department of Fisheries divided state waters into four harvest areas: The San Juan Islands, Strait of Juan de Fuca, Central Puget Sound, and South Puget Sound/Hood Canal. Commercial exploitation of these areas now rotates, so each district goes unfished for 3½ years after a 6-month harvest. A seasonal restriction has also been imposed, with fishing allowed for 6 months a year, from 1 May to 31 October. The period for closure was decided with respect to the seasonal atrophy of the viscera of *P. californicus* described by Fankboner and Cameron (1985). This rotation of harvest areas should allow the sea cucumbers to spawn at least once before being harvested. Recent research on the

biology of this species provides a scientific basis for the management of the fishery. Limited-entry legislation was also approved in 1990, and the number of boats licensed has declined.

Figure 7 shows the data for the Eastern Pacific fishery from 1975 to 1990. These landings figures, however, should be viewed cautiously, as some catches may have gone unreported. Up to 1977 the sea cucumber landings remained under 10 t/year and then fluctuated for 10 years at an intermediate level under 200 t/year. A marked increase is shown for the last three years with a record catch in 1989 of over 1,000 t. Table 4 summarizes the parameters of the fishery. The value per kilogram increased 2.5-fold during the years 1986–90, making the fishery attractive for divers. Since 1983, the number of boats and effort, in dive hours, increased until the 1990 legislation on limited entry. The number of buyers also increased. The CPUE, in number of sea cucumbers, although variable, is decreasing in the different districts, and, simultaneously, the divers are harvesting in deeper waters.

Among the different measures taken to prevent overfishing, the limited-entry legislation is probably the most important conservation strategy. In the meantime, assessments of the residual resource left behind after fishing and of the recovery rate of holothurian populations are being conducted by fishery biologists. At present, the Washington

<sup>3</sup>A. Bradbury, Washington Department of Fisheries, Brinnon, Wash. Personal commun., 1992.

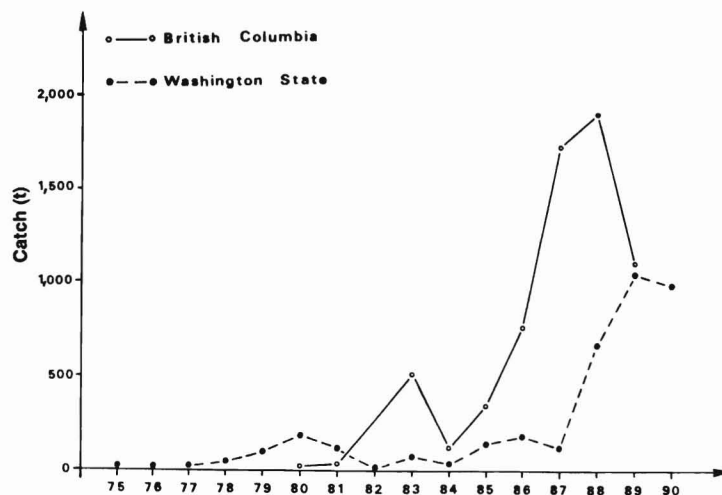


Figure 7. — Catches of *Parastichopus californicus* in Washington and British Columbia.

<sup>2</sup>T. Naidenko, Institute of Marine Biology, U.S.S.R. Academy of Sciences, Vladivostok. Personal commun., 1992.



dive-fishery is the best documented and the most carefully managed sea cucumber fishery in the world.

The sea cucumber landing statistics from California<sup>4</sup> are as follows: 1984, 24 t; 1985, 33 t; 1986, 35 t; 1987, 49 t; 1988, 72 t; 1989, 72 t; 1990, 6 t. Landings consistently stayed under 100 t and, after a relative peak in 1988–89, appear to be declining.

The fishery in British Columbia exhibited rapid development since Sloan's (1986) review. Landings statistics<sup>5</sup> (Fig. 7) show a maximum approaching 2,000

t in 1988. The subsequent decline in 1989 is based on preliminary data.

## Main Markets

### Hong Kong Market

Hong Kong is by far the world's major bêche-de-mer market. Table 5 and Figure 8 show tonnages, total value in Hong Kong dollars, and the average price per kilogram. The US\$ equivalent was calculated from exchange rates given in FAO (1991). For the most important countries, the statistics are expressed as percentage of annual tonnage and value of product supplied to Hong Kong.

The historical record for tonnage imported to Hong Kong was 7,700 t in 1988, followed by a drop in 1989. The record value for imports was in 1990 at HK\$231,500 (equivalent to US\$29,326),

and the mean price per kg is increasing. Hong Kong imports bêche-de-mer largely from ten countries, listed here in decreasing order of importance as of 1989: Indonesia, Singapore, The Philippines, Fiji, People's Republic of China, Maldives, Solomon Islands, Papua New Guinea, Madagascar, and New Caledonia. The mean price per kilogram is low for the products imported from The Philippines and Indonesia and is slightly higher for the Pacific Islands. Products coming from the Western Indian Ocean (Madagascar, Tanzania, Mozambique) fetch good prices. Prices are highest for the temperate Pacific countries (United States and Canada).

Re-exports peaked in 1987 with nearly 5,000 t of bêche-de-mer leaving Hong Kong for other markets. During the last few years, the average price has

<sup>4</sup>W. Klawe, IATTC, Scripps Institution of Oceanography, La Jolla, Calif. Personal commun., 1991.

<sup>5</sup>A. Campbell, Fisheries and Oceans, Canada, Pacific Biological Station, Nanaimo, B.C. Personal commun., 1991.

Table 4. — The dive fishery for sea cucumber in Washington.<sup>1</sup>

Year	Catch (t)	Value <sup>2</sup> (US\$10 <sup>6</sup> )	Price (US\$)	Boats <sup>3</sup>	District 1			District 2			District 3			District 4		
					CPUE <sup>4</sup>			CPUE <sup>4</sup>			CPUE <sup>4</sup>			CPUE <sup>4</sup>		
					E <sup>5</sup>	N	kg	E <sup>5</sup>	N	kg	E <sup>5</sup>	N	kg	E <sup>5</sup>	N	kg
1983	170			9				99	530		281	275				
1984	39			14	68	271	80	225	495		310	220		28	502	
1985	146			15	74	232	69	162	397		1,763	272		336	636	
1986	181			16	345	200	59	253	425		1,116	249		237	321	
1987 <sup>6</sup>	127	0.89	0.70	25	837	248	73									
1988	871	1.07	1.23	78				6,462	381	106						
1989	1,146	1.87	1.63	125							11,437	239	66			
1990	992	1.75	1.76	79										5,833	264	73
1991	1,243	3.79	2.03	70	10,341		120									

<sup>1</sup> Bradbury (text footnote 3).

<sup>2</sup> Estimated from the average price paid per bucket of slit, drained sea cucumbers.

<sup>3</sup> Number of boats making at least one landing.

<sup>4</sup> Mean number (N) or weight in kg per dive hour from harvest log.

<sup>5</sup> Total dive hours.

<sup>6</sup> Since 1987, area openings are rotating by district.

Table 5. — Sea cucumber imports and re-exports from the Hong Kong market.

Year	Tonnage <sup>2</sup>	Value <sup>3</sup>	Price <sup>4</sup>	Imports by main country of origin <sup>1</sup>											
				Philippines			Indonesia			Pacific Islands			Singapore		
				%T	%V	P	%T	%V	P	%T	%V	P	%T	%V	P
1986	5,193	110,947	21.3	30	19	13.5	47	31	13.8	7	11	36.1	6	11	39.7
1987	5,896	131,820	22.3	33	16	10.9	37	28	17.1	13	14	24.4	6	13	44.4
1988	7,716	191,240	24.8	22	13	14.2	40	31	19.0	18	19	26.0	10	14	33.5
1989	4,526	134,306	29.7	14	8	16.3	39	29	21.7	9	9	27.6	23	20	25.4
1990	6,596	231,467	35.1	18	10	19.9	32	27	29.3	9	13	50.0	20	17	29.3

Year	Tonnage <sup>2</sup>	Value <sup>3</sup>	Price <sup>4</sup>	Re-exports by main country of destination <sup>1</sup>											
				China			U.S.A.			Taiwan			Singapore		
				%T	%V	P	%T	%V	P	%T	%V	P	%T	%V	P
1986	4,535	59,822	13.2	86	54	8.2	1	10	84.0	6	16	31.9	3	14	56.2
1987	4,975	55,479	11.2	87	52	6.7	1	8	96.9	8	20	26.6	2	13	71.5
1988	3,303	56,322	17.0	79	45	9.6	1	9	119.5				4	14	66.3
1989	1,847	46,723	25.3	74	46	15.7	3	15	60.6				3	7	60.6

<sup>1</sup> T=tonnage, V=value, P=price per kilogram.

<sup>2</sup> In metric tons.

<sup>3</sup> In 1,000. 1 HK\$ equivalent in US\$ for 1986 is 0.1284; 1987, 0.1284; 1988, 0.1281; 1989, 0.1282; 1990, 0.1267. Exchange rates from FAO (1991).

<sup>4</sup> Price per kilogram in HK\$.

been lower for re-exports. This is due to cheaper products destined for the People's Republic of China, which represents 75% of the re-exports.

### Singapore Market

Singapore is the second largest market for imports and re-exports, but the

local retail market is also very important. The available statistics for the past few years are analyzed and the results are recorded in Table 6 and Figure 9. As noted by Van Eys and Philipson (1991), the import statistics are unreliable because *bêche-de-mer* does not carry an import duty and is therefore not

always specifically identified in shipments of dried seafood. This explains why in 1986 the re-export statistics exceeded the import statistics. For the last few years, however, the figures appear to be more accurate. Because there is no local production, domestic consumption can be estimated from the difference between imports and re-exports. Local consumption increased from 22 t in 1987 to 69 t in 1988 and 105 t in 1989. It decreased to 42 t in 1990. Compared with Hong Kong, there has been only a slight, more or less regular, increase in the tonnages imported, which as for Hong Kong, peaked in 1988. On the whole, for the recent period, Hong Kong handled six times more *bêche-de-mer* than Singapore. At present, the major suppliers to the Singapore market are the Maldive Islands, Pacific Islands, Tanzania, and Malaysia. Until recently, the main suppliers were Sri Lanka, India, and The Philippines. Re-export destinations have also changed. More than half of the re-export tonnages are now destined for Hong Kong. Based on the mean values per kilogram, high-grade *bêche-de-mer* goes preferentially to Taiwan, and the low-grade product goes to Malaysia.

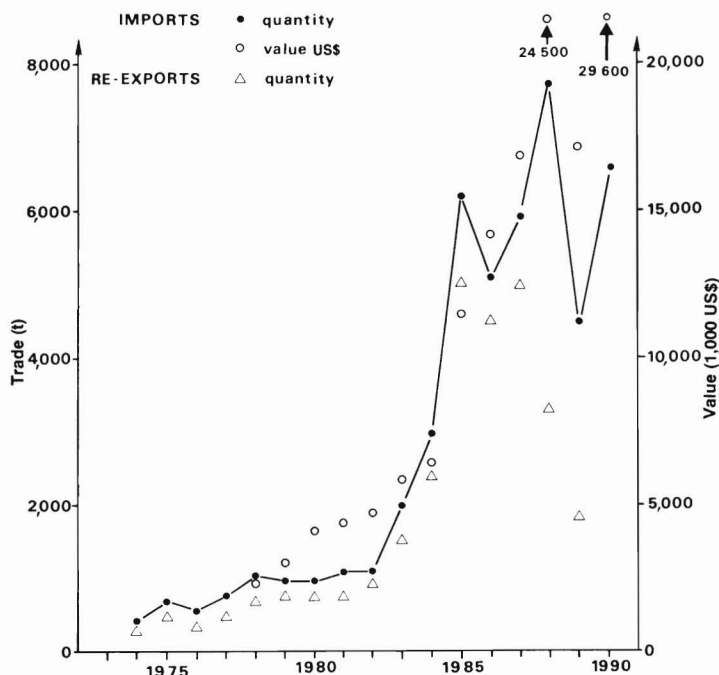


Figure 8. — Hong Kong trade statistics for *bêche-de-mer* (1973–90). Values in US\$ are calculated from exchange rates given in Table 5.

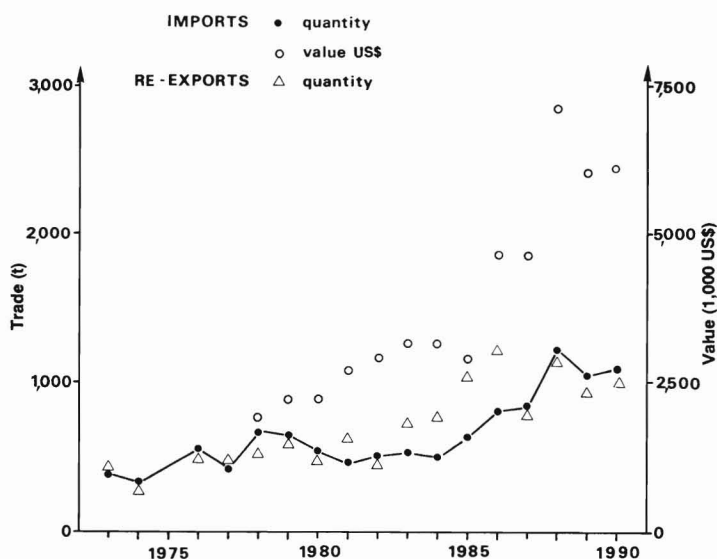


Figure 9 — Singapore trade statistics for *bêche-de-mer* (1973–90). Values in US\$ are calculated from exchange rates given in Table 6.

### Trade Between Hong Kong and Singapore

Trade between Hong Kong and Singapore was obtained from their respective import and re-export statistics (Table 7). If there were good agreement between the statistics, imports from Singapore should be equal to re-export to Hong Kong, and imports from Hong Kong should be equal to re-exports to Singapore. Comparison of the data, however, shows that while the order of magnitude is the same, the figures do differ. Hong Kong's import and re-export tonnages are higher than the corresponding re-exports and imports from Singapore. On the whole, the general tendency is a flux from Singapore to Hong Kong which is opposite to the flux which existed between 1981 and 1984 (Conand, 1986). The exchange is made through sister companies, with higher grades of *bêche-de-mer* being imported by Singapore and lower grades by Hong Kong, probably because Hong Kong supplies the Chinese market with lower grade product.

**Table 6. — Sea cucumber imports and re-exports from the Singapore market.**

Year	Tonnage <sup>2</sup>	Value <sup>3</sup>	Price <sup>4</sup>	Imports by main country of origin <sup>1</sup>											
				Malaysia			Tanzania			Pacific Islands			Maldives		
				%T	%V	P	%T	%V	P	%T	%V	P	%T	%V	P
1986	814	9,599	11.8	17	10	6.7	14	6	5.1	23	24	12.1	0.4	0.5	15.6
1987	840	9,251	11.0	17	12	7.8	24	12	5.5	16	17	11.3	2	3	15.5
1988	1,225	14,614	11.9	8	4	5.9	21	15	8.6	14	12	10.0	28	34	14.5
1989	1,023	11,863	11.4	7	3	5.1	16	11	7.8	23	17	14.4	25	22	10.8
1990	1,068	12,321	11.5	6	3	5.3	10	5	6.8	15	17	13.4	29	25	9.9

Year	Tonnage <sup>2</sup>	Value <sup>3</sup>	Price <sup>4</sup>	Re-exports by main country of destination <sup>1</sup>								
				Hong Kong			Malaysia			Taiwan		
				%T	%V	P	%T	%V	P	%T	%V	P
1986	1,217	6,683	5.5	54	47	4.8	35	33	5.1	9	16.9	9.4
1987	818	7,395	9.0	47	55	10.5	36	27	6.8	14	13	8.6
1988	1,156	11,232	9.7	54	62	11.1	34	20	5.8	7	13	16.0
1989	938	10,043	10.7	46	46	10.6	27	14	5.7	16	29	18.5
1990	1,026	11,022	10.7	63	56	9.6	15	9	6.7	12	21	18.9

<sup>1</sup> T=tonnage, V=value, P=price per kilogram.

<sup>2</sup> In metric tons.

<sup>3</sup> In 1,000. 1 S\$ equivalent in US\$ for 1986 is 0.4593; 1987, 0.4751; 1988, 0.4970; 1989, 0.4990; and 1990, 0.5072. Exchange rates from FAO (1991).

<sup>4</sup> Price per kilogram in S\$.

## Other Markets

Taiwan, like other major importers (The People's Republic of China, Malaysia, Thailand), was once considered to depend on re-exports from Singapore and Hong Kong (Sachithanathan, 1972). This paper is the first detailed analysis of Taiwanese imports. It gives precise information, since 1983, on tonnages, values, and countries of origin (Table 8). From the 8 years analyzed, it appears that in 1987 and 1988, imports doubled compared with the mean for this period. The decrease in imports in 1989 and 1990 is compensated for by the increase in mean value per kilogram. Up to 1985, the origin of the product was essentially Indonesia. Imports are now more diverse with supplies coming from Singapore and Japan. Very high quality products are supplied by Japan. The Pacific Islands (New Caledonia, Fiji, Papua New Guinea) and Indian Ocean countries (Mozambique, Sri Lanka) show variable contributions. Unlike Hong Kong and Singapore, there are no re-exports from Taiwan, because all imports of *bêche-de-mer* are consumed locally.

## Discussion

### General Trends

Although the statistics are incomplete, a tentative evaluation of the *bêche-de-mer* production in the Indo-

**Table 7. — Exchanges of *bêche-de-mer* between Hong Kong and Singapore (1986–90).**

Item and unit	1986	1987	1988	1989	1990
Hong Kong					
Imports from Singapore					
T <sup>1</sup>	301	399	798	1,068	1,313
V <sup>2</sup>	11,938	17,719	26,710	27,138	38,447
P <sup>3</sup>	39.7	44.4	33.5	25.4	29.3
Re-exports to Singapore					
T <sup>1</sup>	153	103	123	55	
V <sup>2</sup>	8,551	7,364	8,157	3,334	
P <sup>3</sup>	56.2	71.5	66.3	60.6	
Singapore					
Imports from Hong Kong					
T <sup>1</sup>	84	30	48	18	47
V <sup>2</sup>	1,744	542	847	301	1,060
P <sup>3</sup>	20.8	18.1	17.6	16.7	22.6
Re-exports to Hong Kong					
T <sup>1</sup>	656	386	631	439	651
V <sup>2</sup>	3,157	4,068	6,977	4,660	6,221
P <sup>3</sup>	4.8	10.5	11.1	10.6	9.6

<sup>1</sup> Tonnage.

<sup>2</sup> Value in 1,000 HK\$.

<sup>3</sup> Price/kg in HK\$.

<sup>4</sup> Value in 1,000 S\$.

<sup>5</sup> Price/kg in S\$.

Pacific and of the temperate fisheries landing is presented in Table 9. When data from different sources were discordant, national statistics were given preference. Between FAO statistics on catches, imports, and exports, and the main market statistics, the most representative data were chosen based on personal knowledge of the fishery.

Recently, *bêche-de-mer* fisheries have increased markedly in tropical countries. This increase was marked by two phases: In 1985–86, production increased threefold over previous activity, and during 1987–89 it doubled again. A slight decline in 1989 was recorded

by many national fisheries. This decline would have been more dramatic if the Indonesian landings were not overestimated, as evident from the market data.

Indonesia and The Philippines continue to dominate the world market in terms of tonnage produced. The recent increase in production by the Eastern Indian Ocean fishery is due to the Maldives fishery which as yet is poorly documented with regard to the species harvested, the processing methods, and the trade. The increase in world production since 1985 was stimulated by an increase in demand from the People's Republic of China for a less expensive,

Table 8. — Taiwan's sea cucumber imports, 1983–90.

Year	Tonnage <sup>2</sup>	Value <sup>3</sup>	Price <sup>4</sup>	Imports by main country of origin <sup>1</sup>								
				Indonesia			Singapore			Japan		
				%T	%V	P	%T	%V	P	%T	%V	P
1983	411	1,350	3.28	90	86	3.13	1	1	3.76			
1984	345	1,425	4.13	96	93	4.03						
1985	423	1,772	4.18	92	89	4.02	1	1	6.75	3	5	5.86
1986	429	1,479	3.44	81	79	3.38	2	1	2.84		1	18.87
1987	787	3,452	4.38	64	49	3.38				4	26	25.07
1988	877	4,663	5.31	57	42	3.97	2	2	4.46	6	30	26.00
1989	357	2,965	8.30	56	35	5.17	10	8	6.23	11	42	30.21
1990	356	3,023	8.49	40	22	4.78	20	18	7.66	12	40	26.92

<sup>1</sup> T=tonnage, V=value, P=price per kilogram.

<sup>2</sup> In metric tons.

<sup>3</sup> In US\$.

<sup>4</sup> Price per kilogram in US\$.

lower grade product. This resulted in a rapid change in the holothurian species being exploited, from first-category species (i.e. *H. nobilis* and *H. fuscogilva*), to a second-category species, *A. miliaris*. Temperate fisheries have been more consistent, with landings of around 12,000 t/year. The slight recent decrease in the Western Pacific fishery was compensated for by the development of the Eastern Pacific fishery.

### Statistics

Access to the statistics at the various levels shown in Figure 3 and their reliability is considered in order to present some conclusions and recommendations for further assessment and management of holothurian resources. Stock assessment is relatively easy for these sedentary animals, and it needs to be carried out by a combination of methods such as direct underwater counts, counts from photographs of quadrats, and remote sensing of shallow-water reefs. As described for New Caledonia, these methods are useful in assessing the biomass of the main commercial species in reef environments (Conand, 1979).

Stock assessments are rarely undertaken, and those that are available do not provide the environmental parameters required for interpretation. Catch and particularly effort data are seldom collected in tropical sea cucumber fisheries. The available statistics only provide a gross evaluation, as there are many sources of variation depending on the species, the fishing areas, and the aptitude of the fishermen. Although the

Table 9. — World sea cucumber catch from the main regions, 1983–89.

Fisheries and regions	Catch (t)						
	1983	1984	1985	1986	1987	1988	1989
Tropical fisheries							
Dry weight (t)	1,445	1,414	5,400	4,000	8,000	8,200	7,800 <sup>2</sup>
Catches (t) <sup>1</sup>	14,450	14,140	54,000	40,000	80,000	82,000	78,000 <sup>2</sup>
Percentages by:							
Tropical Pacific	4	22	6	20	29	22	9
Western Central Pacific	76	66	84	67	62	66	77 <sup>2</sup>
Eastern Indian	10	7	1	3	1	5	8
Western Indian	8	5	9	10	8	7	6
Temperate fisheries							
Catches (t)	12,958	12,215	11,558	11,653	11,903	12,468	11,922
Percentages by:							
Western Pacific	95	91	95	92	84	78	81
Eastern Pacific	5	9	5	8	16	22	19
World catches <sup>3</sup>	27,408	26,355	65,559	51,653	91,903	94,468	89,922 <sup>2</sup>

<sup>1</sup> Data increased by one order of magnitude to account for the processing weight loss.

<sup>2</sup> Data might be overestimated for Indonesian catches.

<sup>3</sup> Tropical + Temperate catches.

statistics are of questionable quality, they show that depletion of fishing grounds due to overfishing can occur rapidly for these slow-moving animals, as shown in New Caledonia by the decreased CPUE for *H. scabra versicolor* and *H. scabra* (Conand, 1989a). Adequate capture and processing statistics are needed to establish surplus production models and should be standardized using either logbooks or assessment at the landing sites or in processing plants.

National customs agency statistics are very useful to estimate local fisheries. In this review, national export statistics are considered to represent production, and national import data are considered to represent consumption. This implies that producer countries are not consumers and that consumers are not producers. This first bias and other inaccuracies result from various customs legislation on imports and exports. Considering the present increase in bêche-de-mer fisheries, data which need to be collected include detailed records

for the different species harvested and grades produced. The validity of the information should be tested through a consultation between the fisheries agencies and customs departments of each country.

World market statistics (Hong Kong, Singapore, Taiwan), as well as international FAO statistics, are very useful in checking and complementing the available national data. Their reliability to indicate national production is nevertheless reduced due to the reciprocal exchange of product between the markets. Some products are first imported by one market, then re-exported to another one, before arriving in the consumer country, as shown for Hong Kong and Singapore.

The South Pacific Commission<sup>6</sup> has recently started the *Bêche-de-mer Information Bulletin*, which is a useful source of information on the state of the fisheries, the markets, resource surveys,

<sup>6</sup>SPC, B.P. D5, Nouméa, New Caledonia.

and recent research on the biology of commercial species.

### Management Recommendations

Recent trends in bêche-de-mer fisheries show a marked increase in landings due to a strong increase in demand. The risk of overexploitation at present is high. Predicting yields, an important objective of fishery research, is obtained by structural and heuristic models. Structural models need the input of data, both from the populations parameter and from the fisheries. Recent research on the reproductive biology of the majority of the commercial species allows recommendations to be made on size regulations for the fresh, or processed, product based on size at first sexual maturity (Conand, 1989a). This information needs to be utilized for fishery management. Information on recruitment, growth, and mortality of holothurians is only available for a few species (Shelley, 1985; Conand, 1989b), and research on these subjects should be given priority. Structural and heuristic models are considered to play complementary roles. As noted by Fogarty (1989), it is often possible to provide more accurate predictions with heuristic models. Fogarty (1989) also gives a number of examples where landings of mollusks and crustaceans have been related to explanatory (environmental) variables.

The case of sea cucumber fisheries shows a very complex system of interactions, where economic and social factors play important roles. To quantify the different trade pathways, price analyses have to be conducted at the national level and for the world markets in Hong Kong, Singapore, and Taiwan.

### Acknowledgments

We wish to thank the colleagues who kindly supplied valuable information: A. Bradbury (United States); A. Campbell (Canada); C. P. Chen (Taiwan); T. Do Chi and A. Crispoldi (FAO); J. P. Gaudechoux, G. Preston, and C. Hoffschir (New Caledonia); D. B. James and B. K. Baskar (India); W. Klawe (United States); P. Lokani (Papua New Guinea); P. Mladenov (New Zealand); T. Naidenko (Russia), and the FAO and the

French Trade Commission in Singapore which provided statistics. An anonymous reviewer provided useful comments which improved the manuscript.

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