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EVALUATION OF THE SEA CUCUMBER FISHERY IN THE GALAPAGOS MARINE RESERVE

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Photograph: Alex Hearn

Evaluation of the sea cucumber fishery in the Galapagos Marine Reserve

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Introduction

In 2011, population monitoring of sea cucumbers (*Isostichopus fuscus*) in the Galapagos Marine Reserve (GMR) estimated a density of 12 cucumbers per 100 m^2 in the western Isabela macrozone (Reyes *et al.*, 2011). This density was higher than the Critical Reference Point (11 cucumbers/100 m^2 in the western Isabela macrozone) established in the Fishery Management Chapter of the GMR Management Plan. Based on this information the Participatory Management Board (PMB) decided to open this fishery after having closed it for two consecutive years.

The Fishery Management Chapter recommends that if the sea cucumber fishery is opened, it should include 60 days of fishing, an established allowable quota, and a clear designation of closed areas, including sites required for recruitment or where population densities are low. Following these guidelines, the JMP decided to open a sea cucumber fishing season from 15 June to 13 August 2011 and established a total quota of one million individuals. Fishing was permitted around the islands of Española, San Cristóbal, Santa Cruz, Isabela and Fernandina, and was prohibited in the Bolivar Channel.

This paper presents an evaluation of the 2011 sea cucumber fishery in the GMR and puts the 2011 fishing season in an historical context based on fishery and socioeconomic indicators. It then provides recommendations for more effective long-term adaptive management of this fishery.

Methods

Since 1999, when formal assessment of the sea cucumber fishery in the GMR began, eight different indicators have been used (Table 1).

The number of active fishers and fishing boats during sea cucumber fishing seasons was the baseline used for determining fishing capacity. The ratio of active fishing boats and fishers to the number listed in the Fishing Register of the Galapagos National Park Service (GNPS) was also calculated.

Catch per unit effort (CPUE) was defined as the average number of sea cucumbers captured per diver per one hour dive.

The number of sea cucumbers exported to mainland Ecuador from each fishing pier was also determined. In addition, the price per individual and per pound in US$ was determined for each fishing season.

Table 1. Time periods and sources of data used for the various indicators for the evaluation of the sea cucumber fishery in the GMR, based primarily on data from the Galapagos National Park Service (GNPS).

Indicator	Period	Source of information
Number of active fishing boats	1999-2011	Monitoring certificates - GNPS
Number of active fishers	1999-2011	Monitoring certificates - GNPS
Number of registered fishing boats	2000-2011	Fishing Register - GNPS
Number of registered fishers	2000-2011	Fishing Register - GNPS
Number of sea cucumbers harvested	1999-2007	Murillo & Reyes (2008)
	2008	Reyes *et al.* (2009)
	2011	Monitoring certificates - GNPS
Catch per unit effort	1999-2007	Murillo & Reyes (2008)
	2008	Reyes *et al.* (2009)
	2011	Monitoring certificates - GNPS
Density	1999-2011	Population monitoring (GNPS-CDF-Fishing Sector)
Price	1999-2011	Date base - GNPS

Finally, the percentage of individuals retained with respect to the total number caught was calculated for each fishing season.

Results

The fishing capacity of the sea cucumber fishery in the GMR peaked in 2000. Since then it has declined based on the number of active fishers and active fishing vessels per fishing season (Figure 1).

The ratios between active and registered boats and fishers (listed in the Fishing Register of the GNPS) have decreased over time, with a slight increase in 2011 (Figure 2). Currently the passive fishing capacity, defined as the percentage of boats and fishers registered but not active, is 49% (204 vessels) and 52% (536 fishers), respectively.

The average annual sea cucumber catch from 1999 to 2011 was 3.28 million individuals. The sea cucumber catch has declined since 2002, when it peaked at 8.3 million (Figure 3). Since 2004, the catch has not reached the allowable quota. In 2011 the catch was 4522 cucumbers shy of the quota of one million.

The data show a clear drop in the sea cucumber CPUE over time (Figure 4). The year 2011 had the lowest CPUE of all the seasons; the 2011 value (35.8) was less than half (45%) of the historical average CPUE (79.8 cucumbers per diver per hour).

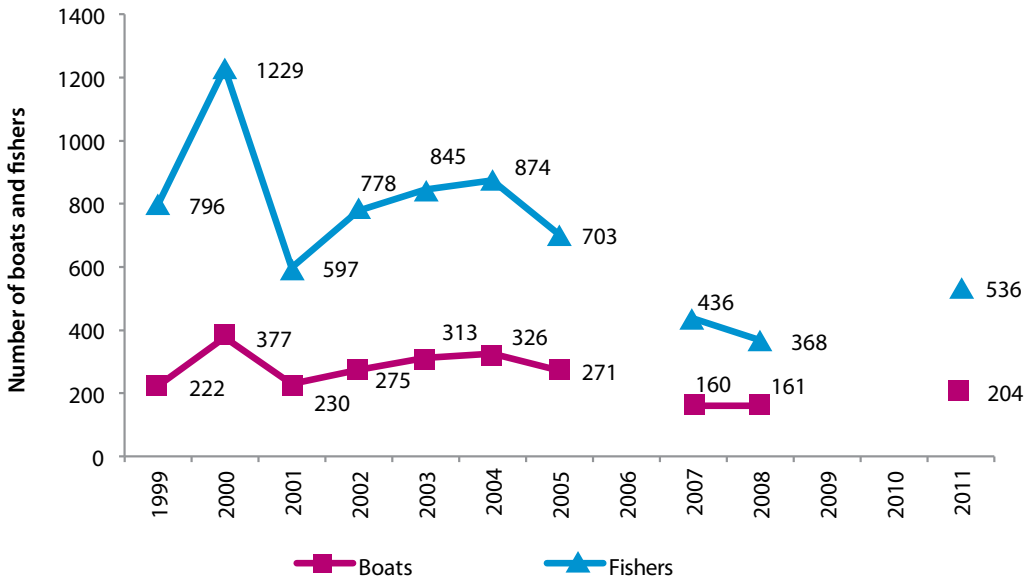

Figure 1. Number of active fishers and fishing boats during the sea cucumber fishing seasons 1999-2011.

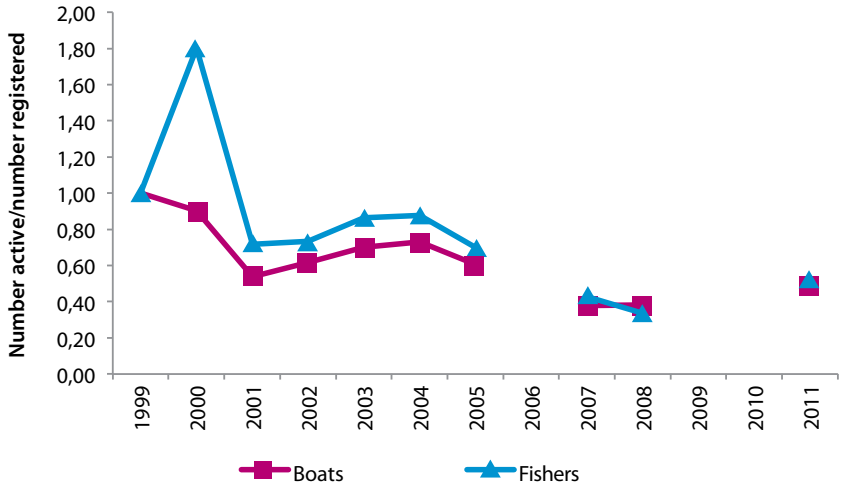

Figure 2. Ratio of active and registered fishing boats and fishers during the sea cucumber fishing seasons 1999-2011.

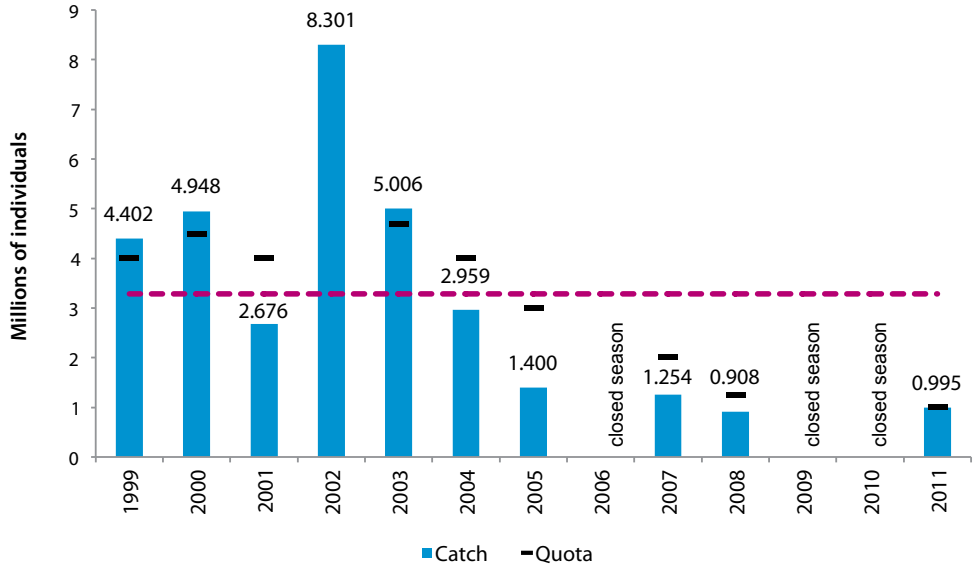

Figure 3. Total annual catch and total allowed quota for sea cucumbers from 1999 to 2011. Note: Dashed line indicates the average total catch during the study period. In 2002 no quota was established.

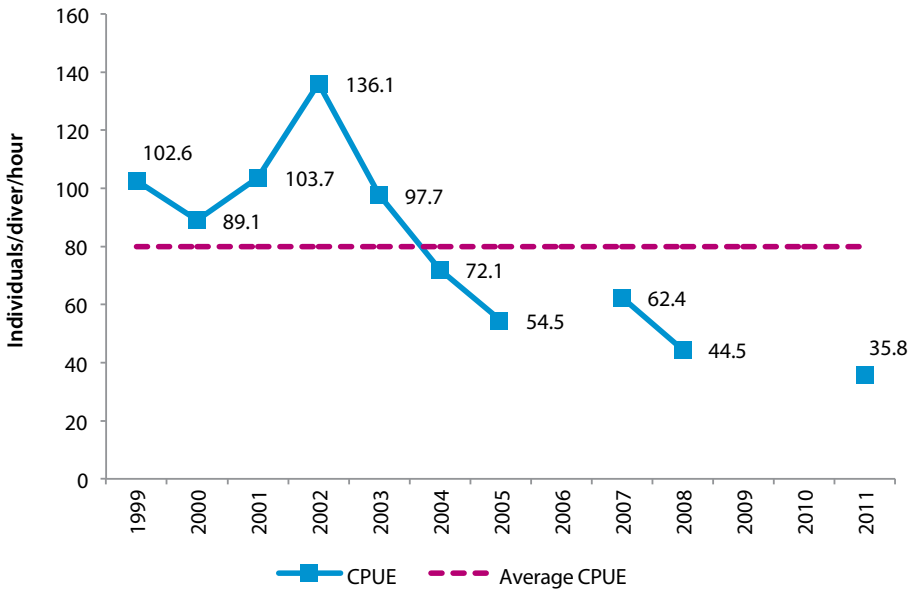

Figure 4. Change in the CPUE for sea cucumbers from 1999 to 2011. Note: Dashed line indicates the average CPUE during the study period.

Since 2001, when the highest CPUE value was observed, the average sea cucumber density in the GMR has decreased. Since 2004, sea cucumber density has been below the overall average (13.5 cucumbers per 100 m^2; Figure 5).

The price for sea cucumbers has increased over the years (Figure 6). The year with the highest prices, both per unit and per pound of salted sea cucumbers, was 2011.

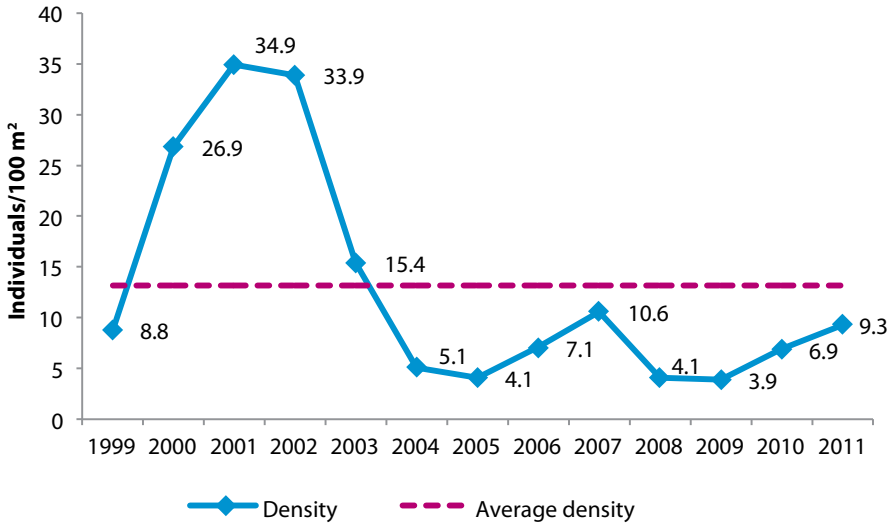

Figure 5. Change in the average population density of sea cucumbers in the GMR from 1999 to 2011.

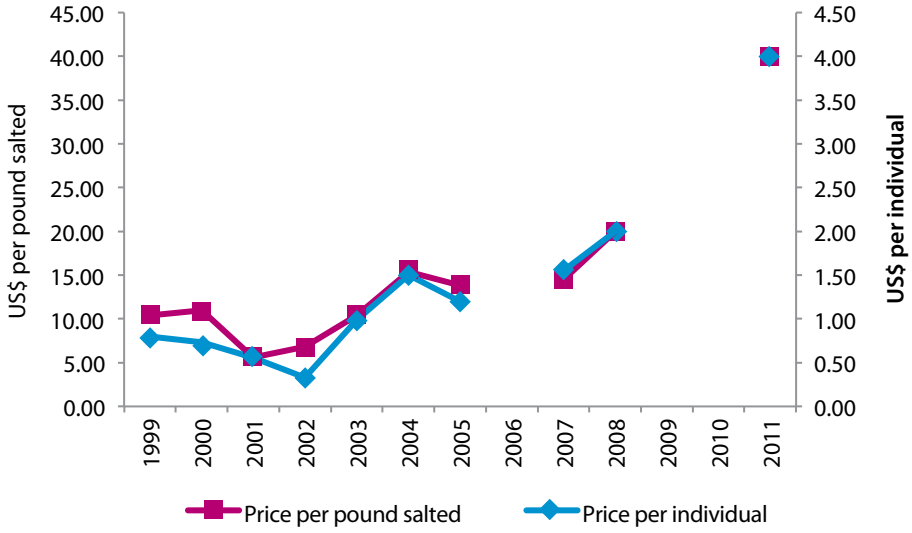

Figure 6. Change in the price per individual sea cucumber and per pound of salted sea cucumbers from 1999 to 2011.

Discussion

The Fishery Management Chapter of the GMR Management Plan considers designating a recovery phase for sea cucumber populations when population monitoring indicates a density between 11 and 20.9 individuals per 100 m^2 to the west of Isabela Island. Based on those figures, the sea cucumber fishery is considered in recovery. However, historical indicators evaluated here suggest that the recovery is very slow and incomplete, and the assertion that the population is recovering should be taken with caution.

In 2011 fishing indicators were well below historical values. The 2011 CPUE represented only 26% of the CPUE of 2002. The allowable quota for the 2011 season was the lowest ever established and the total catch was the second lowest in the entire study period. Sea cucumber densities declined by 73% from 2001 to 2011. All of this suggests that sea cucumber stocks have yet to recover.

Wolff *et al.* (2012) explain the main causes of the overexploitation of sea cucumbers in the GMR. A primary reason is that fishing quotas established by the GMR's participatory management system have been based more on political than technical or scientific criteria. There

have even been cases of quotas being implemented that were two to three times higher than the technical recommendations. It appears that these decisions have strongly affected the recruitment potential of *I. fuscus*.

It is important to note that the recruitment of *I. fuscus* is also related to sea temperature. It has been observed that El Niño events favor the recruitment of this species, while the cold waters of La Niña have a negative affect (Herrero-Perézrul *et al.*, 1999; Wolff *et al.*, 2012).

Also, sea cucumber populations in various regions of the world take a long time to recover. For example, in Australia and Papua New Guinea sea cucumber fisheries were closed for *Holothuria scabra* from 1996 to 2000 without significant recovery of the population (Skewes *et al.*, 2006). The same effect was observed with the closure of the fishery for *H. whitmaei* in Queensland, Australia (Purcell, 2010). Although there is insufficient information to determine the actual effect closures have on sea cucumber populations in the GMR, it appears that the recovery of *I. fuscus* is slow. Even with closures in 2006, 2009 and 2010, both the CPUE and the population density of sea cucumbers are below their annual averages.

There are several reasons why the sea cucumber has been slow to recover or has not recovered after a closure of the fishery. One possibility is that the density of breeding individuals could have been very low prior to the closure of the fishery. Another reason is that the population depends heavily on larvae from another population, which could also be depleted. Finally, recruitment may also be affected by the presence or absence of environmental factors required for the transport and development of larva (Purcell, 2010).

Finally, it is important to consider the passive fishing capacity for the sea cucumber fishery in the GMR (the percentage of fishers and boats registered but not active). While the number of active fishers and boats has declined over time, the passive capacity has increased. Currently 50% of registered fishers and boats are inactive. If these fishers return to being active, they could negatively impact the possible recovery of sea cucumbers.

Recommendations

The following recommendations are designed to streamline the adaptive management of the sea cucumber fishery in the GMR and ensure the recovery of the population:

- Improve annual population monitoring of sea cucumbers including: 1) mapping the entire sample area to determine the actual percentage of sea cucumber habitat; 2) designation of random sampling sites, and 3) collection of data needed to determine the feasibility of implementing rotation-based management of fishing sites.
- Take advantage of the annual population monitoring to determine the feasibility of implementing a rotation-based management system for sea cucumber fishing areas in the GMR. The objective of this type of management is to allow the sea cucumber population to recover at designated sites, while fishing is permitted elsewhere. This requires (Purcell, 2010):
  - Greater knowledge about the growth rate and annual recruitment of *I. fuscus*,
  - Determining the variation in population size among fishing sites, and
  - Determining the limitations and requirements of participating fishers.
- Given the slow recovery of sea cucumbers in the GMR, the Critical Reference Point should consider the median density of all of the monitored islands, not just western Isabela.
- To reduce passive fishing capacity it is necessary to revise the GNPS Fishing Registry based on the existing effort and the level of exploitation of the resource (Castrejón, 2011; Ramírez *et al.*, 2012).
- Future sea cucumber fishing seasons should: 1) establish the total allowable quota based on pre-fishery population monitoring, rather than political considerations, and 2) designate no-take areas near populated islands that are identified as sea cucumber recruitment centers and/or areas with low population densities.

Acknowledgments

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