Galapagos Islands: a hotspot of sea cucumber fisheries in Latin America and the Caribbean

Verónica Toral-Granda
FAO Consultant
Puerto Ayora, Santa Cruz Island, Galapagos Islands, Ecuador
E-mail: veronica.toral@gmail.com

Toral-Granda, V. 2008. Galapagos Islands: a hotspot of sea cucumber fisheries in Central and South America. In V. Toral-Granda, A. Lovatelli and M. Vasconcellos (eds). Sea cucumbers. A global review of fisheries and trade. *FAO Fisheries and Aquaculture Technical Paper*. No. 516. Rome, FAO. pp. 231–253.

SUMMARY

The sea cucumber fishing activities started in the Galapagos Islands, Ecuador, in 1991 after the collapse of this venture in mainland Ecuador. Although there is only one species (*Isostichopus fuscus*) that can be legally harvested in the Galapagos Islands, oriental scouts have promoted the illegal capture of *Stichopus horrens*, *Holothuria kefersteini* and *H. atra*, with no biological or ecological information available for these species. Fishing operations in Galápagos are restricted to the artisanal fishing fleet; however, the current practices fit more with a semi-industrial scale. Fishing for *I. fuscus* is done by means of small wooden ("*pangas*") or fiber glass ("*fibras*") boats that will store the catch in mother boats ("*botes*"); collection of the animals is done using hookah. The catch is boiled on board and then salted and dried in the inhabited ports. All of the catch is sold to middlemen. The fishing for *I. fuscus* used to be the most important economical activity; however, low catches and recent lack of interest have yielded this fishery of less importance. This activity is regulated by means of a season, total allowable catch, minimum landing size, effort control and spatial and temporal closure, along with the implementation of an adaptive and participatory management plan, incorporating the main stakeholders of the Galápagos Marine Reserve. Nonetheless, despite all efforts, the population status of *I. fuscus* has follow a similar faith of other sea cucumbers commercially harvested worldwide, and its population is seriously overexploited.

1. INTRODUCTION

Upon depletion of the traditional fishing grounds for bêche-de-mer in Asia and Pacific Islands Nations and Territories (Conand, 2001), this fishery arrived to mainland Ecuador in the late 1980s and after uncontrolled activities, the resource was depleted, promoting the migration of this activity to the Galapagos Islands, where it settled in 1991 (De Paco *et al.*, 1993; Camhi, 1995; Powell and Gibbs, 1995; Martínez, 2001). This fishing activity in Ecuador and Galapagos was one of the first successful commercial activity in Latin America, although there are informal reports of oriental marketing scouts visiting other countries within the region (Alvarado, J.J., TNC–Costa Rica, personal communication.).

The Galapagos Islands sea cucumber fishery is one of the oldest fisheries of its kind in South America (ca. 16 years), and its management has been a model for many other nations wishing to start such an activity. Although it has been surrounded by conflicts, negotiations and an incipient and inefficient participatory and adaptive management process, the fishery within the Galapagos Marine Reserve (GMR) has not been any different to most other fisheries elsewhere, with the population of *Isostichopus fuscus*, the commercial species, severely depleted (Toral-Granda, 2005b). However, the Galapagos case study represents an interesting scenario from which to evaluate how a non-traditional activity has come to shape the management regime and strategies within the GMR. The sea cucumber fishery also represented a "gold-rush" that modified the socio-economical environment in the Galapagos Islands, creating a wake of migrants aiming to benefit from this activity. Moreover, it provided a high income to local fishers who became used to lucrative alternatives and disregarded their traditional activities.

Additionally, this activity has one of the most comprehensive theoretical management plans ever put in place in the GMR. The Galapagos Islands, although not a highly diverse or commercially important sea cucumber area, was chosen as a hotspot, as a showcase for other Central and South American countries and other non-traditional fishing grounds, wishing to start this activity, to have a similar scenario from which to learn from and avoid mistakes that could lead to the depletion of the resource and the socio-economic distress that follows.

2. BIOLOGICAL AND POPULATION STATUS

2.1 Current species in trade

In the Galapagos Islands there are 38 shallow water species of sea cucumbers (Maluf, 1991). The first and only sea cucumber species to be legally commercially harvested in the Galapagos Islands was the brown sea cucumber *Isostichopus fuscus* (Ludwig, 1875) (Aspidochirotida: Stichopodidae), however due to current market pressure and decrease in abundance of this species within the GMR, catches of *S. horrens* (Hearn and Pinillos, 2006; Reyes and Murillo, 2007), *H. atra* (Reyes and Murillo, 2007) and *H. kefersteini* (Toral-Granda *et al.,* 2005a) have also been recorded. The capture of these species, or any other sea cucumber species, is illegal within the GMR. Informal records from fishers also claim that there are more species under illegal commercial exploitation; however, no formal records or a species list exist.

The sea cucumber *I. fuscus* is one of the most common species found in the Eastern Pacific (Maluf, 1991) and it used to be the most conspicuous invertebrate in the shallow subtidal zone in the Galapagos Islands (Wellington, 1974). This species can be found from Baja California to mainland Ecuador, including Galapagos, Socorro, Cocos and Revillagigedos Islands (Deichman, 1958; Maluf, 1991). Hooker, Solís-Marín and Leellish (2005) include Peru (Islas de Lobos de Afuera) in its geographical distribution. It can be found in the coastal zone from the shallow subtidal to 39 m depth (Deichman, 1958; Maluf, 1991). In Galapagos, *I. fuscus* prefers rocky bottoms where the seaweed *Ulva* sp. is predominant (Toral-Granda and Martínez, 2007) and where it is more active at night (Shepherd, Toral-Granda and Edgar, 2003). It can be found all throughout the archipelago, with higher densities in the Western Islands (Fernandina and Isabela) (Murillo *et al.*, 2002a).

I. fuscus is gonochoric (separate sexes) and does not present sexual dimorphism. It reproduces continuously throughout the year disregarding variation in sea water temperature (Mercier, Ycaza and Hamel 2007; Toral-Granda and Martínez, 2007). However, Mercier, Ycaza and Hamel (2007) establish that *I. fuscus* in captivity has a lunar periodicity in its reproductive cycle, spawning between one and four days after the new moon. Spawning generally occurred at night (Mercier, Ycaza-Hidalgo and Hamel, 2007). It attains sexual maturity (SOM) between 161.0 and 170.9 g drained wet weight (Toral-Granda and Martínez, 2007) and has a planktotrophic larval development (Mercier, Ycaza-Hidalgo and Hamel 2004). The same species in Baja California shows an annual reproductive season influenced by the influx of warm water (Fajardo-León *et al.,* 1995; Herrero-Pérezrul *et al.,* 1999) and prefers coral and rocky habitats (Herrero-Perezrul *et al.,* 1999). In Galapagos, the population has a mean total length (± SD) of 20.8 ± 2.81 cm with sizes ranging from 13 to 31 cm total length (TL), with a population mode of 21 cm TL (Toral-Granda and Martínez, 2007). Only one massive recruitment event has been recorded in the Galapagos Islands, present only in the Canal Bolívar area (Murillo *et al.,* 2002a; Hearn *et al.,* 2005). This pulse was first registered in the "before" fishing survey in 2000 and it ended in the "after" fishing survey in 2002 (Figure 2) (Toral-Granda, 2001). Since 1993, five sites within the Canal Bolívar, have been monitored on a yearly basis (Martinez, P., unpublished information; Toral-Granda and Martínez, 2004), and recruitment indices were very low from 1993 until 1998 (Martínez, 1999). This recruitment event is probably connected to the El Niño in 1997–1998 (Murillo *et al.,* 2002a; Hearn *et al.,* 2005) when increased sea surface temperature aided a successful reproductive event, and a subsequent La Niña event, with a high productivity helped the development and growth of *I. fuscus* juveniles (Murillo *et al.,* 2002a). Studies of larval biology of *I. fuscus* are limited to that of Hamel, Ycaza-Hidalgo and Mercier (2003), who raised larvae in captivity and reported that this species completes its metamorphosis and settles between 22 and 27 days, and attains 35 mm in 72 days under culture treatment (Mercier, Ycaza and Hamel, 2004).

There are no growth rates estimates for *I. fuscus* within the Galapagos Islands, however Herrero-Perezrul *et al.* (1999) gave preliminary growth estimates using FiSAT (Gayanillo and Pauly, 1997) which included estimations of asymptotic length (L_∞ = 36.118 cm) and the growth coefficient (K = 0.180 y^{-1}). Reyes-Bonilla and Herrero-Perezrul (2003) obtained similar results (L_∞ = 29.108 cm, K = 0.243 yr^{-1}).

I. fuscus is harvested to meet the bêche-de-mer demand in oriental countries where it is sought as a high value species (Clarke, 2002). In China it is favoured for its consistency and flavour, which is similar to that of *A. japonicus*, the preferred species for Chinese consumption (Chen, J., Yellow Sea Fisheries Research Institute, personal communication).

The warty sea cucumber, *S. horrens* is found in the Pacific Ocean from Malaysia to the Society Islands, French Polynesia, and from southern Japan and Hawaii to New Caledonia (Massin *et al*., 2002) and in the Galapagos Islands, where it is found on rocky substrates from 5–20 m depth (Hickman, 1998), although current evidence show an abundant population over 30 m depth in certain islands (Hearn, A., Charles Darwin Foundation, personal communication). During the day, it is usually found in crevices, cracks and caves where it seeks shelter to emerge at night to feed (Hearn and Pinillos, 2006). The population seems to be comprised of juvenile and adult individuals (9 to 31 cm TL, mode = 20 cm) with the absence of smaller animals (Hearn and Pinillos, 2006) perhaps due to different habitat preference. Ongoing research on the reproductive biology of *S. horrens* show that this species reproduces throughout the year (Mora, J., Charles Darwin Foundation, unpublished information). Hearn and Pinillos (2006) presented a L_∞ = 37.7 cm and a Z/K = 4.95 with (r^2 = 0.967) (Powell-Wetherall analysis).

Stichopus horrens is generally harvested for the medicinal properties of its coelomic fluid or "gamat" in Malaysia (Baine and Choo, 1999) and Madagascar (Rasolofonirina, Mara and Jangoux, 2004) with medicinal purposes and as delicacy in China (Ilias and Ibrahim, 2006). However, in the Galapagos Islands, this species is collected for the production of bêche-de-mer, although fetching a much lower price than *I. fuscus*.

Holothuria atra is a large (20–30 cm TL) and robust sea cucumber that inhabits shallow waters, generally lying exposed on lava substrates or coral rubble. Its geographic distribution includes Mozambique to Hawaii, Clipperton and the Galapagos Islands

(Hickman, 1998). No information is available on the biology or ecology of this species for the Galapagos Islands.

Holothuria kefersteini is also a large (average 20 cm TL) sea cucumber. This species can be found both day and night, although camouflaged with sand. It inhabits both intertidal and subtidal habitats typically exposed on coral sand bottoms. It is often the most common species on white sandy bottoms. It can be found in tropical waters from Mozambique to Hawaii, Clipperton and the Galapagos Islands (Hickman, 1998). No information is available on the biology or ecology of this species for the Galapagos Islands.

2.2 Population status

2.2.1 Fishery independent information

The fishery for *I. fuscus* started in mainland Ecuador in 1989 (Carranza and Andrade, 1996) after the rapid decline of sea cucumber populations in the traditional fishing grounds in Asia and the Pacific Island Nations and Territories (Conand, 2001; Toral-Granda and Martínez, 2004). No stock assessment surveys were carried out in mainland Ecuador before the commencement of the fishery, and it came to a halt upon depletion of the resource. This promoted the migration of the fishers to the Galapagos Islands where extraction began in 1991 (De Paco *et al*., 1993; Camhi, 1995; Powell and Gibbs, 1995; Martínez, 2001). From the beginning, commercial fishing activities for *I. fuscus* in the Galapagos Islands developed without baseline biological and ecological data and without a monitoring plan (Martínez, 2001) and it was surrounded by political and social problems (Bremner and Perez, 2002). Most fishing activities were centred in Western Isabela and Fernandina, a high population density area (Figure 1).

Although this fishery was suppose to be mainly for local fishers, the arrival of the activity brought many illegal mainland fishers, whose demand for work and access to the resource produced many conflicts that led to the ban of the fishery in 1992 (De Paco *et al*., 1993; Powell and Gibbs, 1996; Toral-Granda and Martínez, 2004). Due to pressure exerted by the fishers, this activity re-opened in 1994, focusing mainly in the western region of the archipelago; nonetheless, it had to be closed before the end of the season as the original quota of 500 000 individuals was greatly surpassed, amounting between 8 and 12 million individuals (De Miras, Andrade and Carranza, 1996). All fishing activities for *I. fuscus* were illegal between 1994 and 1999.

A pilot stock assessment carried out over 17.3 km of coast of eastern Fernandina in 1993 yielded a mean population density of 6.24 ind. m^{-2} (± 0.20 ind. m^{-2} standard deviation) (Aguilar *et al.,* 1993). Other stock assessments, which included the whole of the Canal Bolívar recorded between 0.8 to 6.2 ind. m^{-2} (Aguilar *et al*., 1993; Richmond and Martínez, 1993). A stock depletion model ran for the Canal Bolívar area (Hearn *et al.,* 2005) yielded initial densities of adults (≥16 cm TL) which fluctuated between 0.27 and 0.4 ind. m^{-2} from 1994 to 1997, similar to those obtained in 1999 (Toral-Granda and Martínez, 2004). Current density estimates for this region, between 1999 and 2007, range from 0.03 in the post fishery survey in 2005 to 1.03 ind. m^{-2} in the pre fishing survey in 2001 (Figure 2).

Since the re-opening of *I. fuscus* fishing activities in Galapagos in 1999, population surveys were declared mandatory in order to achieve its sustainable management. These surveys were carried out in six of the islands where higher population densities were present and where fishing activities were to take place. These islands are: Fernandina, Isabela, Santa Cruz, San Cristóbal, Floreana and Fernandina (Figure 1). Twice a year, before (between January and April) and after (between June and August) each fishing season, a team, comprised of fishers, managers, naturalist guides and scientists, visit permanent monitoring sites over an average of 10 working days (Toral-Granda and Martínez, 2004). Since 1999, a total of 533 550 m^{-2} have been surveyed in those islands covering a range of depths between 3 and 25 m. In 2006 only one population survey

FIGURE 1
The Galapagos Islands and mainland Ecuador. The shaded section in the Galapagos Islands map is known as the Bolivar Channel

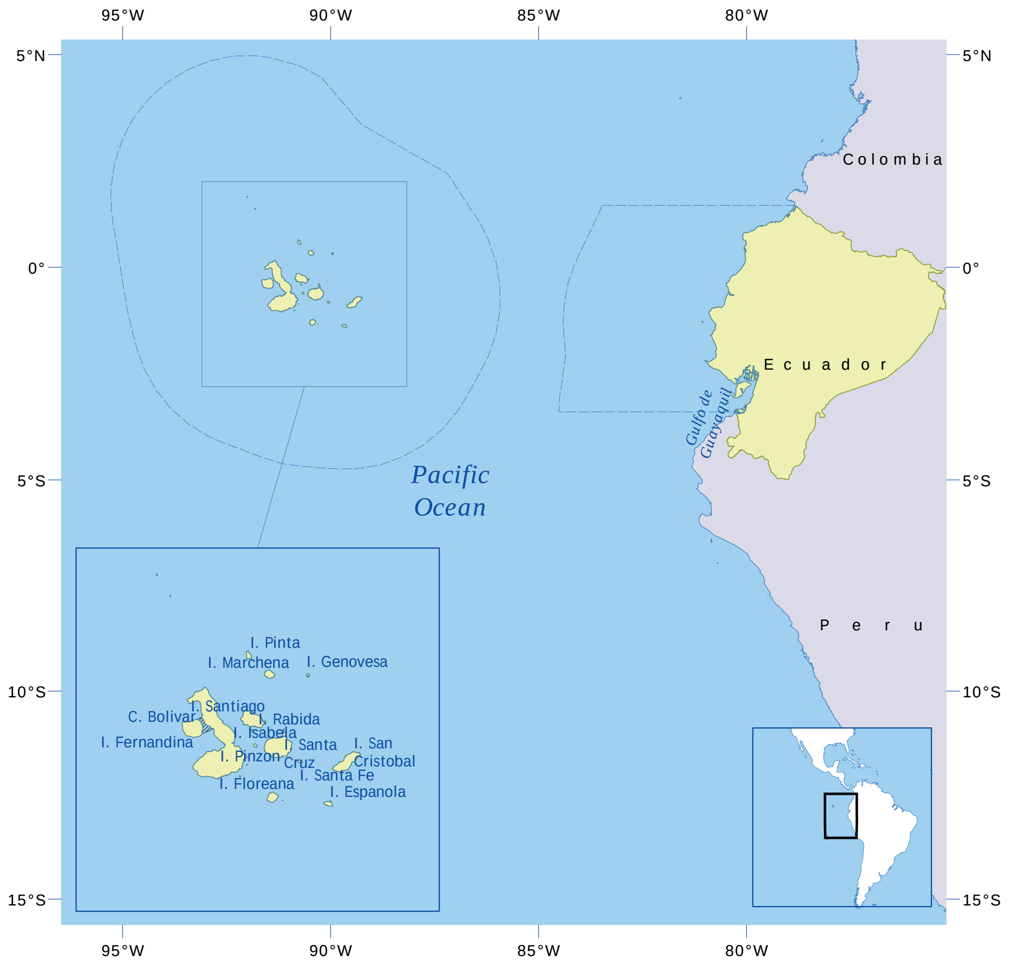
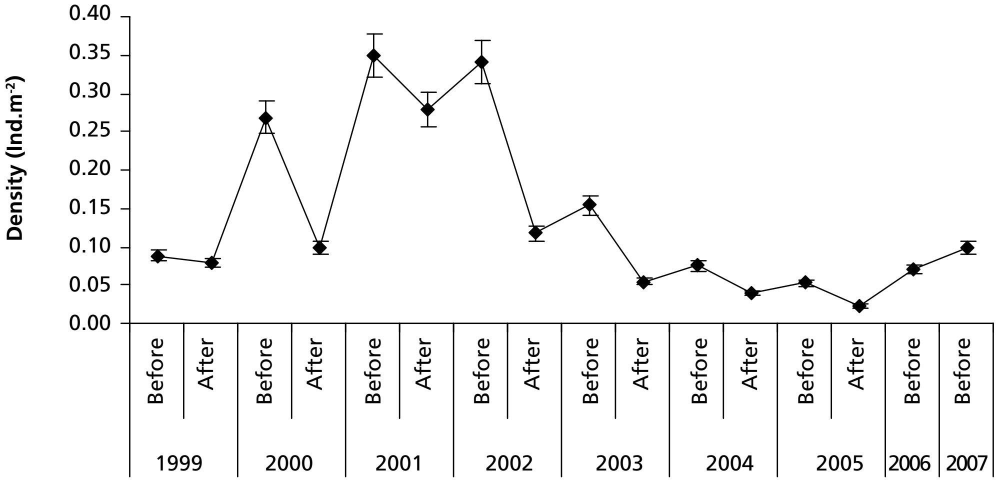


FIGURE 2
General population densities of *I. fuscus* in Española, Fernandina, Floreana, Isabela, Santa Cruz and San Cristóbal before and alter each fishing season, 1999–2007



Source: Toral-Granda, 2005a; Avendaño, Llerena and Gravez, 2006; UCOOPEPGAL, 2007.

was carried out as the fishery remained closed, mainly because the fisher sector never exerted enough pressure for its opening, and there was no need to evaluate the status of the population. In 2007, the fishery was opened in five of the six islands (Floreana remained closed due to low population densities with only preliminary results available (Servicio Parque Nacional de Galapagos, 2007).

From 1999 to 2007, population densities in all six islands were variable, with a serious population decline as of 2003 (Figure 2). The greatest variation of total average density was observed in Fernandina and Western Isabela, where the values were almost an order of magnitude higher than those observed in other surveyed islands (Toral-Granda and Martínez, 2004). The high peaks in 2000 and 2001 were due to the strongest recruitment pulse ever recorded in the islands since population monitoring began in 1993. This pulse began in 1999 (Martínez, P.C., World Wildlife Fund–Galapagos, personal communication) and lasted until the beginning of 2002 when it started to diminish (Toral-Granda and Martínez, 2004; Hearn *et al.*, 2005). Every year, there is a marked decrease in the "after" population survey due to the impact of the fishery, and a slight recovery in the next year "before" survey. As of 2003, the overall population presented similar values (Figure 2).

Population densities from April 2007 (0.09 ind. m^{-2}) show similar values to those in 1999 (Figure 2), with Fernandina and Western Isabela with the highest population densities (0.17 and 0.14 ind. m^{-2}, respectively) (UCOOPEPGAL, 2007); however, caution should be used when comparing this last data point with previous years due to possible different sites studied, methodology and surveying depth.

2.2.2 Fishery dependent information

With the reopening of the fishing season in 1999 fisheries data such as total catch per unit effort (CPUE) became available. Based on the landings, the CPUE had an overall decrease from 102.6 ind. $diver^{-1}$ $hour^{-1}$ in 1999 to 54.5 ind. $diver^{-1}$ $hour^{-1}$ in 2005 (Toral-Granda *et al.*, 2005). There was a fishing ban in 2006. From 2001 until 2003 there was an increase in CPUE probably due to the recruitment event recorded in the Western Islands; nonetheless, this CPUE contains illegal size (≤19.9 cm TL) individuals. Certain islands, such as San Cristóbal, have presented a continuous decline in CPUE, whilst other, such as Fernandina and Western Isabela show similar values throughout the study (Table 1). Floreana has been kept as a closed zone since 2003 (Toral-Granda *et al.*, 2005).

After a detailed analysis of the fishing sites, it was noticed that areas that were previously characterized by high catches, are now seldom visited by fishers due to low *I. fuscus* density (Toral-Granda *et al*., 2005; Toral-Granda, 2005b). Although the population density surveys reveal very low numbers of sea cucumbers, the catch

TABLE 1
Catch per unit of effort for *I. fuscus* in the Galapagos Marine Reserve from 1999 until 2005

Fishing zones	CPUE (ind. $diver^{-1}$ $hour^{-1}$)						
	1999	2000	2001	2002	2003	2004	2005
Española	131	62	*	92	*	69	45
Fernandina	178	*	128	138	116	128	86
Floreana	ND	58	89	51	*	*	*
North and East Isabela	ND	108	52	100	67	55	42
Western Isabela	104	*	112	144	115	82	73
Southern Isabela	85	73	64	111	65	58	56
San Cristóbal	75	60	46	*	44	50	39
Santa Cruz	83	76	56	*	83	69	42
Average CPUE	**102.6**	**89.1**	**103.7**	**136.1**	**97.7**	**72.1**	**54.5**

* = Closed to fishing activity for that year.
ND = No data available.

Source: Toral-Granda *et al.*, 2005.

rates were maintained due to the stability in CPUE (sensu Hilborn and Walters, 1992), mainly due to the fact that it is a sedentary resource with patchy distribution. Additionally, there is a change in diver behaviour, who concentrates their effort on the very few places where sea cucumbers remain (Toral-Granda, 2005b). In this case, CPUE may have little value as an indicator of abundance, and perhaps misleading, as often noted for benthic sedentary or strongly aggregating populations (Oresanz, Parma and Hall, 1998).

During the 2007 fishing season a total of 1 200 000 sea cucumbers were collected in 55 days out of which only 12 000 were impounded due to illegal size (Servicio Parque Nacional de Galápagos, 2007), hence denoting the low level of enforcement and political will to follow up the regulations stated in the management plan for the fishery.

After eight years of legal fishing activities for *I. fuscus* within the GMR, the resource is severely depleted (Toral-Granda, 2005a). Little recovery has been observed between fishing seasons (see Figure 2) perhaps due to the constant illegal fishery that takes place in the Islands (Reyes and Murillo, 2007) and the small number of juveniles entering the population (Hearn *et al.,* 2005). Although little information is available for the other sea cucumber species which are being illegally harvested, it is possible to infer that similar fate will await these species, spiralling into overexploitation of sea cucumbers species within the GMR.

3. FISHING ACTIVITY

3.1 Catches

The total catch figures for *I. fuscus* are based on the Fishing Monitoring Programme, a joint venture between the Galapagos National Park Service (GNPS) and the Charles Darwin Foundation (CDF) with the support from the Galapagos fishing cooperatives. No legal catches for *S. horrens*, *H. atra* and *H. kefersteini* are recorded for the Galapagos Islands. From 1999 until 2005, almost 30 million sea cucumbers have been harvested legally within the GMR or the equivalent of over 8 000 tonnes live weight (Table 2). Historically, Western Isabela and Fernandina have been the fishing regions that have yielded the most of the catches (Table 2).

As with CPUE, total catch is highly variable with some islands showing a decrease if compared to initial catches in 1999 (i.e. San Cristóbal, Española and Western Isabela) (Table 2). In 2001 and 2002 catches were higher in most islands if compared to previous

TABLE 2
Total allowable catches (TAC) and total catches in numbers of *I. fuscus* per fishing region and season, 1999–2005

Fishing zone	1999	2000	2001	2002	2003	2004	2005
Fernandina	169 877	*	624 105	758 775	736 006	380 751	72 307
North and East Isabela	282 883	378 418	52 689	1 551 529	267 879	88 514	87 154
Western Isabela	1 641 360	2 615 495	1 735 181	5 395 804	3 054 595	1 187 079	580 417
Southern Isabela	98 724	117 206	73 419	279 913	484 814	462 833	149 326
Española	489 669	256 980	*	79 775	*	117 098	150 852
San Cristóbal	1 163 104	621 405	52 697	*	121 845	327 584	125 030
Floreana	78 980	239 843	47 324	235 652	*	*	*
Santa Cruz	477 060	717 600	86 931	*	340 435	395 043	235 282
Total	**4 401 657**	**4 946 947**	**2 672 346**	**8 301 448**	**5 005 574**	**2 959 091**	**1 400 368**
TAC	4 000 000	4 500 000	4 000 000	-	4 700 000	4 000 000	3 000 000

* = Closed to fishing

Source: Toral-Granda *et al.*, 2005.

years; however, these catches included undersized individuals (≤19.9 cm TL) (Toral-Granda *et al.,* 2005). Additionally, in 2002 there was no TAC and a conflict between the GNPS and the Navy, meant little patrolling and enforcement.

3.2 Type of fishery

The Galapagos sea cucumber is open only to Galapagos artisanal fishers. Currently there are 1 032 registered fishers in the GMR (PR.C.P003.R002, 2007), with the majority of them in San Cristóbal (Murillo, Reyes and Hearn, 2007). Although the sea cucumber fishery is the one with the most fishers involved, during the 2007 fishing season, only 436 were active during the 50-day fishing period (PR.C.P003.R002, 2007). This activity relies on the use of hookah diving and it is normally carried out from small wooden vessels ("*pangas*") or fibreglass fast boats ("*fibras*") that work from a mother boat ("*bote*"). In the 2007 fishing season, there were only 160 vessels (out of 446) carrying out sea cucumber fishing activities (PR.C.P003.R002, 2007). Fishers may dive down to 45 m depth, and although it is believed that there is a positive correlation between population density and depth, this has not been proven scientifically (Toral-Granda *et al.,* 2005).

Although by law, the only fishing activity allowed to be carried out within the GMR is artisanal, the current fishing practices (between 1999 and 2007) coincide more with those of a semi-industrial activity. During the last fishing season (2007), a reduced number of fishers (only 436) were involved in this activity due to the decline of the resource and lack of incentive for the low revenues. All catches are sold to middlemen, generally of oriental origin, and shipped to the Asian markets.

4. MANAGEMENT OF THE FISHERY

4.1 Management tools

Since 1998, with the passing of the Special Law for the Galapagos Islands, the GMR is under a Participatory and Adaptive Management Scheme (PAMS) which consists of a three-pole system with the Participatory Management Board (PMB), the Inter-Institutional Management Authority (IMA) and the GNPS. The PMB members are locally-based and represent the direct users of the GMR; decisions are made based on a consensus. The IMA is on a ministerial level where all decisions taken in the PMB are decided by means of a voting system. The GNPS is the entity in charge of putting into effect all resolutions taken by both the PMB and the IMA (for further information see Altamirano, Toral-Granda and Cruz, 2004; Toral-Granda and Martínez, 2004). All activities within the GMR are regulated by the PMB and the IMA. Since 1999, the only sea cucumber that can be legally fished within the GMR is *I. fuscus.*

The sea cucumber fishing activity has been regulated by means of a fishing season (two months between March and August), a TAC, a minimum landing size (20 cm TL), a minimum dry size (7 cm TL), No-Take Zones (NTZ), which include closure of nursery grounds, specific islands and areas under the coastal zoning scheme (Altamirano, Toral-Granda and Cruz, 2004). Individual Transferable Quotas (ITQ) were used only in 2001 (Altamirano, Toral-Granda and Cruz, 2004). The nursery grounds that have been closed for several seasons, locally known as the Bolivar Channel, is the only area where large amounts of juveniles were found in 2000 and 2001. In this area, small individuals (about 4 cm) were found amongst the adults.

Additionally, all fishers that partake in the fishing activity must have their catch monitored to ensure legal size and to give fishing information (i.e. fishing sites, effective fishing hours, total number of divers) (Table 3). Any illegal catch is impounded. If fresh, it will be returned to an arbitrarily designated nursery ground near-by, disregarding the origin of the individuals to be released; and if processed, will be stored in GNPS containing facility. Information gathered during the fisheries monitoring process will be used to evaluate the fishery and theoretically provide information to proceed with an adaptive management system that seeks sustainable use of the resources.

The two-month fishing season is normally enforced, with specific regulations set in place (i.e. number of days that boats at sea have in order to come back to nearest port, number of days during which all market activities must come to an end). As it does not require a high number of personnel and a large budget it is easier to enforce; however, as the months during which the fishing season take place is variable, total catches and CPUE are hard to compare as oceanographic and weather conditions vary greatly between the months mentioned above. One of the reasons given by fishers to explain low catches is that physical and oceanographic conditions have worsened throughout the years, resulting in lower catches and less income. However, it is unclear to what extent this is a generalized perception among the fishing sector, or a strategy for negotiating larger quotas.

The TAC for each fishing season has normally been given based on political pressure rather than using scientific information. The CDF, as the official scientific advisor of the GNPS and the Ecuadorian Government, provide the best information available on a yearly basis in order to make informed decisions. The different yearly TACs were established on an auction-like procedure where fishers generally proposed very high quantities, with which they expected to meet their economic whims. On the other hand the CDF scientific team proposed scientifically-based quantities, intended to provide a sustainable use of the resource, which were normally low compared to the expectations raised for each fishery. In general, however, the adopted TAC was a quantity that had no scientific basis whatsoever, but rather a figure that satisfied the expectations of the fishing sector.

For 1999, 2000 and 2003, the TAC was exceeded by amounts between 300 000 and 450 000 individuals; on the other hand, for the remaining years, the TAC was not reached, with deficits between 1.0 and 1.6 million individuals. For 2007, the catch was a mere 32 percent of the TAC, just a month prior to the closure of the fishery. For those years in which the TAC was exceeded, this was mainly due to the fact that the most productive fishing grounds are in the far west of the archipelago, where no radio communication is available. Upon reaching the TAC, the fishers have to be notified so that they can stop fishing and return to their port of origin. This caused the difference between the TAC and the real amount landed.

On the other hand, for those years that the TAC was not reached, many reasons were given by the fishers, amongst them: (i) poor fishing due to oceanographic and atmospheric conditions; (ii) changes in fishing method; (iii) poor price paid for the product that did not encourage starting any fishing activities; (iv) fishing grounds too far to reach on day trips and too few mother boats willing to carry the "*fibras*"

TABLE 3
Different management and monitoring measures implemented in the Galapagos sea cucumber fishery from 1999 to 2007

	Fishing season							
Measures	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2007**
Two-month season	✓	✓	✓	✓	✓	✓	✓	✓
Total allowable catch (TAC)	✓	✓	✓	–	✓	✓	✓	✓
Individual transferable quotas (ITQ)	–	–	✓	–	–	–	–	–
Fisheries monitoring	✓	✓	✓	✓	✓	✓	✓	✓
Minimum landing size	–	–	✓	✓	✓	✓	✓	✓
Coastal zoning	–	–	✓	✓	✓	✓	✓	✓
Closure of nursery grounds	–	–	✓	✓	✓	✓	✓	✓
Closure of islands (i.e. Floreana)	–	–	–	✓	✓	✓	✓	✓
Population density evaluation	✓	✓	✓	✓	✓	✓	✓	✓

or "*pangas*". Low densities of *I. fuscus* in the fishing grounds were never given as an option to explain the low catches.

Due to the natural morphological plasticity of sea cucumbers, the minimum landing size has not been successful in ensuring that only individuals that have reached sexual maturity are caught. When handled, sea cucumbers may either contract or relax, hence changing their total length. Additionally, the value given as a minimum landing size was not based on science. Toral-Granda (1996) established the SOM for *I. fuscus* at 23.6 cm TL (or 260 g drained weight). The minimum landing size (22 and then 20 cm TL) that is currently used was put in place in order to accommodate the lack of big individuals within the population. Additionally, the minimum landing size in dry state (6 cm) does not correspond to that of a 20 cm animal (estimated at 9 cm TL by Castrejon *et al.,* 2005), and was also set on the PMB in order to help the fishing sector oblige to this regulation.

Since 2000, the coastal perimeter of the Galapagos Islands is under a zoning scheme. This scheme allows the use of 5 percent for inhabited ports (zone 2.4), 78 percent of the coastal zone for fishing activities (zone 2.3), 11 percent for tourism activities (zone 2.2), 6 percent for conservation (zone 2.1) (Calvopiña *et al.,* 2006). Zones 2.1 and 2.2 could be considered as no-take zones as fishing is not legal. Fishing activities are allowed exclusively on zone 2.3, where there is the highest abundance of this species (Edgar *et al.,* 2004). Nonetheless, one of the more common infringements (23 percent of total) by the Galapagos fishing sector is carrying out fishing activities outside the 2.3 zone (Toral-Granda *et al.,* 2005a) hence showing the lack of respect to this management tool.

The area known as the Bolivar Channel (between the islands of Fernandina and Western Isabela) is of high ecological importance, as it comprises the nesting sites of the endemic Galapagos Flightless Cormorant (*Phalacrocorax harrisi*), the Galapagos Penguin (*Spheniscus mendiculus*), as well as the Galapagos sea lion (*Zalophus wollebaeki*) amongst others, and it is one of the most important tourist areas. Additionally, this region showed the highest density of juveniles of *I. fuscus* in 2001 and 2002 and was identify as a nursery ground in a PMB meeting. Due to this importance, this region has been closed to sea cucumber fishing activities since 2000 until 2005 as a way to preserve the most important nursery ground for this species and as the breeding ground for charismatic endemic Galapagos species. Yet again, this area shows high level of illegal fishing and it is where most of the illegal fishing outside the fishing season takes place (Toral-Granda *et al.,* 2005).

Ever since the start of the legal fishing activities in 1999, only six islands were open as fishing grounds; however, due to the adaptive management principle included in the GMR Management Plan, any island may be closed in response to low populations densities, if such are observed in a "before" fishing survey. Because of this, different islands were closed in certain fishing seasons (in 2000 – Fernandina; in 2002 – San Cristóbal and Santa Cruz; in 2003 – Española and Floreana) (Table 3).

In 2004, the "before" fishing survey included six more islands (Genovesa, Pinta, Marchena, Santiago, Pinzón y Rábida; Figure 1). This scouting for new fishing grounds could be regarded as (i) the fishers aimed to identify new fishing grounds that may yield high catches; (ii) the fishers wanted to explore more islands to have a larger fishing area; or (iii) the fishers wanted to use these islands with low densities as a trading item in order to be granted a fishing season in all islands with high density. The interest on those islands was first stated since the fishery reopened in 1999, however, the sea cucumber density were lower than those of the islands commonly fished (Figure 3). Genovesa was the only island to merit some consideration as it had density values similar to Floreana. However, the distance of this island to any of the inhabited ports, made it a non viable option for this fishery. There were no further attempts to open a legal fishery on these islands; nonetheless, although illegal, few catches have been recorded in these islands through the Fisheries Monitoring Programme (CDF, Fisheries Monitoring Programme Database).

Floreana, an island with low productivity, has been closed to sea cucumber fishing activities since 2002 (Table 3). According to a mass-balance model developed by Okey *et al.* (2004) the 1999 and 2000 fishing seasons accounted for 88 percent of the total mortality of *I. fuscus* in Floreana. This mortality greatly exceeded the optimum sustainable capture rate indicating unsustainable fishing pressure (Okey *et al.*, 2004). Monitoring of *I. fuscus* in Floreana showed that population densities have been erratic, with clear evidence of a population collapse between 2002 and 2004, a slight increase in 2005, and values similar to those of 1999 in the pre–fishery survey in 2007 (Figure 4) (UCOOPEPGAL, 2007); although it covered only two out of eight sites that were monitored in previous years. The recent trends in densities indicate a possible recovery of the stock following the closure in 2003. However, figures obtained by UCOOPEPGAL (2007) should be dealt with caution due to difference

FIGURE 3
Population density of *I. fuscus* around 12 islands during the "before" fishing survey in 2004. Columns in red represent the new islands that were prospected for legal fishing activities

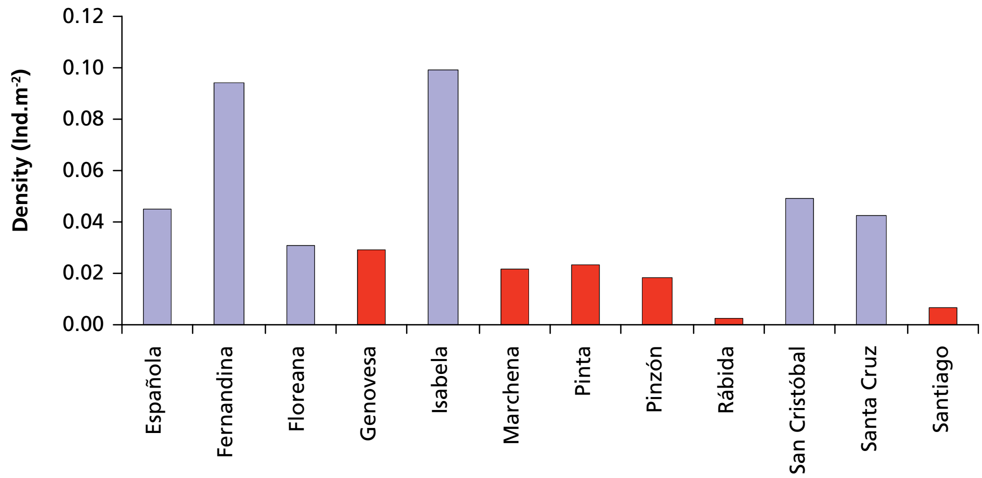
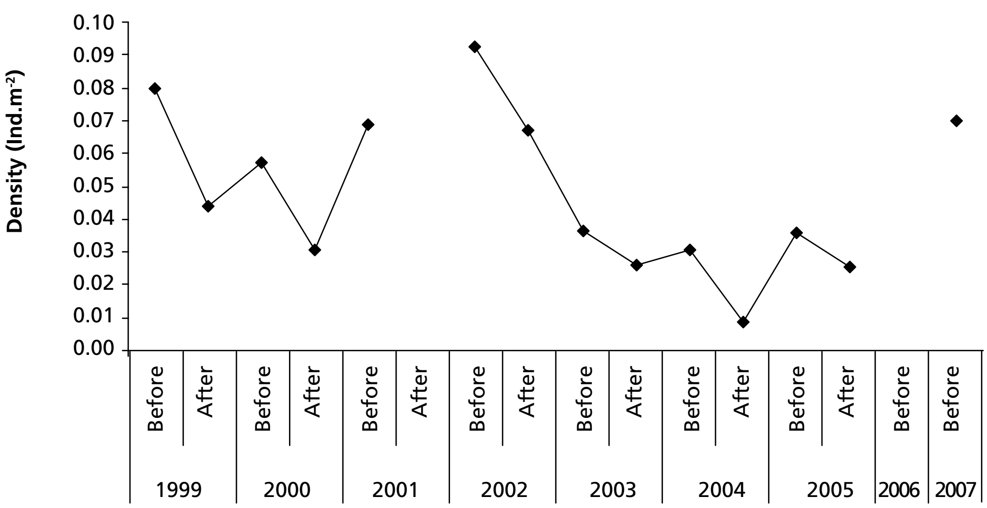


FIGURE 4
Mean population density of *I. fuscus* in Floreana Island declared as a No-Take Zone since 2003



in methodology, sites sampled and depth range surveyed. Also, during the years of the closure of Floreana, the GNPS have registered illegal fishing activities, both during and outside the fishing season (Espinoza, E., Galapagos National Park Service, personal communication).

Individual Transferable Quotas (ITQs) were used only in 2001. This ITQ was obtained by equally dividing the TAC (4 million sea cucumbers) amongst all fishers and fishing vessels, disregarding if they were active or not. This yielded a total of 3 174 sea cucumbers per fisher and per vessel (Murillo *et al.,* 2002b). In the 2001 fishing season, the TAC was not reached and the total number of fishers and vessels were low in comparison to previous years (Murillo *et al.,* 2002b). Most fishers sold their ITQ to other fishers as the total given did not merit starting a fishing operation. Further attempts to implement this form of management have not been successful due to the opposition by the fishing sector that claim that this management tool only seeks to impoverish them more, as they normally work on a cash advance system with the trader. It is claimed that an ITQ will never yield enough to cover these cash advances and provide them an economic benefit. An ITQ system will probably work in the Galapagos if each cooperative cleans-up the list of members, leaving only those that are active fishers rather than opportunistic ones. Some of the registered fishers work as captains or crew on tourist boats, in the construction or public sector and are only active during the sea cucumber fishing season. Murillo *et al*., (2002b) considered this the most lucrative fishing activity; however, now-a-days it is not considered as such.

The most common management tools used in these eight years of legal fishing activities are: fisheries restricted to two-month season, fisheries monitoring and population density evaluation (see Table 3). In 2002, there was no TAC, as the fishers demanded an open fishery due to the high densities present. As a consequence, a serious population decline was observed in that year (see Figure 2).

4.2 Enforcement

Although the GPNS has the required infrastructure and facilities to carry out patrolling and enforcement within the GMR, currently there are not enough personnel to operate the patrolling vessels or carry out fisheries monitoring activities. Although, the GNPS has three oceanic vessels that can do long-distance and long-term monitoring activities most of them operate only during legal fishing seasons, with little or no control over illegal activities (Reyes and Murillo, 2007).

Additionally, even though the GMR is part of the Ecuadorian National Parks System, any GNPS vessel must carry a Navy officer on board in order to be able to intercept or approach a vessel carrying out any activity within the GMR. The Navy officer must have all expenses paid by the GNPS. During 2004 and 2005, there were serious problems between the GNPS and the Navy, which meant that little patrolling activities were carried out both during and outside the fishing seasons.

Another problem with enforcement is that if the GNPS detects and stops illegal fishers and vessels, they are seldom punished to the full extent of the law. The main reasons being: (i) political pressure exerted to release the vessel and illegal fishers; (ii) the administrative burden within the GNPS that does not allow to process the case in a timely manner, hence releasing the violators as stated in the law; (iii) lack of sufficient number of GNPS lawyers in order to maintain the case going and do follow-up procedures; and (iv) examples from previous similar cases that have set a precedent on not exerting the law on illegal activities.

4.3 The bottom-up management approach for the Galapagos Marine Reserve

The innovative participatory management approach for the GMR was created to ensure the participation of the local stakeholders of the GMR in the decision-making process. It was created in 1998 after a series of major social upheavals mainly related to the sea cucumber crisis that surrounded Galapagos in the 1990s (Stone, 1995; Powell and Gibbs, 1995; Jenkins and Mulliken, 1999; Shepherd *et al.*, 2004). When the Participatory and Adaptive Management System (PAMS) was enacted, it was expected that the local-based decision-making process would promote commitment from the local users favouring management and conservation of natural resources (Viteri and Chavez, 2007). This system incorporates the rights and responsibilities of the local stakeholders in the decision making process, which is a novel approach for the Galapagos Marine Reserve and Ecuador as a whole (Heylings and Bravo, 2007; Viteri and Chavez, 2007).

The GMR is a multi-user marine reserve, and its management system involves the major stakeholders. On the local level, the PMB includes the tourism, fishing, conservation and management sectors. All decisions are approved by consensus. At the national level, there is the IMA, comprised of the Ministers of Defence, Tourism and Fisheries, the Galapagos Chamber of Tourism, the Galapagos fishing sector and the CEDENMA, a conglomerate of environmental groups within Ecuador (Altamirano, Toral-Granda and Cruz, 2004). The GPNS is the secretary of IMA and the CDF is the scientific advisor. Decisions are taken by majority vote, although if any given topic arrives with a consensus from the PMB, it is generally ratified by the IMA (Altamirano, Toral-Granda and Cruz, 2004).

For every fishing season, scientific information has been provided to the PMB and IMA, however, in most cases, it was disregarded and decisions were taken based on the current interests of the members present. Moreover, the fishers accused the scientist of providing false information on the pretence of discouraging the fishing season as a personal attack on the fishing sector. Scientists and conservationists were accused of caring more for the wild than the well-being of the human population that inhabit the Islands. Even though, during each fishing survey and the elaboration of the reports, members of the fishing sector were present, at a later stage, and during PMB meetings, the Fishing sector representative will refuse to acknowledge the members as true fishers, accuse them of having sold out to the conservationists and of going against their own sector. As a consequence, in following years, few fishers would accept to participate in the population surveys or in the making of the final report.

All sites surveyed during the stock assessment trips were chosen with the fishers, so as to ensure that their traditional knowledge was taken into account. Out of these, 17 were chosen as permanent monitoring sites in order to provide comparable data throughout the years. Every year, during the PMB meetings in which the management measures for the fishery are discussed, it is common practice for fishers to disregard the monitoring sites, claiming that those are not traditional fishing grounds and will then refuse to accept the results. This refusal affects the different management measures to be put in place, leading to the auction-like procedure of the TAC and minimum landing size described earlier.

The PMB and the IMA have not proven to be a successful mechanism to manage the sea cucumber fishery in the GMR, although having all possible tools to become a clear example of the benefits of co-management. Political interventions and continue change of the Park Directors (more than 10 in less than two years) debilitate the management process, causing its weakness and allowing the intrusion of the opportunistic politicians in the system. One of the major flaws of the system is that the stakeholders were not ready to be involved in management towards sustainability, but rather took this opportunity to achieve specific goals that would benefit them personally or within their own specific sector. Since then, many of the stakeholders' official representatives have used the PMB as a political platform, and the turn-over rate amongst fishing sector representatives is the highest in comparison to other sectors.

The GMR participative process has been rooted in conflict, argumentation, manipulation and negotiation, with the well being of the natural resources at stake.

Although the shift from conflict to consensus models for environmental management and decision making were at its highest in the 1980s (Peterson, Peterson and Rai Peterson, 2005), it only reached Galapagos in the late 1990s, when it was decided that a consensus will be the most favourable, to both stakeholders and resources, way forward to attain conservation. Peterson, Peterson and Rai Peterson (2005) state that "sustainable development's focus on local conditions, diversity, participation, and locally produced development strengthened this link, particularly as consensus is more readably attainable at smaller, local scales".

Consensus works on a "win-win" strategy which hopes to develop a sense of ownership and responsibility for the resources managed (Peterson, Peterson and Rai Peterson, 2005). However, in most of the PMB meetings that dealt with the management of sea cucumbers, none of the stakeholders left with a clear sensation of "winning", but rather frustrated and disillusioned, as they had had to give up many things in order to achieve something that in turn did not leave them satisfied. This sense of loss is probably the main culprit of the poor level of achievement in the management of the GMR.

In the participatory management of the GMR, the sea cucumber resource has been viewed as the resource that can be sacrificed on behalf of others. The sea cucumber fishery used to be the most lucrative, and by giving in to the political demands favouring the opening of the fishery, the fishing sector will be content and will settle for less-favourable management regimes in other fisheries (e.g. spiny lobster, ban on shark finning, long-lining ban). However, this strategy proved unsuccessful as the spiny lobster fishery is also in bad state (Hearn and Murillo, 2007); there have been considerable seizures of shark fins both in the Galapagos (Murillo, Reyes and Hearn, 2007) and in mainland (Castro, M., Sea Shepherd Conservation Society, personal communication) and the use of long lining is still a constant within the GMR.

The Participatory and Adaptive Management Scheme (PAMS) is currently taking most the blame of the collapse of some resources within the GMR; however, there are some possible explanations that could help elucidate the light a the end of this tunnel: (i) the validity of the participatory management system for *I. fuscus* vs. for the GMR, with a new and incipient system trying to manage a gold-rush fishery, worldwide characterised for boom-and-bust cycles; (ii) the incessant prerogative from fishers not to comprehend the validity of scientific data produced; and, (iii) the perennial decision to overlook scientific evidence in favour of social and economical reasons rather than conservation ones.

Applying the PAMS to the sea cucumber fishery *per se* may not have been the wisest choice. This fishing activity yielded a unprecedented economical gain that lead the fishers to push for its yearly opening, despite the clear scientific evidence provided against the stability of the resource (Toral-Granda and Martínez, 2004; Toral-Granda *et al.,* 2005). The high income generated by this fishery led it to be the target of many politicians, who offered in many cases an open-access fishery in order to gain constituents for the next elections. Perhaps co-management should have started with low income generator fisheries (i.e. white fish fishery) as a pilot study, with inclusion of other fisheries at a later stage.

5. TRADE

In October 2003, *I. fuscus* was included in Appendix III of the Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES) becoming the first, and so far the only sea cucumber species included in a CITES Appendix. Appendix III can be a valuable tool by which a CITES Party seeks help from other Parties in the protection of a specific species, especially if such species is under illegal trade to supply to foreign markets (Willock, Burgener and Sancho, 2006). An Appendix III does not include the "introduction from the sea" and "the look-alike" provision.

Appendix III is the easiest one to apply as it can be done unilaterally by a range State in any given time. Catches that are to be imported need to have a CITES Permit stating the origin of the catch and its legality. Other range States wishing to export their catch, must only present a certificate of origin. Importing countries require only such certificate, in order to accept the importation.

Since the 2004 fishing season, the official CITES permits have provided information on the main export destination and trade route for the 2004 and 2005 fishing seasons. In both years, China has been the major importing country with 98.5 percent in 2004 and 95.9 percent in 2005. Minor imports were recorded for Peru and the United States of America (Table 4). Within China the major ports of entry are Keelung in Taiwan Province of China and China Hong Kong Special Administrative Region (SAR).

According to the total catches of *I. fuscus* per year (see Table 2), between 2004 and 2005 there were close to 400 000 sea cucumbers that were caught within the GMR but did not have a CITES permit (Table 4). Since all *I. fuscus* catches are to supply the oriental market, any difference could be explained by misreporting problems originating from Ecuador, and that are maintained through the importing country and a later stage in CITES trade database.

Due to the high interest in *I. fuscus* in the oriental market, the low catches from the Galapagos capture fisheries, and the depletion of this resource in mainland Ecuador, aquaculture ventures started in mainland Ecuador in abandoned shrimp ponds (Mercier, Ycaza and Hamel, 2004). This is the only species under aquaculture production in Ecuador. The listing of *I. fuscus* in Appendix III does not differentiate between wild and farmed individuals, so any exports would require a CITES permit. However, the aquaculture production leaves the country without the CITES permit as it is claimed that it is not *I. fuscus* (Galiano, P., Ministry of Environment, personal communication). Only 80 kilograms of dried *I. fuscus* have been exported from aquaculture production (Ruidiaz, L., Subsecretaria de Pesca del Ecuador, personal communication) although the final destination is not known.

Although China and China Hong Kong SAR are the major importers of sea cucumbers from Ecuador, their trade statistics report that only 91 000 animals that have entered the country (Hong Kong Census and Statistics Department, personal communication) leaving a void of Ecuadorian exports that have not been recorded by China, or China Hong Kong SAR. The Food and Agriculture Organization (FAO) reported a total of 389 tonnes of sea cucumbers from capture fisheries in Ecuador from 1988 to 2005 (FAO, 2007). The highest reported catch (152 tonnes in 1992) coincides with the initial exploitation phase in the Galapagos Islands. From 1993 to 2005 catches are steady at 12 and 15 tonnes per year (FAO, 2007). The recorded caches from 1995

TABLE 4
Number of *I. fuscus* imported per importing countries according to the CITES Appendix III permits and total number of individuals landed in 2004 and 2005

Importing country	Port of entry	2004	2005	Total
China	Hong Kong SAR	760 015	482 931	1 242 946
	Dalian	172 684	0	172 684
	Keelung (Taiwan PC)	1 711 216	343 405	2 054 621
	Taipei (Taiwan PC)	48 790	186 413	235 203
	Qingdao	42 229	41 180	83 408
	Yantai	0	96 085	96 085
China – Total	–	2 734 934	1 150 014	3 884 948
Peru – Total	Lima	36 227	49 494	85 721
USA – Total	Los Angeles	5 832	0	5 832
Total exported		**2 776 993**	**1 199 508**	**3 976 513**
Total catches*		2 959 091	1 400 368	4 359 459
Unaccounted for		182 098	200 860	382 958

Source: GNPS and CITES permit databases; * Table 2 and Toral-Granda *et al.* (2005).

until 1998 may be either from mainland Ecuador as there was a ban on all fishing activities within the Galapagos Archipelago, or could represent illegal harvest from the Galapagos Islands. Ecuador does not report aquaculture production of sea cucumbers to FAO (FAO, 2007).

Between 1996 and 2006, the GNPS has seized over 670 000 individuals of *I. fuscus* (Reyes and Murillo 2007). These impoundments, however, do not show the real amount of catches from Illegal, Unreported and Unregulated (IUU) fishing, and up to date, there is no information on the actual numbers that have been caught. Illegal fishers generally fish at night and deliver their catch to mother boats waiting in the vicinity. Those catches may be landed in mainland Ecuador, where they may be shipped by land to Peru, and eventually exported as Peruvian goods (Willock, Burgener and Sancho, 2006). This is a clear example on how the lack of cooperation among range states of *I. fuscus* is detrimental to the Galapagos populations. Every range State that has not listed this species in Appendix III is a potential channel for illegal caught specimens (Willock, Burgener and Sancho, 2006).

Fishing for *S. horrens* is illegal within the GMR; hence the only figures available are those of impounded catches. Latest official numbers establish a total of over 74 000 individuals raided by GNPS (Reyes and Murillo, 2007) generally from illegal campsites, fishing boats and private houses (Hearn and Pinillos, 2006). Reyes and Murillo (2007) provide one seizure of almost 19 000 *H. atra* within the GMR. No figures exist for *H. kefersteini*.

Sea cucumbers are traded as fresh individuals or per kilogram in brine. The price for either product has greatly varied over time. In 1999, when the fishery started, a single fresh *I. fuscus* had an average price of USD 0.80 which declined continuously until 2002 when it reached the lowest value paid (USD 0.33). With the decline in population, there was a drastic price increase until 2004, when it reached the highest price paid (USD 1.50). For the 2005 fishing season, the price declined to USD 1.20 (Toral-Granda *et al.,* 2005). Prices for 2007 were USD 1.40 (Servicio Parque Nacional de Galápagos, 2007).

6. SOCIO-ECONOMIC IMPORTANCE TO LOCAL COMMUNITIES

In the Galapagos, sea cucumber fishery is a semi-industrial activity, however it has some characteristics of an artisanal fishery, such as the fact that the catch and the processing is done by the fishers themselves or a member of their family unit. The sea cucumber fishery is considered the most lucrative fishing activity within the GMR and has been very profitable for the small number of fishers participating (Bremner and Perez, 2002; Murillo *et al.,* 2002a). No clear values are available of the total income generated by the 1994 fishery, but the total economical gain from this season started the gold-rush fever which lasts up to the present day.

Between 1993 and 2000, during the highest point of sea cucumber activities, the number of registered fishers increased from 392 to 682 (74 percent), probably due the arrival of seasonal migrants from mainland Ecuador and Galapagos native fishers who turned to this highly lucrative fishery (Bremner and Perez, 2002). Currently there are 1 032 fishers operating within the GMR, out of which only 25 percent are active through the year with a greater increase in number of active fishers during the sea cucumber fishing seasons. Of these, 97.7 percent are men with the remaining 2.3 percent women (Murillo, Reyes and Hearn, 2007). During the 2000 fishing season, there was a total of 1 229 active fishers whilst in 2001 (the year with ITQs) there were only 597 (Toral-Granda *et al.,* 2005; Murillo, Reyes and Hearn, 2007). During the early years of this fishery, women and children were known to wade, snorkel and free dive in the shallow coastal areas and to process the catch themselves. Presently, most women are boat owners ("*armadoras*") rather than fishers (Murillo, Reyes and Hearn, 2007).

Full-time fishers rely on the income generated from the sea cucumber and spiny lobster fishery for the whole year. Few of them participate in other fishing activities (i.e. white fish, high seas fishing) although due to the decline in catches in both resources, fishers are starting to do more fishing trips with the aim of catching fish (Murillo, Reyes and Hearn, 2007). Nonetheless, each year, although there is common knowledge that *I. fuscus* populations have declined throughout the marine reserve, fishers will demand the opening of the fishery claiming that the lack of alternatives and the strict management controls and regulations are making them poorer every year.

The easiness of catching, processing and storing bêche-de-mer renders this an activity that could be done all year long even if illegal. Illegal catches can be sold on the black market, hence provide cash flow that will allow every day living and purchase of commodities.

When the resource was still abundant, and prior to the start of a fishing season, the middlemen used to hand out cash advances to fishers in order to help them prepare for the season, and then would buy the catch at a bargain price. The final price paid after the first fishing outing would often not be enough to cover the fishers' basic expenses, hence asking for yet another cash advance, therefore would create a debt cycle that was hard to break. In the 2007 fishing season, no cash advances were given limiting the number of fishers that took part in the fishery (167 active fishers [Servicio Parque Nacional de Galápagos, 2007], a drastic decrease from the 703 fishers in the 2005 season [Toral-Granda *et al.*, 2005]).

7. ADDITIONAL THREATS TO SEA CUCUMBER POPULATIONS

The search for new species to meet the growing international demand for bêche-de-mer is a constant threat for sea cucumber populations in the Galapagos Islands. In the early years, commercial activities focused on *I. fuscus*, as a high value abundant sea cucumber species. However, as the resource diminished and the catches dwindled, new species became the target. Currently there are four species under commercial exploitation (*I. fuscus*, *S. horrens*, *H. atra* and *H. kefersteini*), although only one is legally permitted. Trade and market scouts are always searching for new species, and since the fishing infrastructure and know-how already exist in Galapagos, there is always the chance of new species being harvested, both legally and illegally.

As the *I. fuscus* population is showing signs of severe depletion, and the market demand for it has not declined, there is a current interest to develop mariculture for restocking depleted populations in the Galapagos Islands (Toral-Granda, 2005b). This initiative was prompted by the successful completion of the reproductive cycle in captivity (Hamel, Ycaza-Hidalgo and Mercier, 2003) and rearing of this species in abandoned shrimp ponds in mainland Ecuador (Mercier, Ycaza-Hidalgo and Hamel, 2004). The Galapagos fishing sector is demanding the development of this activity as an alternative form of employment and income.

Nonetheless, Toral-Granda (2005c) suggests a series of studies that should take place before the commencement of this activity, including: a complete genetic delineation of the Galapagos stocks; larval and juvenile natural history; optimal release conditions; as well as studies on diseases and predation. It is also suggested that any mariculture or sea ranching activities be directed to mainland Ecuador where there is the right physical setting. If such initiative would materialize it would certainly reduce fishing pressure within the GMR.

8. RECOMMENDATIONS

8.1 Recommendations for improving sea cucumber fisheries management and conservation

For *I. fuscus* there should be a complete ban on fishing activities in order to allow the stocks to recover. In the mean time, scientific research should be conducted on population genetics, larval biology and ecology. Genetic studies carried out by Lohr

(2003) on populations of *I. fuscus* from the southern islands of San Cristobal, Española and Floreana, indicate historical genetic connection between populations from the Galapagos Islands and mainland Ecuador, suggesting the mainland population as source with higher diversity of alleles and the Galapagos as sink populations. However it is not known when and how this genetic connection is manifested. Such information would certainly have important management implications for the fishery. Nevertheless, further genetic research efforts should concentrate on populations of the Bolivar Channel, western Galapagos, which include the area where the only mass recruitment *I. fuscus* has been recorded. All this could mean that rather than implementing a local management plan, a regional one may need to be developed and implemented with the aid of all countries within the region.

Fished populations should be monitored regularly so as to provide basic information on recovery rates and resilience. As sea cucumbers are an important part of the food web, ecosystem monitoring should be encouraged in order to understand the possible changes caused by their removal. In the Galapagos, *S. horrens* used to be rare (Toral-Granda, M.V., personal observation); at present, their abundance in certain areas is very high (Hearn, A., CDF, personal communication) possibly due to less inter-specific competition and niche release. However, Martínez, P.C. (WWF–Galapagos, personal communication) state that this is not the case, and that this species used to be abundant especially in the early 1990s.

Despite all the scientific information available, the innovative management plans and the commitment of the stakeholders to make the *I. fuscus* fishery a sustainable one, this activity provoked the severe depletion of its natural populations. Lessons should be learned from this fishery, so as not to make the same mistakes and to allow other fisheries to be sustainable over time.

For other sea cucumber species entering the fishery, basic biological and ecological information should be gathered before the start of any fishing activity. Furthermore, an increase communication exchange with the fishing sector of Galapagos is encouraged, if they were to accept any scientific result. For these "new" species, the three "phases" stated in Perry, Walters and Boutillier (1999) should be carried out. For "Phase 0", all information related to the given sea cucumber fishery should be collated, and presented to the stakeholders. For "Phase 1", mistakes should be learned from other sea cucumber fisheries and once key scientific information has been identified, obtain the funds and the commitment to undertake relevant investigations; for "Phase 2", the best management practices or the ones that have yielded satisfactory results on the conservation of the given species, should be kept and evaluated against new ones that could be implemented. This study should also investigate similar problems elsewhere, and seek advice from places where sea cucumber fisheries have not collapsed.

Constant monitoring of NTZ should be undertaken, as these provide shelter for commercial and non-commercial species. Despite the little information available on the benefits of these tools for sea cucumbers, they have a proven record to benefit other species of both demersal and pelagic species. In the GMR, there is 20 percent of coastal perimeter protected as NTZ; specific analysis should be undertaken to understand the benefits, if any, of such a management tool.

A ban of SCUBA diving or hookah can also help conserve deepwater stocks, which would in turn help through reproduction. Otherwise a ban to carry hookah compressors onboard, out of the fishing season could help stop illegal fishing activities.

The current "chain of custody" in place in the GMR for sea cucumbers and spiny lobsters has served a major stepping stone for fishers to understand the need of monitoring and reporting. Thanks to this chain, the GNPS has a clear understanding of the number (and/or kg) that have been extracted, processed and shipped outside the GMR. Additionally, fishers understand the need of the permits and certificates, hence being an active part of the management of the fisheries. Such a programme could be followed in many other places, as it allows control, enforcement and understanding.

As *I. fuscus* is the only sea cucumber species included in CITES, trade monitoring should be improved so as to understand the trade route and identify bottlenecks where IUU catches may be exported to. Better reporting from both the CITES administrative authority (the GNPS in the Galapagos and the Ministry of Environment in mainland Ecuador) should be encouraged, as well as better communication with the CITES Secretariat. Moreover, a thorough evaluation of the effectiveness of the Appendix III listing of *I. fuscus* should be undertaken, which will in turn provide tools for other countries with sea cucumber populations in peril due to international trade.

As a way to ensure accurate and fast identification of *I. fuscus* in the international market, the Ecuadorian Government, through the GNPS, advised by the CDF, have sent samples of dried specimens of *I. fuscus* to China Hong Kong SAR, where they are used for education and training purposes (Kwan, B., Hong Kong Census and Statistics Department, personal communication) and to the US National Oceanic and Atmospheric Administration (NOAA) in Los Angeles, an important re-exporting port for many sea cucumber species (Torres, R., NOAA, personal communication). Similar procedures can be used for other species in the international market.

8.2 Evaluation of the pros and cons of a CITES listing

I. fuscus it is the only sea cucumber species included in the CITES Appendix III. Since its inclusion came into effect (16 October 2003), most of the catches from capture fisheries have been recorded in CITES permits; however, about 400 000 individuals are unaccounted for, perhaps due to early mistakes in recording and registering the permits. The 2007 fishing season will yield more information on how the CITES permits are being handled and will elucidate more on the possible benefits of an Appendix III listing.

Identification of specimens is intrinsic to the proper functioning of a CITES listing, and this may become a handicap for marine species as these can sometimes be traded in processed forms that may complicate visual recognition. Moreover, commodity codes may classify shipments in highly generic terms (Willock, Burgener and Sancho, 2006).

The listing of *I. fuscus* in CITES has advantages and disadvantages. Below a list of some of the advantages and disadvantages:

Advantages:

i) Certainty of the legality of the catch of the exported goods.
ii) Increased awareness of the need to conserve and manage sea cucumber populations.
iii) Possibility of identifying trade bottlenecks where laundering of illegal catches may occur.
iv) Better opportunities for technical assistance, targeted research and capacity building.
v) Creating and putting into place standardized and comprehensive trade reporting codes and data gathering amongst countries.
vi) Catch and export data is centralized in one location allowing faster analysis and interventions.
vii) Understanding of the trade route when the products leave Ecuador.
viii) Understanding that international trade is the major force behind the exploitation of *I. fuscus* in the GMR.
ix) Curtailing international trade by means of an attached CITES permit that ensures the legality of the catch.

Disadvantages:

i) Increased burden to CITES administrative officers (i.e. processing of permits, compilations and submission of annual reports to the CITES Secretariat).

ii) Increased costs to train and educate managers, border patrol and custom officers particularly in species identification.
iii) Slow communication between concerned CITES authorities may delay action responses.
iv) Delay in acquisition of the CITES Secretariat trade reports on CITES species.

Currently, Ecuador is not considering either the inclusion of *I. fuscus* in Appendix II or listing any other sea cucumber species in any CITES Appendix. As a developing country, with different needs and prerogatives, a CITES listing has become more of a burden than a help, and no clear advantages have been shown to managers, fishers or scientists. However, it is well understood that a clear and thorough evaluation of the current listing of *I. fuscus* is a priority, as this would help clarify some possible misconceptions and to aid the government to make the best use of the CITES permits as management tool, which in turn will help in the conservation and sustainable use of sea cucumber populations.

Finally, the inclusion of *I. fuscus* in Appendix III by other range states would possibly help to reduce laundering of this species and ensure a better control of its international trade.

ACKNOWLEDGEMENTS

My sincere thanks to Alessandro Lovatelli who believed in me and made me part of the team. To Marcelo Vasconcellos, Alex Hearn, Annie Mercier and Priscilla Martínez who helped improving the document and gave key inputs so as to make this document more accurate. To Cesar Peñaherrera, who designed the GIS map. To Tom Poulsom, who provided great cups of tea, support and editorial assistance. Data presented in this report was collected thanks to the financial support of the David and Lucille Packard Foundation, the Interamerican Development Bank and WWF–USAID. This is Charles Darwin Foundation contribution number 1073.

REFERENCES

Aguilar, F., Chalen, X., Castro, F., Sonnenholzner, J. & Herrera, M. 1993. Evaluación del recurso pepino de mar Holothuroidea al este de la Isla Fernandina en la Provincia de Galapagos. Guayaquil, Instituto Nacional de Pesca: 20.

Altamirano, M., Toral-Granda, M.V. & Cruz, E. 2004. The application of the adaptive principle to the management and conservation of *Isostichopus fuscus* in the Galapagos Marine Reserve. *In*: *Advances in Sea Cucumber Aquaculture and Management*. Lovatelli, A., Conand, C., Purcell, S., Uthicke, S., Hamel, J.-F. & Mercier, A. (eds). *FAO Fisheries Technical Paper*. No. 463. Rome, FAO. 2004. 425p.

Avendaño, U., Llerena, S. & Gravez, V. 2006. Evaluación poblacional del pepino de mar *Isostichopus fuscus* en la Reserva Marina de Galápagos, Pre-Pesquería 2006. UCOOPEPGAL-COPAHISA-COPESAN-COPES PROMAR-COPROPAG. Informe de Monitoreo. 8 pp.

Baine, M. & Choo, P.S. 1999. Sea cucumber fisheries and trade in Malaysia. pp. 49–63. *In*: *The conservation of sea cucumbers in Malaysia — their taxonomy, ecology and trade: Proceedings of an international conference.* Baine, M. (ed). Department of Agriculture, Kuala Lumpur, Malaysia. February 1999. Heriot-Watt University, Orkney, Scotland.

Bremner, J. & Perez, J. 2002. A case study of human migration and the sea cucumber crisis in the Galapagos Islands. *Ambio*, 31(4): 306–310.

Calvopiña, M., Visaira, R., Cruz, E., Piu, M. & Dumas, J. 2006. Implementación de la zonificación consensuada de la Reserva Marina de Galapagos. *In: Pasos hacia la sustentabilidad de la Reserva Marina de Galápagos.* WWF-USAID, Puerto Ayora, Santa Cruz, Galapagos.

Camhi, M. 1995. Industrial fisheries threaten ecological integrity of the Galapagos Islands. *Conservation Biology*, 9(4): 715–724.

Carranza, C. & Andrade, M. 1996. Retrospectiva de la pesca del pepino de mar a nivel continental. Fundación Charles Darwin para las Islas Galapagos/ORSTOM. Quito. 54 pp.

Clarke, S. 2002. Trade in Asian dried seafood: characterization, estimation and implications for conservation. Wildlife Conservation Society Working Paper No. 22 (15 December 2002).

Conand, C. 2001. Overview of sea cucumbers fisheries over the last decade – What possibilities for a durable management? Echinoderms 2000. Barker (ed.) pp. 339–344.

De Paco, C., Hurtado, M., McFarland, C., Martínez, P., Reck, G. & Richmond, R. 1993. Evaluación de la pesquería de pepinos de mar en las islas Galápagos, Ecuador. Informe para la Unión Mundial para la Naturaleza (UICN) como resultado de la Misión realizada a solicitud de la Fundación Charles Darwin para las Islas Galápagos. Fundación Charles Darwin, Quito, 25 pp.

Deichmann, E. 1958. The Holothuroidea collected by The Velero II and IV during the years 1932 to 1954, Part II. Aspidochirota. *Allan Hancock Pacific Expeditions*, 11(2): 253–348.

De Miras, C., Andrade, M. & Carranza, C. 1996. Evaluación socioeconómica de la pesca experimental de pepino de mar Galápagos. Unpublished report, FCD and ORSTOM: 45 pp.

Edgar, G.J., Bustamante, R.H., Fariña, J.M., Calvopiña, M., Martínez, C. & Toral-Granda, M.V. 2004. Bias in evaluating the effects of marine protected areas: the importance of baseline data for the Galápagos Marine Reserve. *Environmental Conservation*, 31(3): 1–7.

FAO. 2007. Capture production 1950–2005. FISHSTAT Plus – Universal software for fishery statistical time series [online or CD-ROM]. Food and Agriculture Organization of the United Nations.

Fajardo-León, M.C., Michel-Guerrero, E., Singh-Cabanillas, J., Vélez-Barajas, J.A. & Massó-Rojas, A. 1995. Estructura poblacional y ciclo reproductor del pepino de mar *Isostichopus fuscus* en Santa Rosalía, B.C.S., México. *Cienc Pesquera*, 11: 45–53

Gayanilo, F.C. Jr. & Pauly, D. (eds) 1997. FAO-ICLARM stock assessment tools (FiSAT). Reference Manual. FAO Computerized Information Series (Fisheries). No. 8, Rome, FAO. 262 pp.

Hamel, J.-F., Ycaza-Hidalgo, R. & Mercier, A. 2003. Larval development and juvenile growth of the Galapagos sea cucumber *Isostichopus fuscus*. *SPC Beche-de-Mer Information Bulletin*, 18: 3–8.

Hearn, A. & Murillo, J.C. 2007. Life History of the Red Spiny Lobster, *Panulirus penicillatus* (Decapoda: Palinuridae), in the Galapagos Marine Reserve, Ecuador. Pacific Science, 62(2): 191–204.

Hearn, A. & Pinillos, F. 2006. Baseline information on the warty sea cucumber *Stichopus horrens* in Santa Cruz, Galapagos, prior to the commencement of an illegal fishery. *SPC Beche-de-Mer Information Bulletin*, 24: 3–10.

Hearn, A., Martínez, P., Toral-Granda, M.V., Murillo, J.C. & Polovina, J. 2005. Population dynamics of the exploited sea cucumber *Isostichopus fuscus* in the western Galápagos Islands, Ecuador. *Fisheries Oceanography*, 14(3): 1–9.

Herrero-Pérezrul, M.D., Reyes-Bonilla, H., García-Domínguez, F. & Cintra-Buenrostro, C.E. 1999. Reproduction and growth of *Isostichopus fuscus* (Echinodermata: Holothuroidea) in the southern Gulf of California, México. *Mar Biol*, 135: 521–532.

Heylings, P. & Bravo, M. 2007. Evaluating governance: A process for understanding how co-management is functioning, and why, in the Galapagos Marine Reserve. *Ocean & Coastal Management*, 50(2–3): 174–208.

Hickman, C.P. 1998. Guía de campo sobre estrellas de mar y otros equinodermos de Galápagos. Serie vida marina de Galápagos. Sugar Spring Press, Virginia, USA. 83 pp.

Hilborn, R. & Walters, C.J. 1992. Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty. Chapman and Hall, New York. 570 pp.

Hooker, Y., Solís-Marín, F.A. & Lleellish, M. 2005. Equinodermos de las Islas Lobos de Afuera (Lambayeque, Perú). *Rev. Peru. Biol.*, 12(1): 77–82.

Ilias, Z. & Ibrahim, K. 2006. National Report: Malaysia. *In: Proceedings of the CITES workshop on the conservation of sea cucumbers in the families Holothuriidae and Stichopodidae.* Bruckner, A.W. (ed.). NOAA Technical Memorandum NMFSOPR 34, Silver Spring, MD 244 pp.

Jenkins, M. & Mulliken, T.A. 1999. Evolution of exploitation in the Galapagos Islands: Ecuador's sea cucumber trade. *Traffic Bulletin*, 17: 107–118.

Lohr, H.R. 2003. Genetic variation among geographically isolated populations of the commercially important sea cucumber *Isostichopus fuscus* in the Eastern Pacific. M.S. Thesis, Moss Landing Marine Laboratories, California State University, San Francisco, USA.

Maluf, L.Y. 1991. Composition and distribution of the central eastern Pacific echinoderms. Nat. Hist. Mus. *Los Angeles Co. Technol. Rep*., 2: 1–242.

Martínez, P.C. 1999. Estado Poblacional y Biología Reproductiva del Pepino de Mar *Stichopus fuscus* en las Islas Galápagos. Informe Técnico. Fundación Charles Darwin, Santa Cruz, Galápagos 13 pp.

Martínez, P.C. 2001. The Galapagos sea cucumber fishery: a risk or an opportunity for conservation? *SPC Beche-de-Mar Information Bulletin*, 14: 22–23.

Massin, C., Zulfigar Y., Tan Shau Hwai, A. & Rizal Boss, S.Z. 2002. The genus *Stichopus* (Echinodermata: Holothuroidea) from Johore Marine Park (Malaysia) with the description of two new species. *Bulletin de l'Institute Royal des Sciences Naturelles de Belgique*, 72: 73–99.

Mercier, A., Ycaza-Hidalgo, R. & Hamel, J.-F. 2004. Aquaculture of the Galapagos sea cucumber, *Isostichopus fuscus*. *In*: *Advances in Sea Cucumber Aquaculture and Management*. Lovatelli, A., Conand, C., Purcell, S., Uthicke, S., Hamel J.-F. & Mercier, A. (eds). *FAO Fisheries Technical Paper*. No. 463. Rome, FAO. 2004. 425p.

Mercier, A., Ycaza-Hidalgo, R. & Hamel, J.-F. 2007. Long-term study of gamete release in a broadcast spawning holothurian: predictable lunar and diel periodicities. *Marine Ecology Progress Series*, 329: 179–189.

Murillo, J.C., Reyes, H. & Hearn, A. 2007. Aspectos sociales de las pesquerías en Galapagos. *In: Informe Galápagos 2006–2007*. FCD-SPNG-INGALA.

Murillo, J.C., Martínez, P., Toral, M.V. & Hearn, A. 2002a. Pepino de Mar. *In: Reserva Marina de Galápagos, Línea Base de la Biodiversidad.* Danulat, E. & Edgar, G. (eds). Fundación Charles Darwin y Servicio Parque Nacional de Galápagos, Santa Cruz, Galápagos, Ecuador.

Murillo, J.C., Vizcaino, J., Nicolaides, F., Moreno, J., Espinoza, E., Chasiluisa, C., Andrade, R., Born, B., Villalta, M., Yépez, M. & Molina, L. 2002b. Informe técnico final de la pesquería del pepino de mar (*Stichopus fuscus*) en las islas Galápagos, 2001 Análisis comparativo con las pesquerías de 1999 y 2000. Fundación Charles Darwin/ Parque Nacional Galápagos. 29 pp.

Okey, T.A., Banks, S., Born, A.F., Bustamante, R.H., Calvopiña, M., Edgar, G.J., Espinoza, E., Fariña, J.M., Garske, L.E., Reck, G.K., Salazar, S., Shepherd, S., Toral-Granda, V. & Wallem, P. 2004. A trophic model of a Galápagos subtidal rocky reef for evaluating fisheries and conservation strategies. *Ecological Modeling*, 172: 383–401.

Orensanz, J.M., Parma, A.M. & Hall, M.A. 1998. The analysis of concentrating and crowding in shellfish research. *In: Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management*. Jamieson, G.S. and Campbell, A. (eds). *Canadian Special Publication on Fisheries and Aquatic Sciences*, 125: 441–459.

PR.C.P003.R002. 2007. Más de un millón de pepinos de mar se capturaron en la RMG. *Galapagos National Park Press Release*. 20 August 20 2007.

Perry, R.I., Walters, C.J. & Boutillier, J.A. 1999. A framework for providing scientific advice for the management of new and developing invertebrate fisheries. *Reviews in Fish Biology and Fisheries*, 9: 125–150.

Peterson, M.N., Peterson, M.J. & Rai Peterson, T. 2005. Conservation and the myth of consensus. *Conservation Biology*, 19(3): 762–767.

Powell, J.R. & Gibbs, J.P. 1995. A report from Galapagos. *TREE*, 10(9): 351–354.

Reyes-Bonilla, H. & Herrero-Perezrul, M.D. 2003. Population parameters of an exploited population of Isostichopus fuscus (Holothuroidea) in the southern Gulf of California, Mexico. *Fisheries Research*, 59: 423–430.

Reyes, H. & Murillo, J.C. 2007. Esfuerzos de control de pesca ilícita en la Reserva Marina. *In: Informe Galápagos 2006–2007*. FCD-SPNG-INGALA.

Richmond, R.H. & Martínez, P.C. 1993. Sea cucumber fisheries in the Galápagos Islands. Biological aspects, impacts and concerns. World Conservation Union (IUCN) Technical Report: 18 pp.

Servicio Parque Nacional de Galápagos. 2007. Boletín de prensa sobre la pesquería del pepino de mar *Isostichopus fuscus* en la Reserva Marina de Galápagos. 1 pp.

Shepherd, S.A., Toral-Granda, M.V. & Edgar, G.J. 2003. Estimating the abundance of clustered and cryptic marine macro-invertebrates in the Galapagos with particular reference to sea cucumbers. *Noticias de Galápagos*, 62: 36–39.

Shepherd, S.A., Martinez, P., Toral-Granda, M.V. & Edgar, G.J. 2004. The Galapagos sea cucumber fishery: management improves as stocks decline. *Environmental Conservation*, 31(2): 102–110.

Stone, R. 1995. Fishermen threaten Galapagos. SPC *Beche-de-Mer Information Bulletin*, 7: 22.

Toral-Granda, M.V. 1996. Biología reproductiva del pepino de mar *Isostichopus fuscus* en la isla Caamaño, Santa Cruz, Galápagos. Tesis de Licenciatura, Universidad del Azuay Cuenca. 89 pp.

Toral-Granda, M.V. 2001. Monitoreo de las poblaciones de *Isostichopus fuscus* antes y después de la temporada de pesca 2000. Informe interno, Estación Científica Charles Darwin. 25 pp.

Toral-Granda, M.V. 2005a. Estado poblacional del pepino de mar *Isostichopus fuscus* posterior a la temporada de pesca 2005. Informe Técnico. 29 pp.

Toral-Granda, M.V. 2005b. Requiem for the Galapagos sea cucumber fishery? *SPC Beche-de-Mer Information Bulletin*, 21: 5–8.

Toral-Granda, M.V. 2005c. Should stock enhancement and re-stocking be an option for the Galapagos sea cucumber? Charles Darwin Foundation Internal Document. 10 pp.

Toral-Granda, M.V. & Martínez, P.C. 2004. Population density and fishery impacts on the sea cucumber (*Isostichopus fuscus*) in the Galapagos Marine Reserve. *In*: *Advances in sea cucumber aquaculture and management*. Lovatelli, A., Conand, C., Purcell, S., Uthicke, S., Hamel, J.-F. & Mercier, A. (eds). *FAO Fisheries Technical Paper*. No. 463. Rome, FAO. 2004. 425p.

Toral-Granda, M.V. & Martinez, P.C. 2007. Reproductive biology and population structure of the sea cucumber *Isostichopus fuscus* (Ludwig, 1875) (Holothuroidea) in Caamaño, Galapagos Islands, Ecuador. *Marine Biology*, 151: 2091–2098.

Toral-Granda, M.V., Murillo, J.C., Piu, M., Nicolaides, F., Moreno, J., Reyes, H., Castrejón, M. & Hearn, A. 2005. Evaluación de la pesquería de pepino de mar (*Isostichopus fuscus*) en la Reserva Marina de Galápagos en el año 2005. Fundación Charles Darwin/Parque Nacional Galápagos. Puerto Ayora, Santa Cruz. 41 pp.

UCOOPEPGAL. 2007. Evaluación poblacional del pepino de mar *Isostichopus fuscus* en la Reserva Marina de Galápagos. Pre-pesquería 2007. Sector pesquero artesanal de Galápagos (UCOOPEPGAL), Galápagos, Ecuador. 16 p.

Viteri, C. & Chavez, C. 2007. Legitimacy, local participation, and compliance in the Galapagos Marine Reserve. *Ocean & Coastal Management*, 50: 253–274.

Wellington, G.M. 1974. Ambientes marinos de Galápagos. Reporte Técnico para el Departamento de Parques Nacionales y Vida Silvestre. 357 pp.

Willock, A., Burgener, M. & Sancho, A. 2006. First Choice or Fallback? An examination of issues relating to the application of Appendix III of CITES to marine species. *TRAFFIC International*. 57 pp.