Fisheries status and management plan for Saudi Arabian sea cucumbers

Mohamed Hamza Hasan[1]

Abstract

Sea cucumber resources in Saudi Arabia have long been exploited by an open access fishery with no management in place. The lack of information on the fishery makes it difficult to ascertain its characteristics, as well as determine sea cucumber stocks. Seven sea cucumber species are exploited mainly for the export market. Signs of stock reduction have become evident as fishers search for new fishing grounds and dive deeper and deeper to reach sea cucumber stocks.

The catch per unit of effort (CPUE) for the three major fishing grounds (Al-Wajh, Thowal and Farasan Islands) dramatically decreased during the two survey periods: April to August 2000 and February to July 2003.

A management plan was put in place to prescribe types of licence eligibility, licence requirements, export requirements, prohibition, closure and reporting requirements. It was suggested that licences should be closely monitored by the Saudi Ministry of Agriculture to ensure they comply with all management measures. In particular, reporting by exporters is important as these reports provide the only trade information that the Ministry of Agriculture collects. A total allowable catch must be set for all species. Trade of undersized beche-de-mer must be completely banned to protect populations.

Introduction

The highest diversity of holothurians occurs in the tropics where multispecies fisheries take place. The Red Sea, as a part of the tropical system, suffers from multispecies overfishing (Hasan 2003, 2005; Hasan and Hasan 2004; Lawrence et al. 2004; El-Ganainy et al. 2006; Kalaeb et al. 2008). The rapid decline of sea cucumber populations worldwide for the beche-de-mer trade (Conand 2001) was the beginning of this fishery in Saudi Arabia's Red Sea in 1999. In the Saudi Arabian Red Sea, sea cucumbers are collected by hand while snorkelling or scuba diving at depths ranging from 2–40 m. Since the start of the fishery, a considerable number of sea cucumbers have been harvested, both legally and illegally, which has resulted in huge population declines. The constant reduction of sea cucumber populations in the Saudi Arabian Red Sea drives populations to very dangerous limits, which can yield changes in ecosystem functioning due to their important role as nutrient recyclers (Bakus 1973; Conand 1993). Saudi Arabia's sea cucumber fishery has undergone cycles in which the total catch decreases despite an increase in fishing effort. This in turn leads to the overexploitation of the species and low economic returns. The same phenomenon has been reported in many other places around the world (Ibarra and Soberor 2002).

Due to the accelerating overexploitation of holothurians worldwide (Holland 1994; Conand and Byrne 1993; Conand 1998, 2004; Jaquemet and Conand 1999; Trianni 2002; Altamirano et al. 2004), management strategies must be adopted to address these stock depletions. Conservative management should be the key to sustainable sea cucumber fisheries.

Over the last decade, sea cucumbers in Saudi Arabia's Red Sea have been the target of a continuous fishery. The increasing growth of this activity and its potential impacts prompted Saudi Arabia's Ministry of Agriculture to ban the entire fishery. The current study is initiating a participatory management programme to assess and preserve sea cucumber stocks in Saudi Arabia. The objectives are to ensure that the economic and social benefits, together with environmental impacts of the fishery, are recognized. In recognition of data deficiencies and the strong incentives for rapid overexploitation, this work aims at discussing the available fishery data and preparing and implementing a management plan for sea cucumber stocks in Saudi Arabia's Red Sea.

1. National Institute of Oceanography and Fisheries, Red Sea and Gulfs of Suez and Aqaba branch, PO Box 182, Suez, Egypt. Email: marinehamza@yahoo.com

Materials and methods

Study sites

Site selection was based on the extent of sea cucumber fishing. In this respect, three areas were considered to be the main fishing grounds (Fig. 1): Al-Wajh, Thowal and the Farasan Islands.

Figure 1. Saudi Arabia and the three main sea cucumber fishing sites: Al-Wajh, Thowal and the Farasan Islands.

Al-Wajh area

This area is located in the northern part of the Saudi Arabian Red Sea coast, about 600 km north of Jeddah. Along its shores lies a spectacular group of islands with offshore shallow reefs that are considered to be ideal habitat for sea cucumbers. The area accommodates various types of habitat, including small to moderate patches of sand among coral heads. Live corals flourish, rising up to 2 m from the sea bed and forming circular patches that trap sand. This habitat is ideal for sea cucumbers, especially the white teatfish, *Holothuria fuscogilva*. Also, in many of the sites, huge areas of sandy bottom with large seagrass beds gradually sloping downward to 15 m depth where there are small rocky patches.

Thowal area

This area is located at the middle of the Saudi Arabian Red Sea coast. It has a variety of physical features and substrates, including underwater islands beginning at depths of 10 m below the surface, and exposed offshore reefs. The substrate is composed of live and dead corals, rocks and huge sandy areas. A steep sandy slope descends to 30 m to a 100 m-wide terrace. The substrate is composed mainly of white sand interspersed with dead and live coral patches. The area has very favourable conditions for sea cucumbers, but shows clear signs of overfishing.

Farasan Islands

The Farasan Islands lie 50 km offshore opposite the Jazan area at the southern end of Saudi Arabia. Sites within this area contain underwater islands, live and dead corals, rocks, exposed reefs, and offshore and nearshore sites that are favourable for sea cucumbers, including sandy areas and extensive seagrass beds. Despite this, sea cucumber stocks in this area are very low and populations are severely depleted. Illegal overfishing is widespread in the islands and many boats were seen fishing in different areas.

Data collection

Data collected from sea cucumber harvesters included date of harvest, harvest location, number of harvesters, number of hours fished, species harvested, and total weight of sea cucumbers harvested. From these data, catch size each year was calculated and CPUE was computed as kilograms of sea cucumber per fisherman per day, with an average of eight working hours per day. Data were obtained from the Jeddah Fishery Research Centre (JFRC) and directly from fishermen.

The exploitation system

After harvesting, sea cucumbers are gathered by collectors and then processed into dried beche-de-mer. Shipments are delivered to exporters who transfer the product to Southeast Asian markets. It was very difficult to obtain information about sea cucumber exploitation from fishers, collectors or exporters due to distrust.

In Saudi Arabia, the beche-de-mer trade has four levels of stakeholders: 1) the fisherman who catches the sea cucumbers and sells them to the collector; 2) the collector who buys sea cucumbers from fishermen, and processes them as beche-de-mer and sells them to operators; 3) the operator who buys batches of beche-de-mer from various collectors, gathers them and sells them to an exporter; and 4) the exporter who sends the beche-de-mer to Asian markets (Fig. 2).

Fishery system

Fishers mostly use small motorized boats for collecting sea cucumbers. Each fishing boat carries four to five divers, with one diver remaining onboard, both for security reasons and to receive the catch. Each diver gets a continuous air supply from a hose and pump that are onboard. Divers spend from seven to nine hours a day diving. After all the sea cucumbers in an area are collected, the fishers move to another site. In shallow waters, fishers use a snorkel to gather sea cucumbers.

Figure 2. Three sea cucumber processing steps used in Saudi Arabia.

Results

Species exploited

Nine sea cucumber species were commercially harvested from the Red Sea coast of Saudi Arabia between 1999 and 2004 (Table 1). At the beginning of the fishery in 1999, only three species were collected. Fishing increased into 2001, with nine species of sea cucumber being harvested. Beginning in 2002, the number of harvested species decreased to six, with the disappearance of the high value species *Holothuria scabra* and *Stichopus herrmanni* from the catch. In 2004, only three medium and low value species were being harvested (Table 1).

Sea cucumber production

In 1999, the beginning of Saudi Arabia's sea cucumber fishery, the total catch for the year was 1,997 metric tonnes (t) (wet weight). The highest production occurred in 2001 and 2002, with recorded catches of 7,201 t and 5,132 t (wet weight) for those years, respectively. As a result of overfishing, the total sea cucumber catch dramatically decreased to 1,150 t in 2003, and continued to decease to 230 t in 2004 (Table 2).

Catch per unit of effort

Due to a lack of data on the sea cucumber fishery, the CPUE (kg fisher^{-1} day^{-1}) was acquired for only two periods: April to August 2000, and February to July 2003. CPUE was obtained for the three major sea cucumber fishing grounds.

Monthly analysis of CPUE for the three major sea cucumber fishing grounds showed significant variations among periods and locality. The Farasan Islands had a very high CPUE during the period April–August 2000, ranging from 118.7–126.9 kg fisher^{-1} day^{-1}, while there was a dramatic decline from February–July 2003, with a CPUE of 16.1 kg fisher^{-1} day^{-1} in February, rapidly decreasing to 1.9 kg fisher^{-1} day^{-1} in July. The same pattern was seen at Al-Wajh, which in 2000, recorded a CPUE of 97.5–1,03.4 kg fisher^{-1} day^{-1}, and a significant decrease beginning in February 2003 of 11.5 kg fisher^{-1} day^{-1} to 6.3 kg fisher^{-1} day^{-1} in July. There was no sea cucumber fishing in the Thowal area in 2000, but in 2003, CPUE decreased from 69.4 kg fisher^{-1} day^{-1} in February to only 0.7 kg fisher^{-1} day^{-1} in July.

Resource management

Because of unreliable fisheries data and poor control over actual catches, it is difficult to construct analytical models for managing sea cucumber resources. It is important that a well defined management plan be adopted in order to maintain sea cucumber resources. The imposition of improper protection methods could intensify problems.

Several important measures are needed for managing holothurians. Some of these include establishing conservation management guidelines and baseline surveys prior to the start of the fishing season. A management plan should also impose a ban on harvesting during the breeding season, introduce a quota system and minimum landing sizes, establish permanent survey sites and preserved areas, require the maintenance of records on harvesting data, and impose a ban on using scuba equipment,

Table 1. Holothurian species harvested in the Red Sea waters of Saudi Arabia.

Species	1999	2000	2001	2002	2003	2004
Holothuia fuscogilva	+	+	+	+	+	
Holothuria nobilis	+	+	+	+	+	
Holothuria scabra		+	+			
Holothuria atra			+	+	+	+
Actinopyga mauritiana		+	+	+	+	
Actinopyga echinites			+	+	+	+
Bohadschia vitiensis			+			+
Thelonota ananas	+	+	+	+	+	
Stichopus herrmanni			+			

Table 2. Sea cucumber landings from Saudi Arabia's Red Sea coast.

Year	1999	2000	2001	2002	2003	2004
Production (in t wet weight)	1,997	5,031	7,201	5,312	1,180	230

which enables fishers to spend much more time underwater collecting sea cucumbers.

Scope and approach

The increased international demand of beche-de-mer exerts more pressure on sea cucumber stocks. Overfishing of highly commercial sea cucumbers in Saudi Arabia has caused depletion of stocks, which will lead to a shift to less valuable species. Management regimes control the fishery's harvest, but more importantly, they maintain resource sustainability.

The suggested management plan of Saudi Arabia's sea cucumber takes into account the different habitats, ecosystems and socioeconomic aspects of the country. This plan contains the following terms:

- Maximum sustainable yield — The highest possible catch of beche-de-mer that can be harvested without, or with minimum, effect on the stock's ability to replenish itself.
- Precautionary approach — Setting down restrictions to control harvesting in the absence of adequate scientific data.
- Scientific advisor — This person advises decision makers (Ministry of Agriculture, Jeddah Fishery Research Centre, JFRC). The scientific advisor provides scientific information about stock status and the effects of opening fishing, and gives recommendation on the total allowable catch (TAC), the species allowed to be fished, and other matters.
- Sustainability — Refers to the ability of a resource to maintain its stock at a fishable level.
- Total allowable catch (TAC) — This is the amount of catch allowed to be taken out of a fishery in any one season or year. The TAC is set at a safe level based on stock assessment data.
- NMAC — National Management Advisor Committee.

Species targeted

All sea cucumber species on the Saudi Arabian Red Sea coast are targeted.

Precautionary approach

Consistent with the FAO Code of Conduct for Responsible Fisheries (1982) and management objectives of the National Fisheries Authority, precautionary management approaches shall apply in the following matter:

a) In the absence of adequate scientific data, the Ministry of Agriculture and JFRC shall take into account any uncertainties with respect to the size and productivity of the stock, to other management reference points such as maximum sustainable yield, the level and distribution of fishing morality, and the impact of fishing activities on associated and dependant species and including climatic, oceanic, environmental and socioeconomic conditions.
b) In managing targeted species, the Ministry of Agriculture and JFRC shall consider the associated reef ecosystems of the Saudi Arabian Red Sea. The Ministry shall develop research projects

to assess the impact of fishing on non-targeted species and their environment, adopt plans (if necessary) to ensure the conservation of non-target species and consider the protection of habitat of special concern.

c) The precautionary approach shall be based on the best scientific information available.

National management arrangement

The beche-de-mer fisheries will be managed nationally and at the highest levels of government. The Ministry of Agriculture will work closely with JFRC and the scientific advisor to implement the management plan. The plan will be revised by the Deputy Minister at least once every three years.

It is suggested that a committee, called the National Management Advisor Committee (NMAC), be created to review the success of the management plan and advise on any modifications to improve it. NMAC will also determine the TAC for each species, closed seasons and areas, and periods of restriction.

Management measures

The following management measures set out in the management plan shall be enforced.

Licensing

- Two types of licences will be required: 1) A fishery licence that will be given to the investor. The licence includes the number of boats permitted, maximum length of the boats, number of collectors, the area of fishing, and the total allowable catch. 2) An export and storage facility licence, which will be given to the exporter. This licence will be valid for one year and subject to renewal.

Total allowable catch (TAC)

- Each location will have TACs, applicable to a 12-month period that is calculated using the best information available.
- The TAC will be divided into two groups: high value species and low value species. These will be referred to as value groups.
- NMAC will advice the Deputy Minister on TACs. TACs will be set after the yearly closure of the fishery in each area and prior to the opening of the fishery the following year. Once a TAC has been set, it shall not be changed until the next year.
- JFRC will monitor the TAC for each value group in each area.

Note: If the allocated TAC for any area is reached and exceeded by a considerable amount, that excess amount will be taken off the next season's TAC.

Export requirements

- Exports will be only for the allowable sizes.
- The export of part or parts of or broken beche-de-mer is prohibited.

Prohibitions

- Non-citizens shall not take part in any aspect of the beche-de-mer fishery.
- The use of trawl and scuba for the fishery is prohibited.
- The collection, buying, selling of all species of beche-de-mer is prohibited during the closed seasons or when a TAC is reached.

Closure of the fishery

- NMAC will close the fishery when a TAC is reached or when the compulsory season closure date is reached, whichever occurs first.
- Closing areas may be done, with some areas opened for fishing while other areas will be closed for two to three years. The areas must be switched. The closure or opening of areas will be determined by NMAC after consultation with JFRC.
- NMAC may specify a date by which all holdings of beche-de-mer must be exported.
- NMAC and JFRC reserve the right to close any area of the fishery for conservation regeneration purposes if it is considered necessary to do so for the sustainable management of the fishery.

Processing

- An important way by which the management of the sea cucumber fishery can be improved is to upgrade the skills of processors through training. A substantial proportion of animals may be rejected by purchasers due to incomplete drying or improper storage.

Reporting

- Standard trade names and scientific names must be used in all reporting when possible.
- Licensed exporters must submit holding data to JFRC on all beche-de-mer products handled. This includes species composition, grades, supplier's name, ward of origin, weight in kilograms, and any other information that JFRC may deem necessary.
- Failure to submit the required report within 10 days, or submitting incorrect data, including incorrect trade names may result in suspension or cancellation of the export licence.

Discussion

Sea cucumber populations on the Saudi Arabian Red Sea coast are seriously endangered due to commercial exploitation. Declining exports and strong competition between collectors indicate overexploitation of this resource, which affects

both the local economy and the environment. Only a comprehensive management plan involving the best available scientific information together with a serious commitment from the fishing sector to follow the rules imposed in the plan and the continuous control by Saudi Arabia's Ministry of Agriculture, will allow any commercial activities to be sustained over time.

It is difficult to obtain accurate data on fishing effort along the Saudi Arabian coast, and quantitative estimates for fishing effort are rare. Apart from limited catch data collected by JFRC and from personal communication with sea cucumber fishers, little is known about the catch, catch effort, catch per unit of effort, and other fishery parameters. It was clearly observed that the fishers deliberately withheld their catch statistics and the little data they provided were incomplete.

Saudi Arabia's sea cucumber fisheries began in a very limited way, and it is difficult to state the exact date. In fact, no fisheries information exists before 1999 and it is concluded that before that date, sea cucumber fisheries were scattered and on a very small scale due, in part, to the fact that the people involved perform a wide range of other work activities. The number of species exploited began with three high value species in 1999. Fishers were selective in their catch due to the availability of populations. They therefore directed their efforts on the largest and highest value species. The number of species fished increased to five species in 2000. Up until this time, the fishery was selective as a result of stock availability and the low number of fishers involved. In 2001, nine species were exploited without differentiation. The highest catch and maximum pressure on sea cucumber stocks were exerted in 2001, leading to the disappearance of *Holothuria scabra* from the catch composition in the following years. Moreover, the number of species harvested declined to six species in 2002 and 2003. Finally, the catch collapsed in 2004 to only three medium and low value species. The overexploitation of high value species during the period 2000–2003 led to a total collapse in stocks. Experience elsewhere indicates that recovery of overfished sea cucumber stocks is a lengthy process, taking several years (Purcell et al. 2002), because holothurians, like many other invertebrates, are broadcast spawners, and their fertilization success is highly dependant on population density (D'Silva 2001). It is predicted that recovery of these species will be very difficult.

Data on total sea cucumber landings indicate that fishers initially had harvest success at the commencement of the fishery. This is reflected by increased landings of 1,997 t wet weight in 1999, to 7,201 t in 2001. After 2002, the harvest rate dropped, with the 2003 total catch amounting to 1,180 t. This was followed by a collapse of the fishery in 2004, with landings of only 230 t. This drop was due to a combination of seasonal conditions and overexploitation of accessible areas, with the seasonal advent of calmer areas previously unexploited were targeted (Trianni 2002) resulting in high harvest rates. The decline of sea cucumber stocks due to overfishing occurred not only on Saudi Arabia's Red Sea coast, but also in many other places of the world, even in the largest sea cucumber producing countries (Conand 2004).

Other Red Sea countries, such as Yemen, Egypt and Eritrea, showed similar patterns of sea cucumber stock collapse. For example, in 1992 in Yemen, the catch was 48 t dry weight, and increased over the following two years to reach 65 t dry weight. The catch then began to decrease, reaching 60 t in 1996. Yemen's sea cucumber fishery collapsed in 1999, when the total catch was only 1 t (Conand 2004). The sea cucumber fishery in Egypt, at the northern end of the Red Sea, started in 2000 with a total catch of 20 t dry weight that year, increasing to 139 t dry weight in 2001 (Lawrence et al. 2004). The fisheries collapsed between 2002 and March 2003, forcing the Egyptian government to ban all sea cucumber fishing in the country. In Eritrea, sea cucumber production steadily increased from 11 t of gutted and dry weight in 2000, to reach a maximum production of 452 t in 2003. In 2004, production dropped to 283 t and fluctuated between 380 t in 2005 and 278 t in 2006 (Kalaeb et al. 2008). These reported declines encouraged other countries to begin exploiting sea cucumbers, and Saudi Arabia was among these countries. As elsewhere, Saudi Arabia is experiencing problems in managing this resource.

The mean CPUE calculated from the submitted data showed two distinct patterns: high CPUE for all areas for the period April to August 2000, and a dramatically decreased CPUE for the period February to July 2003, indicating overfishing. During the first period, CPUE was higher than that recorded from Madagascar, which ranged from 4.96–10.67 kg fisher^{-1} day^{-1} (Rasolofonirina et al. 2004) and the Northern Mariana Islands, which ranged from 68.2–118.0 kg fisher^{-1} day^{-1} (Trianni 2002). According to data, 2000 was a promising year for Saudi Arabia's sea cucumber fishery, while in 2003, the fishery nearly collapsed. This is coincident with catch data, which also revealed that the years 2000 to 2002 recorded a maximum production, while beginning in 2003, production had declined significantly.

Despite the ban on all sea cucumber fishing operations in Saudi Arabia, illegal fishing continues to play a key role in the depletion of sea cucumber populations. The primary aim of fisheries manage-

ment is the protection of stocks in order to provide a continuing and sustainable income for fishers. The depletion of sea cucumber stocks as a result of resource management problems is related to overfishing, legislation and/or administration (Altamirano et al. 2004; Conand 2004). The absence of effective control, surveillance and enforcement of regulations has resulted in widespread illegal fishing of sea cucumber populations, and depletion and destruction of the resource's habitat. There is little awareness of the benefits that may be gained from an effective sea cucumber fishery managed by investors in this sector and this is a critical cause for the overexploitation and depletion of sea cucumbers. More effective training opportunities for fisheries managers, fisheries scientists, personnel for shoreline protection, environmental protection officers, cooperative staff, and fishers are required for proper surveillance and management of sea cucumber stocks. Overfished sea cucumber populations could take decades to recover if current harvesting methods continue, unless new and more effective procedures to protect and manage stocks are implemented.

Two types of illegal fishing take place. One occurs in southern Saudi Arabia near the Farasan Islands, and is mainly done by Yemeni fishers who enter Saudi Arabian waters with numerous small boats. The danger from this illegal fishery comes from the high number of fishing boats and the destructive *kapandara* collection method they employ. In this method the fisher receives a continuous supply of compressed air from the fishing boat through a hose and mouth piece so that he can spend more time underwater. With the second type of illegal fishing, used in the north near Al-Wajh, local fishers use professional scuba divers to collect sea cucumbers. The Saudi Arabian Red Sea coastline is long with many islands and offshore reefs that make the control of illegal sea cucumber harvesting difficult. The landing of catch poses difficulties for effective surveillance, monitoring and control. It is concluded that banning of sea cucumber fishing alone is very effective in the conservation of the resource. More appropriate methods for controlling the fishery include raising awareness among the general public to report any person who illegally collects or deals with sea cucumbers, and strengthening surveillance on the roads and at sea cucumber processing points.

Because of issues with overfishing, illegal fishing, and the potential for total and permanent destruction of Saudi Arabia's sea cucumber stocks, it is critical for Saudi Arabia to adopt an effective management plan. As a result of sea cucumber stocks becoming depleted in many other areas of the world, management plans began to be adopted. For example, in the Pacific Adams (1993) recommended the management of individual South Pacific holothurian fisheries, which served as the basis for beche-de-mer fisheries management in that region. Other examples include Papua New Guinea (Polon 2004), the Philippines (Gamboa et al. 2004), and Australia Baine (2004).

Before sustainable management measures can be enforced, it is vital that stocks are allowed to recover to a near pristine biomass level. Only then can management regimes such as TACs, closed seasons, restricted areas and size limits, be effective in achieving maximum benefits from the resource. Sea cucumber populations have been overexploited, which calls for immediate closure of the fishery to enable stocks to recover to levels where they can be managed sustainably. Whatever management measures are officially enacted, the underlying success of management will depend on effective enforcement.

Acknowledegments

I wish to express thanks to my colleagues at Jeddah Fishery Research Centre in Jeddah, Saudi Arabia for their help during data collection and providing data from the Centre.

References

Adams T. 1993. Management of beche-de-mer fisheries. Beche-de-mer Information Bulletin 10:34–35.

Altamirano M., Toral-Granda M.V. and Cruz E. 2004. The application of the adaptive principle to the management and conservation of Isostichopus fuscus in the Galapagos Marine reserve. p. 247–257. In: Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J.F. and Mercier A. (eds). Advances in sea cucumber aquaculture and management. FAO, Rome.

Bakus G.J. 1973. The biology and ecology of tropical holothurians. p. 325–367. In: Jones O.A. and Endean R. (eds). Biology and ecology of coral reefs, vol. 2. Academic Press, New York.

Baines M. 2004. From the sea to the market place: An examination of the issues, problems and opportunities in unraveling the complexities of sea cucumber fisheries and trade. p. 119–132. In: Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J.F. and Mercier A. (eds). Advances in sea cucumber aquaculture and management. FAO, Rome.

Conand C. 1993. Recent evolution of Hong Kong and Singapore sea cucumber markets. SPC Beche-de-mer Information Bulletin 5:4–8.

Conand C. 1998. Overexploitation in the present sea cucumber fisheries and perspectives in mariculture. p. 449–454. In: R. Mooi R. and Telford M. (eds). Echinoderms. Balkema, San Francisco.

Conand C. 1999. Manuel de qualité des holothuries commerciales du Sud-Ouest de l'Océan Indien. PRE/COI. 39 p.

Conand C. 2001. Overview of sea cucumber fisheries over the last decade. What possibilities for a durable management? p. 339–344. In: Barker (ed). Echinoderm 2000.

Conand C. 2004. Present status of world sea cucumber resources and utilization an international overview. p. 13–23. In: Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J.F. and Mercier A. (eds). Advances in sea cucumber aquaculture and management. FAO, Rome.

Conand C. and Byrne M. 1993. A review of recent developments in the world sea cucumber fisheries. Marine Fisheries Review 55(4):1–13.

D'Silva D. 2001. The Torres Strait beach-de-mer fishery. SPC Beche-de-mer Information Bulletin 15:2–4.

El-Ganainy A.A., Hasan M.H. and Yassien M.H. 2006. Population structure of two endangered holothurian species from the Gulf of Aqaba, Red Sea, Egypt. Egyptian Journal of Aquatic Research 32(2):456–467.

Gamboa R., Gomes L., Nievales M.F., Bangi H.G. and Juino-Menez M.A. 2004. The status of sea cucumber fisheries and Mari culture in the Philippines. p. 69–78. In: Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J.F. and Mercier A. (eds). Advances in sea cucumber aquaculture and management. FAO, Rome.

Hasan M.H. 2003. Ecology and distribution patterns of the threatened holothuroids as correlated with over-fishing in the Gulf of Aqaba, Northern Red Sea, Egypt. Journal of Egyptian Academic Society of Environmental Development 4(3):101–118.

Hasan M.H. 2005. Destruction of a *Holothuria scabra* population by overfishing at Abu Rhamada Island in the Red Sea. Marine Environmental Research 60:489–511.

Hasan M.H. and Hasan Y.S. 2004. Natural ecological factors and human impacts influencing the spatial distribution of holothuroid species in the Gulf of Aqaba. Journal of the Egyptian German Society of Zoology 43(D):287–306.

Holland A. 1994. The status of global beche-de-mer fisheries with special reference to the Solomon Islands and the potentials of holothurian culture. M. Sc. Thesis, University of Newcastle. 134 p.

Ibarra A.A. and Soberon G.R. 2002. Economic reasons, ecological actions and social consequences in the Mexican sea cucumber fishery. SPC Beche-de-mer Information Bulletin 17:33–36.

Jaquemet S. and Conand C. 1999. The beche-de-mer trade in 1995–96 and an assessment of exchange between the main world markets. SPC Beche-de-mer Information Bulletin 12:11–14.

Kalaeb T., Ghirmay D., Semere Y. and Yohannes F. 2008. Status and preliminary assessment of the sea cucumber fishery in Eritrea. SPC Beche-de-mer Information Bulletin 27:8–12.

Lawrence A.J., Ahmed M., Hanafy M., Gabr H., Ibrahim A. and Gab-Alla A.A.F.A. 2004. Status of the sea cucumber fishery in the Red Sea-The Egyptian experience. p. 79–90. In: Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J.F. and Mercier A. (eds). Advances in sea cucumber aquaculture and management. FAO, Rome.

Polon P. 2004. The Papua New Guinea national beche-de-mer fishery management plan. p. 205–220. In: Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J.F. and Mercier A. (eds). Advances in sea cucumber aquaculture and management. FAO, Rome.

Purcell S., Gardener D. and Bell J. 2002. Developing optimal strategies for restocking sand fish: a collaborative project in New Caledonia. SPC Beche-de-mer Information Bulletin 16:2–4.

Rasolofonirina R., Mara E. and Jangoux M. 2004. Sea cucumber fishery and mariculture in Madacascar, a case study of Toliara, Southwest Madagascar. p. 133–150. In: Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J.F. and Mercier A. (eds). Advances in sea cucumber aquaculture and management. FAO, Rome.

Trianni M.S. 2002. Summary of data collected from the sea cucumber fishery on Rota, Commonwealth of the Northern Mariana Islands. SPC Beche-de-mer Information Bulletin 16:5–11.