GUEST EDITORIAL

GALAPAGOS CORAL CONSERVATION: IMPACT MITIGATION, MAPPING AND MONITORING

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This special edition of Galapagos Research is devoted to research outcomes from the U.K. Government's Darwin Initiative project 14-048 entitled *Galapagos Coral Conservation: Impact Mitigation, Mapping and Monitoring*. The Darwin Initiative was established in 1992, to assist countries rich in biodiversity but poor in resources to meet their obligations under the Convention on Biological Diversity (CBD). Projects supported from Darwin Initiative funding link U.K. institutions with public and voluntary sector institutions in partner countries.

Marine and Coastal biodiversity is a major thematic programme within the CBD, since 1995. Coral reefs provide significant ecological services and social, economic and environmental benefits to society, including storm protection, fisheries production, erosion control and the cycling of carbon, nutrients and sediments, as well as biodiversity resources and tourism opportunities (MEA 2005). Global climate change is identified as one of five major impacts on coral reefs. Although degradation resulting from direct human impacts, including overfishing and coastal development, is the primary problem in some regions (*e.g*. Caribbean), the increasing number and severity of coral bleaching events induced by climate change is a major cause of concern (Fig. 1). Hermatypic (reef building) corals are sensitive to elevated temperatures, which have been linked to coral bleaching (loss of symbiotic zooxanthellae), with many studies reporting significant decline and mortality of corals during El Niño events (Stone *et al*. 1999).

As a result, the seventh meeting of the Conference of the Parties (COP-7) to the CBD in 2004 revised the work plan on coral bleaching to make it increasingly oriented towards management action and strategies to support reef resilience, rehabilitation and recovery (CBD 2004). The amendments to the plan recognize the need to manage coral reefs for resistance and resilience to, and recovery from, episodes of raised sea temperatures and/or coral bleaching, including taking such factors into account in marine protected area network design. One of the goals of the Marine and Coastal Protected Areas programme is the establishment and maintenance of protected areas that are effectively managed using an ecosystems approach and that contribute to a global network of marine and coastal protected areas.

The coral reefs of the Galapagos Islands contribute significantly to species richness and diversity in the Galapagos Marine Reserve (GMR). They support thousands of species, including many rare and endemic corals. However, their distribution has been strongly affected by extreme climatic events over the last 30 years, especially El Niño events where extensive coral reefs were reduced by 95% in 1982–3, with further mortality in 1997–8. Following these losses, the northern islands of Wolf and Darwin harbour > 95% of the coral species in the GMR including rare corals (*e.g*. *Leptoseris* sp.) that may become locally and indeed globally extinct, and demand special conservation attention.

In fact, their importance as part of Ecuador's natural heritage seems disproportionate to their size. The coral reef fringe in Wolf and Darwin represents a tiny fraction (*c.* 0.9 %) of the overall shallow (<20 m) Galapagos coastal habitat, yet its ecological contribution as a distinguishing biogeographic subunit is considerable. These productive oceanic pinnacles surrounded by the deep abyssal plain and largely low-productivity, blue-water "deserts" are potential stepping stones for many transitory Indo-Pacific, Panamic and circumtropical species uncommon in the rest of the islands. The unique confluence of currents that connect within the archipelago and between other neighbouring marine protected areas such as Cocos Island (Costa Rica) and Malpelo (Colombia) may well connect refuge habitats afforded to coral reef communities. In addition, these reef ecosystems are major pelagic species hotspots with remarkable aggregations of sharks, tuna,

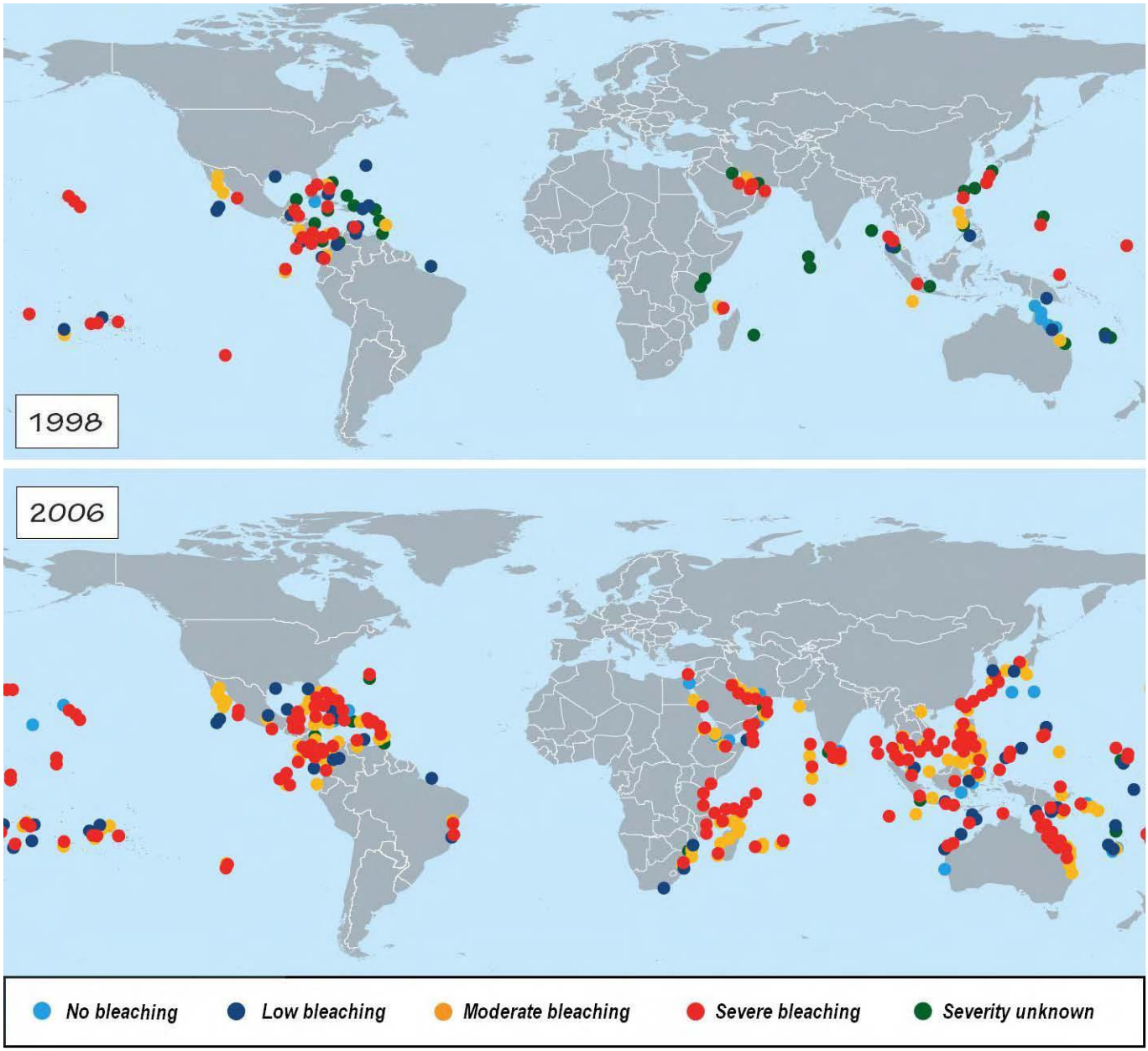


Figure 1. Global trends in the extent and severity of mass coral bleaching, 1998–2006 (adapted from Marshall & Schuttenberg 2006).

turtles, dolphins and other cetaceans, all ecologically linked to the area's reef complexes.

The economic value of the local live-aboard dive tourism industry attracted by such a fascinating natural seascape is considerable. Two sites in Wolf and Darwin accounted for more than half of the registered dives in 2007 across Galapagos. This raises urgent questions as to what represents an appropriate level of use and how best to mitigate adverse effects, such as anchor damage. The Galapagos National Park Service (GNPS) views this with concern and has embraced the concept of low-impact anchorages which was developed within this Darwin Initiative project. With strong industrial fishing pressure across adjacent unprotected regions, it would seem common sense to prioritise conservation measures across such small yet clearly vital, productive oases for tropical marine life.

The purpose of this project was therefore to assist the Ecuadorian Government, through the Galapagos National Park, in protecting the last remaining extensive Galapagos coral reefs of the northern islands as a crucial step to helping Ecuador meet its obligations under the CBD. This was achieved through the following outputs:

1. improved baseline knowledge of coral reefs and associated biodiversity of the northern GMR;

2. reduced coral damage due to the installation and establishment of permanent boat moorings;

3. training, workshops and other capacity-building exercises, to increase the knowledge of the stakeholders participating in coral monitoring and conservation.

Great advances in regional coral research from the early 1970s were led by key figures including many of the participants in this project and authors of papers in this issue. However, the present project constitutes the most comprehensive study using innovative mapping and rapid assessment techniques undertaken to date in the remote northern Galapagos islands. It has helped put important historical observations and the large body of recent field research into the context of pressing contemporary management issues. The papers in this special issue report on the outcomes and analysis of coral survey and monitoring expeditions conducted over the period 2005–7, as well as providing some updated review material. The project has brought input from a large number of international and local marine and coral scientists, including from other regional marine protected areas, and Charles Darwin Research Station scientists, to address the particular conservation challenge faced by Wolf and Darwin Islands. The project has discovered new species both to science and to Galapagos, including zooanthid species from the genera *Hydrozoanthus*, *Parazoanthus, Antipathozoanthus* and possibly *Epizoanthus*, although the latter may be an entirely new genus as yet undescribed. Other reef-building corals have been identified, which are new to Galapagos, including *Pocillopora effusus*, *P. inflata*, and *Pavona chiriquiensis*. In addition, a possible new gorgonian of the genus *Pacifigorgia* (*Octocorallia: Gorgoniidae*) species has been collected, together with a new reef-building coral, *Leptoseris* sp. All collections are currently being prepared for systematic morphological and molecular analyses. Further scientific publications are anticipated.

In addition to the establishment of comprehensive baseline biodiversity data sets, the project engaged the fishing and tourism industries for improved management of the marine environment through capacity-building of tourism and dive guides and fishers, and established permanent mooring buoys to avoid boat anchor damage.

Responsible stewardship of such a fascinating natural resource demands a combination of objective science-based recommendations with clear outreach, training and well-informed actions such as impact mitigation methods, plus the establishment of policies, such as zoning rules, that regulate uses, diving practices and sustainable fishing codes. A previous Darwin Initiative marine project (no. 162/6/174, 1997–2000) supported crucial early decisions to determine no-take zones and tourism and fishing practices. These moves were motivated by the goal of achieving UNESCO World Heritage status for Galapagos marine areas to complement this status for terrestrial areas, through establishing sound management practices, and resulting in the declaration of the GMR in 1998. A first biodiversity catalogue helped underpin discussions leading to a marine management plan. A decade later, the contributions in this volume improve our knowledge and appreciation of the value and current condition of the Galapagos's northerly coral communities and establish conservation measures and stakeholder commitments to protect these valuable habitats. This step forward demonstrates how relatively modest external aid can empower applied marine research and lead to management policy. Such results of research for conservation support the GNPS as it navigates the changeable, often difficult seascape in search of the holy grail of sustainable development. Such steps are critical if natural ecosystem function is to be conserved to maintain Galapagos's intrinsic value and contribution to the wellbeing of future generations.

LITERATURE CITED

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