Subtidal ecological monitoring of the coastal management subzones: 2004 to 2006

Stuart Banks

Charles Darwin Foundation

In April 2000, the location, limits, and characteristics of the three coastal management subzones in Zone 2 (Limited Use) of the Galapagos Marine Reserve (GMR) were approved, based on a proposal created by stakeholders through consensus agreement. The subzones are: 2.1 – Comparison and Protection; 2.2 – Tourism (non-extractive) and Conservation; 2.3 – Fisheries (extractive and non-extractive uses) and Conservation; and 2.4 – Special Management Use areas, established in multiple use zones, such as populated ports, military outposts, and other.

Zoning, and in particular creating subzones, is an adaptive management tool to help decision makers and planners respond to evolving challenges in the GMR. Originally designed to adapt to the changing natural state and human use of the coastal waters, they provide a framework for management of the principal biogeographic regions of the GMR. The use of subzones helps to protect important tourism areas and sites that are critical to the functioning of marine ecosystems and the conservation of vulnerable species. They also contribute to the sustainability of Galapagos fisheries by providing potential areas from which stocks can recover, at the same time assuring that the artisanal fishers have access to the majority of richest fishing sites.

The preliminary results of the subtidal ecological monitoring of the coastal management subzones, carried out from 2004 to 2006, will be used in the development of the next GMR management plan. The two-year data set includes information compiled from 66 sites and forms part of the CDF's planned evaluation of GMR coastal resources under the different management subzones in 2007.

Relative species abundance in protected and artisanal fishing areas throughout the GMR were compared at 66 sites selected by the Participatory Management Board (Figs. 1-3). Although tentative, the patterns are encouraging - especially given the problems of effective patrolling and stakeholder respect for these zones.

As an ecosystem-level analysis, the study emphasizes the role and interactions of species as functional components within the marine subtidal ecosystem.

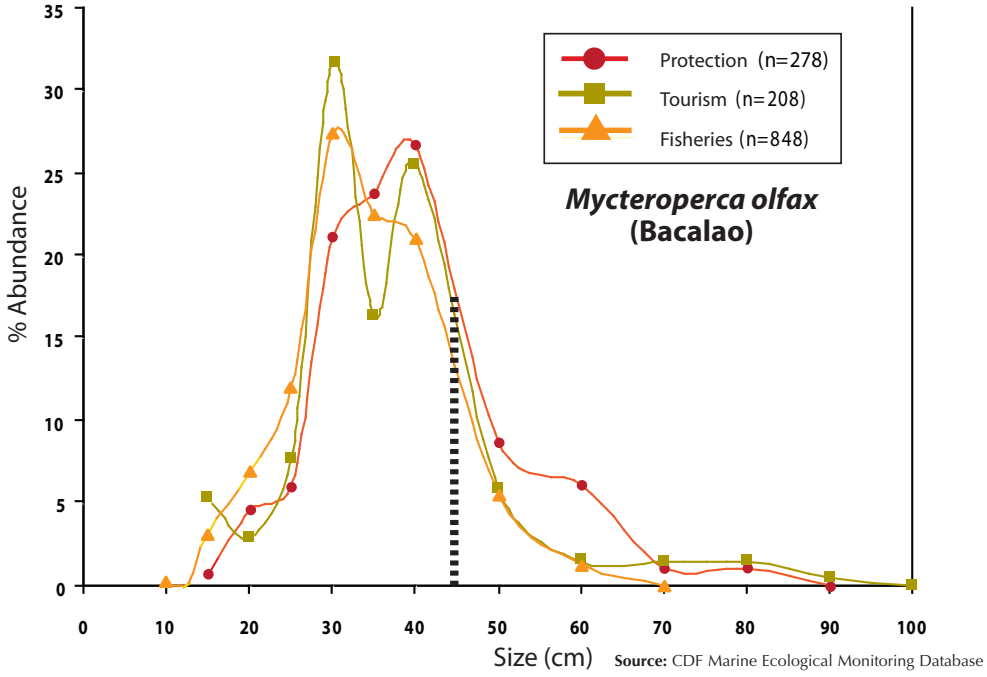
Despite a general lack of awareness and compliance with no-take areas in the coastal zone, the data suggest partial benefits associated with the few areas that have had some degree of patrolling (mostly sites near Park outposts or areas frequented by tourism).

> Improved understanding of the associated benefits, respect, and strengthened patrolling of the different zones will permit an increase in the positive effects of the no-take zones within the GMR.

Case: the endemic bacalao

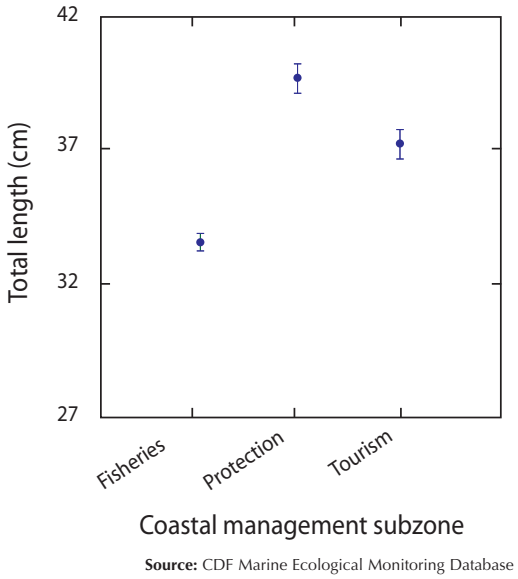
Monitoring shows shifts in size distribution for the endemic grouper bacalao (*Mycteroperca olfax*) between populations within extractive zones and those in zones that have had some degree of protection. This species is hermaphroditic, first reaching sexual maturity as a female at 45.5 cm, then converting to a male upon reaching 83.1 cm. A greater proportion of female adults over the median reproductive age (45.5 cm) are found within no-take zones and significantly larger individuals are found within areas demarcated as exclusively protected areas (17% over 50 cm in protected areas compared to 11% in tourism areas and 7% in fisheries zones). Notably, the few large males that play a crucial role in fertilization (over 80 cm and estimated to be ~12 years old) form less than 2% of the population and were only found in no-take zones. Although these zones have only been recently physically demarcated, these data suggest that the overall effect of these zones is potentially positive and the trends are likely to improve if the zones are respected. Already red listed as vulnerable by IUCN, the existing zoning scheme is one of the few protective measures that exists for this over-fished species.

Figure 1a. Relative abundance of bacalao (endemic grouper) by size and coastal management subzone. The dotted line indicates estimated size at reproductive age



Source: CDF Marine Ecological Monitoring Database

Figure 1b. Mean total length of bacaloa (endemic grouper) by coastal management subzone



Source: CDF Marine Ecological Monitoring Database

Note:

(ANOVA df=2/1331, F=26.2, P=0).

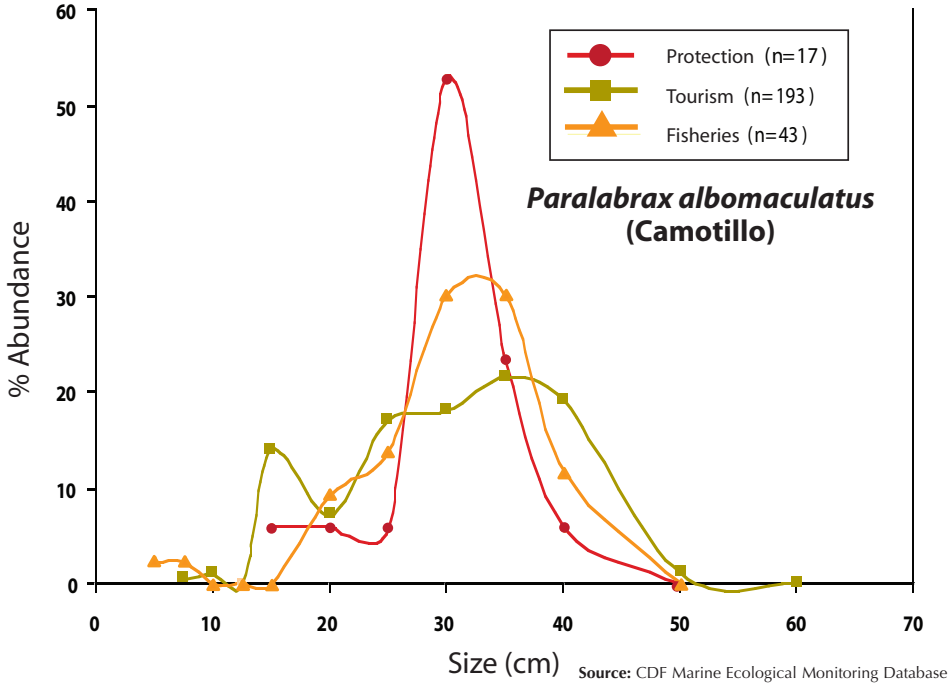
Bacalao, commonly fished in the coastal zone, is less abundant in current harvests than in previous years (Fig. 1a). The proportion of individuals of reproductive age is significantly higher in protected areas compared to areas designated for fishing and tourism. Significant differences in the mean total length between zones are clearly evident in Figure 1b.

Case: the endemic camotillo

Camotillo (*Paralabrax albomaculatus*), an endemic sea bass, is a deep water fish species and an important endemic predator that prefers colder waters. It was also prevalent in the tourism areas sampled, with more individuals of reproductive age within those zones than in fishing or protected zones (Fig. 2). Again, these tend to be sites, such as Tagus Cove in western Isabela, that are close to GNP patrol outposts and that provide a suitably cold water habitat. Two factors contribute to this: 1) these sites were probably chosen for tourism because of the abundance of species, and 2) frequent tourism traffic results in a reduced number of fishing infractions. For species such as camotillo, these sites may now be important refuge, nursery, and reproduction areas.

The proportion of larger individuals of bacalao, camotillo, and the Galapagos grunt is significantly higher in the protected zones than in the Extractive Use zones.

Figure 2. Relative abundance of camotillo (endemic sea bass) by size and management subzone

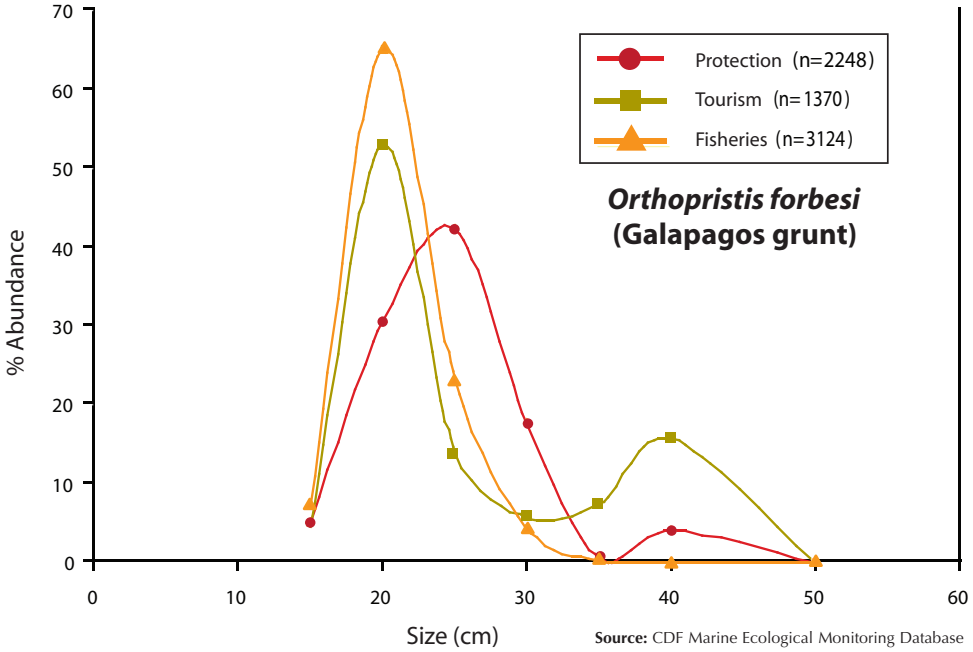


Source: CDF Marine Ecological Monitoring Database

Case: the Galapagos grunt

The Galapagos grunt, *Orthoprostis forbesi*, is an omnivore that is found across the archipelago. As in the previous examples, there are two peaks in protected and non-extractive tourism areas with respect to size distribution, with intermediate-sized individuals found in greater numbers in protected zones (Fig. 3). While not actively fished, the greater abundance of this species in protected areas suggests possible indirect benefits for non-target species due to the management of these sites.

Figure 3. Relative abundance of the Galapagos grunt by size and management subzone



Source: CDF Marine Ecological Monitoring Database

Case: Composition of the sea floor

The composition of the sea floor (benthic environment) over all 66 sample sites is shown in Figure 4. In terms of functional group composition or role within the ecosystem, there is not a major difference between management subzones. The relative proportion of functional groups is similar even though species composition and biodiversity within each area may differ. Anecdotal observations from before the strong 1982-83 El Niño suggest that there has been a unilateral shift in benthic habitat across the Reserve yet to be validated by recent data.

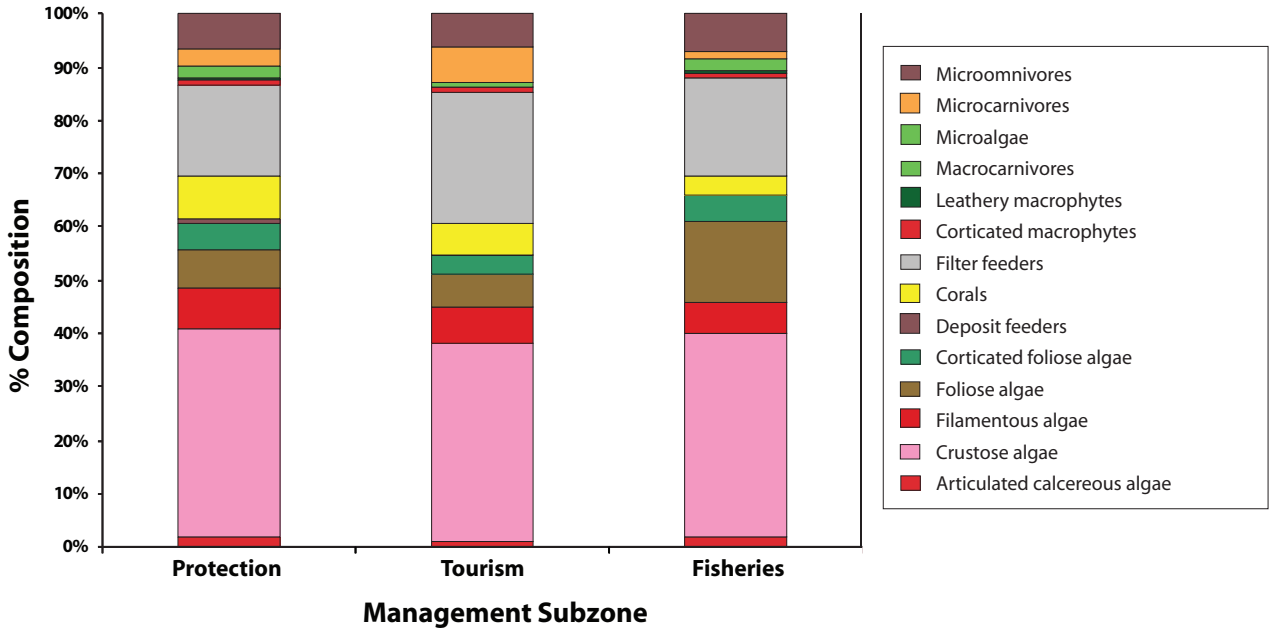
Across the Reserve there is a predominance of encrusting, calcareous, and filamentous algae, indicative of urchin barrens - subtidal areas where the population growth of sea urchins has gone unchecked resulting in overgrazing. In contrast, the macroalgal and coral components, both important habitat-forming species, are very small. The CDF will examine the historical data to determine how the composition has changed over the last 40 years and expects to see a changing equilibrium between habitat-forming species and natural reef predators (sharks, lobsters, and reef fish).

> Intensive Extractive Use zones demonstrate the absence of natural predators, such as lobsters, indicating a trophic disequilibrium in the ecosystem now dominated by urchins (particularly the pencil urchin *Eucidaris galapagensis*).

The absence of these predators is an indicator of trophic disequilibrium in the ecosystem causing unchecked urchin (herbivore) population explosions, overgrazing, and compromised recovery of corals and macroalgae.

Another interesting feature is the greater abundance and diversity of filter feeders and microcarnivores at tourism sites, which again reflects that these sites are usually chosen for their aesthetic value and for being in high-current environments that favor pelagic species valued in dive tourism. The coral population is low and fragmented and its recovery to pre 1982 conditions is still far in the future. However, coral abundance is still greatest in protected areas in comparison with fisheries areas and tourism zones.

Figure 4. The composition of the sea floor (benthic environment) over all 66 sample sites



Conclusions and recommendations

Although a comprehensive analysis of the information collected in 2004 to 2006 is not yet completed, some general observations can be made. Key among them is that certain sites are of great importance to associated threatened species particularly sensitive to natural and human disturbance (Table 1.).

In the areas that have had a greater level of protection for more than six years (such as at the GNP outpost in western Isabela) or sites with high levels of tourism (such as Sullivan Bay), there is a greater abundance and diversity of species, including top-level predators such

as the grouper bacalao and the yellow-tailed snapper. On the other hand, there is evidence of dominance by urchins and reduced benthic diversity in areas with similar habitats and comparable environmental conditions, but which have been fished intensively. These trends will be analyzed in greater detail through a study that compares levels of extraction with the level of adherence to the established zoning.

It appears that seasonality affects the composition of marine communities—especially during sustained periods of climatic stress such as El Niño. Small patches of water that depend upon the upwelling of nutrient-rich cold waters to provide refuge for some highly threatened species exist, primarily to the west of Isabela and Fernandina (Tagus Cove, Cape Douglas, Cape Hammond, Black Turtle Beach, and Iguana Cove, etc.). Management recommendations for timely intervention in these areas during El Niño events should be incorporated into contingency plans.

The trend toward greater biodiversity and abundance of marine life at tourist dive sites reflects not only the effects of no-take zones, but also the fact that these sites were originally selected for their high value to divers. An observed increase in the use of sites such as Darwin, Española, and Genovesa may affect the behavior of animals as well as the security and enjoyment of the divers in the water. Further study of resource use in these zones (including a review of the threat from invasive marine species upon hulls) is required.

Cape Douglas (Fernandina), the Marielas (Elizabeth Bay), and Cape Iguana (southern Isabela) should be included as fixed monitoring sites in the future given that they show high levels of endemism and represent the last habitats for the macroalgal and endemic kelp beds that were common in the GMR prior to 1981.

Table 1. Important sites for associated threatened species that are particularly sensitive to natural and human disturbance[1].

Site / Island	Species of conservation importance that are sensitive to disturbance	No. Threatened Taxa
West coast , Fernandina	Habitat for the Endangered kelp *Eisenia galapagensis*	**6**
Cousins Islet, Santiago	A site with two Critically Endangered corals (*Tubastraea floreana* and *Rhizopsammia wellingtoni*) that are both known from only one other site	**7**
Iguana Cove, Isabela	The only known site for the Vulnerable alga *Myriogramme kylinii*, other threatened large *Eisenia* kelps	**8**
Punta Moreno, Isabela	The only known site for the Vulnerable alga *Laurencia oppositocladia*	**7**
Punta Essex, Isabela, and León Dormido	The only known sites for the Vulnerable gastropod *Neorapana grandis*	**6**
Wreck Bay, San Cristóbal	The only known site for the Vulnerable alga *Pseudolaingia hancocki*	**4**
Gordon Rocks, Santa Cruz	One of two known sites for the Critically Endangered coral *Rhizopsammia wellingtoni*	**7**
Gardner-by-Floreana, Floreana	One of two known sites for the Critically Endangered coral *Tubastraea floreana*	**4**

Source: Edgar *et* al in prep[1].

Although seven years have passed since the development of the last Management Plan for the GMR, sustainability in the marine environment of Galapagos has not yet been achieved. However, the most recent results of coastal zoning, described in this report, indicate that change is possible, although it can be a long and slow process. The increasing use of the coastal zones for fisheries leading to greatly reduced populations of key species and the increase in tourism impacts in the coastal communities have together created an urgent need for the development of new management practices that are supported by all stakeholders and that will catalyze positive changes in the short- to mid-term.