Towards a paradigm shift using mixed-methods to evaluate the socio-economic and ecological integrity of Rosary Caye in Hol Chan Marine Reserve, Belize

Hacia un cambio de paradigma utilizando métodos mixtos para evaluar la integridad socioeconómica y ecológica de Cayo Rosario en la Reserva Marina Hol Chan, Belize

Vers un changement de paradigme utilisant des méthodes mixtes pour évaluer l'intégrité socio-économique et écologique de Rosary Caye dans la réserve marine de Hol Chan, Belize

ADDIEL U PEREZ[1]* MIGUEL O ALAMILLA[2] , AARON J ADAMS[1,3], OMAR W ARCEO[4] , and CORALYSE L PEREZ[5]

[1] Bonefish and Tarpon Trust, 2937 SW 27th Avenue, Suite 203, Miami, FL 33133 USA,addiel@bonefishtarpontrust.org, aaron@bonefishtarpontrust.org,
[2]Independent Biologist and Community Representative, San Pedro Town, Belize. mikeobze@yahoo.com,
[3]Florida Atlantic University Harbor Branch Oceanographic Institute 5600 IS-1, Fort Pierce, FL 34946 USA
[4]Independent Guide and Community representative, San Pedro Town, Belize, omarfreelancefishing@yahoo.com
5Independent Biologist, Orange Walk District, Belize, coryleiperez@gmail.com
Corresponding co-author email: addiel@bonefishtarpontrust.org or addieluperez@yahoo.com
ORCID (AUP): 0000-0002-0867-1162
ORCID (JJSS): 0000-0003-4736-8382
ORCID (AJA): 0000-0003-3181-2215

EXTENDED ABSTRACT

The sustainable use of flats species and their habitats are socio-economically and ecologically important to coastal communities of Belize (Perez et al. 2019, 2021). However, coastal development activities that include mangrove clearing and dredging threaten changes in the ecosystems and human dynamics that depend on them. One of many cases are threats to the flats fishery (as a recreational fisheries) and habitats Rosary Caye (RC) better known by locals as "Cayo Rosario", a small island surrounded by flats within Hol Chan Marine Reserve. This island is proposed for the development of villas and bungalows over mangrove cover of the private property, but also over the flats on the north and south of the island which is outside the property and inside the marine reserve. RC is part of the Northern Belize Coastal Complex that includes four protected areas that supports users of four major communities (Corozal Town, Sarteneja Village, San Pedro Town, Caye Caulker Village) and is close to Ambergris Caye where most of the tourism is concentrated for the entire country. In 2019 we used a mixed-methods approach (Perez-Cobb et al. 2014; Perez et al. 2019) to conduct a Rapid Rural and Ecological Appraisal (RREA) to evaluate RC's importance to the fisheries and its ecological characteristics.

The RREA consisted of secondary sources of information and face-to-face interviews, field notes and participant observation to collect local knowledge on socio-economic and ecological variables. We then conducted a Rapid Ecological Assessment, which included habitat mapping, seining, point intercept transects, and rover diver to collect ecological information on benthic cover (vegetation and animals) and other organisms. Our results indicate that 120 guides from the flats, reef fishing and tour-operators directly use RC (Table 1). The total household size of guides and dependents was 338 individuals and that would largely be affected by coastal development. For the northern region in 2013, the flats sector generated approximately 1,226 jobs and Bz $ 64,744,504 million annually (Fedler 2014). Our habitat mapping showed supertidal vegetation in RC consisted of 60.7% mangroves, 16.1% palmeto mix, 10.1% littoral forest and 1.1 % grass, with the greatest cover of higher density of vegetation on the west and north-west of the island (Figure 1). A total of 17 morphospecies of marine (eight red algae, six green algae, two seagrasses and leaves of red mangrove) and one soft coral were recorded in the six sites sampled in the waters surrounding RC, with highest abundance records in the north site. Additionally, we recorded 28 species of macro-invertebrates, with highest abundance in the north and south. A school of 564 large adult bonefish were seined from the flats off the south end of the island. A total of 61 bonefish were tagged and measured (average size of 33.3 cm and range 29.0-41.4 cm) and the remaining 503 bonefish were released untagged. Another school of an estimated 800 juvenile bonefish with was observed in the southwestern portion of the island but was not seined. A total of eight species of juvenile fishes (total length <12.5 cm) were recorded in addition to spiny lobster, stone crabs and seven reef fish pre-adult in the north side, which are important species in the Artisanal Subsistence and Commercial (ASC) fisheries.

Local knowledge indicated that RC is a seasonal refuge, feeding and resting area for bonefish, permit and tarpon, species important to the recreational flats fishery. In interviews with fishing guides, each of these species were recorded to occupy a specific area and season around RC. The area also provides needs for bait fish year-round but most abundant during summer in the areas south, west and east of RC. Crevalle jack, a species important and captured in recreational fishing (flats and reef fishing) and ASC fisheries, have a similar presence and abundance as this species are seasonal that follow bait fish for feeding. Finally, we also observed and recorded the use of RC by other recreational tourism stakehold-

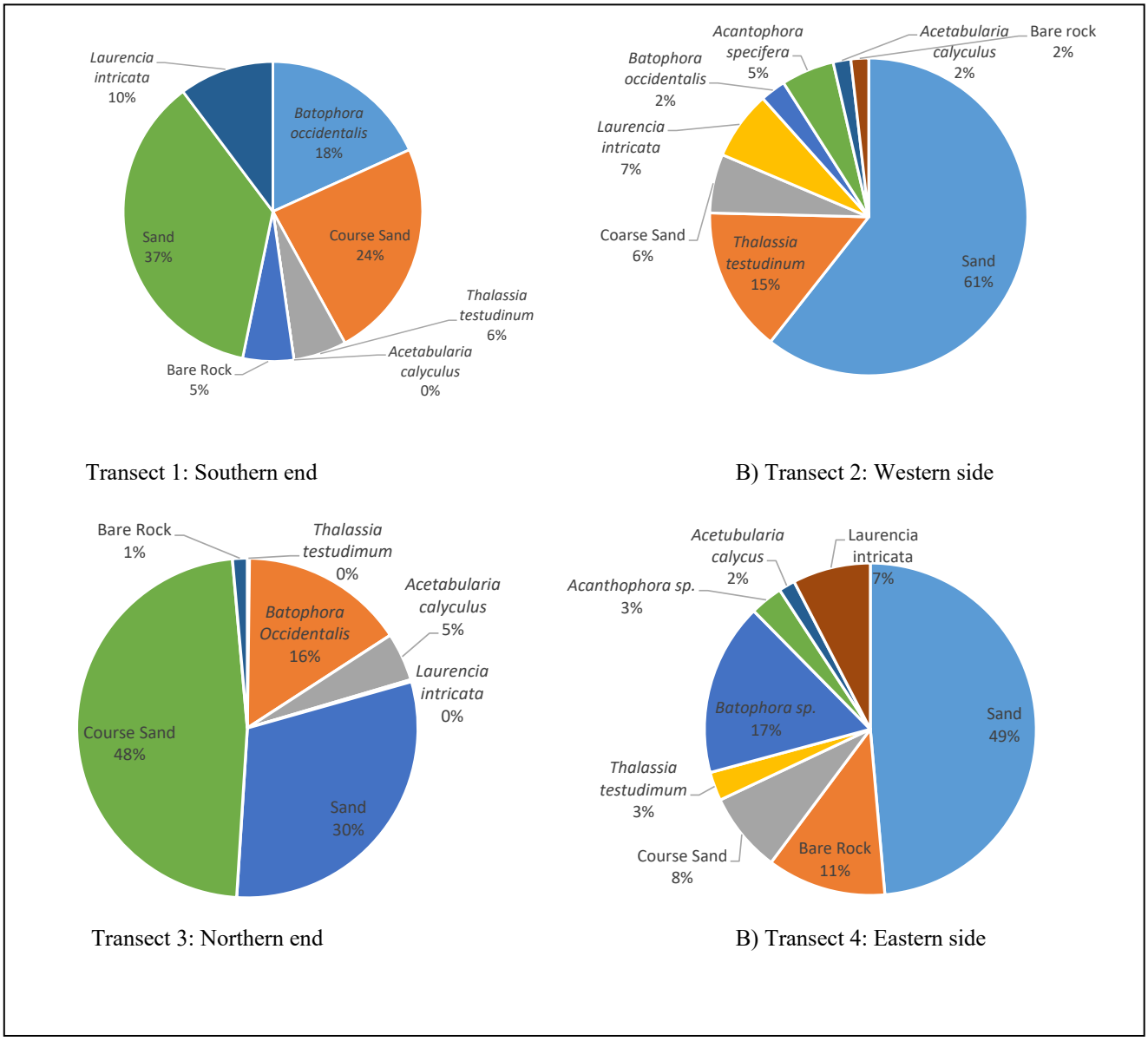

Figure 1. Point intercept sampling revealed the substrate in Rosary Caye is comprised of vegetation, mainly seagrass and algae with dominance mainly of seagrass and algae.

ers, mainly tour-operators that offer chartered beach tours and fishing (Table 1). Overall, the RREA shows the north, west and south of Rosary Caye are the most ecologically diverse in aquatic vegetation, macro-invertebrates, fish and other species of fisheries importance. These are important to the ecosystem and the primary reason for its productivity, the energy it introduces for aquatic organisms including fish. Sand, which was sandy-muddy, was commonly found in all sampling sites. This type of sediment differs from the sand (coarser) in the flats plain where permit feed. Sandy-muddy bottoms are important as burrowing habitat as shelter and feeding for macro-invertebrates. Our conclusions indicate the vegetation in RC and the surrounding habitats are interdependent and part of the coastal habitat mosaic required by adult flats species and recruitment needs of some reef species. Also, a recent study in 2022, shows the flats fishery now generates approximately 2,767 full-time equivalent jobs and an annual economic impact of BZ$ 146.1 million (Fedler 2022). This growth in comparison from the previous study shows the importance of the flats fishery in northern Belize and calls for resource managers and government to consider maintaining the ecological integrity of CR and similar habitats to sustain the significant socio-economic benefits of the flats fishery, other fisheries and non-fisheries activities. The approach (socio-economic and ecological sampling techniques) used in this study should be considered and applied to conduct Environmental Impact Assessments to improve conserva-

Table 1. Number of employees and their household dependents by establishment and sector. .

Sector	Establishment	Number of employees	Household size
Flats fishery	El Pescador	76	208
	Omar's Freelance fishing	3	14
	Bluebonefish	8	31
	Tres Pescados	7	19
	Cayo Frances	2	4
	Go Fish	8	25
	Freelance guides	8	9
Recreational fishery (reef fishing: ramas, bottom and reefs)	Freelance guides	1	3
Tour-operators	Amigos del mar	1	3
	Freedom Tours	6	22
TOTAL		**120**	**338**

tion and spatial management in marine protected areas in Belize, the Caribbean and Latin America that share similar inshore and non-coral reef ecosystems and alternative livelihoods such as guided fishing

KEYWORDS: Protected areas, coastal ecosystems, Environmental Impact Assessment, fisheries management, habitat threats

LITERATURE CITED

Fedler AJ (2014) 2013 economic impact of flats fishing in Belize. Vero Beach, FL

Fedler AJ (2022) 2022 Belize Flats Fishing Economic Report. Gainesville, Florida

Perez AU, Schmitter-Soto JJ, Adams AJ (2021) The first estimate of interjurisdictional population dynamics for bonefish, *Albula vulpes*, a shared resource in the western Caribbean. Environ Biol Fishes 104:341–356. https://doi.org/10.1007/s10641-021-01081-z

Perez AU, Schmitter-Soto JJ, Adams AJ, Heyman WD (2019) Connectivity mediated by seasonal bonefish (*Albula vulpes*) migration between the Caribbean Sea and a tropical estuary of Belize and Mexico. Environ Biol Fishes 102:197–207. https://doi.org/10.1007/s10641-018-0834-z

Perez-Cobb AU, Arce-Ibarra AM, García-Ortega M, et al (2014) Artisanal recreational fisheries: using a combined approach to fishery assessment aimed at providing insights for fishery managers. Source: Marine Resource Economics 29:89–109