# The impact of ecotourism activities on wildlife and sessile benthic species in the Galapagos Marine Reserve

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## Introduction

Ecotourism, when developed according to management guidelines that permit its sustainability, has been highlighted as a socioeconomic alternative with high potential that can be used as a conservation tool in protected areas (Clarke, 1997; Curry *et al.*, 2001; Sirayaka *et al.*, 2001; World Tourism Organization, 2002; Levett & McNally, 2003; Sundstrom, 2003).

In order for ecotourism to become a conservation tool, potential impacts associated with its development must be evaluated and mitigated. The dependence of ecotourism in Galapagos on unique and attractive species, as well as on well-conserved ecosystems, puts the natural balance under pressure and requires that visitor conduct be managed according to guidelines that minimize the effects of their presence.

## Methods

The relation between the behavior of visitors and the reactions of key megafauna species during snorkeling, dinghy rides, and SCUBA diving were analyzed (Table 1), as was the frequency of contact with the substrate and sessile benthic species such as sponges and corals (Table 2).

**Table 1.** Description of human actions and behavioral reactions of the fauna evaluated during ecotourism activities in the Galapagos Marine Reserve.

| Human Actions | | Animal Reactions | |
|---|---|---|---|
| **Category** | **Action** | **Category** | **Reaction** |
| **Persecution** | Visitors move directly toward the animal | **Evasion** | Change in direction withdrawing from the visitors o leaving the area |
| **Use of flash** | Use of flash to photograph an animal | **Alert** | Interruption in the behavior observed when first encountered followed by the animal directing its attention to the visitors |
| **Abrupt movement** | Sudden movement of an extremity or the torso by the visitor nearest to the observed animal | **Approach** | Voluntarily approaches the visitors |
| **Noise** | Knocking the tank, use of diving alert signal bells, shouting, laughing, speaking loudly | **None** | No change in behavior or direction of movement is observed |
| **Simple presence** | None of the above actions occur, the visitor only observes | | |

**Table 2.** Description of categories for frequency of contact with benthos analyzed during marine ecotourism activities in the Galapagos Marine Reserve.

| Category | Contact with Benthos* |
|---|---|
| Constant | Visitor grabs hold for more than 1 minute |
| Frequent | Number of contacts greater than 9 |
| Moderate | Number of contacts between 3 and 9 |
| Rare | Number of contacts less than 3 |
| None | No contact observed |

* The count was reinitiated each time the type of substrate or benthos changed.

## Results

### Reactions of the animals

Samples were taken on 87 days, between July and September 2006 and March to November 2007, aboard 13 cruises that offered snorkeling and dinghy rides. An additional 125 sampling days were completed during 15 live-aboard tours. Fifteen focal species of megafauna were evaluated with a total of 3361 encounters, with the number of encounters per trip ranging from 40 to 613.

Snorkeling was the activity most associated with evasive reactions by the animals. Observing on land while walking along trails at the visitor sites generated the highest occurrence of alert reactions, while SCUBA diving was, in relative terms, the activity most associated with no reaction from the animals. Dinghy rides were most associated with alert and evasive reactions. At the level of species, the frequency of reactions when encountered ranged from 24 to 65%.

The white-tipped shark, whale shark, marbled ray, stingray, and the green sea turtle were the species that showed the highest occurrence of evasive reaction (Table 3). Birds, eagle rays, and marine iguanas mostly showed alert signals, while Galapagos sharks, sea lions, and bottlenose dolphins were the species with a greater tendency to spontaneously approach the visitors. Only in the case of the stingray was there no statistically significant reaction.

Animals responded to flash photography and direct persecution with evasive reactions, with some completely leaving the area. In response to noise, their normal behavior was interrupted and they paid attention to the tourists. Abrupt movements generated both alert and evasive reactions. When confronted with only the presence of the tourists, without any major actions, the animals either showed no change in their behavior or approached spontaneously (Chi-square CoA 905.357, $p < 0.001$, 12 d.f.). The five species that most showed evasive reaction were those that were pursued with greatest frequency and viewed most closely by tourists. The

whale shark was pursued in 73% of the encounters.

When a group of tourists remained quiet in front of an animal or a focal group, there was generally no reaction. When tourists moved about during the period of observation, the frequency of evasive reactions increased significantly. At the same time, when tourists were quietly present, there was a significant increase in spontaneous approaches (Pearson's Chi-square 156.507, $p < 0.001$, 3 d.f.).

Preliminary results indicate that the occurrence of alert and evasive reactions in whale sharks is related to the number of divers present (Log Likelihood Chi-square 31.265, $p = 0.001$, 11 d.f.). The number of encounters tends to increase with the number of divers and the number of alert and evasive reactions by whale sharks increases with the number of encounters (Figure 1).

**Table 3.** Most frequent reactions to marine ecotourism activities in 15 focal species during the periods July to September 2006 and March to November 2007.

| Group | Species | No. of Encounters | Encounters with Reaction (%) | Most common Reaction | Significance |
|---|---|---|---|---|---|
| BIRDS | Albatross | 52 | 44 | Alert (37%) | Chi-square 41.231, p < 0.001, 3 d.f. |
| | Cormorant | 90 | 57 | Alert (41%) | Chi-square 45.022, p < 0.001, 3 d.f. |
| | Blue-footed booby | 205 | 49 | Alert (40%) | Chi-square 149.556, p < 0.013, 3 d.f. |
| | Penguin | 187 | 64 | Alert (43%) | Chi-square78.647, p < 0.001, 3 d.f. |
| SHARKS | Hammerhead shark | 613 | 24 | No dominant reaction | Chi-square 852.012, p < 0.001, 3 d.f. |
| | White-tipped shark | 88 | 48 | Evasion (32%) | Chi-square 9.667, p = 0.022, 3 d.f. |
| | Galapagos shark | 245 | 47 | Approach (27%) | Chi-square 122.984, p < 0.001, 3 d.f. |
| | Whale shark | 190 | 43 | Evasion (32%) | Chi-square 62.663, p < 0.001, 2 d.f. |
| RAYS | Eagle ray | 130 | 42 | Alert (19%) | Chi-square 77.630, p < 0.001, 3 d.f. |
| | Marbled ray | 69 | 54 | Evasion (38%) | Chi-square 10.174, p = 0.006, 2 d.f. |
| | Stingray | 40 | 65 | Evasion (43%) | Chi-square 2.450, p = 0.294, 2 d.f. |
| REPTILES | Green sea turtle | 551 | 44 | Evasion (31%) | Chi-square 371.577, p < 0.001, 3 d.f. |
| | Marine iguana | 281 | 50 | Alert (32%) | Chi-square 44.420, p < 0.001, 2 d.f. |
| MAMMALS | Sea lion | 544 | 61 | Alert (33%), Approach (24%) | Chi-square 154.495, p < 0.001, 3 d.f. |
| | Dolphin | 59 | 38 | Approach (29%) | Chi-square 50.714, p < 0.001, 3 d.f. |

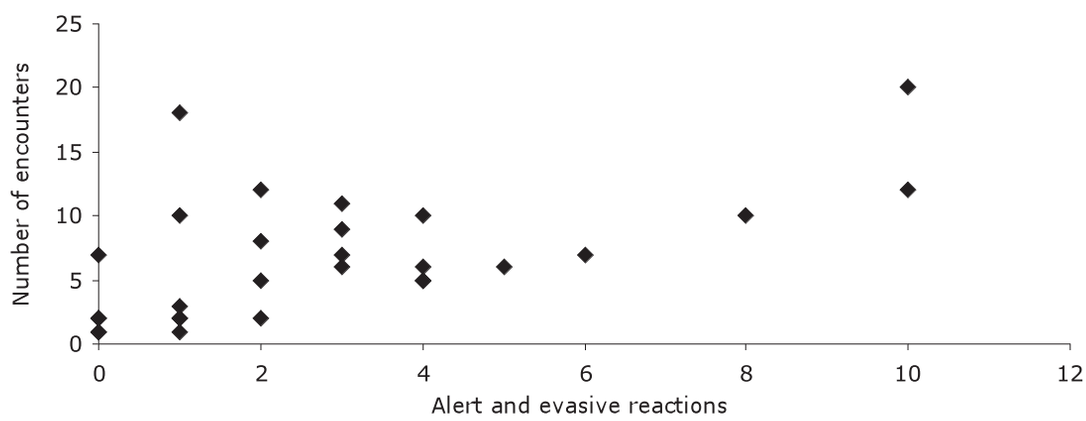


**Figure 1.** Relation between the number of encounters by divers and the occurrence of alert and evasive reactions by whale sharks during SCUBA dives at Darwin Arch, Galapagos Marine Reserve, July to November 2007.

## Effects on the benthos

Eleven snorkeling and 11 dive sites were visited, with a total of 199 and 1007 observations, respectively. At snorkeling sites, the frequency of contact with the substrate varied (Likelihood Chi-square 33.044, p = 0.321, 30 d.f.), with the absence of any contact most frequent. At six sites, 28 to 45% of observations included contact (Figure 2).

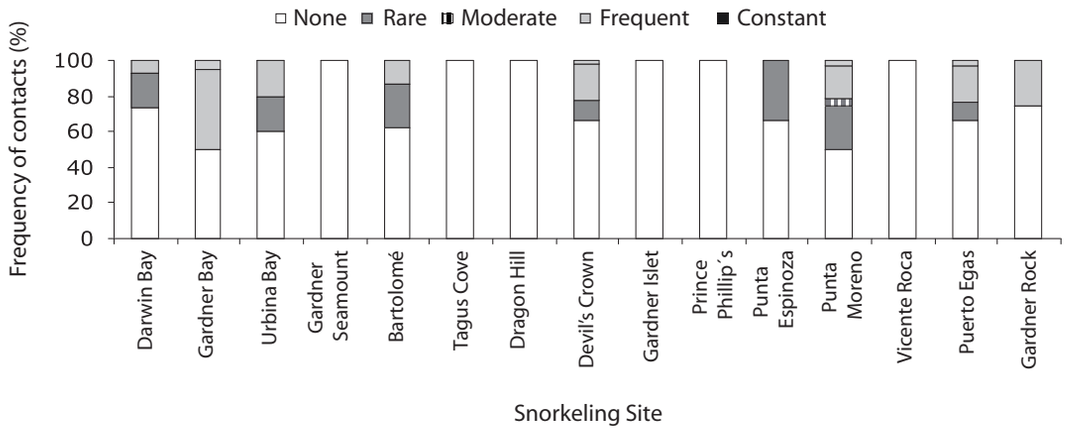


**Figure 2.** Frequency of contact with the benthos at monitored snorkeling sites in the Galapagos Marine Reserve, July to September 2006 and March to November 2007.

Although the average depth at the 11 sites was significantly different, with a range of less than 0.5 m to 15 m (ANOVA F = 9.960, n = 108, p < 0.001, 10 and 97 d.f.), in general, the depths are such that the visitors cannot touch the substrate. However, with the exception of Gardner Islet and Punta Vicente Roca, all of the sites have shallow areas where it is more likely that visitors will make contact with the substrate.

In the case of SCUBA activities, the frequency of contacts with the substrate and sessile benthos also varied among sites. Darwin Arch and Shark Bay were the sites with the highest frequency of contact (Pearson Chi-square 239.381, p < 0.001, 36 d.f.) (Figure 3). When the current was more intense, the frequency of contact was greater (Chi-square CoA 91.404, p < 0.001, 12 d.f.).

The type of substrate and sessile benthos subject to contact varied according to the site. At Darwin Arch, El Derrumbe, La Punta, and Shark Bay, most contacts were with barnacles and corals; in Banana Islet with sponges, barnacles, and anemones, and in Cousins with black coral. At Mosquera Islet and North Seymour the predominant contact was with rock, while at North Seymour there was also a high occurrence of contact with sand (Chi-square CoA 82.911, p = 0.000, 24 d.f.).

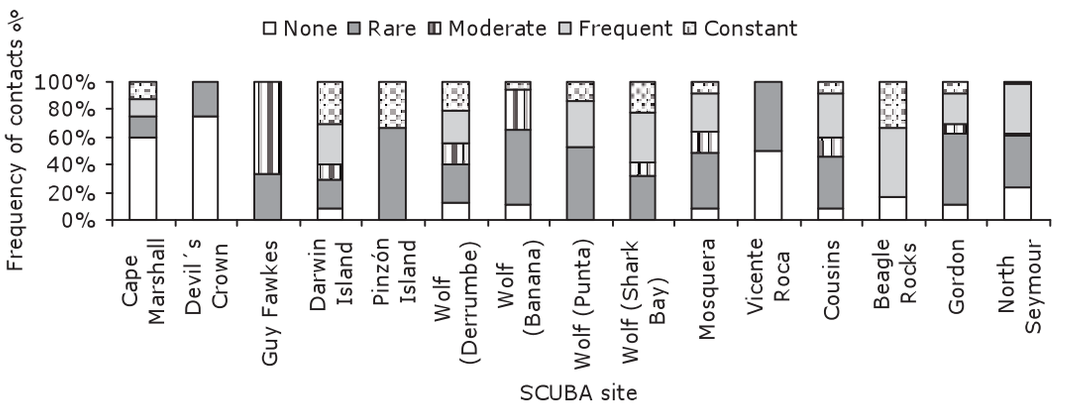


**Figure 3.** Frequency of contacts with the benthos in monitored SCUBA dive sites in the Galapagos Marine Reserve, July to September 2006 and March to November 2007.

## Conclusions

The results of this study reveal clear associations between specific visitor conduct and concrete reactions of the animals. We recommend that special attention be paid to visitor behavior when near white-tipped sharks, whale sharks, marbled rays, stingrays, and green sea turtles, as these are the species that are most pursued and most show evasive behavior.

Snorkeling activities showed a low level of contact with the benthos at the sites monitored. On the other hand, during SCUBA diving, a high level of contact with the benthos was observed, especially at Darwin Arch, El Derrumbe, Shark Bay, and Cousins. Actions taken to improve the conduct of divers could result in a decrease in these occurrences, especially in zones with fragile benthos.

The relationship between the occurrence of alert and evasive reactions by whale sharks and the quantity of divers present and the number of encounters suggest that, apart from only managing visitor conduct, it may be necessary to limit the number of divers interacting at the same time with a specific shark. Since it is likely that some divers may not be willing to remain away from the whale shark while others approach, it may be best to limit the number of divers in the water at any given time.

We recommend that annual monitoring similar to the study presented here continue. It is also important to analyze population dynamics of the megafauna species targeted in this report and to study the percent cover by benthos at the sites with the highest number of contacts.