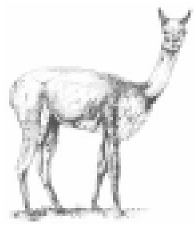
CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES
OF WILD FAUNA AND FLORA



Twenty-second meeting of the Animals Committee
Lima (Peru), 7-13 July 2006

SEA CUCUMBERS

1. This document has been prepared by the Secretariat.

2. The Conference of the Parties adopted at its 13th meeting (Bangkok, 2004) the following two Decisions concerning sea cucumbers, directed to the Animals Committee and the Secretariat respectively:

   13.48 The Animals Committee shall:

   a) review the proceedings of the International technical workshop on the conservation of sea cucumbers in the families Holothuriidae and Stichopodidae (March 2004, Kuala Lumpur), as well as those of the forum on Advances in Sea Cucumber Aquaculture and Management (ASCAM) convened by the Food and Agriculture Organization of the United Nations (October 2003; Dalian); and

   b) prepare, for consideration at the 14th meeting of the Conference of the Parties (CoP14), a discussion paper on the biological and trade status of sea cucumbers in the above families to provide scientific guidance on the actions needed to secure their conservation status.

   13.49 The Secretariat shall assist in obtaining funds to support the preparation of the Animals Committee discussion paper on the biological and trade status of sea cucumbers in the families Holothuriidae and Stichopodidae.

3. At its 21st meeting (Geneva, May 2005), the Animals Committee agreed that a draft of the discussion paper called for in Decision 13.48 should be prepared by a consultant for consideration by the Committee at the present meeting. It developed terms of reference for the consultant's work and a format for the discussion paper [see document AC21 WG5 Doc. 1 (Rev. 1)].

4. Having secured the necessary financial support thanks to a grant from the Government of the United States of America, the Secretariat, as requested for by the Committee, contracted an expert, Ms Verónica Toral-Granda of the Charles Darwin Foundation in the Galapagos Islands, to produce a draft discussion paper on the biological and trade status of sea cucumbers in the families *Holothuriidae* and *Stichopodidae*, which is annexed hereto.

<u>Issues for consideration</u>

5. The Animals Committee is invited to review and finalize the discussion paper presented in the Annex to this document in order to ensure timely reporting for CoP14, in compliance with Decision 13.48.

DISCUSSION PAPER

THE BIOLOGICAL AND TRADE STATUS OF SEA CUCUMBERS IN THE FAMILIES HOLOTHURIIDAE AND STICHOPODIDAE

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1 Background

1.1. Sea cucumbers and CITES

At the 12th meeting of the Conference of the Parties (CoP12; Santiago, November 2002), the Parties discussed trade in sea cucumbers in the families Holothuriidae and Stichopodidae (see document CoP12 Doc. 45) and adopted Decisions 12.60 and 12.61 on these taxa. The CITES Secretariat was directed to obtain funds for and convene a technical workshop on this issue, and the Animals Committee (AC) was to review the outcomes of the workshop and prepare for consideration at the 13th meeting of the Conference of the Parties (CoP13) a discussion document on the biological and trade status of these sea cucumbers to provide scientific guidance on the actions needed to secure their conservation status.

The CITES Secretariat held an international technical workshop on the conservation of sea cucumbers in the families Holothuriidae and Stichopodidae in Kuala Lumpur, Malaysia, from 1 to 3 March 2004. However, the AC Chairman reported at CoP13 that principally due to time constraints, the Committee had been unable to compile a discussion paper (see document CoP13 Doc 37.1). The Parties therefore adopted Decisions 13.48 and 13.49 to (i) extend the deadline for completing the AC discussion paper until the 14th meeting of the Conference of the Parties (CoP14); and (ii) call on the Secretariat to assist in obtaining funds to support the drafting of the discussion paper (see document CoP13 Doc. 37.2).

Decision 13.48 also instructs the AC to review the proceedings of the international technical workshop organized by the CITES Secretariat and those of the forum on Advances in Sea Cucumber Aquaculture and Management (ASCAM) convened by the Food and Agriculture Organization of the United Nations (FAO) (October 2003; Dalian). A comparison of the main recommendations from both workshops is presented in Annex 1. Further details on the objectives and results of the two workshops can be found in information document AC22 Inf. 1 for the 22nd meeting of the Animals Committee (AC22).

This draft discussion paper generally follows the guidelines and terms of reference provided by the AC [see document AC21 WG5 Doc. 1 (Rev. 1)], and represents the work funded by the CITES Secretariat in accordance with Decision 13.49.

2. Biological and trade status

2.1. Natural history and population status of sea cucumbers

2.1.1. Taxonomy

Holothurians (sea cucumbers) are one of the five extant classes of echinoderms. There are about 1,500 species distributed in six orders and 25 families. The six orders are divided by the presence or absence of tube feet or podia (ambulacral system), the shape of the mouth, the presence or absence of oral retractor muscles, respiratory trees and cuvierian tubules (Conand, 1990). According to Conand (2005a) and Bruckner (2005b), there are about 42 species of sea cucumbers that area commercially important; however, this number is very likely going to increase in the near future due to ongoing taxonomic reviews. Most commercially harvested species belong to the Aspidochirota (families Stichopodidae and Holothuriidae), with a few commercially important species belonging to the order Dendrochirota (Family Cucumariidae) (e.g. *Cucumaria frondosa*). Many taxonomic uncertainties occur within the commercial species, and a study to revise the taxonomy has been identified as a priority (Uthicke and Benzie, 2003; Lovatelli *et al*, 2004; Uthicke *et al.,* 2005).

2.1.2. Reproductive behaviour

Most sea cucumbers are broadcast spawners, releasing their gametes into the water column. The success of reproduction depends directly on the density of adults to ensure high enough concentrations of sperms and eggs that they may come into contact. Water currents play an important role as they carry the released gametes, helping in the reproduction; however, no information is available on whether water currents *per se* induce reproduction. To the author's knowledge, no information is available on the role of food availability on reproductive behaviour. Reproductive events of some species may be correlated with sea temperature. Sea cucumber species may have an annual reproductive cycle (Conand, 1993; Hamel and Mercier, 1996; Herrero-Perezrul *et al*., 1999; Shiell and Uthicke, 2005), bi-annual (Harriot, 1985) or even some without a reproductive pattern (Harriot, 1985). Although most holothurians are dioecious (i.e. separate sexes, males and females) there are a few species in which individuals have both sexes (hermaphroditism) with a few species reproducing asexually by fission. Fertilized eggs develop into a pelagic larvae found as plankton that after 10 to 90 days settle on the sea bottom. Larvae may settle in specific habitats, with smaller individuals migrating into a different habitat later in life.

2.1.3. Distribution, ecosystem importance and ecology

Sea cucumbers can be found throughout the marine environment, from the intertidal and shallow seas to abyssal depths. They can be demersal or pelagic (mostly abyssal forms) with the highest species diversity in the Indian and western Pacific Oceans. Holothurians are slow-moving invertebrates that can live on sand, mud, rock and reef flats, often related with seaweeds, coral and sea grasses whilst some others live buried in the sand with their oral tentacles exposed. Many sea cucumber larvae exhibit diurnal behaviour to make them less accessible to predators (e.g. burrowing in the sand). Adult sea cucumbers may be either diurnal or nocturnal with diurnal sea cucumbers showing higher patterns of activity during the day, and burrowing in sand or seeking crevices to spend the night. Nocturnal species may hide or burrow during the day, to be active at night.

Most commercial sea cucumbers are detritivores, a key role within the marine ecosystem as they conduct functions including nutrient recycling and bioturbation (Bakus, 1973; Barnes, 1977; Uthicke and Klumpp, 1998; Uthicke, 1999; Uthicke, 2001). Like earthworms, sea cucumbers consume and grind sediment and organic matter into finer compounds, turning over the top layers in the sea bottoms, allowing oxygen to enter the sediment. This prevents the accumulation of organic matter and may help controlling pathogens. Adult sea cucumbers have few predators: sea stars, certain fishes and crustaceans (Francour, 1998). Juveniles and larvae are predated by fishes such as those in the families Balistidae, Labridae, Lethrinidae and Nemipteridae (Dance *et a*l., 2003). As a defence mechanism, adult sea cucumbers can eviscerate parts of their internal organs, which regenerate later, to fend off predators. Such behaviour has not been observed in juveniles. Additionally, holothurians have toxic chemicals that protect them. Several species have unique symbionts, including molluscs and fish such as pearl fishes that may disappear once a species is overexploited (Bruckner, 2003). The consequences of sea cucumbers becoming locally ecologically extinct are not fully understood, but cascade effects may be expected such as the ecological or biological extinction of other benthic species. This area of research has also been identified as a priority (Lovatelli *et al*., 2004; Bruckner, 2005b).

2.1.4. Population and fishery status

Sea cucumbers, known as 'beche-de-mer' or 'trepang'[1], are generally consumed in Asia, where it is regarded as traditional medicine, a delicacy and an aphrodisiac. The rising demand in these markets prompted declines of many holothurian populations worldwide. Tropical sea cucumber fisheries in traditional fishing grounds of the Indo-Pacific are multispecific, with several species targeted in the same fishing grounds. In other tropical fisheries such as in the Indian Ocean, eastern Pacific and Caribbean, the fishery generally focuses on a few species that seldom occur in the same fishing area. Temperate fisheries are monospecific (Conand, 2004, 2005b; Bruckner, 2005b). The stocks of many tropical and temperate species are reportedly over-harvested (Lovatelli *et al*., 2004; Bruckner, 2005b; Uthicke and Conand, 2005; and references therein) (see Annex 2).

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[1] *Also known as 'Hai-som' by the Chinese and 'Iriko' by the Japanese.*

Since the 1980s, sea cucumber harvesting has followed a 'boom-and-bust' cycle, with an increase of producing countries and species in trade to attempt to supply the increasing demand in Asian markets. The 'boom' part of the cycle usually reduced the resource to such low levels that there was little capacity for natural recovery and replenishment. It often took three to four decades before sea cucumbers stocks recovered again to profitable commercial levels, mainly due to the fact that sea cucumbers can be harvested to low levels, beyond those needed for natural replenishment of the populations (Battaglene and Bell, 2004). The fishery in the Solomon Islands provides a good example of this case, with peak catches in 1878 followed by overfishing and a rapid depletion of the resource. This low level of exploitation was maintained for much of the 20th century, with higher catches in the 1980s, peaking again in 1992. The catches then declined again by 1996 (Battaglene and Bell, 2004). Additionally, Richmond (1997) refers to the sea cucumber fishery in Chuuk (Truk) where there was no observed recovery 50 years after overexploitation. In Papua New Guinea (PNG), population surveys undertaken several years after the closure of the fishing indicate little recovery, with both adults and recruits absent (D'Silva, 2001).

The over-exploitation of traditional fishing grounds in the Pacific and Indian Oceans prompted fishers to migrate to new locations or to target less valuable species (Uthicke *et al*., 2004), which could be a good indicator of resource over-exploitation (Uthicke, 2004). Based on the available literature, many sea cucumber fisheries, whether tropical or temperate, appear to be in different stages of overexploitation (Annex 2). For example, the Torres Strait fishery for *Holothuria scabra* was closed in the mid 1990s and the current biomass is still very low (Skewes *et al*., 2000). Bi-annual population surveys of *Isostichopus fuscus* conducted since 1999 in fished sites of the Galápagos Islands identified smaller breeding populations each time, and only one recruitment event (i.e. massive presence of juveniles) was recorded in 2000-2001 (Toral-Granda, 2005a) probably due to low adult densities. In PNG, catches of *Holothuria nobilis* peaked in the early 1990s. However, these declined few years later prompting migration to newer fishing grounds in and outside PNG or targeting less valuable species (Kinch, 2002, 2005).

Conand (2004) identified 42 species under population stress as a result of international trade to satisfy the beche-de-mer market and later, Bruckner (2005b) refined such list and identified them as priority species for international conservation and protection (Annex 3). At the CITES workshop (Bruckner, 2005), each species was categorized according to different levels of conservation concern. Five species were identified as being of high concern (i.e *Holothuria fuscogilva, Holothuria nobilis*, *Holothuria scabra, Isostichopus fuscus* and *Thelenota ananas*), seven of concern in certain countries of its range (e,g. *Actinopyga echinites*, *Actinopyga Mauritania, Stichopus horrens*), four of potential for future concern as harvest increases (e.g. *Cucumaria frondosa, Isostichopus badionotus, Parastichopus californicus*), 15 of no concern (e.g. *Apostichopus japonicus*, *Holothuria edulis, Parastichopus parvimensis*) and 6 as being minor species of little commercial importance (e.g. *Holothuria impatiens*, *Stichopus mollis*). The following seven criteria were used to designate these categories: (i) commercial value; (ii) vulnerability to harvest and environmental fluctuations; (iii) geographic distribution; (iv) historical and present status of the different populations; (v) importance in world trade; (vi) concern raised by several countries; and (vii) knowledge of particular biological features (i.e. slow growth) or genetic information (i.e. isolated populations).

Additionally, during the CITES workshop (Bruckner, 2005) participants also identified geographical hotspots for sea cucumber diversity, which included the east coast of Africa (Egypt, Kenya, Mozambique, Somalia, Sudan, Tanzania and Yemen), West Indian Ocean island countries (including the Comoros, Madagascar and the Seychelles), the western Pacific (Fiji, New Caledonia, Papua New Guinea, Solomon Islands, Tonga, Vanuatu), Asia (China, Indonesia, Malaysia, the Philippines, Thailand, Viet Nam) and the central and north western parts of South America (Costa Rica, Ecuador, Guatemala, Honduras, Mexico).

2.1.5. Harvesting techniques

Fishers may operate from the shore, hand collecting sea cucumber in shallow waters by means of reef flat gleaning at low tide or wading, or use small wooden or fibreglass boats equipped with outboard or stationary engines to access populations offshore or in deeper waters. When diving, fishers may use hookah (air supplied by means of a compressor on mother boat) or SCUBA gear. Few traditional fishers still use free diving to reach populations in calm seas. Small trawl boats (roller pulling nets, beam trawl nets, scallop-drag gear) are also used in soft bottom habitats. Divers may use spears, hooks, scoop nets or their hands to collect sea cucumbers.

2.2 Utilization of sea cucumbers

2.2.1. Characteristics of main species in trade

Beche-de-Mer species can be ranked as of high, medium or low commercial importance based on abundance, appearance, odour, colour, thickness of the body wall, main market demand and value. Once processed and according to the dish and the occasion during which it will be served, beche-de-mer obtains different prices according to moisture content, exterior appearance, size, flesh thickness and species type (Lo 2005). Once caught, sea cucumbers are gutted, boiled and/or dried or roasted. Beche-de-mer is then preserved through drying, smoking, canning or freezing (Bruckner, 2005c). Currently the highest value species are *Holothuria scabra*, *Holothuria fuscogilva*, and *Holothuria nobilis* which are worth USD 15-40/kg. Species of medium value include *Actinopyga echinites, Actinopyga miliaris* and *Thelenota ananas*, worth USD 10-12/kg. Low value species include *Bohadschia marmorata*, *Holothuria atra*, *Holothuria fuscopunctata*, *Stichopus chloronotus* and *Stichopus variegatus*, fetching USD 2-10/kg (Bruckner, 2005b). The quoted prices are those on final markets.

2.2.2. Levels and types of utilisation

Trade in beche-de-mer is very widespread and one of the oldest form of commerce in the Pacific Islands, (Conand and Byrne, 1993) mostly to satisfy oriental markets for luxury food. Major consumers are China PR, Hong Kong SAR, Taiwan Province of China, Singapore, Korea and Malaysia (Ferdouse, 2004). A few species are also used for medicinal purposes (e.g. *Stichopus horrens* in Malaysia) and for display in aquaria (sea apples, *Pseudocolochirus* spp., *Holothuria atra*, *Holothuria edulis*, *Holothuria impatiens*). The visceral organs, such as fermented intestines (konowata) and dried gonad (kuchiko) of commercially important species are marketed in Japan, Korea and China (Stutterd and Williams, 2003). Sea cucumber meat is believed to contain beneficial chemicals that possess antibacterial and antifungal properties (Hamel and Mercier, 1997) and even considered an aphrodisiac in China (Uthicke and Klumpp, 1996).

In China, sea cucumbers are regarded as a folk remedy and a medicine, and their utilization has been recorded since the Ming Dynasty (1368-1644 BC) (Chen, 2004). Sea cucumbers are considered a health tonic, normally used to treat weakness, impotence, debility of the aged, constipation and frequent urination, and as a food item in China where Chinese cooks have revered sea cucumbers since ancient times. This has led to long lasting traditions especially in coastal communities where its consumption has become part of local cultures and customs (Chen, 2004). Sea cucumber presents a high nutritional value due to its high protein, low fat content, aminoacid profile and presence of trace elements, which makes them a valuable food item (Chen, 2004). As a medicinal item, sea cucumbers have a variety of chemical compounds used to threat anaemia, inhibit some cancers, enforce immune function and reduce arthritic pain (Chen, 2004).

The main use for sea cucumbers as food is for the consumption of the body wall, mostly as: (i) dried product (known as trepang, beche-de-mer, hai-som) of which Chinese are the main consumers; (ii) boiled or salted; (iii) raw, for which Japan is the main market; and (iv) as traditional food cooked in coconut milk (Conand, 1990). There is a local fishery for *Stichopus variegatus* in the Cook Islands, Palau, Pohnpei, Samoa and other countries which by means of a puncture on the dorsal area harvest only the intestines. The animals are later returned to the sea where they regenerate their organs. In some East Asian countries, sea cucumbers are also used as medicine. In Malaysia (Baine and Poh-Sze, 1999a,b; Poh-Sze, 2004) the use of species of the genus *Stichopus* (locally known as 'gamat') is reported for their medicinal properties in a variety of circumstances such as the treatment of wounds, stomach ulcers and as a painkiller. Their chemical composition has been found to be useful in reducing arthritis pain and artharalgia, and the saponins in sea cucumbers have antiflammatory and anticancer properties (Awaluddin, 2001). Additionally, gamat oil and by products are found in a variety of products such as liniment oil, toothpaste, body lotion, soaps (Poh-Sze, 2004; Conand, 2005b). In Japan, there is a patent for sea cucumber chondroitin sulphate in HIV therapy (Conand, 2005b).

2.2.3 Threats

Over-exploitation to satisfy demand for beche-de-mer is the main threat to sea cucumber populations. Additionally, the mechanization of fishing techniques, like the use of hookah or SCUBA diving, are rendering otherwise unexploitable populations suitable for fishing (i.e. inhabiting deeper zones). Despite the commercial importance of sea cucumbers, their biology, ecology and population dynamics remain poorly understood. Current information on growth rates, larval ecology, recruitment processes, habitat use, ecological role, maximum sustainable yields, minimum stock size and threshold value for reproductive success, amongst others, is scant and in cases available for only a few species. An indirect threat is the lack of scientific information to produce comprehensive management plans that could ensure the conservation of these species and sustainable harvest regimes. However, in the case of *Isostichopus fuscus* in the Galápagos Islands, which has a moderate array of information to sustain a fishery under sustainability indicators (Toral-Granda and Martínez, 2004), interested parties exerted socio-economical and political pressures so as to forego scientific information and open the fishery under clearly non sustainable management practices (Toral-Granda and Martínez, 2004, Altamirano *et al*., 2004, Toral-Granda, 2005a). When a fishery is no longer economically viable, the activity would probably be directed towards another species of sea cucumber with less commercial value (i.e. *Stichopus horrens* in the Galápagos Islands) for which no or far less biological or ecological information is available. This example from the Galápagos Island shows how sea cucumber fisheries can spiral into overexploitation and eventual collapse, and a gap of scientific information that cannot be retrieved.

Another threat to sea cucumbers is habitat degradation and loss. Many commercial sea cucumbers are found in coral reefs and coral beds which are being degraded due to climate oscillations (e.g. El Niño), environmental disasters (e.g. tsunamis), and many human-induced causes, including unsustainable fishing practices (e.g. blasting and poisoning) and coastal pollution and sedimentation. Although poorly documented, but still a threat, some species have been scientifically over-exploited (e.g. samples for scientific studies), such as *Holothuria fuscogilva* in New Caledonia (Conand, 2005a) and *Isostichopus fuscus* in an islet off Santa Cruz island, Galápagos Islands (V. Toral-Granda, pers. obs.).

2.3 Production methods and volumes

2.3.1 Capture fishery (targeted, bycatch)

Tropical fisheries in the Indo-Pacific Ocean target multiple species, whereas temperate fisheries are monospecific (Conand, 2004, 2005a,b). In countries ranging from temperate to tropical regions occur about 42 commercially important sea cucumber species (Conand, 2005a) that yield mostly food. Traditional artisanal fisheries in the western Pacific and Indian Ocean export dry sea cucumbers. Temperate countries generally produce fresh or frozen products (Conand, 2005b). The global beche-de-mer market is basically ruled by Chinese traders, who have been searching for and buying sea cucumbers for over 1000 years in areas as varied as India, Indonesia, the Philippines, Australia (Conand and Byrne, 1993) and later, upon depletion in some of these, moved westwards to new fishing grounds such as Africa and the Americas.

World sea cucumber capture fisheries drastically increased from 4,300 tonnes in 1950 to a peak of 23,400 tonnes in 2000, decreasing to 18,900 tonnes in 2001 (fresh or chilled, frozen, dried, salted or in brine, canned) (Vannuccini, 2004). The recorded increase is probably due to a combination of more countries producing sea cucumbers, a greater number of species harvested, the increase of fishing effort by targeting deepwater stocks and the gradual expansion of fishing areas (Bruckner, 2005b). Certain countries (i.e. United States of America, Bruckner, 2005c; Ecuador, Toral-Granda, 2005a) have documented drastic decreases in their landings due to overexploitation of wild populations. For all species except *Apostichopus japonicus*, Indonesia is the world's largest producer followed by the Philippines with over 1,000 tonnes (Gamboa *et al.,* 2004), followed by the United States of America, which probably includes Canadian catches, and Papua New Guinea (Conand 2005b). Japan is the largest producer of *Apostichopus japonicus* with over 7,000 tonnes, followed by Korea (900 tonnes) and China (over 350 tonnes) (Conand, 2005b).

Holothuria scabra is a species with a broad distribution and probably the most valuable and most widely harvested in tropical regions (Conand, 2005a). Many other *Holothuria* species have relatively low value but are still collected, particularly once that higher value species have become scarce. The populations of the most profitable species, *Holothuria scabra* and *Holothuria nobilis*, have collapsed in various locations throughout their range (e.g Torres Strait, Australia) and new species are now being collected, adding to the number of commercial species. In the eastern Pacific, the most important sea cucumber fishery is in Mexico and the Galápagos Islands for *Isostichopus fuscus* (Toral-Granda, 2005a), with incipient activities in Peru and Chile (Guisado, 2005) focusing on *Pattalus mollis* and *Athyonidium chilensis* (Cucumariidae).

In most tropical countries where there is traditional sea cucumber fishery, harvesting is done by hand, wading at low tide, or by snorkelling or SCUBA. These targeted methods produce little bycatch of sea cucumbers. However sea cucumbers may become the bycatch from other fishing operations, particularly when dredging or trawling [e.g. *Holothuria scabra* in prawn nets in Madagascar (Rasolofonirina *et al.,* 2004)]. In Quebec and New Foundland, Canada, *Cucumaria frondosa* is a bycatch of scallop fishing and although they are returned to the sea, most die (Hamel and Mercier, 1999). Sea cucumber can also be targeted to supplement other fishing operations in other commercial taxa. For example, fishers for geoduck (the saltwater clam *Panope abrupta*) and sea urchins (*Strongylocentrotus* spp.) in British Columbia (Bruckner, 2005a) collect sea cucumbers. In tropical reef areas, sea cucumber fishery may be a more or less important component of multi-taxon fisheries targeting reef fishes, corals and other invertebrates. In Mozambique, some sea cucumbers are caught in trawl and gillnets. Low amounts of sea cucumbers are taken as bycatch in trawl fisheries around Australia (i.e. northern prawn fishery and Torres Strait prawn fishery), noting that it is not permitted to keep any sea cucumbers caught as a result of bycatch within those fisheries.

2.3.2. Aquaculture

Despite growing concerns about the impact of aquaculture on biodiversity and the environment (Naylor *et al.,* 2000) this is one of the fastest-growing food production systems in the world, particularly in developing countries. Aquaculture is expected to continue its contribution to food security and poverty alleviation (Williams *et al*., 2000). According to FAO (2004b), the part of aquaculture in the global fisheries production has increased from 3.9 % in 1970 to 29.9 % in 2002, with an average growth of 8.9 % per year in comparison to 1.2 % for capture fisheries. Of the total world production (51.4 tonnes worth USD 60 billion), China produces 54.7 % of the total value of aquaculture production (FAO, 2004b). However, most of this production concerns finfish, molluscs, aquatic plants and crustaceans (FAO, 2004b), with holothurian production still regarded in its infancy.

In the early 1980s, Chinese living standards improved considerably, stimulating the consumption of sea cucumbers despite higher prices (Xilin, 2004). This, along with the reduction of wild sea cucumber populations (see Annex 2), created a bottleneck in supply that prompted the development of sea cucumber hatcheries of *Apostichopus japonicus* (Family Stichopodidae). Research and development of sea cucumber seed production, farming and stock enhancement has become a priority since the early 1980s when pond farming, pen culture and sea ranching methods were developed (Chen, 2004). The successful propagation and rearing of sea cucumbers (*Apostichopus japonicus*) was first reported in Japan in 1950.

Additionally, the Chinese have established conservation zones to help maintain the original stock of *Apostichopus japonicus*. Mariculture and sea ranching of sea cucumbers have become a vigorous sector in Chinese mariculture (Chen, 2004) with this activity gradually expanding within China (i.e. Fujian, Guandgong and Hainan Provinces) where vast quantities of sea cucumber are produced. Similar cultivation or propagation ventures have expanded to other countries such as Viet Nam, Indonesia, Japan, the Marshall Islands and New Zealand. These countries are producing sea cucumbers in captivity and releasing juveniles to enhance the existing wild stocks (Purcell, 2004), or produce sea cucumbers as an alternative to harvesting wild populations (Azari *et al*., 2005).

The sandfish *Holothuria scabra* has been identified as one of the most promising sea cucumber species for aquaculture (Stutterd and Williams, 2003; Pitt and Dinh Quang Duy, 2004) with breeding experiments in Australia, India and Viet Nam. There are other species currently being used experimentally in aquaculture ventures with unsuccessful results to date [i.e. *Holothuria atra* (Ramofafia *et al*., 1995), *Holothuria nobilis* (Preston, 1990) *Actinopyga echinities* (Chen and Chian, 1990), *Actinopyga mauritiana* (Preston, 1990) and *Actinopyga miliaris* (Battaglene, 1999), *Stichopus horrens* (Sarver, 1995) and *Holothuria fuscogilva* (Battaglene, 1999)].

Currently, no aquaculture production of sea cucumbers has been reported to FAO by member countries (Vannuccini, 2004) but with current production trends, it can be assumed that sea cucumbers from aquaculture ventures constitute a large portion of total world production (Vannuccini, 2004).

In 2002, China's production of sea cucumber reached 6,335 tonnes, 5,865 tonnes of which were produced in aquaculture ventures (Chen, 2004). In 2004, however, Chinese sea cucumber farming entered a new age with a total production for the Shandong province alone reaching over 100,000 tons (fresh weight), with further increases in 2005 (Jianxin Chen, pers comm.). Sea ranching[2] accounts for over 75 % of the total aquaculture production (Chen 2004). Total aquaculture production may be higher than official Chinese statistics report because many producers sell their product directly in live or semi-processed forms to local consumers. However, the production cannot meet the current demand and China continues to import processed sea cucumbers from other countries, with the main trading port being Hong Kong SAR where over 5,000 tonnes of sea cucumbers (dried, salted or in brine) were imported in 2004 (Hong Kong Census and Statistics Department, pers. com.).

2.3.3. Regulatory controls and protective measures

Historically, sea cucumber fisheries have been managed under tenurial systems held by local communities, especially in traditional fishing grounds. However, with the expansion of this activity to non-traditional grounds, the loss of long-established cultures and higher demand for the product, commercial fisheries have often been poorly managed, leading to the implementation of management once the stocks began diminishing. In most developing countries, new fisheries start as open access fisheries, and management plans or regulations such as banning (e.g. area closures), or harvesting seasons are put in place after problems arise in an attempt to mitigate the decline of the resource.

Most fisheries in temperate regions have had their catches monitored and management plans set into place when problems have arisen (e.g. west coast of Canada and the United States of America) (Conand, 2005b). In tropical regions, fisheries are on a small scale but of great socio-economic importance (Conand, 2004, 2005a,b). Management measures have been taken in certain tropical countries (Toral-Granda and Martínez; 2004, Altamirano *et al.*, 2004) but these generally remain little enforced, probably due to the lack of human and other resources, weak capacities to implement and control regulations, the absence of effective scientific monitoring mechanisms and inadequate management responses that take into consideration scientific information (Bruckner, 2005a).

No Take Zones: Worldwide, No Take Zones (NTZs) have been recognized for their benefit to exploited species (Ward *et al.,* 2001, Gell and Roberts, 2003). A few examples exist for sea cucumbers. In Egypt, NTZs had higher diversity and densities of commercial sea cucumber species (Lawrence *et al.*, 2004). In Australia, *Holothuria nobilis* (black teatfish) densities were 75 % higher in NTZs than in fished areas (Uthicke and Benzie, 2000; Uthicke, 2004). Negative relationships have been found between increased harvesting effort and sea cucumber densities, typifying unsustainable harvest rates (e.g. *Parastichopus californicus* in Washington; Tuya *et al*., 2000). In contrast, Schroeter *et al*. (2001) found no significant changes in the abundance of *Parastichopus parvimensis* in two NTZs in California. In the Galápagos Marine Reserve (GMR), Toral-Granda *et al*. (2003) found no positive impact of NTZs in the GMR on *Isostichopus fuscus* with declining abundances in all management zones, whilst Edgar *et al.* (2004) found higher densities of *Isostichopus fuscus* outside NTZ in the GMR. Further evaluation of the impact of NTZs in the GMR is needed to identify if findings may be biased by socio-political processes that may accompany selection of sites for NTZ (i.e. Edgar *et a*l., 2004) or the lack of control and enforcement of the protected areas. Spatial closure areas should be developed using the best available information on current flows (so as to address source and sink populations), sea cucumber biology and areas of special interest to local communities in order to develop a sense of ownership and stewardship (Bruckner, 2005b).

NTZs can benefit both commercial and non-commercial species, especially when they have been developed and approved jointly with stakeholders such as fishers. However, their success greatly depends on the continuous support from fishery communities, effective policing and enforcement, and demonstrable benefits to local stakeholders. The Provisional Zoning Scheme of the Galápagos Marine Reserve (GMR) was designed with the input from the five main stakeholders, but its benefits to sea cucumber populations remain to be demonstrated because fishers ignore the NTZ and funds are lacking to effectively patrol the vast area (ca. 138,000 km^2). Selection criteria for NTZs should consider the habitat type, size, shape and number and characteristics of other NTZs (Bruckner, 2005a). Terrestrial reserve design theory may provide some guidance for other selection criteria; nonetheless, this has been identified as a priority area of research (Lovatelli *et al.,* 2004; Bruckner, 2005).

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[2] *Sea ranching defined as "…*at first, the crop is reared in restricted areas, then its juveniles are released into the natural environment and finally its adults are fished from this natural environment*" (Jia and Chen, 2001)*

Complete closure of the fishery: In Mexico, the government imposed a total closure on all fishing activities for *Isostichopus fuscus* in 1994 (Aguilar-Ibarra and Ramirez-Soberón, 2002), but this management strategy did not benefit the species because fishers did not comply with the measure while controls and monitoring of the catches were absent (Aguilar-Ibarra and Ramirez-Soberón, 2002). To date, no significant recovery of the population has been registered despite fishing bans, minimum landing size and restriction of collection only to scientific purposes. This may be a result of continued illegal harvesting. Alternatively, the population may have been driven to such low levels that it may take decades to recover.

After the 1994 experimental fishery in the Galápagos Islands, the Ecuadorian Government declared a total ban on sea cucumber fishing activities until further notice (Carranza and Andrade, 1996). In spite of the closure, illegal activities were rampant (Toral-Granda, 2005a) and population densities of *Isostichopus fuscus* declined (see e.g. Toral-Granda and Martínez, 2004). In waters of mainland Ecuador, all fishing activities were banned for *Isostichopus fuscus*, but no recent information is available to ascertain whether populations have recovered to pre-fishing levels. In India, in 2001, all commercial sea cucumbers were added to Schedule I of the Wildlife Protection Act, which closed all fishing activities. This was aimed to help recovery in overexploited populations, however, illegal fishing continues and most stocks are or remain seriously depleted (Nithyanandan, 2003).

Despite the possible benefits to wild populations, a complete closure of a sea cucumber fishery has major social and economic consequences and has not been effective in practice. When the fishers are prohibited to perform such activity, and unless alternatives are provided, a major source of their income is lost and they will probably turn to illegal fishing which can be even more detrimental to wild sea cucumbers and is negative for humans because no biological thresholds can be enforced nor fair prices paid.

Limited entry: Limited entry generally means some sort of licensing or permitting system whereby the numbers of fishers or vessels partaking in the fishery are restricted. This management tool can reduce scramble competition amongst fishers and help maintain a fishery in a sustainable way. It also improves compliance with management measures and can help ensuring that the economical gains stay with the local community. Moreover, assigning territorial rights to fishing cooperatives may help manage open-access fisheries. This management method seems to be effective in developed countries where there are other alternatives for displaced sea cucumber fishers (i.e. in Australia, Canada and the United States of America). In the Washington State Fishery in the United States of America, logbooks with daily reporting of catch have helped to avoid exceeding the quotas (Bruckner, 2005a). However, in traditional systems the procedure can be difficult as all fishers have equal rights to exploit ‘their’ resources, and the process itself can be straining to fishery management authorities or eventually lead to social unrest and conflicts. Fisheries cooperatives should be organized so as to ensure that licenses are given to those whose main source of income is sea cucumber fishing, rather than to give them away to any member of the cooperative. In Fiji (Stutterd and Williams, 2003) and in the Galápagos Islands (Toral-Granda, 2005a) sea cucumber fishing activities are restricted to native fishers.

Quotas: Quotas or Total Allowable Catch (TAC) are the maximum amount of individuals or biomass that can be harvested annually, during a fishing season, per fisher or fishing trip, within certain areas, etc. Generally TACs should be established in such a way that the maximum sustainable yield (MSY) is not affected. To ensure its effectiveness there should be continuous monitoring and enough enforcement capacity to close the fishery when the quota or TAC has been attained. Quotas can be set outside MSY levels and just reflect a ceiling with no biological or ecological background, while mostly aiming to satisfy the fisher needs (i.e. Galápagos Islands). Management by TACs can cause problems due to the patchy spatial component of the fishery and holothurian populations (Bruckner, 2005a). This management strategy can be an effective tool to control fishing but it may require significant and frequent monitoring to ensure its compliance (Bruckner, 2005b). When TACs are used to manage sea cucumber fisheries, it needs to be re-evaluated frequently as new scientific information becomes available, so as to prevent overexploitation (Brucnker, 2005b). In multispecies fisheries, a TAC should be set for each fished species to avoid serial depletion. This may represent a handicap as many fisheries are not managed at the species level. Another problem with TACs is that a relatively large amount of scientific information is needed to establish the quota (Bruckner, 2005b). In Australia’s East coast sea cucumber fishery, a TAC for the white teatfish (*Holothuria fuscogilva*) was introduced after the collapse of the black teatfish fishery (*Holothuria nobilis*) in1999. The TAC for *Holothuria fuscogilva* is reviewed annually whilst *Holothuria* *nobilis* is still banned (Stutterd and Williams, 2003). In the Australian Northern Territory, a TAC of 127 mt has been set for the white teatfish (Bruckner, 2005a). In Alaska, a quota is set for each fisher and each fishery management unit (Bruckner, 2005a). In PNG, a quota is set for each province, however is often exceeded (D'Silva 2001).

Minimum sizes: Minimum sizes are based on the Size of Maturity (SOM) so as to ensure that the stock reproduces at least once before entering the fishery. This can help avoiding a population collapse due to recruitment failure. Additionally, this management tool helps target bigger individuals which fetch higher market prices. However, sea cucumber size and weight are highly dependent on the water content of live and processed individuals, making enforcement difficult in some cases. However, for many commercial species, biological information on which to base minimum harvest size is lacking. As an example of this regulatory approach, the Galápagos sea cucumber fishery has a minimum landing size of 20 cm for fresh animals and 7 cm for dry ones. This management tool is also used in Australia, PNG, Fiji and Tonga in conjunction with other regulatory approaches such as quotas. Nonetheless, the sizes vary amongst countries, regions and species. For instance in Australia's east coast, all commercial species have a minimum landing size of 15 cm whilst in Australia's western region the minimum size depends on each species harvested (Stutterd and Williams, 2003). An advantage of this management strategy is that controls can be performed at the landing and market levels, and since the beche-de-mer price is highly dependent on size, better control can be exerted. However, discarded individuals are already dead and represent a loss to the reproductive capacity and overall health of the population. It is important to improve the training of fishers to avoid collection of sub-sized individuals. Rejected sub-standard sea cucumbers can also be sold on the black market at much reduced prices (e.g. in the Galápagos Islands).

Fishing season: Fishing seasons are aimed at protecting the population during critically important periods in their biological cycle, such as during reproductive events, or to maximize the quality of the product. This management option provides an indirect fishing ban during which natural processes such as growth and reproduction can take place and ensures that a higher number of animals are available for harvesting. It should however be noted that this approach could negatively affect the spawning stock if no other options (i.e. TAC, minimum landing size) are put in place so as to leave sufficient reproductive biomass for the following seasons. Closed seasons during spawning are in place in Japan for *Apostichopus japonicus* (Uthicke and Klumpp, 1996), the Cook Islands for *Actinopyga mauritania* (Bruckner, 2005a) and in the Galápagos islands for *Isostichopus fuscus* (Toral-Granda 2005a). In multispecific fisheries, this may represent a handicap as there is asynchrony of spawning seasons between species (Bruckner 2005b)

Gear restrictions: Gear restrictions mean that some fishing techniques are banned, or restricted to certain fishers or specific fishing zones. The most common gear restriction is the prohibition to use underwater air supplies (Hookah or SCUBA gear) and to only allow free diving collection, intertidal wading or reef flat gleaning. This would limit the time underwater, optimize the capture to bigger individuals (hence higher value) and leave some individuals hidden to ensure natural reproduction. Gear restrictions can be easily achieved with limited enforcing capacity. In New Caledonia, black and grey morphos of sandfish are found in deeper waters, which can act as buffer and a source of new recruits in fished shallow zones (Uthicke and Benzie, 2000). Gear restrictions may protect critical portions of the population of a few species with wide depth distributions, but other species with a shallow distribution are unlikely to benefit from this measure (Lokani *et al*., 1996).

Restocking and stock enhancement: Recent advances in aquaculture provide the potential to greatly reduce the time required to re-establish depleted stocks through the release of cultured juveniles or to restore spawning biomass to a more productive level (restocking), and may also increase productivity of operational fisheries by overcoming recruitment limitation by maintaining populations closer to the carrying capacity of the habitat (stock enhancement) (Dance *et al.*, 2003; Bell and Nash, 2004).

Much attention has been given to the possibility of using aquaculture and stock enhancement as a way to reverse the overexploitation trends. These measures have become more prominent as the methodology for spawning and for larval and juvenile rearing has been developed for a small number of commercially important species (Lovatelli *et al*., 2004). However, the access to technology for producing juveniles alone is not enough to proceed with restocking and stock enhancement programmes.

For populations where stock assessments reveal that the spawning biomass is at chronically low levels, it can be assumed that by the release of hatchery-reared juveniles, the number of spawners could be restored (Bell and Nash, 2004). However, for such restocking to be effective (i.e. to achieve the desired outcome of restoring fishery productivity), the juveniles that are released into the wild and the remnant wild sea cucumber need to be protected from fishing. Moreover, the protected area should be closed for long enough time to allow the progeny of the released sea cucumbers to replenish the population to the desired spawning biomass. If this is the case, managers need to verify whether a moratorium on fishing for the remnant wild population alone would be sufficient to achieve replenishment (Purcell S., pers. com.).

Additional scientific information should be available before attempting stock enhancement or re-stocking, such as:

- Genetic delineation of stocks: The release of hatchery-produced animals can reduce genetic diversity which can lead to long-lasting effects (i.e. loss of adaptability to natural conditions, inbreeding depression, genetic bottleneck) that are detrimental to native stocks (Uthicke and Purcell, 2004). The number of spawners must be carefully chosen to avoid reduction in the genetic pool (Ryman *et al.,* 1995) which can lead to losses of genetic variation through decreased heterozygosity or the loss of rare alleles (Utter, 1998). In case restocking is attempted with hatchery-reared juveniles, the animals should ensure that no effect will be caused to the natural genetic diversity of the species (Bell and Nash, 2004; Purcell, 2004), which could be achieved by using the same genetic stock for the restocking project (Bell and Nash, 2004).

- Juvenile habitat: Recruitment of larvae may occur in specific habitats, with small individuals migrating into adult habitat later in life (Purcell, 2004). Adult habitat may be less sheltered and have higher risk of predation or may not have suitable habitat for larval settlement (Purcell, 2004). Identifying adequate habitats and its key features before releasing juveniles is therefore critical (Purcell, 2004), particularly because cultured juveniles cannot be released effectively into all habitats where adults occur (Dance *et al.*, 2003). As in other marine taxa, there is higher survival when hatchery-produced sea cucumbers are released at a larger size. However, time and space is a major constraint in land based cultures, as most of them have to ensure economical benefits within a short period of time and limited space (Purcell, 2004) (i.e. rearing ponds, grow out tanks) that are constantly in demand for new generations, specially as holothurians cannot be reared in the water column as they must be associated with the substratum (Battaglene and Bell, 2004). For example, a restocking programme willing to release 2 million juveniles would need over 13 ha of grow-out ponds (Battaglene and Bell, 2004). The benefits and costs to produce large juveniles have to be compared with a higher survival rate. To evaluate the optimal-size-at-release requires knowledge of survival rates and production costs for juveniles of various sizes (Purcell, 2004), which may be costly and time demanding.

- Optimal release conditions: Not only the size but also the optimal density, time of the day and season to carry out the release have to be investigated. Many sea cucumber larvae have a diurnal behaviour such as burrowing in the sand to make them less accessible to predators (Purcell, 2004). But a night release might also provide better results as most predators are less abundant (Dance *et al*., 2003). Purcell (2004) recommends that release should be in the natural season for recruitment.

- Diseases: Another consideration before releasing hatchery-produced juveniles into the wild is that they should be checked for diseases and parasites to avoid introduction of harmful diseases into the wild (Purcell, 2004). Much research is still needed in this field, but the diseases can arise from bacterial, fungal and viral infections, and *a priori* limits should be set for acceptable levels of diseases, parasites and infections of juveniles to be released (Purcell, 2004). Mercier *et al*. (2004) found it impossible to grow *Isostichopus fuscus* without the presence of a deadly parasite, and stated that if the disease is not contained in the earliest phase, the whole culture may crash. The impact of this parasite on the wild populations is unknown.

- Costs: To date, much of the research needed for the hatchery production of sea cucumber juveniles and their release into the wild has been undertaken by national research agencies, universities and regional and international organizations (Bell and Nash, 2004). There is growing concern and awareness that such programmes can no longer be funded by the government alone but that beneficiaries should contribute as well (Bell and Nash, 2004). A decision to engage in stock enhancement or restocking programmes by the private sector or fisheries cooperatives would be possible when fishers are granted access or property rights (Bell and Nash, 2004). It is important to have a general assessment that will guarantee that the costs of restoration of natural populations should not exceed the value of the additional production in the long term, which would not be available until all the scientific research is completed (Battaglene and Bell, 2004).

Mercier et al. (2004) found that *Isostichopus fuscus* can grow and survive in abandoned shrimp ponds available in mainland Ecuador, whilst in China a polyculture of shrimp and sea cucumbers has begun with good results (Yaqing *et al.,* 2004). However, Purcell et al. (2006) state some negative impacts of the co-culture to *Holothuria scabra* (i.e. slower growth due to ammonia excreted by the shrimp). In Japan, a beneficial co-culture between the charm abalone and *Apostichopus japonicus* has yielded good results for both species, suggesting that this co-culture can reduce levels of inorganic nitrogen and enhance abalone growth (Kang *et al.,* 2003). Polyculture is a possible way to defraying costs as it will save costs of constructing and managing rearing ponds (Battaglene and Bell, 2004).

2.4 Trade

Trade in beche-de-mer is very widespread and one of the oldest form of commerce in the Pacific Islands, (Conand and Byrne, 1993) mostly to satisfy oriental markets for luxury food. Major consumers are China, Hong Kong SAR, Korea, Malaysia, Singapore and Taiwan Province of China (Ferdouse, 2004).

Legal trade in sea cucumbers accounts for important revenue in many developing and developed countries (Conand, 2005a) and one of the oldest forms of commerce in the Pacific islands (Conand and Byrne, 1993), with catches aimed at satisfying oriental markets such as China, Hong Kong SAR, the Republic of Korea, Malaysia, Singapore and Taiwan Province of China (Ferdouse, 2004), where it is mainly consumed as a delicacy (Conand, 2005a,b). Most sea cucumber catches are imported into Asia mostly via Hong Kong SAR, Singapore and Taipei, from where they are re-exported to other countries (Ferdouse, 2004; Conand 2004a,b). The market is mostly for dried tropical sea cucumbers of all varieties, and a small amount of skinless and air-freight chilled sea cucumbers (Ferdouse, 2004). In the Pacific region, the leading suppliers are Papua New Guinea, the Solomon Islands, Fiji and Australia (Ferdouse, 2004) whilst in South Asia, the main producing and/or exporting countries are Sri Lanka, the Maldives and India. Their production is however relatively small in comparison with Southeast Asia and the Pacific (Ferdouse, 2004).

Import statistics from Hong Kong SAR show an increase in the number of countries exporting dried, salted or in brine sea cucumbers: 25 countries in 1989, 49 in 2001 and 78 in 2005 (HKG C&S, 2005). In 2005, eight countries exported over 1,000 tonnes each to Hong Kong SAR, six countries between 500 and 1,000 tons, 10 countries between 150 and 500 tonnes and the remaining 54 countries with catches less than 150 tonnes (HKG C&S, 2005). The main exporters to Hong Kong SAR are Indonesia, the Philippines, Papua New Guinea, Singapore and Fiji (HKG C&S, 2005).

Hong Kong SAR is the main port for Chinese sea cucumber imports, totalling over 29,200 tonnes from 1999 to September 2005 and over 5,000 tonnes in 2004 alone (HKG C&S, 2005). Hong Kong does not produce beche-de-mer itself, and typically re-exports the products, primarily to mainland China (64.1 %), Viet Nam (24.5 %) and Taiwan Province of China (4.7 %) (HKG C&S, 2005). The overall value of beche-de-mer imports and re-exports into and from Hong Kong SAR from 1999 to 2005 was USD 453 million, gradually increasing from USD 33 million in 1999 to USD 79 million during the first 9 months of 2005 (HKG C&S, 2005) (Annex 4).

Trade values registered as import statistics from Hong Kong SAR show an increase in the number of countries exporting dried, salted or in brine sea cucumbers from 25 countries in 1989 to 78 in 2005 (HKG C&S, 2005). In 2005 alone, eight countries exported over 1,000 tonnes each to Hong Kong SAR with the main exporters to Hong Kong being Indonesia, the Philippines, Papua New Guinea, Singapore and Fiji (HKG C&S, 2005) and gross annual incomes ranging from USD 33 to 99 million (Annex 4). However, available trade figures are thought to be an underestimation of the total global commerce, as trade routes are complicated, export data are incomplete and individual species are rarely differentiated in trade statistics (Bruckner 2003; Ferdouse 2004). FAO trade figures on global exports are low due to lack of published data from exporting countries (Ferdouse, 2004).

The second most important sea cucumber import market is Singapore. Its imports declined from 820 tonnes in 1997 to 629 tonnes in 2000, mostly due to an economic recession (Ferdouse, 2004). The main exporters to Singapore are Hong Kong SAR, India, Yemen, the United States of America and South Pacific island-countries. Most of the imports were lower quality sea cucumber, with the best-quality products imported from Australia and other Pacific sources (Ferdouse, 2004).

Sea cucumber poaching has a long history. In the 1700s, the Macassans from what is now Sulawesi (Indonesia) travelled across the Timor Sea to fish in what is now the Northern Territory in Australia (Stutterd and Williams, 2003). Currently, illegal fishing still occurs in Australian waters (Torres Strait) with both day and night poaching irrespective of the fishing closure since 1993 (Stutterd and Williams, 2003). Another problem to sea cucumber populations is poaching by foreign vessels. In May 2001, 110 Malagasy fishermen were arrested for illegal fishing in the Seychelles, and several metric tones of sea cucumbers were confiscated (Rasolofonirina *et al*., 2004). In Venezuela, over 900 kg of illegally caught sea cucumber were impounded from Asian fishermen in 1991 and 1992 (Bruckner, 2005a). In the Galápagos Islands, local fishermen harvest both *Isostichopus fuscus* and *Stichopus horrens* and later deliver their catch to foreign vessels anchored just outside the Galápagos Marine Reserve (Toral-Granda pers. com.). Philippine boats fish illegally in Malaysian waters and Indonesian fishers in Australian waters (Bruckner, 2005a). Due to its very nature, it is difficult to establish the volume and value of the illegal, unreported and unregulated (IUU) trade.

Sea cucumber fishery arrived to the Galápagos Islands in 1991 and was unregulated until 1994 when the first legal fishery started in October for three months. The fishery was closed prior to the closing date, and illegal activities persisted until its reopening in 1999 (Toral-Granda, 2005a). In early years, *Isostichopus fuscus* was the sole target of illegal activities. However, as its population declined, large quantities of *Stichopus horrens* were caught which were later traded at much reduced prices or on the black market (Toral-Granda, 2005b). Since the re-opening of the fishery in 1999, under a participatory and adaptive scheme, Ecuadorian export statistics do not reflect the total catch in the Galápagos Islands, with at least 112 tonnes that were not recorded (Altamirano, in prep). Additionally *Isostichopus fuscus* has been exported to Peru from where it was re-exported under Peruvian flag. Since 1999, Hong Kong SAR reports a total of 61 tonnes imported from Peru (Conand, 2005b).

Most illegal activities are fuelled by international buyers exerting pressure to local fishers and offering high prices for sea cucumbers. Generally, fishers get into a loan-debt cycle that fuels illegal activities (i.e. prohibited species, undersize animals or out of season). Illegal sea cucumber fishing can spiral into overexploitation of valuable species. Legal beche-de-mer trade is a lucrative market but illegal national and international trade can cause major problems in certain areas and help should be sought from countries worldwide to halt this practice and help conservation of sea cucumbers.

Ecuador announced at the 12th meeting of the Conference of the Parties (CoP12; Bangkok, 2004) the inclusion of *Isostichopus fuscus* in Appendix III, which came into effect in October 2003. Since the Ecuadorian Government included *Isostichopus fuscus* in Appendix III, less unreported catches have been registered, and there exists now a clearer trading route which in due time could be used by Ecuadorian authorities to protect native stocks. *Isostichopus fuscus* is the only species of sea cucumber currently included in the CITES Appendices.

2.4.1. CITES implementation and identification issues

The effectiveness of a CITES listing depends amongst other things on the ability of enforcement personnel, such as Customs officials, to identify correctly a listed species and the products thereof, for instance to prevent the laundering of illegally obtained specimens under different names, or fraudulent labelling (FAO, 2004a). For beche-de-mer, this was recognized in the two technical workshops as a major problem and good identification was found to be essential for managing international trade (Sant, 2005). Problems arising from labelling and identification may cause the clearance of shipments to be delayed or prohibited, with possible economical consequences. For example, in Malaysia, sea cucumber by-products are used in toothpaste and lotions. Improved labelling can help address concerns relating to identification of such products in trade, and currently there are many documentation and labelling laws and schemes aiming at controlling or identifying the source of fishery products in trade (FAO, 2004a). The ultimate goal would be to have an international standard for traceability of fishery products which would provide all information relevant to the product itself (FAO, 2004a).

Currently, further research is being undertaken on the subject. FAO has hired an expert to develop an identification guide for commercial sea cucumber species. The guide will include photos of the live commercial sea cucumber and processed beche-de-mer, and whenever possible a picture of the espicules taken from the dorsal body wall.

If considering the inclusion of sea cucumbers in Appendix II and using the 'look-alike' provision[3], most of the commercial species of beche-de-mer (42 species, Conand 2005a) might have to be included, hence most of the international trade would become regulated under the provisions of the Convention. The 'look-alike' provisions are important for sea cucumbers as these are often traded in different processing forms (i.e. brine, frozen, dried) making some species difficult to identify and distinguish (Sant, 2005). Additional identification tools or mechanisms should include proper documentation and labels so that the product would be 'readily recognizable', especially in the case of by-products used in cosmetic and health products, for instance *Stichopus horrens* in Malaysia.

If one or more species of sea cucumbers were to be included in Appendix II, international trade in specimens of these species would require CITES documents. Important pre-conditions for issuing CITES export permits are that the CITES Management Authority of the exporting country should have established that the sea cucumbers to be exported were obtained legally, and the Scientific Authority should have advised that the exportation will not be detrimental to wild populations of the species (i.e. is sustainable). For many sea cucumber species, fishery, biological and ecological information is scarce, with some tropical fisheries still trying to identify the species in trade. For such cases, establishing safe levels of exportation would require a more cautious approach than for species for which these parameters are well understood. However, the fishery management tools outlined in section 2.3.3 can avoid unsustainable harvest and trade. Nonetheless, there are countries with lax or inadequate fishery regulations that are poorly enforced. Making adequate legal findings that the specimen to be exported was not obtained in infringement of national laws could therefore be difficult but CITES-listings could actually offer incentives and the rational for improving these.

Although that the taxonomic recognition up to the family level is generally easy, identification of sea cucumbers at the species level is still regarded as problematic. Due to the taxonomic uncertainties in many species, it is very probable that some varieties will have to be classified as full, separate species in future. Some of the commercially important species are still under taxonomic review as live specimens (including *Holothuria scabra*, Uthicke and Purcell, 2004; *Holothuria nobilis*, Conand, 2005, Uthicke *et al*., 2004; *Holothuria fuscogilva*, Uthicke *et al*., 2004). Once on the international markets, the processed forms of some species of sea cucumber can be almost impossible to distinguish from others even to the trained eye (Conand 2004), hence the need to develop an identification guide that allows clear guidance on the identification of commercial sea cucumbers (Sant, 2005).

Live sea cucumber taxonomy is based on anatomical features, such as the oral tentacles, podia and the shapes and combination of microscopic spicules (the skeletal components in the body wall of all sea cucumbers). These spicules can take widely different shapes such as be rosettes, C-shaped rods, buttons, and plates (Hickman, 1998) and are present in larvae (Massin *et al.*, 2000; Rasolofonirina and Jangoux, 2005) and adults (Hickman, 1998; Conand, 2005b). Additional work on the molecular phylogeny (Uthicke and Benzie, 2003; Uthicke *et al.,* 2004), morphology (Cherbonnier, 1980), and visual (Conand, 1990) and skeletal features (Cherbonnier, 1980; Conand, 1990; Uthicke, *et al*. 2004) has also been undertaken. However most of these technologies are costly, need to be performed by trained personnel and yield results in longer time. Places such as Hong Kong SAR or Singapore, which deal with most of the international beche-de-mer imports, need timely and precise methodologies so as to identify which species is being marketed and help in international conservation efforts and trade management.

Toral-Granda (2005b) identified the use of the calcareous spicules as a cost-effective and handy methodology for identifying *Isostichopus fuscus* and *Stichopus horrens* in different levels of processing (fresh, in brine or dried). The proposed methodology targets dried specimens that are already in the international market and it enables quick and easy identification, it is cost-effective and can be performed by biologically untrained personnel. However, care must be exerted when using this methodology on all

[3] *"…the specimens of the species in the form in which they are traded resemble specimens of a species included in Appendix II under the provisions of Article II, paragraph 2 (a), or in Appendix I, such that enforcement officers who encounter specimens of CITES-listed species, are unlikely to be able to distinguish between them;" [Resolution Conf. 9.24 (Rev. CoP13)]*

species as the composition of the body wall spicules has not yield positive results in all species analysed (Uthicke *et al*., 2004, 2005). A catalogue identifying the key external characters as well as the spicules present in the body of the commercially important species has been identified as a priority work by FAO and work is currently underway.

2.4.2 Social and economic aspects

Tropical beche-de-mer fisheries are traditionally artisanal with many species being harvested whilst temperate ones are more mechanized and involving one or few species. Beche-de-mer fisheries are one of the most important sources of revenue for local fisher communities in several developing countries, such as Ecuador (Galápagos Islands) (Toral-Granda, 2005a), Madagascar (Rasolofonirina *et al*., 2004), Papua New Guinea (Kinch, 2002, 2005) and the Solomon Islands (Richards *et al*., 1994). Coastal communities in Small Islands Developing States (SIDS) often have few other options to derive any income (Battaglene and Bell, 2004). In Papua New Guinea, this fishery has a direct impact on the social and economic well-being of the fishing communities as it allows more participation than other fisheries (Kinch, 2005), as well as income in isolated rural communities where other sources of income are rare or not available (Kinch, 2005).

The easiness to collect sea cucumbers and the simple, low technology needed for beche-de-mer processing make it an ideal resource for untrained people (i.e. non-fishers, women and children) to rely on as their source of income. For example, in the Galápagos Islands, when *Isostichopus fuscus* was still quite abundant it was common to have school children and housewives wading and snorkelling in the shallow areas in search of sea cucumbers. These will be later processed and sold in the local market with the revenue used for every-day living expenses and commodities. Additionally, as beche-de-mer can be stored for long periods without deterioration it is possible to launder beche-de-mer in the black market and provide a permanent income to fisherfolk with direct consequences to both natural sea cucumber and human populations.

In temperate regions, any concerns about conflicts between subsistence and commercial harvesters have been addressed by means of a fishery management plan or the identification of subsistence areas that would be closed to commercial harvesting (Bruckner, 2005c). In the United States of America, most beche-de-mer fisheries have been managed by licenses (Bruckner, 2005c), hence limiting the number of people that rely on this activity, and maximizing their profits and revenues.

Current trends of overexploitation in many countries (Annex 2) have however led the active beche-de-mer fishers to target less valuable species or undersize individuals so as to keep a source of income. Buyers may exert pressure on local fishers to bring beche-de-mer by providing cash-advances and then buying the product at low prices, creating a loan-debt cycle that is difficult to break. This cycle is very detrimental to both sea cucumber species and local communities.

3. Management and conservation strategies

(i) Management to reduce impacts on wild populations

The lack or the inadequacy of management plans at both the national and regional levels have prompted the overexploitation of many sea cucumber populations (Bruckner, 2005b). Such management plans should be developed at the national level with assistance from Regional Fisheries Management Organizations (RFMOs) or international organizations (e.g. FAO), and should include strategies both at the local/community and the national level. It is highly recommended that relevant national, regional and international institutions cooperate with each other so as to prepare comprehensive management plans (Bruckner 2005b). Another key point affecting trade directly is the identification of the catch. A clear guide of commercially important species should be developed per locality, country and region, plus clear labelling on the species in trade so as to facilitate import and (re-) export and the enforcement of regulations governing international trade.

Joint use of management tools between RFMOs and countries can be the way forward for sea cucumber management and conservation, and they should, if deemed appropriate, be identified with the direct users and stakeholders of the resource. Management regimes could vary from sophisticated stock assessment models that rely on catch and fishery data to relatively simple measures such as minimum size limit to minimum landing size (FAO, 2004a). Additionally, the CITES Secretariat should draw the attention of the national fishery agencies to the vulnerability of sea cucumber populations, especially when dealing with those subject to trade (cfr. the species in commercial trade indicated in Annex 3).

For transboundary species, regional management should be encouraged in order to preserve as much of the original stock as possible. These require bilateral and international agreements to preserve both the stock itself and its habitat (Bruckner, 2005a). Due to the life history of sea cucumbers, much care must be exerted when dealing with source and sink[4] populations, especially because adult individuals are sedentary whilst fertilized eggs and larvae are pelagic. Proactive measures such as a clear understanding of the biological and ecological parameters of possibly exploitable populations should be encouraged. If a sea cucumber fishery already exists, identification of other possible commercial sea cucumber species should be a high priority to ensure scientific data gathering that will allow a management regime based on scientific information. This is due to the very nature of sea cucumber fisheries, i.e. that once a highly valuable commercial species is depleted, fishing interest will be geared towards less valuable species. If scientific information is available on the latter, then management for such species would include current and up-to-date information that will allow a better planning aimed towards its sustainable use. Information such as growth, ecological role and population dynamics should be obtained from virgin populations so as to ensure no bias due to fishing impact.

No-Take Zones should be encouraged as an umbrella option because they provide shelter for commercial and non-commercial species. Despite the little information on the effectiveness of this management tool for sea cucumber populations, its benefits for other commercial marine species and whole ecosystems are well known (Ward *et al.,* 2001; Gell and Roberts, 2003). In addition to NTZs, total allowable catches should be incorporated in traditional management schemes, ensuring that the fishery has a limited entry. A fishing season would allow the natural populations to reproduce and recover, and should be implemented in all cases.

Minimum size is a management tool that can be hard to enforce due to sea cucumber plasticity, both alive and processed. However, if used jointly with a TAC it could encourage responsible fishing activities as small individuals will still count for the TAC, and hopefully fishers will prefer legal-sized individuals that have achieved sexual maturity, hence benefited the natural population. If possible, minimum size limits should be placed on dry individuals as it is not practical for other processed forms due to variable water content and therefore different degrees of shrinkage (Bruckner, 2005b). However TACs can be set outside the Maximum Sustainable Yield or without any scientific basis, thus being a social or political management tool. Gear restrictions, such as trawl nets, should be enforced, mostly to deter incidental bycatch of sea cucumbers and other marine organisms. A ban of scuba diving or hookah can also help maintain deepwater stocks which could help through reproduction.

However, all these management tools must be enforced effectively to be beneficial. Many countries do not have the staff or funds to monitor fishing activities and ensure that regulations are respected. In some tropical countries, beche-de-mer fishing is performed beyond any management scope, and any attempts to set regulations may cause social unrest when large parts of the fisherfolk population rely on this resource for survival and may not be willing to forfeit a free-for-all activity. Nonetheless, a RFMO for sea cucumbers could gather positive experiences in different countries so as to help implement those in other countries with management and scientific information problems. National experiences such as the one in the Galápagos Islands could be beneficial if shared, especially to other developing countries, as it may help overcome problems more easily and address possible problems as they happen.

(ii) Relationship between aquaculture, capture fisheries and conservation of wild populations

Sea cucumber aquaculture production has increased drastically in recent years, yielding a sustainable and profitable option to capture fisheries hence benefiting sea cucumber conservation efforts. However, much care should be exerted when attempting restocking and stock enhancement without proper scientific information so as to minimize unnecessary risks such as introduction of diseases and genetic mixing.

Sea cucumber capture fishery catches have declined worldwide due to overexploitation, which in turn could make other less valuable sea cucumber species desirable for capture, increasing the threat to

[4] *Source populations are those that provide other populations with larvae or juveniles, whilst sink populations are those that receive the juvenile production for other populations, and their own juveniles do not stay within the population boundaries.*

holothurian populations. Currently, mostly *Apostichopus japonicus* is under aquaculture exploitation; however other species such as *Holothuria atra* (Ramofafia *et al.,* 1995), *Holothuria nobilis* (Preston, 1990) *Actinopyga echinities* (Chen and Chian, 1990), *Actinopyga mauritiana* (Preston, 1990) and *Actinopyga miliaris* (Battaglene, 1999), *Stichopus horrens* (Sarver, 1995) and *Holothuria fuscogilva* (Battaglene, 1999), have been included in aquaculture ventures with unsuccessful results (Sttuterd and Williams, 2003).

If attempts are made to manage the overexploitation of sea cucumbers worldwide through aquaculture or restocking because stocks are overfished, then similar measures would also be expected for other species with depleted stocks. Any stock enhancement or restocking programme could increase 'paternalism' toward the fishing sector, and would reinforce the idea that stocks can be overfished because they will later recover following changed management practices.

Aquaculture can provide food security and it can also promote communities to stop relying on capture fisheries to satisfy their economical needs; however, much care should be exerted when new aquaculture ventures for sea cucumbers could destroy natural habitats, for instance mangroves, or exert additional pressure to populations in critical lows (i.e. collection of spawners or broodstock). Wild populations may benefit from such ventures if a complete moratorium is set in place as it will allow natural recovery rates within the population. Additionally, further environmental education and communication with the local community should, in time, allow a change from the current 'boom-and-bust' approach to one that better reflects long-term sustainability.

(iii) Implementation and enforcement of national and international measures (roles for and relationship between CITES and FAO)

A CITES listing could benefit sea cucumber species by (i) curtailing illegal international trade and associated harvest; (ii) enhancing sustainable exploitation of wild stocks that are harvested for international trade through the making of non-detriment findings (for Appendix-II listings); (iii) contributing to a reduction of over-harvests; (iv) increasing awareness amongst stakeholders and decision-makers for the need to manage and conserve sea cucumbers; (v) providing better opportunities for technical assistance, targeted research and capacity building; (vi) helping to address FAO's concerns about overexploitation; (vii) assisting conservation and management for the long-term socio-economic benefit of fishers (Appendix II and III listings); (viii) promoting regulatory measures to comply with CITES provisions; (ix) installing standardized and comprehensive trade reporting amongst countries, and centralized data gathering and analysis on trade; and, (x) encouraging the development of RFMOs for sea cucumbers (Bruckner 2005b). A CITES listing can also offer Parties international tools to avoid that sea cucumber species become seriously endangered due to international trade, and promote the development of management strategies both at the national and regional levels.

Bruckner (2005b) also identified problems with including sea cucumbers in the CITES Appendices, which are: (i) burdens on both range and importing countries to comply with permitting requirements, undertake research, eventually develop new legislation, train stakeholders in new trade provisions and specimen identification, promulgate regulatory measures to comply with CITES provisions, etc.; (ii) short-term socio-economic impacts by the reduction of fishery income, tax revenue and disruption of local fishing communities; and (iii) potential diminished cooperation in market surveys and IUU trade investigations.

At the national level, most financial implications of a CITES listing would depend on the involvement of the country in the international trade of listed species as an exporter, re-exporter or importer. Such cost would relate to listings in Appendices II and III as trade in Appendix I would be extremely limited. However, illegal trade may require the application of additional or new enforcement and surveillance (FAO 2004a). Costs of implementation would normally be absorbed by the Party within its resource management and enforcement budget through the CITES Management Authority. These should be separated as start-up and recurring costs. These costs may in some cases be minimal as enforcing mechanisms may already be in place to deal with other CITES-listed species or fisheries resources. Most costs would be carried by the trade and by border controls at the importing Party.

Start-up costs may include (i) training and capacity building for government officials so as to identify the new species listed; (ii) education and awareness-raising of the fishery and aquaculture sectors about the requirements for trade in CITES-listed sea cucumbers; and (iii) production of tools to assist the identification of sea cucumber species in trade. Recurring costs may include: (i) scientific research upon which to base non-detrimental findings for Appendix-II sea cucumbers, noting however that if the budget constrains this procedure, a NDF could be based on the best available information to the Scientific Authority; (ii) gathering assurances that the specimen was not obtained in contravention of the laws of that State; (iii) processing of permits, compilations and submission of annual reports to the CITES Secretariat; (iv) inspection of imports and exports; and (v) detection and prosecution of illegal trade (FAO 2004a). Funds for both start-up and recurring costs are hard to obtain, especially for developing countries where the government has other priorities.

A CITES listing can be seen as a useful international measure for enhancing conservation of species threatened by trade, but others believe that aquatic species which provide food security should be conserved by means of regional or national regulations and fishing management plans. However, there are few measures that could be implemented by countries alone, whether or not a CITES Party or FAO Member, which could help improve conservation efforts of commercially important aquatic species such as the sea cucumber. On the one hand, FAO could help national agencies to develop comprehensive management plans in order to avoid overexploitation, provide training in fishing and post-handling techniques to maximise the economical gain, and develop easy-to-follow manuals explaining these issues. On the other hand CITES could create the international regulatory conditions to ensure that trade is conducted sustainably and legally, while curtailing illegal international trade and creating awareness of how unregulated trade is negatively impacting on the conservation status of these species. CITES listings could enhance opportunities for research, training and capacity building, hence helping at the national level. A significant problem identified by both workshops is the lack of a standardized methodology for reporting exports (including species in trade, processing forms and units used), and although it should be implemented at the national level, this could be an area in which joint work between CITES and FAO could be greatly beneficial.

4. Conclusions and recommendation

Sea cucumbers are prone to overexploitation due to their limited mobility as adults, late sexual maturity, a density-dependent reproduction, habitat preferences and low rates of recruitment. Moreover, they can be easily exploited because adults are large, often diurnal, easy to detect and collect, and do not require sophisticated fishing or processing techniques. Increasing consumption trends in Asia markets are threatening sea cucumber populations worldwide as new species are being targeted upon depletion of higher value species. Many sea cucumber populations are currently overexploited; and the current demand for such species in the Asian markets, are demanding new fishing grounds, higher catches and an increasing aquaculture production.

Worldwide, some 42 species are known to be widely used for commercial purposes, which could help focus management efforts at the national and international levels. Most of these species are threatened by trade, and given the vulnerable nature of their fisheries, the difficulties in gathering critical biological and management information, and the challenges in the implementation of management plans to overcome overexploitation, international measures such as inclusion of species in CITES Appendix II would benefit wild populations in the long run. Appendix-II listings would additionally result in requirements to make non-detrimental findings and determine legal acquisitions for specimens to be exported, as well as in more detailed trade data. This would benefit the national management of exploited stocks and help pinpoint areas requiring further research or development, as well as possible conflicts or problem areas. A CITES listing would give such species priority for conservation actions, design of management tools, and taxonomic identification.

The inclusion of one or more species of sea cucumbers of the families Holothuriidae and Stichopodidae in CITES Appendix II could benefit their conservation and survival. Cooperation amongst range States would need to be enhanced in order to improve the effectiveness of a listing. Nonetheless, a more beneficial cooperation treaty would be between major range States and major consumer nations to ensure that CITES-listings work effectively. Additionally, regional and international organizations could cooperate by developing regional management plans for shared stocks, whilst scientific organizations should draw funds and attention to obtain basic biological, ecological and fishery information on sea cucumber species, with special attention to critically overexploited species, for which information is deemed vital.

Most sea cucumber species lack important biological, ecological and fishery information and the making of robust non-detrimental findings, as required with Appendix-II listings, might therefore be difficult in some circumstances (Sant, 2005). It should however be noted that such a determination can be based on extensive scientific research but also simply on the best information available to the Scientific Authority. Nonetheless, some species do not seem to have sufficient biological, conservation status, fishery and trade information to decide on their inclusion in Appendix II, and it is encouraged that such research takes place. IUCN categorization could be valuable as it can clearly pinpoint research needs and help prioritize species of conservation concern. Sea cucumber fisheries are an important source of income in many developing countries, and if their populations are to be maintained or restored, funds should be devoted to develop better science, regulations and management strategies irrespective of their inclusion in the CITES Appendices.

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ANNEX 1

Comparison of activities and measures recommended by the CITES and FAO workshops and organizations involved in each activity

Activity/measure	FAO Dalian Workshop	CITES KL Workshop	Organizations involved
Establish and implement management plans for sea cucumber populations	√	√	FAO, research agencies
Implementation of management tools adapted to the situation in the different producing countries	√	√	FAO, research agencies
Need to have a stronger community participation in the designing, developing and implementation of management plans	√	√	FAO
Stock assessment and scientific information gathering before engaging in commercial fishery	√	√	FAO, universities, research agencies
Need for information on catches, processing and exports at the national level in a standardized form	√	√	FAO, CITES
Improve harvesting and post-harvesting methods as a conservation measure. Elaboration of manuals.	√	√	FAO
International intervention needed to assist in the conservation and management of sea cucumbers; training of Customs, clearance and border officers	√	√	CITES
Critical research needs including: parameters for fishery models, minimum stock size for successful reproduction, general ecological and biological studies, effectiveness of Marine Protected Areas, taxonomy.	√	√	Research agencies, universities
Research to promote development of aquaculture, restocking and stock enhancement	√	√	Research agencies, FAO
Need to develop trade bulletins		√	National agencies
Communication and awareness		√	CITES
Identification of trade routes	√	√	CITES

ANNEX 2

Worldwide population status of sea cucumbers

Country or territory	Species	Status	Reference
Australia	*10 species*	Overexploited	Uthicke, 2004
China	*18 species*	Declining	Li, 2004
Comoros Archipelago	*>4 species*	Overexploited	Samyn *et al*., 2005
Cuba	*Isostichopus badionotus*	Stable	Alfonso *et al*., 2004
Ecuador (continental)	*Isostichopus fuscus*	Overexploited	Carranza and Andrade, 1996
Ecuador (Galápagos)	*Isostichopus fuscus*	Overexploited	Toral-Granda, 2005
Egypt	*22 species*	Overexploited	Lawrence *et al*., 2004
Fiji	*Holothuria scabra*	Overexploited	Uthicke and Conand, 2005
India	*> 3 species*	Overexploited	Bruckner, 2005a
Indonesia	*Holothuria scabra*	Overexploited	Uthicke and Conand, 2005
Japan	*Apostichopus japonicus*	Declining	Bruckner, 2005a
Kenya	*14 species*	Declining	Bruckner, 2005a
Madagascar	*28 species*	Overexploited	Rasolofonirina *et al*., 2004
Malaysia	*Stichopus hermani*	Close to extinction	Poh-Sze, 2004
Malaysia	*Holothuria scabra*	Overexploited	Poh-Sze, 2004
Mexico	*Isostichopus fuscus*	Overexploited	Aguilar-Ibarra and Ramírez-Soberón, 2002
Mozambique	*11 species*	Overexploited	Bruckner, 2005a
New Caledonia (France)	*Holothuria scabra*	Overexploited	Uthicke and Conand, 2005
New Caledonia (France)	*Holothuria fuscogilva*	Overexploited	Uthicke and Conand, 2005
Panama	*3 species*	Overexploited	Bruckner, 2005a
Papua New Guinea	*21 species*	Declining	Polon, 2004
Philippines	*Holothuria scabra*	Declining	Gamboa *et al*., 2004
Seychelles	*6 species*	Overexploited	Aumeeruddy and Payet, 2004
Solomon Islands	*Holothuria scabra*	Overexploited	Uthicke and Conand, 2005
Sri Lanka	*3 species*	Overexploited	Terney Pradeep Kumara *et al.*, 2005
Thailand	*> 3 species*	Overexploited	Bruckner, 2005a
United republic of Tanzania	*10 species*	Overexploited	Mmbaga and Mgaya, 2004
United States	*3 species*	Overexploited (in some areas)	Bruckner, 2005c

ANNEX 3

Main commercial species with their commercial value, conservation concern, common name and distribution

#	Species * taxonomy to be revised	Family	Commercial value	Conservation concern	Common name	Distribution
1	*Holothuria fuscogilva**	Holothuriidae	High	1	White teatfish	SP
2	*Holothuria nobilis**	Holothuriidae	Medium	1	Black teatfish	SP
3	*Holothuria scabra*	Holothuriidae	High	1	Sandfish	SP, SEA
4	*Isostichopus fuscus*	Stichopodidae	Medium	1	Brown sea cucumber	EP
5	*Thelenota ananas*	Stichopodidae	High	1	Prickly redfish	SP
6	*Actinopyga echinites*	Holothuriidae	Low	2	Deep water redfish	SP
7	*Actinopyga miliaris**	Holothuriidae	Medium	2	Blackfish	SP
8	*Actinopyga mauritania*	Holothuriidae	Medium	2	Surf Redfish	SP
9	*Holothuria scabra versicolor**	Holothuriidae	High	2	Sandfish	IO, SP, SEA
10	*Stichopus chloronotus*	Stichopodidae	Medium	2	Greenfish	SP
11	*Stichopus horrens*	Stichopodidae	Medium	2	Warty sea cucumber	SP, EP
12	*Stichopus hermanii (S. variegatus)**	Stichopodidae	Medium	2	Curry fish	SP, SEA
13	*Actinopyga lecanora*	Holothuriidae	Medium	3	Stone fish	SP
14	*Holothuria fuscopunctata*	Holothuriidae	Low	3	Elephant trunkfish	SP
15	*Bohadschia argus*	Holothuriidae	Low	3		SP
16	*Isostichopus badionotus*	Stichopodidae		3		
17	*Parastichopus californicus*	Stichopodidae		3	Giant red sea cucumber	EP-Canada
18	*Thelenota anax*	Stichopodidae	Medium	3	Amberfish	SP
19	*Cucumaria frondosa*	Cucumariidae		3	Pumpkins, Orange footed cucumber	WA
20	*Athyonidium chilensis*	Cucumariidae		3	Pepino de mar	EP-Chile
21	*Athyonidium palauensis*	Holothuriidae	Medium	4		SP
22	*Athyonidium agassizi*	Holothuriidae		4		
23	*Holothuria (Halodeima)*	Holothuriidae	Low	4	Lollyfish	SP

	atra					
24	*Holothuria leucospilota*	Holothuriidae	Low	4		SP
25	*Holothuria edulis*	Holothuriidae	Low	4	Pinkfish	SP
26	*Holothuria coluber*	Holothuriidae	Low	4		SP
27	*Holothuria mexicana*	Holothuriidae		4	Donkey dung	VZ
28	*Bohadschia vitiensis**	Holothuriidae	Low	4		SP, IO
29	*Bohadschia marmorata vitiensis**	Holothuriidae	Low	4		
30	*Bohadschia similes*	Holothuriidae	Low	4		SP
31	*Pearshonothuria graeffei*	Holothuriidae	Low	4	Flowerfish	
32	*Stichopus (Apostichopus) japonicus*	Stichopodidae	High	4		PNW
33	*Parastichopus parvimensis*	Stichopodidae		4	Warty sea cucumber	EP-Mexico
34	*Thelenota rubralineata*	Stichopodidae	Low	4		
35	*Astichopus multifidus*	Stichopodidae		4		
36	*Holothuria arenicola*	Holothuriidae	Low	5		SP
37	*Holothuria impatiens*	Holothuriidae	Low	5		SP, MX
38	*Holothuria cinerascens*	Holothuriidae	Low	5		SP
39	*Bohadschia atra*	Holothuriidae	Low	5		SP
40	*Bohadschia subrubra*	Holothuriidae	Low	5		SP
41	*Stichopus mollis*	Stichopodidae		5		NZ
42	*Pattalus mollis*	Cucumariidae			Pepino de mar	EP-Peru
43	*Pseudocolochirus axiologus*	Cucumariidae	Aquaria		Sea apple	SEA-Indonesia
44	*Pseudocolochirus violaceus*	Cucumariidae	Aquaria		Sea apple	SP-Australia

Keys

Geographical areas

CS Caribbean Sea
EP Eastern Pacific
IO Indian Ocean
MX Mexico
NZ New Zealand
PNW Pacific North West
SEA South East Asia
SP South Pacific
VZ Venezuela
WA Western Atlantic

Conservation concern (modified from Bruckner, 2005b))

1 high concern
2 concern in certain countries of its range
3 potential for future concern as harvest increases
4 no concern
5 minor species of little commercial importance,

ANNEX 4

Hong Kong SAR imports of beche-de-mer (dried, salted or in brine; in kg) 1999 – September 2005 and annual gross income (in USD)
Source: Census and Statistics Department, Hong Kong SAR, China 2005

Country/Territory of origin	1999	2000	2001	2002	2003	2004	2005	Total
Indonesia	762,707	1,041,559	1,068,768	1,010,698	977,893	859,486	498,332	6,219,443
Philippines	591,092	1,070,154	737,232	802,023	666,841	593,512	469,093	4,929,947
Papua New Guinea	350,321	524,101	54,122	380,595	447,632	518,296	412,755	2,687,822
Fiji	168,264	364,369	291,093	235,503	264,253	272,276	223,565	2,054,444
Japan	58,343	75,528	110,558	137,999	206,359	259,120	209,098	1,819,323
Yemen	3,287	0	4,848	102,414	134,919	478,744	196,856	1,265,351
Singapore	165,911	284,804	249,278	284,657	409,315	486,299	174,180	1,186,988
United States of America	112,283	170,423	88,816	154,837	113,119	93,189	157,523	1,057,005
Madagascar	166,364	178,392	194,129	193,551	216,354	175,671	140,890	924,350
Solomon Islands	49,737	149,115	259,727	248,751	222,763	153,255	103,640	921,068
Australia	125,289	146,524	185,952	124,665	118,827	128,075	95,018	890,190
Sri Lanka	21,381	53,867	33,288	54,523	64,972	106,858	75,711	609,456
Malaysia	19,854	67,975	73,158	144,754	147,523	96,653	59,539	574,065
Tanzania	41,352	118,166	56,382	91,672	67,555	94,509	50,598	520,234
Thailand	60,331	133,858	101,020	78,528	69,207	95,197	35,924	410,600
Taiwan, Province of China	40,958	37,830	40,143	40,800	34,570	88,971	28,943	312,215
Mozambique	500	109	853	37,000	63,363	41,900	24,021	219,724
Seychelles	0	7,121	15,678	5,662	13,028	18,413	23,189	197,014
Kenya	1,707	51,580	39,444	20,429	22,658	21,809	17,345	185,639
Peru	4,170	7,331	3,881	1,828	8,354	19,906	15,760	179,518
Micronesia and Palau	0	0	0	6,368	2,252	17,798	14,680	178,286
United Arab Emirates	140	9,100	256	17,141	4,508	140,281	14,213	174,972
Australia and Oceania Not elsewhere specified (Nes.)	32,294	24,227	37,574	22,558	21,256	27,000	13,377	167,746
Egypt	0	677	0	6,510	17,220	17,813	13,102	161,063
Canada	4,883	13,837	58,541	17,861	60,506	51,580	12,516	147,793
Ethiopia	0	0	0	0	0	12,000	12,200	83,091
Ecuador	24,567	15,285	991	10,130	3,026	11,322	12,123	81,371
Cuba	2,920	19,023	13,941	3,800	7,648	5,080	8,641	77,444
Viet Nam	34,093	600	3,274	756	5,415	2,735	6,576	69,773
Vanuatu	7,966	28,467	16,647	8,363	9,001	5,305	5,622	61,230
Morocco	0	0	7,438	1,932	0	5,124	4,890	61,053
South Africa	10,149	27,876	30,178	53,792	37,800	14,945	4,778	57,546
Republic of Korea	0	0	0	651	510	796	4,159	55,322
Oman	180	960	490	507	0	3,842	4,015	53,449
Saudi Arabia	782	0		30	0	8,973	3,350	49,924
Kiribati	6,523	9,073	22,774	8,561	5,528	1,932	3,155	41,310
Nicaragua	0	0	0	0	252	0	2,959	41,098
Chile	0	22,318	7,599	2,906	527	4,485	2,934	40,769
Maldives	4,170	53,915	27,928	37,829	49,013	21,347	2,812	24,200
India	6,610	1,906	9,810	2,391	5,655	21,029	2,523	19,384
Mexico	0	150	1,818	3,302	1,270	4,294	2,378	16,459
China (mainland)	25,020	14,946	4,031	37,400	30,657	47,226	1,783	13,212

Colombia	0	0	540	0	0	0	1,646	13,135
Country/Territory of origin	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**Total**
New Zealand	530	7,583	317	1,440	3,471	1,668	1,450	11,627
Russian Federation	0	0	0	0	0	3,259	1,314	11,300
Mauritania	0	0	0	1,860	0	1,930	862	10,680
Sudan	0	0	0	0	0	0	490	9,994
Venezuela	0	0	0	0	0	0	456	6,116
Comoros	0	600	0	0	0	700	300	5,718
Panama	0	0	0	0	0	281	138	4,652
Tonga	0	0	0	0	296	1,130	94	4,573
Netherlands	0	0	8	0	0	0	42	4,565
Djibouti	0	0	1	4,133	134,999	8,660	0	3,835
African Nes.	0	0	0	2,340	19,977	18,993	0	3,211
Tunisia	0	0	0	0	11,300	0	0	3,000
Haiti	0	0	0	1,000	9,680	0	0	2,739
Mauritius	300	3,185	0	667	3,682	3,793	0	2,607
Marshall Islands	0	0	0	0	2,739	0	0	2,186
Turkey	0	0	0	1,290	1,995	1,280	0	1,600
Hong Kong SAR	0	0	0	0	874	0	0	1,520
Democratic People's Republic of Korea	0	0	0	0	284	0	0	1,300
Sao Tome and Principe	0	0	0	0	202	0	0	1,268
Asia Nes.	0	0	0	0	96	0	0	1,200
Dominican Republic	0	0	0	2,562	45	0	0	1,081
Costa Rica	108	664	325	0	7	164	0	874
Serbia and Montenegro	0	0	0	200	0	0	0	645
France	0	0	155	0	0	0	0	494
Brazil	0	0	444	50	0	0	0	490
Spain	0	1,000	0	0	0	81	0	456
Puerto Rico	0	0	0	1,300	0	0	0	419
Macao	0	0	1,200	0	0	0	0	354
Somalia	0	0	0	3,835	0	0	0	284
Senegal	0	0	0	3,000	0	0	0	202
Swaziland	0	354	0	0	0	0	0	200
US Oceania	11,528	17,623	40,622	0	0	0	0	195
Samoa	5,718	0	0	0	0	0	0	155
Central and South American Nes.	0	0	0	0	0	645	0	96
Myanmar	0	0	0	0	0	195	0	50
Total imported (kg)	2,922,332	4,758,719	4,382,272	4,417,354	4,655,496	5,069,825	3,171,558	29,377,556
Average Exchange rate USD to HKD°	7.76	7.79	7.80	7.80	7.79	7.79	7.78	
Total gross income to Hong Kong SAR in USD	33'559 536	55'541 207	50'422 051	56'362 564	77'305 777	99'817 587	79'897 153	452'897 153

° Source: http://www.oanda.com/convert/fxhistory, consulted on 12 December 2005.