

Effects of Hurricane Maria on Hamlet Communities (*Hypoplectrus* spp., Serranidae) in the La Parguera Natural Reserve at Puerto Rico

Efectos del Huracán María sobre las Comunidades de Hamlet (*Hypoplectrus* spp., Serranidae) en la Reserva Natural La Parguera en Puerto Rico

Effets de l'Ouragan Maria sur les Communautés de Hameaux (*Hypoplectrus* spp., Serranidae) dans la Réserve Naturelle de La Parguera à Porto Rico

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ABSTRACT

Hypoplectrus spp. are hermaphroditic, carnivorous, and highly territorial fishes of the family Serranidae, primarily distributed around the Western Atlantic. We studied 10 reefs located in the La Parguera Natural Reserve in Puerto Rico to record differences in *Hypoplectrus* spp. communities after the passage of Hurricane Maria. Our results were compared to surveys performed in the year 2017 (before Maria) and in the year 2000. We found significantly higher diversity after Hurricane Maria than in 2017 before the hurricane, yet lower diversity than recorded in 2000.

KEYWORDS: *Hypoplectrus* spp, survey, hermaphroditic, diversity, Hurricane Maria

Among the diversity in Caribbean coral reef fishes lies a group of simultaneously small hermaphroditic, carnivorous sea basses in the genus *Hypoplectrus* (Perciformes: Serranidae). They are found in the tropical Western Atlantic (WA) ranging from the Florida Keys, Puerto Rico, Mexico, Belize and Cuba (Victor 2012). *Hypoplectrus* species have a strong resemblance with Pomacentridae (i.e. *Stegastes* spp.) using mimicry colour patterns of non-predatory coral reef fish to attack prey successfully (Puebla, Bermingham, Guichard, and Whiteman 2007, Randall and Randall 1960). Hamlets are morphologically similar but have a diverse differentiation of color patterns (Haldane, 2016); hybrids with mixed colour patterns are often found (Barreto and McCartney 2008). Hamlets have been reported to predate on both small crustaceans and fishes (Randall, 1967; Whiteman et al., 2007, Holt et al. 2008).

Substantial portion of the native habitat of hamlets throughout the WA include overfished, eutrophic coral reefs with disrupted reef communities, a situation that can be further aggravated by the sporadic effect natural disasters. In September 20th, 2017, category 4/5 Hurricane Maria struck Puerto Rico affecting the island severely leaving many homeless, floods, runoff, landslides and hundreds of deaths (Kishore et al. 2018). Natural disturbances can affect fish populations due to high wave movement, habitat destruction (coral reefs) and even oil spills. For instance, in La Parguera Natural Reserve (LPNR), ESF-10 response teams assessed 377 total sunken or beached vessels and removed 18,150 gallons of oily water (Coastguardnews.com, 2018).

Before Hurricane Maria, two studies surveyed the hamlet communities in LPNR, including one in 2000 ((Aguilar-Perera 2003), and another in 2017 ((Hench et al. 2017)). By replicating the survey techniques used by the previous surveys, the goal of this study is to determine whether the community composition of hamlets in LPNR changed in the aftermath of Hurricane Maria.

The surveys consisted of 100m × 4m belt transects. In each site two belt transects were made approximately parallel in different depths (13 m - 2 m). The belt transects consisted of two shoulder-to-shoulder scuba divers, where each diver assessed 2 meters on their respective sides. The surveyed areas in the sites were focused on coral reef patches, backreefs, reef edges and gorgonian forests, avoiding sand patches as much as possible. Each reef was surveyed two times (20 surveys in total), with all the surveys performed during clear morning hours (7:00 a.m. to 11:00 a.m.) and lasting about 30 minutes each. The studied sites at LPNR included those surveyed by the previous studies in the inner reefs; outer reef sites were not assessed. Specific locations surveys include Enrique, Mario, San Cristobal, Pelotas, López, La Palma, Turrumote, La Gata, Pinnacles, and Media Luna. During the belt transects the two divers were always communicating and pointing the sighted hamlets to avoid double recording of the same individual. This was practical because *Hypoplectrus* spp. are not wary species usually remaining still in their crevices, or between gorgonians. The data taken was abundance (fish counts) and diversity (differentiating between the different species of hamlets) exclusively inside the belt transects.

Using the data collected for those sites, we performed a non-metric multidimensional scaling (nMDS) analysis via Bray Curtis resemblance matrix transformed to the 4th root for each year (2000, 2017, and 2018). We used the PRIMER v7 package for the nMDS analyses. Significant differences between abundance and diversity of hamlets were observed after Hurricane Maria (Table I) compared to the two pre-hurricane surveys (Aguilar-Perera 2003, Hench et al. 2017). Overall, we recorded five different species of Hamlets, lower than the diversity reported by Aguilar-Perera in 2000 (six species), but significantly higher than that reported by Hench et al. in 2017 (three species). More specifically, compared to the 2000 survey (Aguilar-Perera, 2003), the total relative abundance percentage of different hamlet species recorded was lower for every species with an 8.1% difference in *H. nigricans* and 0.29% difference in *H. unicolor*, with *H. indigo* and *H. aberrans* being recorded in 2000 but not 2018. While *H. chlorurus* and *H. puella* having a higher relative abundance in 2018 than in 2000, with a difference in relative abundance of 20.2% and 0.7% respectively. The surveys performed by Hench et al. in 2017 reflect a higher relative abundance of *H. chlorurus* in 2017 compared to 2018, with a difference of 12.7%, but a lower relative abundance for every other species, with differences of 2.6% and 6.2% for *H. unicolor* and *H. puella* respectively.

The overdominance of *Hypoplectrus chlorurus* (reported by the 2017 survey, but not the 2000 survey) was still observed after the impact of the hurricane but to a lesser degree than that reported before the disturbance (78.4% in 2018 and 91.1% in 2017). Two species that were not recorded before Hurricane Maria in inner reef cays (*H. nigricans* and *H. randallorum*) were recorded after Hurricane Maria (*H. nigricans* was also recorded by Aguilar-Perera 2003).

A nMDS analysis of the studied reefs after Hurricane Maria (Figure I) shows the presence of *H. chlorurus* on all studied reefs, while showing similarities in *Hypoplectrus spp.* community compositions between La Palma and Lopez (both had *H. chlorurus*, *H. puella*, *H. randollarum* and *H. unicolor*). Pelotas and Pinnacles were found to be the least diverse of the study sites, where only one species (*H. chlorurus*) was observed. It is noted that higher visual sedimentation was observed in Pelotas compared to other reefs, thus providing a possible explanation for the higher abundance (Table 1) of *H. chlorurus* on this site (see also Hench et al. 2017).

The nMDS analyses also allow temporal comparisons of hamlet communities from the two previous surveys (Aguilar-Perera, 2003; Hench et al. 2017). Hamlet communities before Hurricane Maria in 2017 (Figure 2) exhibited low species diversity with only *H. chlorurus*, *H. puella*, and *H. unicolor* being present on the same reefs we studied. Contrary to the high diversity of *Hypoplectrus spp.* we

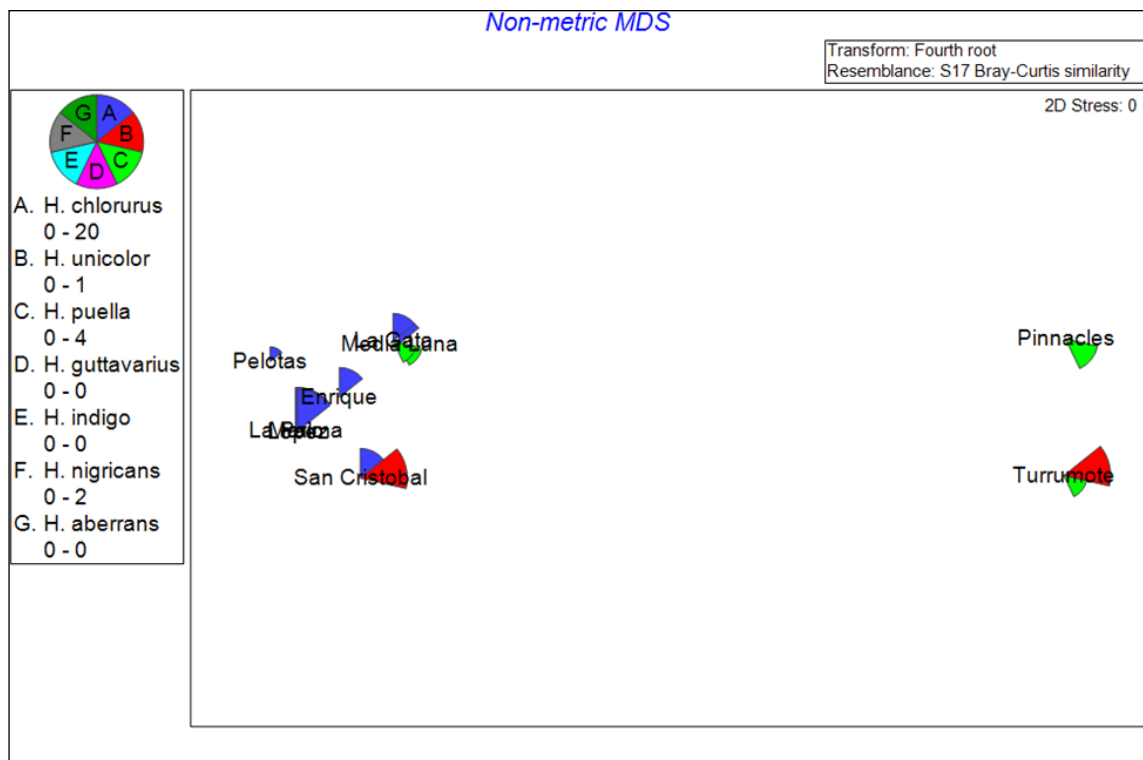


Figure 2. Non-metric multidimensional scaling (nMDS) for 10 reefs off La Parguera, Puerto Rico before Hurricane Maria. Comparison between *Hypoplectrus spp.* communities found on different study sites (reefs). Data obtained from Hench et. al (2017).

report (Figure 1), Hench et al. (2017) (Figure 2) found substantially fewer species and more homogeneity in the reef communities of Mario, Lopez, and La Palma, where only *H. chlorurus* was observed; the most diverse inner reef sites (San Cristobal, Turrumote, La Gata, and Media Luna) recorded in 2017 had only two species.

The nMDS analyses for the year 2000 (Figure 3) tell a whole different story. Aguilar-Perera (2003) recorded the highest diversity in *Hypoplectrus spp.* communities across all the reefs we studied. For instance, Mario's *Hypoplectrus spp.* communities were more similar to Media Luna's, and both had a total of 5 different species of *Hypoplectrus spp.* inhabiting them (*H. chlorurus*, *H. puella*, *H. aberrans*, *H. nigricans*, and *H. unicolor*). Other reefs also showed high diversity of *Hypoplectrus spp.* Considerably less anthropogenic effects (e.g., lower sedimentation) and other environmental factors (e.g., lower water temperatures) during 2000 could be offered as a possible explanation of the differences observed more than a decade after (see also Hench et al. 2017).

For a more comprehensive analysis on the differences in *Hypoplectrus spp.* communities, we merged all previous nMDS and analyzed them on a temporal scale (Figure 4.) including three time points: Time 1, 2000; Time 2, 2017 (pre-Maria); Time 3, 2018 (post-Maria). The major trends of hamlet communities over the years can be described as to follow boomerang pattern (Figure 4.). On all the study sites we saw the same pattern of distribution of *Hypoplectrus spp.* communities, where the year 2000 had the greatest diversity, followed by a steep decline in the year 2017 before Maria, and a slight increase in diversity post-Maria. This trend was to be expected and serves as another instance supporting the intermediate disturbance hypothesis (Grime 1973, Connell 1978, Huston 1979, Dial and Roughgarden 1998, Rogers 1993, Roxburgh et al. 2004). Another

possible explanation for the increase in diversity could be the gradual reduction of water temperatures (*ca.* 2°C) recorded by the National Weather Service. This decrease in temperature could serve as a facilitator for hamlets to move to the now colder (and shallower) parts of the reef. Note that the diversity of hamlets in the outer reefs (not assessed here), including higher depths and lower temperatures, have found to be much higher than that in the inner reefs (Hench et al. 2017)

A positive correlation has been established between the passage of Hurricane Maria and *Hypoplectrus spp.* communities located on the studied sites in La Parguera Puerto Rico. The dominance of *H. chlorurus* was still observed in all the surveyed reefs. A possible relationship between an increase in sedimentation and the dominance of *H. chlorurus* was seen in the study sites (especially in Pelotas), but further experimentation and data is needed to identify a more definite correlation. It remains to be assessed whether a further increase in the diversity of hamlet community will take place as time progresses, reaching similar levels as those recorded in 2000 by Aguilar-Perera (2003). It is also possible that, once the pre-disturbance conditions are restored, the diversity of hamlet communities may return to the 2017 levels as a result of the ever-increasing anthropogenic activities in the area like farming, fishing, and tourism. Different biotic and abiotic factors will probably play a role in determining the fate of the diversity dynamics of these communities.

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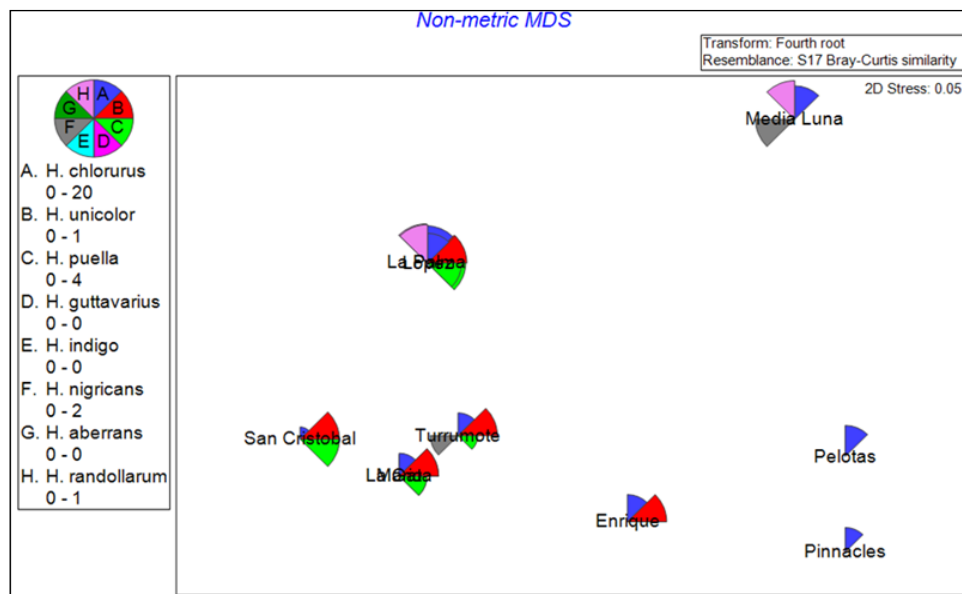


Figure 1. Non-metric multidimensional scaling (nMDS) for 10 reefs off La Parguera, Puerto Rico before Hurricane Maria. Comparison between *Hypoplectrus* communities found on different study sites (reefs).

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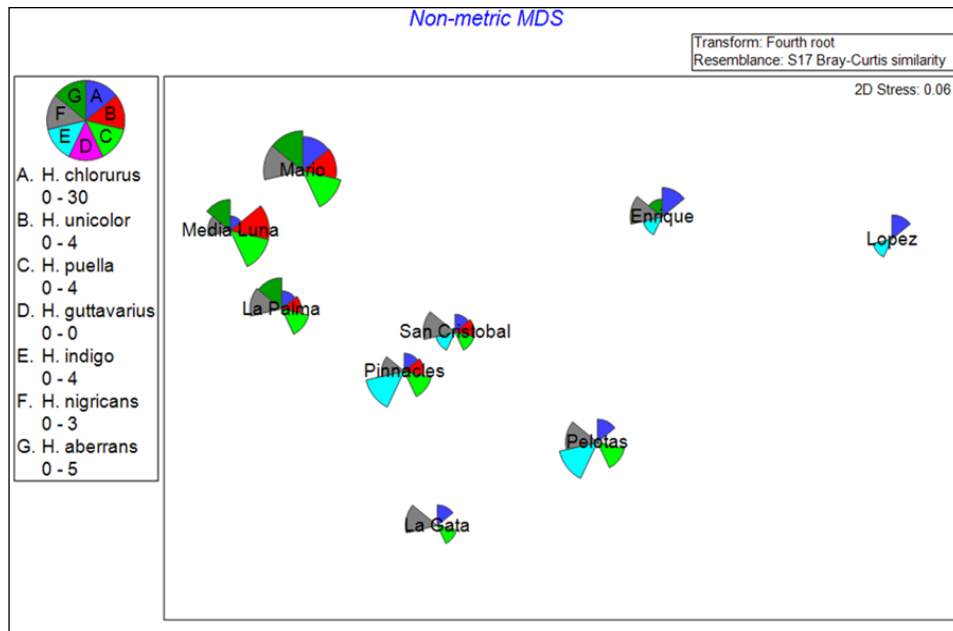


Figure 3. Non-metric multidimensional scaling (nMDS) for 10 reefs off La Parguera Natural Reserve at the year 2000. Comparison between *Hypoplectrus* communities found on different study sites (reefs). Data obtained from Aguilar-Perera (2003).

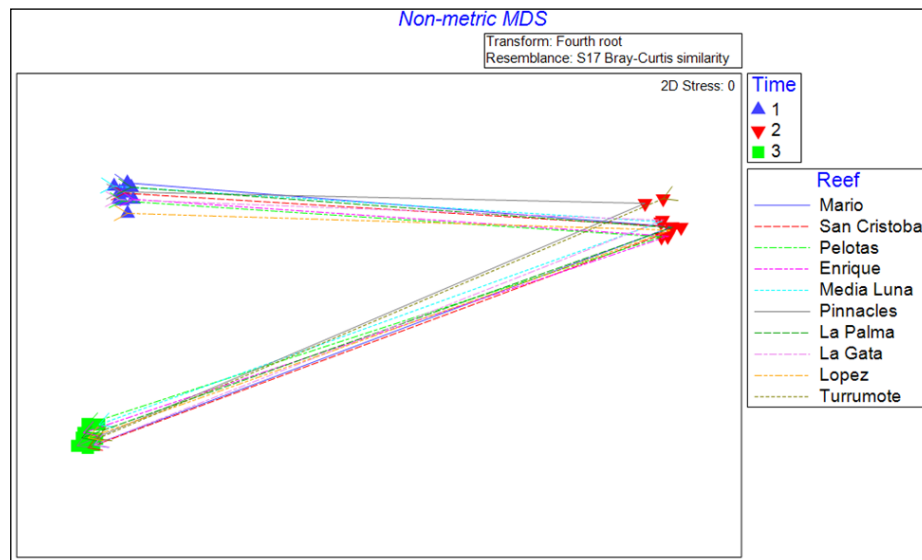


Figure 4. Merged non-metric multidimensional scaling (nMDS) for 10 reefs off La Parguera Natural Reserve for Time 1 (year 2000), Time 2 (year 2017 before Hurricane Maria), and Time 3 (year 2018 after Hurricane Maria). Temporal *Hypoplectrus* spp. community comparisons for the studies sites. Data from 2017 was recompiled from Hench et al. (2017) and of 2000 from Aguilar-Perera (2003).

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Table I. Hamlet counts and relative abundances from 10 surveys of 100m x 4m each across 10 reefs off La Parguera, Puerto Rico, in May 2018. Data from 2017 was recompiled from Hench et al. (2017) and of 2000 from Aguilar-Perera (2003).

Reef	Latitude N°	Longitude W°	Depth (m)	<i>H. chlorurus</i>	<i>H. unicolor</i>	<i>H. puella</i>	<i>H. guttavarius</i>	<i>H. indigo</i>	<i>H. nigricans</i>	<i>H. aberrans</i>	<i>H. randallorum</i>	Total Count
Mario	17.953	-67.056	10.44	4	1	0	0	0	0	0	0	5
Mario	17.953	-67.056	5.48	2	0	2	0	0	0	0	0	4
San Cristobal	17.938	-67.068	6.75	0	0	2	0	0	0	0	0	2
San Cristobal	17.938	-67.068	3.05	2	1	0	0	0	0	0	0	3
Enrique	17.955	-67.053	12.25	1	1	0	0	0	0	0	0	2
Enrique	17.955	-67.053	6.18	9	0	0	0	0	0	0	0	9
Media Luna	17.940	-67.051	8.07	5	0	0	0	0	0	0	1	6
Media Luna	17.940	-67.051	2.01	10	0	0	0	0	2	0	0	12
Pelotas	17.957	-67.070	10.23	9	0	0	0	0	0	0	0	9
Pelotas	17.957	-67.070	5.36	4	0	0	0	0	0	0	0	4
Total Count				46	3	4	0	0	2	0	0	56
Total Relative Abundance (%)				82.14	5.35	7.14	0	0	3.57	0	1.78	
Total Relative Abundance Hench et. Al (2017) (%)				91.1	3.0	5.0	0	0	0	0	0	