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INSIGHTS

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BioMar-ACG: A successful partnership to inventory and promulgate marine biodiversity

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Abstract

Initiated in 2015, the marine inventory of Área de Conservación Guanacaste (BioMar-ACG) is rapidly advancing knowledge of biodiversity. Key aspects include synergizing with parataxonomists, barcoding specimens and making information available. After 85 years, 594 species were reported. Now, after four years, BioMar-ACG documented 1,123 species, for a total of 1,479.

Abstract in Spanish is available with online material.

KEYWORDS

barcode, collaboration, Costa Rica, parataxonomists, partnerships

1 | INTRODUCTION

Taxonomic inventories of marine biodiversity are necessary to develop and enhance protection and conservation programs and to ensure sustainable harvesting of the country's natural resources. They also serve as a baseline to document changes over time. In Costa Rica, marine biodiversity has been studied since the late 19th century and in Área de Conservación Guanacaste (ACG) since the mid 20th century (Cortés 2009). The biodiversity of marine protected areas is less well-known than terrestrial ecosystems, but the combination of technology and new field research techniques are changing this situation. Here, we explain how a synergistic mutualism between four entities is meeting the daunting challenge of knowing and documenting the organisms in a wild, marine area.

ACG has been a leader throughout the tropics in the study of terrestrial biodiversity through a bioinventory program that started in the 1980s. But until, recently, the marine area of ACG was not part of this work. ACG's marine sanctuary of 43,000 ha (*Sector Marino*), comprises 150 km of coastal zones, rocky intertidal zones, beaches, mangroves, coral reefs, soft and rocky bottoms, deep water and a complex archipelago of seven islands (Islas Murciélago) extending from 6 to 19.2 km offshore. *Sector Marino* is in the northern Pacific region of Costa Rica, part of the Golfo de Santa Elena that is exposed to seasonal upwelling resulting in significant temperature drops, increased nutrients and lower pH (Cortés 2016). ACG is a UNESCO World Heritage site, a designation that requires ongoing research, inventories of biodiversity and monitoring of organisms and ecosystems.

In 2015, the inventory of marine species of ACG (BioMar-ACG project) started as a focused project carried out by a government agency (ACG), an academic institution, University of Costa Rica, specifically the Centro de Investigación en Ciencias del Mar y Limnología (CIMAR), the Museo de Zoología (UCRMZ) and the Herbario de Biología (USJ), and a private NGO (Guanacaste Dry

TABLE 1 Total number of marine species in ACG

Taxonomic group	# species (BioMar-ACG)	# species (Cortés 2017)	Spp. in common[a]	Total number species
Bacteria	0	15	0	15
Cyanophyta	5	4	1	8
Chlorophyta	19	4	4	19
Ochrophyta	23	6	4	25
Rhodophyta	62	15	3	74
Mangroves	0	7	0	7
Foraminifera	0	24	0	24
Porifera	18	0	0	18
Cnidaria	47	46	40	53
Platyhelminthes	0	7	0	7
Acanthocephala	0	1	0	1
Mollusca	166	187	29	324
Annelida	70	27	24	73
Nemertea	5	1	0	6
Kinorhyncha	4	0	0	4
Gastrotrichia	9	0	0	9
Brachiopoda	1	0	0	1
Phoronida	1	0	0	1
Crustacea	209	193	110	292
Bryozoa	0	9	0	9
Echinodermata	57	15	12	60
Chordata	427	33	11	449
Totals	1,123	594	238	1,479

[a]Species reported in Cortés (2017) and found with the BioMar-ACG project.

Forest Conservation Fund). Expanding on ACG's success in training and deploying parataxonomists in terrestrial biodiversity surveys (Janzen & Hallwachs 2011), the project also includes two marine parataxonomists who are from the local community and who have been trained in specialized tasks such as collecting specimens, preparing them, and assembling a detailed database. These parataxonomists allow specialized taxonomists to greatly enhance their efficiency in documenting and naming collected material, and in some cases, discovering and describing new species.

2 | MATERIALS AND METHODS

The BioMar-ACG project is an inventory of marine organisms in all coastal and marine sites of ACG. Localities include sandy beaches, rocky outcrops, mangrove forests, coral reefs, rocky reefs, and soft sediment bottoms, and range from the upper intertidal to the deepest areas within ACG, 150 m depth. Sampling has been as deep as 45 m, but there are plans to go deeper using dredges, drags and underwater vehicles. The particular methodology of collecting, fixing and curating is dictated by the group of organisms being collected. The objectives of the project are to: collect (Figure S1a); photograph in situ and in the laboratory (Figure S1b); initially identify in the field and corroborate at the museum (Figure S1c); excise tissue samples for barcoding analysis (Figure S1d); catalogue and archive at the Museo de Zoología, Universidad de Costa Rica (Figure S1e);

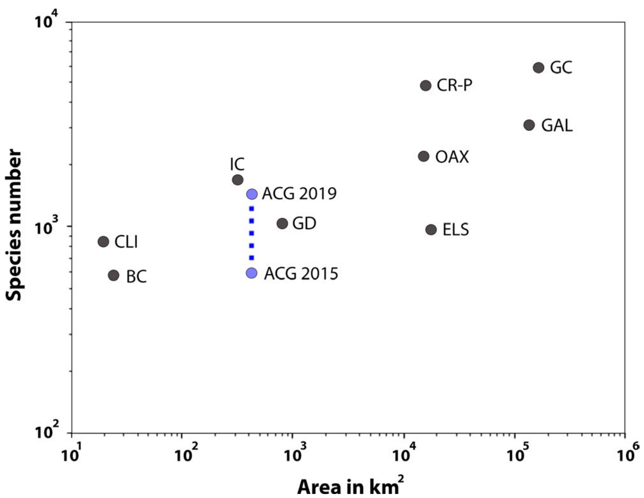

FIGURE 1 Comparison of different sites in the Eastern Tropical Pacific and the change for ACG with the BioMar-ACG project (data in Table S3). BC, Bahía Culebra; CLI, Clipperton; CRP, Costa Rica Pacific; ELS, El Salvador; GAL, Galápagos; GC, Gulf of California; GD, Golfo Dulce; IC, Isla del Coco; OAX, Oaxaca

publish, and share information of the marine biodiversity of ACG. We are in the process of building a barcode reference library (Hebert et al. 2003) that will form the foundation of the inventory and the bases for many different types of ecological studies. Samples from all vouchered specimens are sent to the Center for Biodiversity Genomics, University of Guelph for DNA barcoding. The information generated will be used by ACG to define management and conservation strategies and for their bio-literacy programs (Janzen 2010). Additionally, this project aims to advance and share knowledge about the marine biodiversity of Costa Rica using a novel model of organization: the synergistic merger of government (ACG), university (UCR), private funding (GDFCF) and local community (parataxonomists).

3 | RESULTS

Cortés (2017) generated the base line on marine biodiversity knowledge of ACG compiling published accounts of marine organisms collected within ACG. This list included 594 marine species. Since the project started in late 2015 and including a pre-project fish survey (Lowenstein et al. in prep.), over 7,300 samples of algae, invertebrates and fishes have been collected, consisting of 1,123 species in 16 phyla, of which 69 are likely new species, 885 are new records (species that have been previously described but were not known from the region) to ACG and 119 new records to Costa Rica (Table S1). With these results, the number of species of ACG comes to 1,479, an almost 2.5-fold increase (Table 1).

4 | DISCUSSION

The results of this project and the rate of progress indicate the success of the partnership between government, academia, a private NGO and the local community. In the previous 85 years, 594 marine species were reported for ACG. After 4 years of BioMar-ACG (and one year of pre BioMar-ACG fish collecting and barcoding), new records for 885 species for ACG and Costa Rica have been added. Of these 885 species, 69 may be new species, based on specimens that we have that do not match any known species and on barcode divergences. This number will increase as new areas and ecosystems are explored and as new groups are added to the project. Although we are in the early stages of analyzing results from barcoding, it is clear that this is an extraordinarily powerful addition to existing taxonomic inventories. Even though the success of extraction of some species is relatively low, barcoding has revealed numerous sequences that do not correspond to sequences of known species. In other cases, the barcode sequences of previously described species are placing those species in different locations in *cox1* trees. These results flag potential cryptic diversity, deserving additional scrutiny, as has been shown with butterflies from ACG (Hebert et al., 2004). Since we are dealing with a large number of phyla, we plan to increase the number of genes analyzed because for some groups, COI is not adequate to separate species.

Compared to other regions in the eastern tropical Pacific, ACG is among the most species rich areas (TABLE S2). All of the areas with more species are also much larger than ACG, with the exception of Isla del Coco, which is the most diverse region of Costa Rica (Figure 1). The change in species number in the ACG marine zone has caused a major shift in our perception of this area, what appeared to be a relatively species-poor site now looks more typical compared to the rest of the region. It is quite possible that with continued sampling ACG may be found to possess higher diversity than some of the other sites, due to the diversity of habitats and the effect of the seasonal upwelling and its associated productivity (Cortés et al. 2014).

Students are being trained with this project in the field and working in the laboratory (Figure S2a,b). But also, an effort has been made to present the project and the initial results to the local communities. During most field trips, the taxonomist in charge presents a public talk explaining their part of the project, detailing the groups they study, and preliminary results, with photographs of the organisms collected in ACG. The public talks in Cuajiniquil have been well attended by diverse groups of people including fishermen, tourism operators, school children, homemakers, general public, business people and teachers (Figure S2c). We perceive that the impact has been positive from the feedback received, and observe that these talks are creating awareness in the local communities about their marine surrounding.

Additionally, all the information is passed on to the authorities of ACG to be used for their bio-literacy program, management, protection and implementation of more strict conservation of their marine resources. Having more research and outreach on the marine environments of ACG will result in less illegal fishing in the protected area.

The partnership of a regional government unit for conservation and sustainable development, ACG, research units of the University of Costa Rica, and a private non-profit charitable organization, GDFCF, has resulted in a successful project to inventory and promulgate marine biodiversity. Additionally, BioMar-ACG includes three novel aspects to enhance the inventory and sharing of information: (a) synergism with parataxonomists; (b) barcoding of all species; and (c) explicitly putting the information online so that anyone can access this information. We have demonstrated that we can advance the knowledge of marine biodiversity at a relatively fast rate with this project. For these reasons, the BioMar-ACG project is an example for the rest of Costa Rica and other countries as a model to rapidly advance the knowledge of marine biodiversity.

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DATA AVAILABILITY STATEMENT

Data available from the Dryad Digital Repository: https://doi.org/10.5061/dryad.76hdr7stn (Cortés & Joyce 2020).

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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