

**Marine Management Areas Science  
Abrolhos Node**

**Core Ecological Monitoring**

**Final Report**

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Compiled by

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## CORE ECOLOGICAL MONITORING

### Introduction:

The so-called Abrolhos Bank is an enlargement of the Brazilian continental shelf between 16°49' and 19°40'S (Bahia and Espírito Santo States). Covering about 46,000 km<sup>2</sup>, with maximum widths reaching up to 200 km, this distinctive shelf includes extensive mangroves, seagrass and algae bottoms, coralline reefs and a group of volcanic islands, comprising the highest biodiversity in the South Atlantic. Besides holding a representative assemblage of the Brazilian-endemic coral reef fauna and a number of red-listed species, the region's reefs present unique morphological attributes, growing as gigantic mushroom-shaped pinnacles that are locally known as "chapeirões". Critical knowledge gaps still impede biodiversity conservation and the sustainable use of natural resources in this and in other similar tropical marine and coastal regions across the globe.

The Core Ecological Monitoring (CEM) results reported herein concern the ecological dimension of Marine Management Areas (MMAs), addressing key science gaps that impede their design and implementation. Most studies within the CEM explicitly bridged the ecological and management dimensions of MMAs, as expected in a trans-disciplinary and applied initiative such as the Marine Management Areas Science Program – MMAS. Although geographically focused in Abrolhos, the project addressed both global and site-specific needs, as part of a network of global, comparative observations for MMA effects and effectiveness. The CEM included a set of natural and manipulative experiments designed to understand MMAs' effects on ecosystem health and how biodiversity attributes and physical environment affect MMA function and management, thus contributing to establish major guidelines for MMAs' planning and management. Major studies that are already concluded include seven main themes (15 peer reviewed papers/chapters), as follows.

- **Dynamics of fish assemblages under different management regimes.** The main outputs of this theme are accounted for in a peer reviewed paper (Francini-Filho

& Moura 2008<sup>1</sup>) that reports significant findings from continuous monitoring, across five years, of one community-based multiple-use MMA, two no-take MMAs (established in 1983 and 2001), and one unprotected area, as well as one unprotected deeper area (25–35 m). The study demonstrates that:

- Habitat characteristics strongly influence fish assemblages' structure and dynamics;
- Biomass of commercially important fish, particularly small carnivores, was consistently higher in the older no-take MMA;
- Biomass of black grouper, *Mycteroperca bonaci*, increased 30-fold inside the two no-take MMAs, while remaining consistently low elsewhere;
- A single keystone herbivore, the parrotfish *Scarus trispinosus*, dominated fish assemblages (28.3% of total biomass). Biomass of this species increased on the younger no-take MMA and on the community-based multiple-use MMA, soon after establishment of the former and banning of the parrotfish fishery in the latter. This increase was followed by decline after increased poaching and reopening of the parrotfish fishery inside the community-managed MMA;
- In a single year, fish biomass increased across the entire region, but this increase was stronger in sites closer to deeper reefs, where fish biomass was up to 30-times higher than on shallow reefs. Movement of fish from deeper (and sometimes naturally-protected) reefs to shallower areas under greater fishing pressure may have played a major role;
- The effective use of MMAs in Abrolhos and elsewhere is highly dependent on consistent management rules, adequate enforcement and the protection of critical (and generally neglected) habitats such as deep reefs and mangroves.

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<sup>1</sup> *Aquatic Conserv: Mar. Freshw. Ecosyst.* 18: 1166–1179

- **Spillover of reef fishes from no-take marine reserves.** Although no-take MMAs (marine reserves) may promote spillover of fishes to adjacent fishing grounds, previous studies have measured this effect solely by examining gradients of fish abundance and body size across reserve boundaries. We carried out a pioneer study in Abrolhos (Francini-Filho & Moura 2008<sup>2</sup>), assessing spillover across reserve boundaries before (one year) and after (four years) initiation of protection. Replicate sites were sampled inside and outside a community-managed no-take reserve, with unprotected sites at 0–400, 400–800 and 800–1,200 m from its boundary. The study demonstrates that:
  - Biomass and body size of commercially important species such as *M. bonaci*, *Ocyurus chrysurus* and *S. trispinosus* increased continuously inside the reserve after its establishment, with no similar increases recorded in the control sites (800–1,200 m).
  - Evidences of spillover (i.e. higher biomass inside the reserve and in unprotected sites closer to its boundary) were obtained for *M. bonaci*, *O. chrysurus* and *S. trispinosus*, although this pattern was only marginally significant for *O. chrysurus*. Despite these positive signs, recovery and spillover of *S. trispinosus* were probably inhibited by poaching.
  - The reserve was established a priori on poor quality habitats, and this might be a common pattern in community-based management schemes. Thus, spatial comparisons between protected and unprotected sites generally underestimate changes due to protection.
  - Baseline information and continued monitoring are necessary for understanding the effects of MMAs. Collaboration between natural and social scientists and practitioners, in order to protect high-quality habitats in the long term while accounting for the socio-economic needs of local communities, is also a critical step towards maximizing MMAs benefits.

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<sup>2</sup>

Fisheries Research 93: 346–356

- **Sampling design for assessing and monitoring reef fish assemblages.** Studies focusing on reef fish assemblages are challenged by the need to obtain precise and accurate abundance estimates for a large number of species, as visual sampling is prone to bias from the difficulty of seeing and enumerating fish. In the baseline study reported herein (Minte-Vera, Moura & Francini-Filho, 2008<sup>3</sup>) we evaluated the 2 most widely used sampling units (SUs) for reef fish assemblages (strip transects and stationary cylinders of several dimensions). Main findings were:
  - Small SUs produced the least biased estimates for small fishes, while large ones produced the best estimates for large fishes, regardless of SU shape (strip transects and stationary cylinders);
  - The SU with the lowest cost was the stationary cylinder;
  - A simple improvement in stationary censuses, i.e. a SU composed of 2 nested cylinders (2 m and 4 m radii, respectively), enhanced the accuracy and precision of estimates. Counts of small fish ( $\leq 10$  cm) are made in the smaller cylinder and counts of larger fish ( $> 10$  cm) are made in the larger. Nested cylinders reduce the bias towards large and conspicuous species and allow for separate density estimates for adults and juveniles.
- **Reef resilience and the role of large herbivores.** Roving herbivorous fish (RHs) from families Acanthuridae (surgeonfish) and Scaridae (parrotfish) are abundant and ecologically important members of the reef community, besides being preferred targets of reef fisheries. Since their intense feeding activity reduces competition between corals and algae, RHs are widely recognized as a critical functional group on coral reefs. We studied the foraging activity of three surgeonfish species and five parrotfish species, and its relationship to resource availability and interference competition in Abrolhos. Main conclusions of this study (Francini-Filho et al. 2009<sup>4</sup>) include:

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<sup>3</sup> *Mar. Ecol. Prog. Ser.* 367: 283–293

<sup>4</sup>

□ *Journal of the Marine Biological Association of the United Kingdom* 90(3): 481–492.

- Turf algae were selected by most species in most sites, while other food items were generally avoided.
- Feeding rates, food selection and frequency of agonistic interactions differed significantly between sites for most species;
- Surgeonfish had higher feeding rates than parrotfish, the former grazing more frequently on fleshy algae and the latter on calcareous algae. Both surgeonfish and parrotfish interacted agonistically most frequently with damselfish, followed by confamilial interactions;
- Agonistic interactions were more frequent at sites where herbivorous fish (both roving and territorial) were most abundant, but there was no clear relationship between interference competition and foraging patterns;
- Our findings support the idea that RHs are unable to clear large tracts of reef surface of frondose algae once these have proliferated, and that territorial herbivores do not limit the access of RHs to particular resources;
- Recovery of RHs densities following protection within MMAs may be slow due to limitations in food resources, even in reef that were overgrowth by algae. Consequences for the competitive balance between fast growing algae and slow-growing reef building corals may be severe.

In a separate peer reviewed paper focusing on **reef resilience and the role of large herbivores**, we studied **coral predation by parrotfishes, evaluating their classification into functional groups** (Francini-Filho et al. 2008<sup>5</sup>). Main findings of this study include:

- Some parrotfish species consume live corals, leading to detrimental effects that may offset the benefits of removing competitive seaweeds. Live coral predation is reported for the Brazilian endemic parrotfishes *Scarus trispinosus* and *Sparisoma amplum*

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<sup>5</sup>

*Neotropical Ichthyology* 6(2):191-200,

- Parrotfishes differ in terms of jaw morphology, foraging activity and extent of substratum excavation, and can be divided into 3 functional groups: browsers, scrapers and excavators. The functional group approach helps to understand relative effects in terms of bioerosion, coral fitness and survival, habitat alteration and ecosystem dynamics.
  - *Scarus trispinosus* and *Sp. amplum* allocated 0.8% and 8.1% of their bites to live corals, respectively. *Sparisoma amplum* fed at lower rates, took shorter feeding forays and larger bites than *Sc. trispinosus*. Bite rates and foray size were negatively correlated to body size for *Sc. trispinosus*, but not for *Sp. amplum*. Despite its lower excavating potential, *Sc. trispinosus* is the most abundant parrotfish in Abrolhos, possibly causing a great impact on coral fitness and survival.
  - *Sparisoma amplum* may be recognized as an excavating species, as well as the most specialized coral predator in Brazil, while *Sc. trispinosus* may be recognized as a scraper or excavator, depending on body size. This functional classification corresponds to the classification used for the putative sister taxa of *Sc. trispinosus* (*Sc. coeruleus*) and the sister taxa of *Sp. amplum* (*Sp. viride*) in the Caribbean, indicating that these congeneric species pairs play similar ecological roles in different geographic regions.
- **Coral diseases and the role of microorganisms on reef health and ecosystem functioning.** Although reef corals worldwide have sustained epizootics in recent years, no coral diseases have been observed in the southwestern Atlantic Ocean until 2006 (first reported in 2008). The CEM produced an overview of the main types of coral diseases and their incidence in the Abrolhos Shelf, based on qualitative observations since the 1980s and regular monitoring since 2001 (Francini-Filho et al. 2008<sup>6</sup>). Main conclusions of this synopsis include:
    - Coral diseases intensified only recently (2005–2007). In Abrolhos, six types of coral diseases were already recorded, including syndromes that

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are similar to White Plague, Black-Band, Red-Band, Dark Spot, Aspergillosis and Octocoral Tissue Necrosis, reported elsewhere in the Caribbean and in the Indo-Pacific.

- Based on estimates of disease prevalence and progression rate, as well as on the growth rate of the major reef-building coral species (the Brazilian-endemic *Mussismilia braziliensis*), we predict that eastern Brazilian reefs will suffer a massive coral cover decline in the next 50 years, and that *M. braziliensis* will be nearly extinct in less than a century if the current rate of mortality due to disease is not reversed.

In a second CEM study focusing on **coral diseases and the role of microorganisms on reef health and ecosystem functioning**, Reis et al. (2009<sup>7</sup>) performed the first characterization of the microbiota associated with the reef coral *Mussismilia braziliensis* by means of a culture-independent approach. Main findings include:

- The microbiota of *M. braziliensis* encompasses several potentially novel species and higher taxa and appears to be species-specific;
- Main microbial groups were Proteobacteria, Cyanobacteria and unclassified bacteria according to the 16S rDNA libraries. Most sequences of healthy and diseased *M. braziliensis* did not find close matches in GenBank (i.e. >97% 16S rDNA similarity). Most of the sequences of seawater and mucus of healthy coral fell into tight clusters (17 and 15 clusters respectively).
- In contrast, most sequences of diseased coral did not form clusters. The rarefaction curves indicate saturation in the recovery of higher taxa (approximately 40 phyla). Diseased coral may have provided a suitable place for colonization by opportunistic bacteria, resulting in a greater bacterial diversity.

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<sup>7</sup> *Journal of Applied Microbiology*

In the third CEM study focusing on **coral diseases and the role of microorganisms on reef health and ecosystem functioning** (Alves Jr. et al. 2009<sup>8</sup>), the first taxonomic characterization of culturable microbiota from healthy and diseased corals was performed. Results include:

- 131 vibrio isolates were identified. Vibrios counts in the water and coral mucus were approximately 104 cfu ml<sup>-1</sup> and 106 cfu ml<sup>-1</sup>, respectively.
- Most isolates (n = 79) fell into the core group (pyrH id. marker). Diseased corals did not possess a unique vibrio microbiota. Vibrio species encompassed strains originated from both healthy and diseased corals.
- Pathogenic potential of vibrio isolates (*V. alginolyticus* 40B, *V. harveyi*-like 1DA3 and *V. coralliilyticus* 2DA3) were evaluated in a bioassay with the animal model *Drosophila melanogaster* and caused 25–88% mortality.
- *Vibrio alginolyticus*, *V. harveyi* and *V. coralliilyticus* are dominant in coral mucus and may be a normal component of the holobiont. Brazilian-endemic corals are reservoirs of the potentially virulent strains of vibrios.

The fourth CEM study focusing on **coral diseases** (Francini-Filho et al. 2010<sup>9</sup>) evaluated the seasonal prevalence of white plague like disease on *Mussismilia braziliensis*, a Brazilian- endemic reef coral threatened by extinction due to the recent proliferation of a white-plague like disease (WPL). Despite the severe impacts of coral diseases, the environmental factors leading to disease outbreaks are still poorly understood. The study demonstrates that:

- WPL was 4.5 times more prevalent in summer (January 2007, mean sea surface temperature 27.4°C) than in winter (July 2007, 25.0°C).

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<sup>8</sup> *Environmental Microbiology Reports*. Doi:10.1111/j.1758-2229.2009.00101.x

<sup>9</sup> *Lat. Am. J. Aquat. Res.* 38(2): 292-296

- The prevalence of WPL disease is temperature-dependent, supporting the hypothesis that warmer oceans are facilitating the proliferation of coral diseases worldwide.
- **Fisheries and MMA co-management.** The experience accumulated along one decade in the creation and implementation of the Marine Extractive Reserve of Corumbau (MERC), was summarized and discussed on peer reviewed papers (Moura et al. 2009<sup>10</sup>) and book chapters (Moura et al. 2007<sup>11</sup> and Seixas et al. 2009<sup>12</sup>). Comparisons were also made between this MMA and other areas along the Brazilian Coast. The prospects for the use of MERs as management frameworks for traditional small-scale fisheries in Brazil are also discussed. From these publications we can summarize the following lessons and recommendations:
  - The MERC has well defined physical boundaries, but users are not clearly defined and there is a need to deepen the discussion about the extension of the MERC's limits to land areas;
  - Although the Management Plan has been extensively discussed, there are still many fishers unaware of the meaning of an MER and MERC's specific rules. There are also discontented or rebel fishers that recurrently break the rules. Although rules should be improved by incorporating local knowledge and practices, this does not mean that they will be readily incorporated by the entire fishing community;

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<sup>10</sup> Moura, Rodrigo Leão de; Carolina Viviana Minte-Vera; Isabela Baleeiro Curado; Ronaldo Bastos Francini-Filho; Hélio de Castro Lima Rodrigues; Guilherme Fraga Dutra; Diego Corrêa Alves and Francisco José Bezerra Souto. 2009. Challenges and prospects of fisheries co-management under a Marine Extractive Reserve framework in Northeastern Brazil. *Coastal Management*, 37:617–632.

<sup>11</sup> Moura, R.L, Dutra, G.F, Francini-Filho, R.B., Minte-Vera, C.V., Curado, I.B., Guimães, F.J., Oliveira, R.F., Alves, D.C. 2007. Fisheries Management in the Marine Extractive Reserve of Corumbau – Bahia. In: *Aquatic Protected Areas as Fisheries Management Tools. Protected Areas of Brazil Series*, vol. 4. Brasília: Ministério do Meio Ambiente, pp. 175-188.

<sup>12</sup> Seixas, Cristiana Simão; Carolina V. Minte-Vera; Renata G. Ferreira; Rodrigo Leão de Moura; Isabela B. Curado; and Ronaldo B. Francini-Filho. Co-managing commons: Advancing Aquatic Resources Management in Brazil. 2009. In Lopes, P. and Begossi, A. *Current Trends in Human Ecology*. Cambridge Scholars Publishing. 12, Back Chapman Street, Newcastle, UK.

- Discussion about MERC's rules have been restricted to councilors and the more active fishers and associations. Broader participation in the process of reviewing the Management Plan should be sought in order to increase participation and compliance, and especially to enhance cohesion among fishers;
  - Fishers expect agencies to punish trespassers and rule breakers, but fear being harshly punished themselves. There is a clear lack of enforcement capacity on the side of ICMBio, and a lack of institutionalized mechanisms for rule monitoring within the community. This results in few sanctions being applied to appropriators that deviate from the regime;
  - Conflicts between communities are discussed and sometimes resolved in the scope of the Deliberative Council, but there are no other formal mechanisms to resolve conflicts within communities;
  - The MERC is a federal concession, so there should be a full governmental recognition of agreements, rules, council and associations. Although recognition of rights has clearly improved, the rights to organize and manage resources are not fully supported by official agents.
  - Finally, we emphasize the enduring difficulty that MERC fishers face in commercializing their products. All production is sold locally, mainly to a few middlemen that take the fish to storage plants. A smaller proportion of the catches is sold directly to restaurants or hotels and pousadas. Thus, exclusive rights do not necessarily result in higher income for traditional fishers, and the implementation of the MERC has not yet been translated into better economic indicators.
- A recent contribution summarizing much of the MMAS work developed in Abrolhos was published in a recent article on **Scientific American Brasil**

magazine<sup>13</sup>. This paper available to a broader public aims to discuss the challenges and opportunities for marine conservation in Brazil, using the experiences in Abrolhos as concrete examples. It represents an important Science to Action output, and is a clear example of how the science produced by MMAS Program in Abrolhos can be used to influence national policies in the country.

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<sup>13</sup> RODRIGO LEÃO DE MOURA, RONALDO B. FRANCINI FILHO, CAROLINA V. MINTE-VERA, PAULO Y. G. SUMIDA, GILBERTO M. AMADO FILHO, JERÔNIMO AMARAL, ALEX C. BASTOS, FABIO DOS SANTOS MOTTA, FABIANO L. THOMPSON, RICARDO KRUGER, and GUILHERME F. DUTRA. Pesquisa no Oceano: Desafios e Oportunidades. Scitific American Brasil. Special edition: Biodiversidade: 30-35. September 2010.