Port Honduras Marine Reserve Annual Report 2019 - Research & Monitoring

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Research and Monitoring PHMR 2019

Research and monitoring continue to be an integral part in the management effectiveness of the Port Honduras Marine Reserve (PHMR). Monitoring for the year 2019 included lobster surveys, conch surveys, a sea cucumber survey, a coral health survey, reef fish surveys, reef benthic surveys and coral bleaching surveys. Included with this report will be the commercial species, coral health survey and coral bleaching update 2019. A more detailed analysis of the commercial species, coral health and bleaching, reef fish and reef benthic monitoring will be available in the PHMR Biological Report(s) for 2019.

Queen Conch (*Lobatus gigas*)

Annual monitoring of queen conch takes place in Port Honduras Marine Reserve (PHMR) twice each year in July after the conch season closes and in September before the season opens again. Data on population density, maturity and size frequency of queen conch are collected and analyzed. In 2019, the Belize Fisheries Department closed the queen conch fishery on April 30th, 2019 due to the realization of the queen conch quota in accordance with Statutory Instrument No. 54 of 2012. Hence, closed season queen conch monitoring was conducted in May 2019.

Since September 2011, 20 sites had been monitored; five in Replenishment Zones (RZs), 11 in the General Use Zone (GUZ) and four outside the reserve (OUT). In 2019, an additional site OUT was added making the total number of conch sites monitored at 21. In this 2019 report, planned RZ expansion sites for conch were included in the analysis in order to capture the effect of establishment of these areas as RZs in the future. The RZ expansion sites would encompass the Snake Cayes in one contiguous area; currently the RZs only encompass a 1 mile radius encircling each Caye. These RZ expansion sites are collectively known as 'Expanded Replenishment Zone' (ERZ) sites with two currently located in the GUZ. The ERZ sites, in addition to the RZs sites, are referred to as the Contiguous RZs. At each site, where possible, belt transects are performed with five 50-meter transect lines laid parallel to one another and at least five meters apart. Two divers on each side search a combined 4-meter width along each line. All conch within each 200 m^2 belt transect are counted and conch density, length and lip thickness are measured. At some sites, only three or four were possible due to habitat and depth constraints. The specific number of sites surveyed in each monitoring trip can vary slightly due to weather, resources, and underwater visibility. A map of monitoring sites for each species in each zone in PHMR can be found in appendices A1-A5.

The annual mean conch densities in RZs in 2019 increased 28% from 46 conch per hectare in 2018 to 59 conch per hectare in 2019 (Fig. 1). Mean conch densities at the opening of the season in the RZs were at 86 conch per hectare (Fig. 2). This was a 39% increase from opening of season in the RZs in 2018 and the first year since 2013 that the conch density was above 80 conch per hectare. The annual conch densities in the GUZ slightly decreased to 38 conch per hectare with population values at opening of conch season similar to 2018 levels at 45 conch per hectare. The

OUT sites showed annual conch density similar to levels in 2017-2018 at 15 conch per hectare. The annual conch density in the estimated Contiguous RZ was ~72 conchs per hectare; a 72% increase in population density from 2018 levels at 42 conchs per hectare (see Fig. 1). The increases in conch densities in the RZs and Contiguous RZs was good news. However, for the past 6 years, the conch population has remained below the 88 ha^{-1} minimum density threshold, as determined by the Belize Fishery Department, in all zones and continues to have a negative impact on reproductive success, as the likelihood of conch encountering reproductive mates remains low.

Mean conch shell length in 2019 was similar to 2018 values in all three zones ranging from 19-21 cm; legal shell length as determined by BFD (Fig. 3). The mean shell length since 2009 does not show any major increasing or decreasing trends in the GUZ, RZs or OUT.

The annual mean conch lip thickness (LT) in 2019 was greater in the RZs than in the GUZ at 11 mm and 6 mm, respectively (Fig. 4). Additionally, the Contiguous RZs showed slighter greater LTs than those found in the GUZ. However, these LT annual mean values are still less than literature standards for queen conch fecundity. Additionally, time series analysis shows a general trend toward decreasing lip thickness in the GUZ, RZs and OUT (see Fig. 4). Studies have shown that high fishing (exploitation) rates has typically resulted in an overall decline in the lip thickness of a queen conch population resulting in the harvesting of immature conchs, thus reducing recruitment rates.

The closed seasons, especially in the GUZ, have not yet achieved their intended purpose of increasing abundance to healthy population levels by protecting conch during their reproductive season and thus increasing recruitment rates. This, combined with low mean lip thickness in all zones, indicates poor recruitment via reproduction, with immature adults being predominant. These factors together continue to leave the conch population vulnerable to overexploitation and collapse.

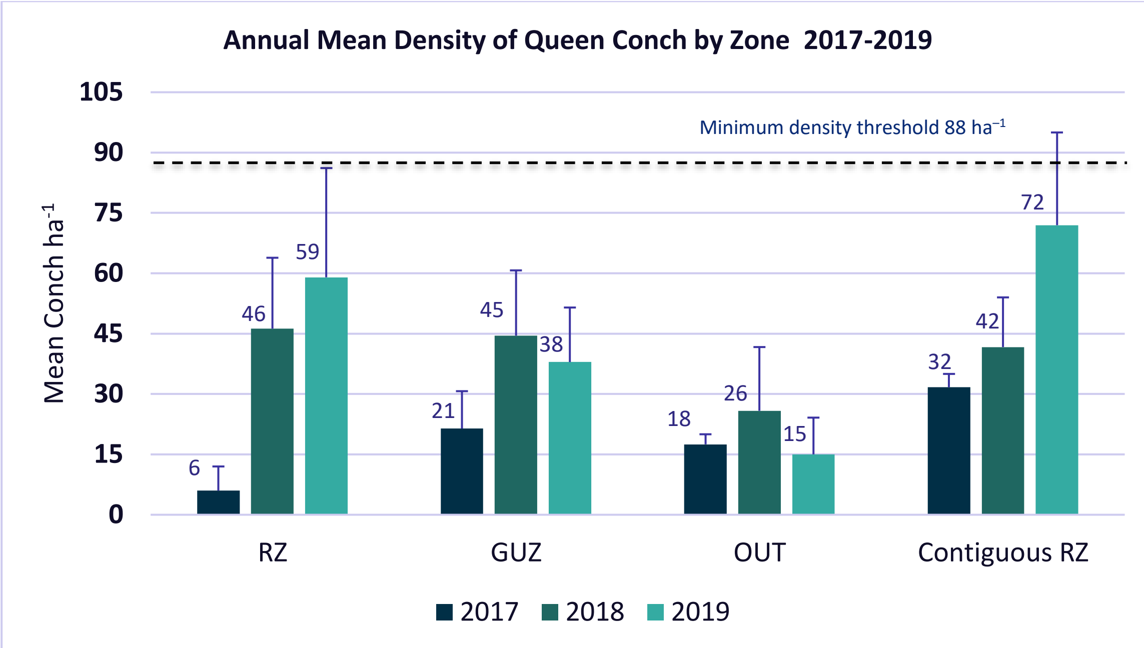


Figure 1. Annual mean density of queen conch, number of conchs per hectare, observed by zone 2017–2019 [Replenishment Zones (RZ), General Use Zone (GUZ), Outside the Reserve (OUT), Contiguous RZ][+Standard Error Bars].

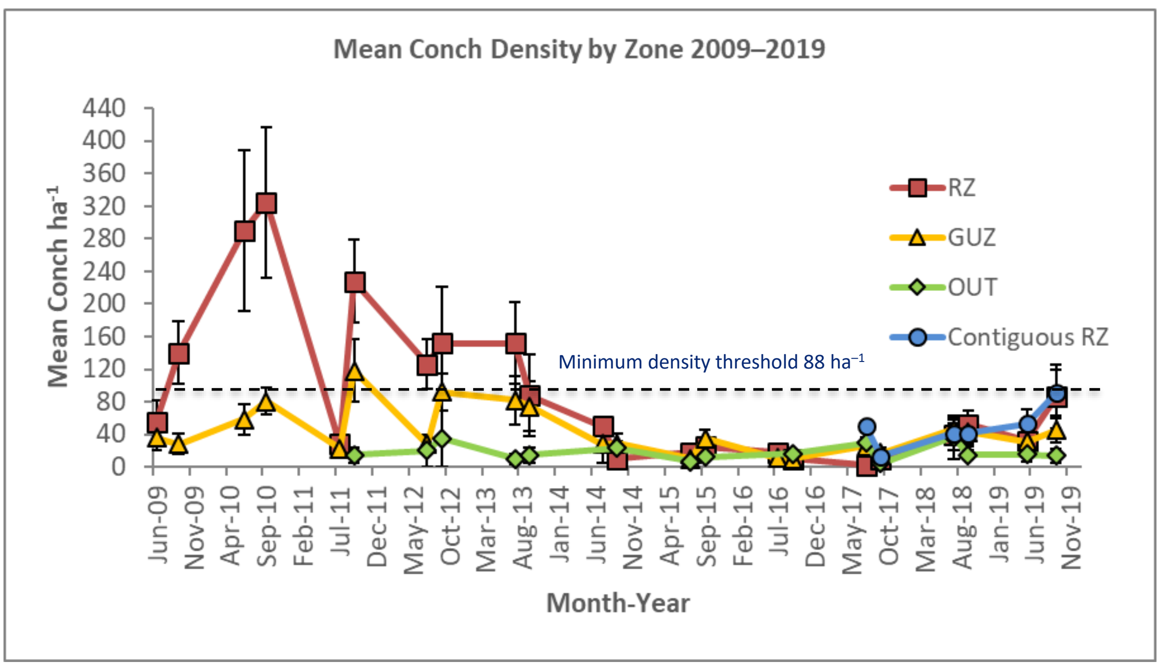


Figure 2. Mean queen conch density, number of conchs per hectare, observed during pre-season and post-season surveys by zone 2009–2019 [Replenishment Zones (RZ), General Use Zone (GUZ), Outside the Reserve (OUT), Contiguous RZ] [±Standard Error Bars].

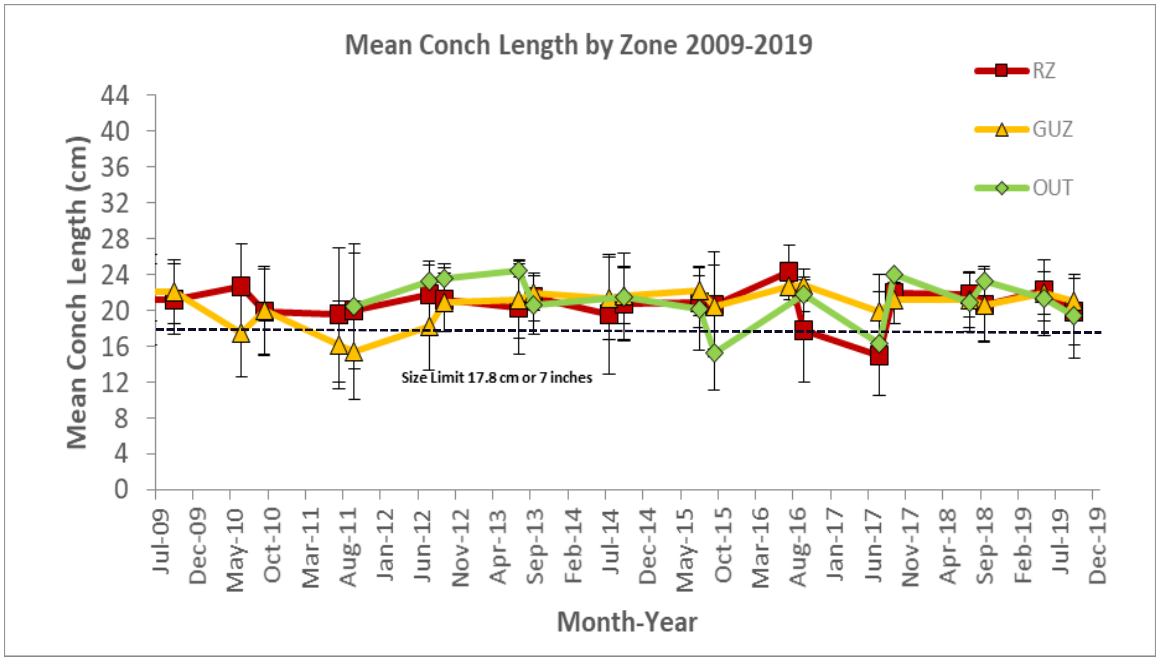


Figure 3. Mean queen conch shell length (cm) observed during pre-season and post-season surveys by zone 2009–2019 [Replenishment Zones (RZ), General Use Zone (GUZ), Outside the Reserve (OUT)] [±Standard Deviation].

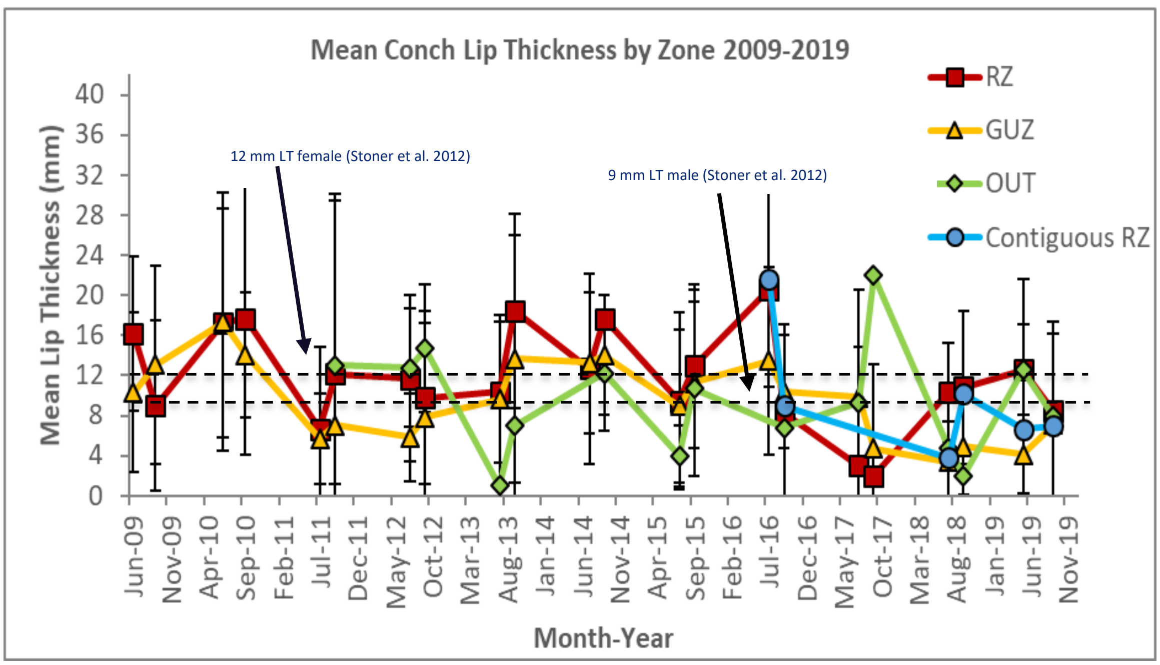


Figure 4. Mean queen conch lip thickness (mm) observed during pre-season and post-season surveys by zone 2009–2019 [Replenishment Zones (RZ), General Use Zone (GUZ), Outside the Reserve (OUT), Contiguous RZ] [±Standard Deviation].

Caribbean Spiny Lobster (*Panulirus argus*)

Caribbean spiny lobster (*Panulirus argus*) populations are surveyed at 18 sites within and adjacent to PHMR twice a year, immediately after the closed season begins (15th February), and immediately before it opens (15th June). Sites are located in the RZs (8 sites), GUZ (7 sites), and outside the reserve (3 sites). In 2016, TIDE added four new sights in areas planned for RZ expansion in order to capture the effect of establishment of these areas as RZs in the future. Only three of these sites are currently monitored regularly. These new sites are collectively known as 'Expanded Replenishment Zone' (ERZ) sites with two currently located in the GUZ and one at the outskirt of current RZ zone at Middle Snake Caye. The ERZ sites in addition to the RZs sites are known collectively as the Contiguous RZs. At each site, where possible, either two diver pairs conduct two 30-minute timed swims simultaneously or a 60-minute timed swim is conducted by a single diver pair. For each lobster located, species, gender, maturity (tar spot, eggs) and carapace length are recorded. The number of sites surveyed in each monitoring period and year can vary slightly due to weather, resources, and underwater visibility. Abundance is calculated as the number of lobsters encountered per hour during each timed swim.

In 2019, lobster abundance decreased from 2018 values in both the GUZ and RZs with annual mean lobster abundance at 4 hr^{-1} and 5 hr^{-1}, respectively (Fig. 5). Though OUT sites are on lobster preferred coral habitat, the lobster abundance was <2 lobster per hour. The planned Contiguous RZ lobster abundance reflected the observed lobster abundances in the RZs in 2017-2019 (Fig. 6). These results imply that the lobster population is under more pressure and not being protected enough for steady increases in abundance and reproductive activity and should be closely monitored.

The mean carapace length in the RZs in 2019 increased to ~9 cm at opening of lobster season, similar to GUZ values, with an annual mean carapace length at 8.7 cm (Fig. 7). The GUZ mean carapace length 2017-2019 at opening of season has been steady at ~9 cm. The OUT and Contiguous RZ showed increases in annual mean carapace lengths at 9.0 cm and 8.7 cm, respectively, with Contiguous RZ mean carapace length observed at 10 cm at opening of lobster season 2019, slightly higher than the GUZ and RZs. That being said, mean carapace lengths do not show large fluctuations in size in zones over time with the exception of GUZ 2016, and that anomaly most likely is due to low population size measured that year (n=3).

The gender ratio in the RZs and GUZ between 2009–2019 exhibited a relatively stable male bias (males ~60–70%; females ~20–40%), with the exceptions in 2013, 2016 and 2018 when the gender ratio became more equal. However, these more equal gender ratios seen in the past could have been attributed to the lower abundances in general. In 2019, males were once again more prevalent than females with males 65-70% and females ~25-35% in the RZs, GUZ and OUT (Fig. 8). It has been suggested that regular fluctuations in population abundances, size distribution and gender ratio in each zone may be attributed to molting, reproductive and feeding activities (1). Additionally, fluctuations in population abundances has been linked to variations in environmental factors (e.g. sea temperature) [2].

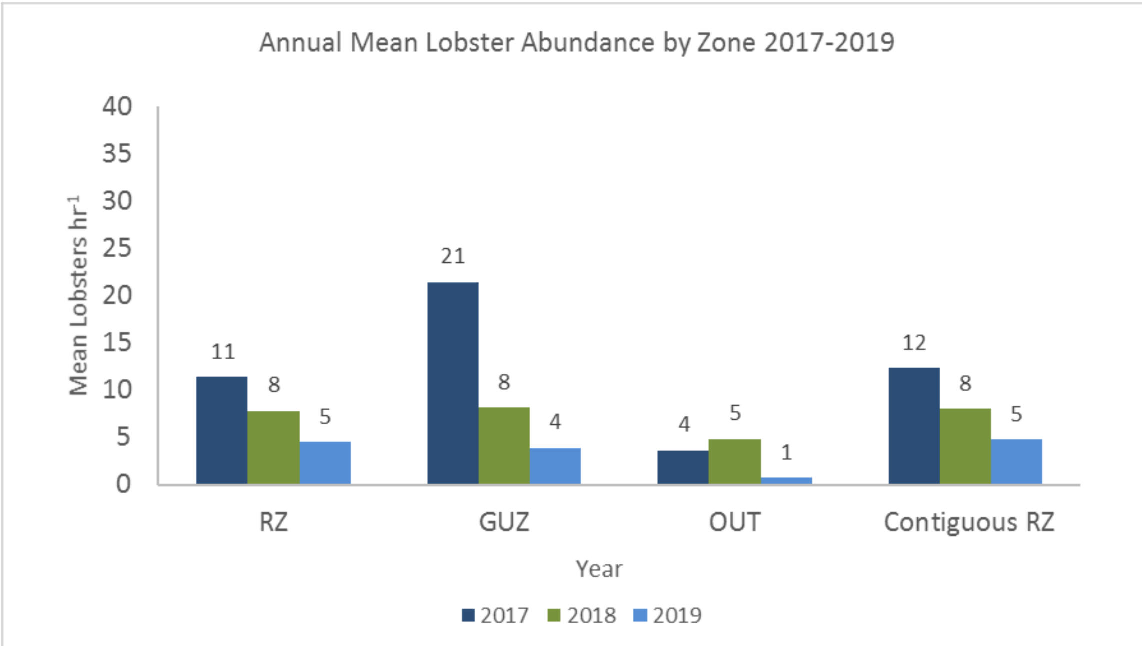


Figure 5. Annual mean spiny lobster, *Panulirus argus*, abundance (lobster per hour) by zone 2017–2019 [Replenishment Zone (RZ), General Use Zone (GUZ), Outside the Reserve (OUT), Contiguous RZ].

(1) MacDiarmid, AB (1991). Seasonal changes in depth distribution, sex ratio and size frequency of spiny lobster *Jasus edwardsii* on a coastal reef in northern New Zealand. *Marine Ecology Progress Series* 70: 129–141.
(2) Davis, GE (1977). Effects of recreational harvest on a spiny lobster *Panulirus argus* population. *Bulletin of Marine Science* 27(2): 223–236.

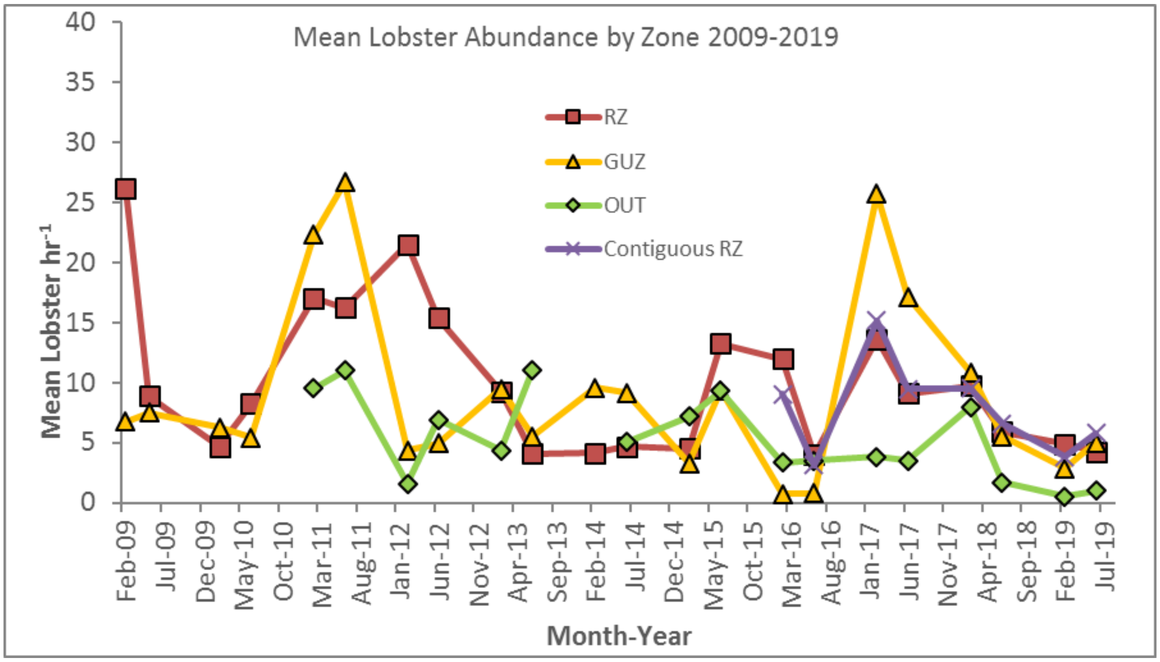


Figure 6. Mean spiny lobster, *Panulirus argus*, abundance (lobster per hour) observed during pre-season and post-season surveys by zone 2009–2019 [Replenishment Zone (RZ), General Use Zone (GUZ), Outside the Reserve (OUT), Contiguous RZ].

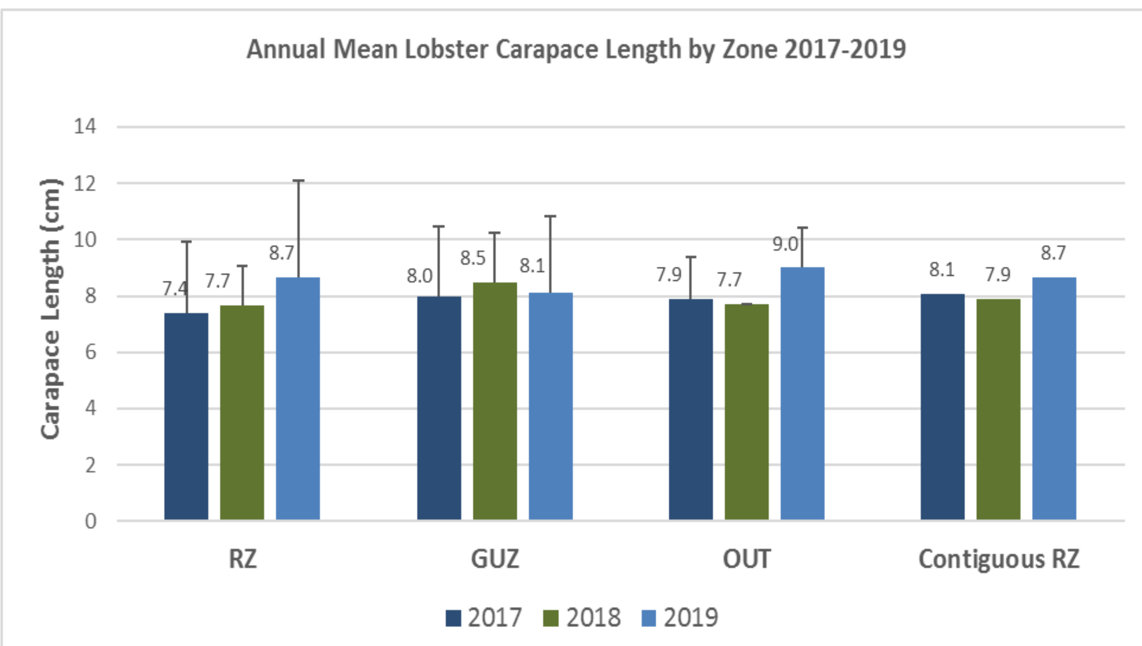


Figure 7. Annual mean spiny lobster, *Panulirus argus*, carapace length (cm) by zone 2017–2019 [Replenishment Zone (RZ), General Use Zone (GUZ), Outside the Reserve (OUT), Contiguous RZ].

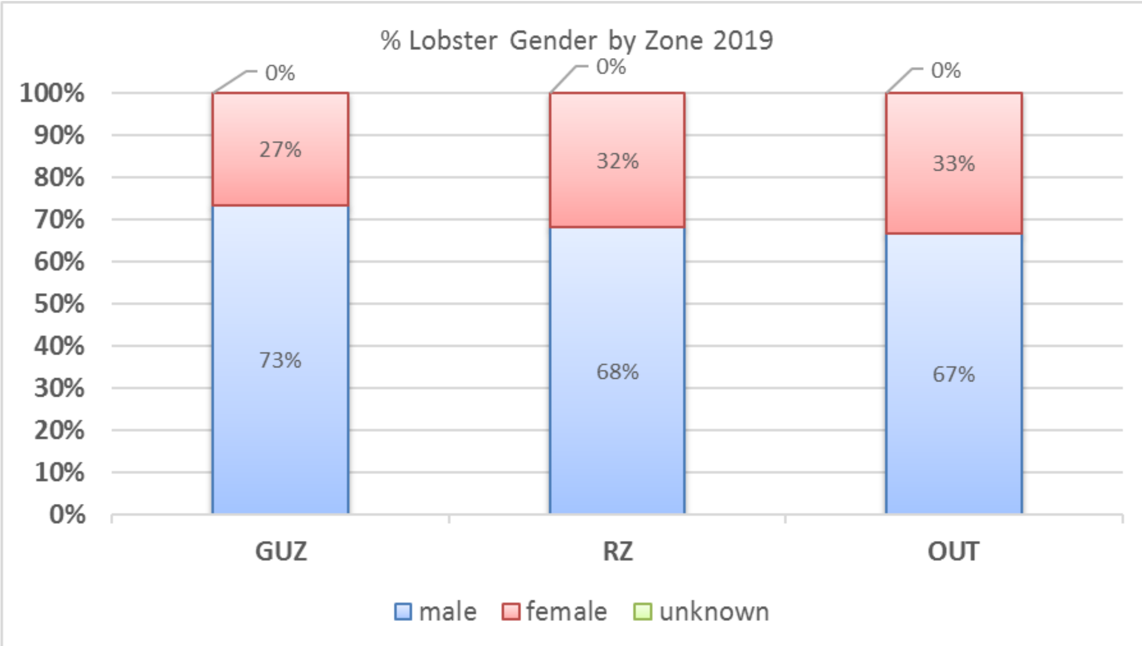


Figure 8. Percent (%) spiny lobster, *Panulirus argus*, gender (male, female, unknown) by zone 2019 [Replenishment Zone (RZ), General Use Zone (GUZ), Outside the Reserve (OUT)].

Sea Cucumber (*Holothuria mexicana*)

A moratorium on sea cucumber harvesting was enacted by the Belize Fisheries Department in 2017 due to the substantial decrease in sea cucumber population abundances in Belize. Nonetheless, monitoring continued to be conducted for sea cucumber in May of 2019. Sites are located in the RZs (5 sites), GUZ (8 sites), and outside the reserve (3 sites). A 11.28 m line (*calculated as*: area of a circle = $\Pi r^2 \rightarrow 400\ m^2/\Pi = 127.32$; $\sqrt{127.32} = 11.28$ m) is attached to a central pole, and two divers swim the line around the pole in a radar-sweep trajectory covering 400 m^2 of habitat. When *H. mexicana* are found, length and width measurements are taken *in situ,* being careful not to touch the specimen as this might cause it to retract. Specimens are then brought up to the boat to be weighed before being returned to their original location. In order to gain population density estimates, the number of *H. mexicana* per hectare is calculated. Mean length and weight are also calculated to determine mean sizes in different management zones.

The sea cucumber mean density decreased significantly since 2012-2013 in both the RZs and GUZ with density by zones <30 per hectare (Fig. 9). The mean sea cucumber density in OUT has been <15 ha^{-1} since monitoring began in 2016 and none were found in that zone during the November 2018 and May 2019 monitoring efforts (Fig. 10). Though a moratorium was placed on harvesting the sea cucumber in 2017, there has been no significant difference (P=.81) in mean sea cucumber densities in all zones since it went into effect. Due to the continual low abundance of the sea cucumber population, only one monitoring survey was conducted in 2019.

Since 2011, mean sea cucumber lengths in the RZs and GUZ have ranged from ~17-28 cm with the overall mean and median of the GUZ and RZs 2011-2019 at 22 cm and 23 cm, respectively, showing no outliers in overall mean values (Fig. 11). The annual mean sea cucumber length in the RZs and GUZ increased from 2018 values from 21-24 cm in the RZs and from 21-28 cm in the GUZ (Fig. 26). This was the highest recorded mean sea cumber length in the GUZ since pre-fishery values. Even so, there was no significant difference (P=.64) in mean sea cucumber lengths in all zones since the 2017 moratorium.

The mean sea cucumber weight in the GUZ from 2011-2019 ranged from ~304-707 g, with the overall mean of the GUZ at 483 g and RZs at 614 g and the overall median at similar values of ~489 g and ~602 g, respectively (Fig. 12). In 2019, the annual mean sea cucumber weights increased in both the GUZ and RZs from 2018 values to 650 g in the GUZ with the RZs being slightly higher (Fig. 28). Again, though there was a moratorium placed on the sea cucumber, there was no significant difference (P=.16) in mean sea cucumber weights in all zones since 2017.

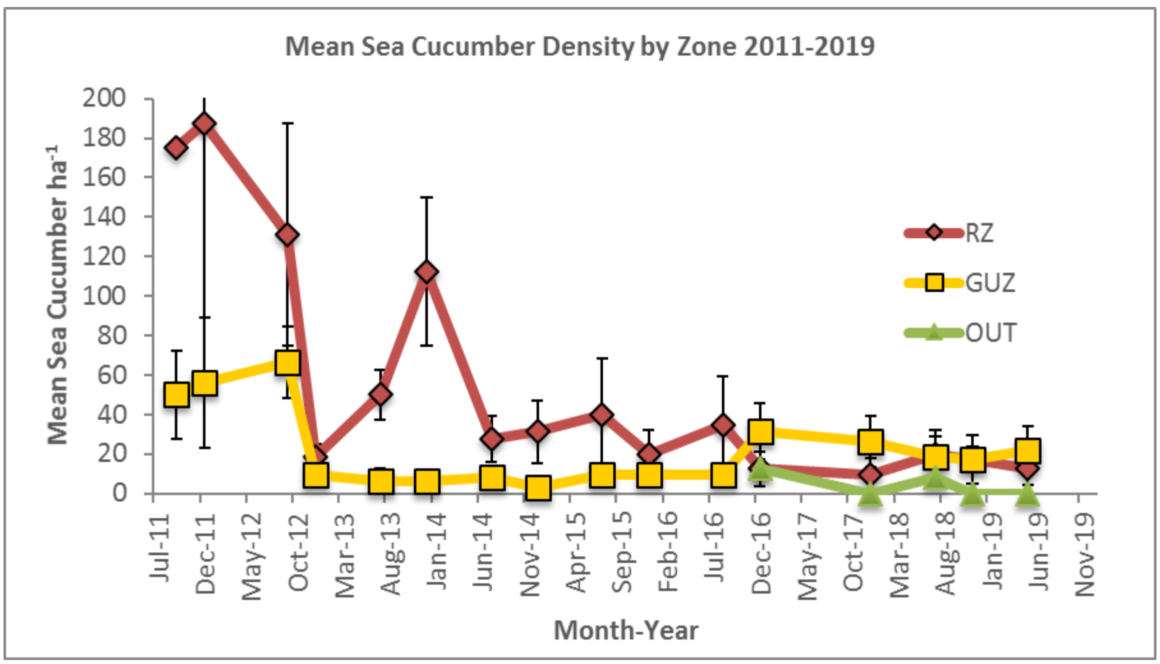


Figure 9. Mean Sea cucumber, *H. mexicana*, density observed during pre-season and post-season surveys conducted 2011–2019 [Replenishment Zone (RZ), General Use Zone (GUZ), Outside the Reserve (OUT)] [±Standard Error Bars].

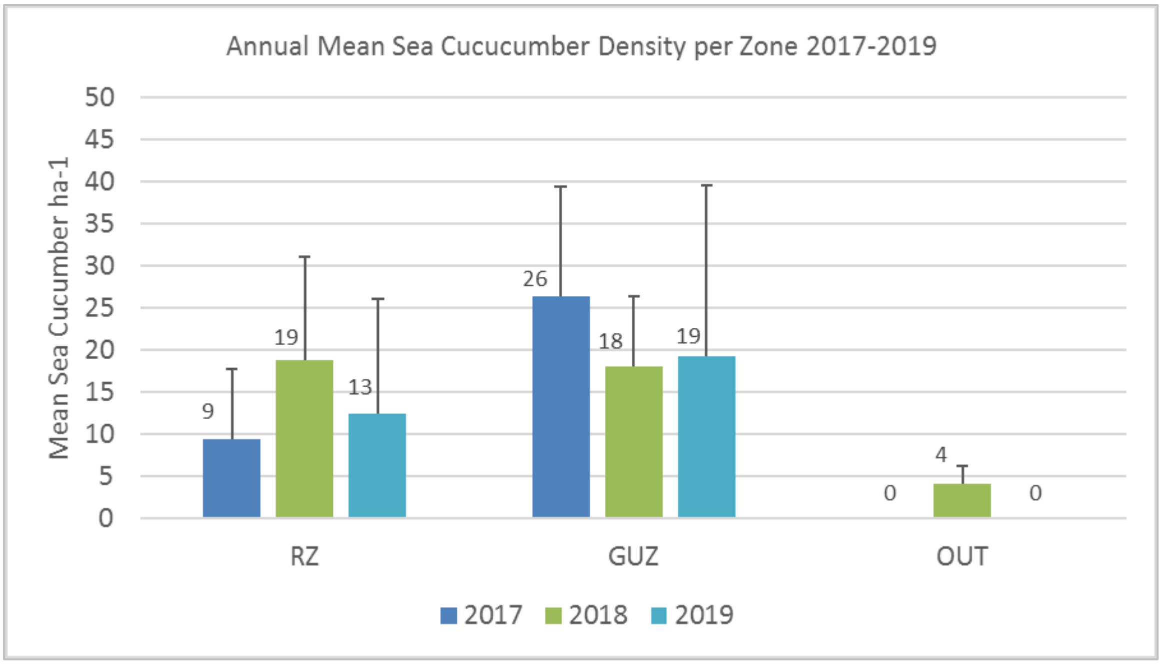


Figure 10. Annual mean sea cucumber, *H. mexicana*, density per zone 2017–2019 [Replenishment Zone (RZ), General Use Zone (GUZ), Outside the Reserve (OUT)] [±Standard Error Bars].

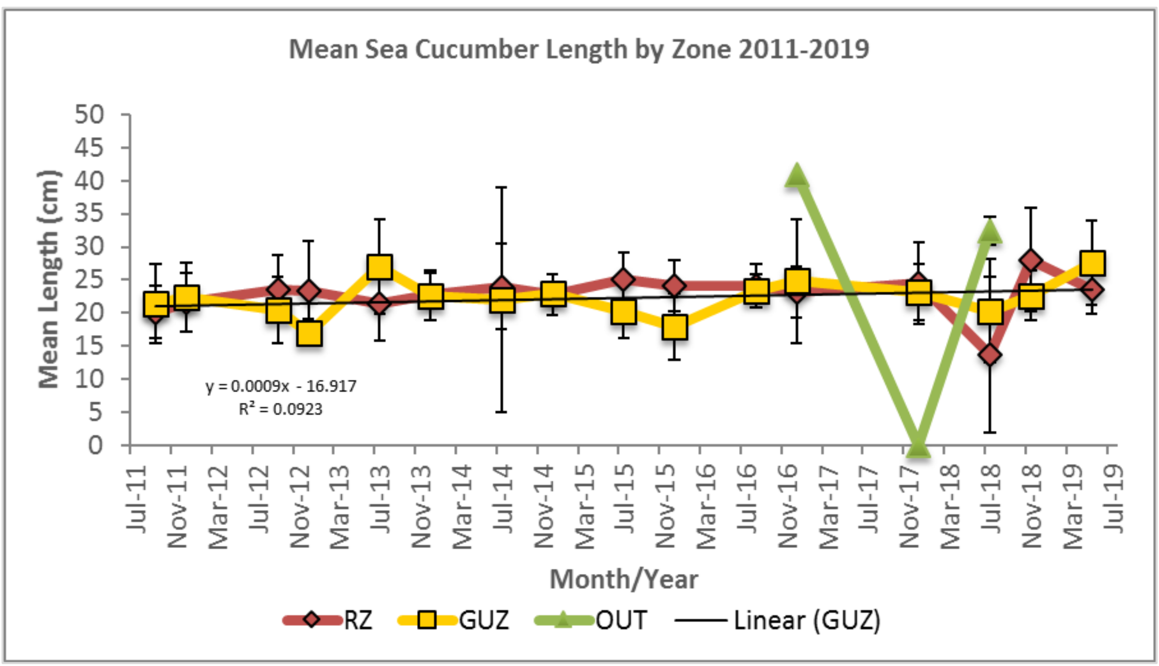


Figure 11. Mean sea cucumber, *H. mexicana*, length (cm) by zone observed during pre-season and post-season surveys conducted 2011–2019 [Replenishment Zone (RZ), General Use Zone (GUZ)] [±Standard Deviation]. Note: Zero length means (n=0).

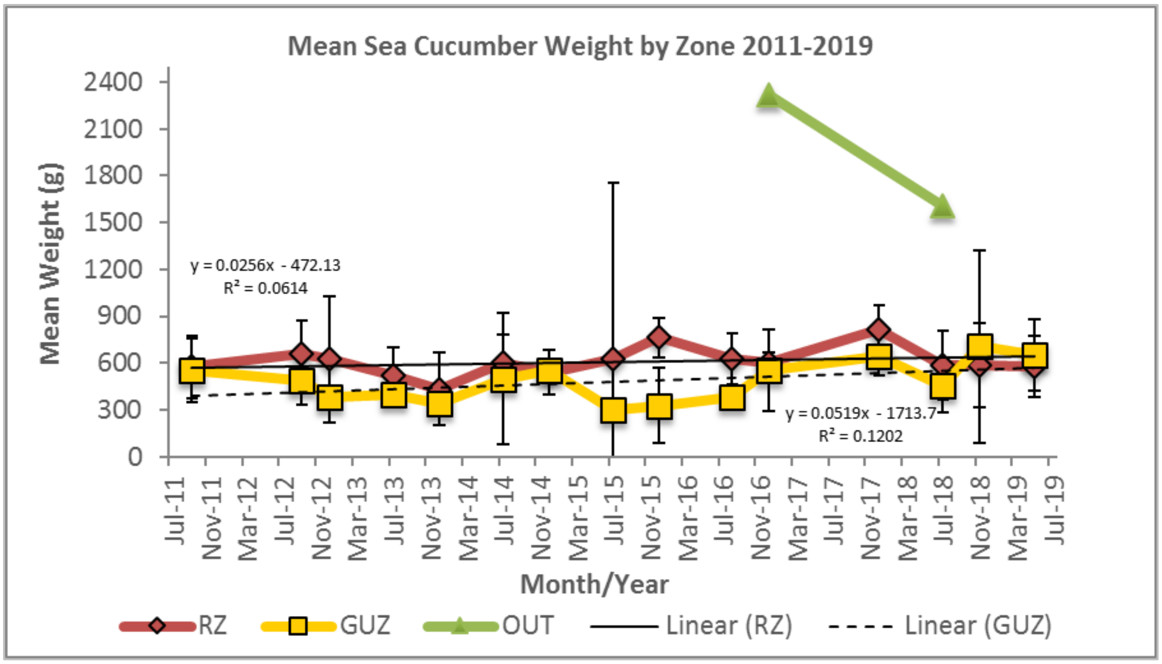


Figure 12. Mean sea cucumber, *H. mexicana*, weight (g) observed during pre-season and post-season surveys conducted 2011–2018 [Replenishment Zone (RZ), General Use Zone (GUZ), Outside the Reserve (OUT)] [±Standard Deviation].

Coral Reef Health

Coral reefs are in decline worldwide due to increased anthropogenic pressures and increased sea temperatures from climate change. Coral bleaching events that once only happed every decade or so are now annual events. Coral reefs are an essential component of the Port Honduras Marine Reserve. The health of coral reef habitats has a significant influence on the vertebrate (i.e. fish) and invertebrate (i.e. mollusks) populations that inhabit them. A healthy coral reef supports far larger populations of species compared to an unhealthy reef system.

TIDE has been conducting ongoing coral and reef fish monitoring in PHMR since 2003. Eight sites were assessed since 2003 with two new sites added in 2011 outside the reserve for comparison with unmanaged reef sites. To determine reef health, a range of variables has been monitored since 2003, including coral species, diversity, mortality and coral disease. The coral composition is assessed using the MBRS-SMP survey method of linear point intercept transects (Almada-Villela 2003) whereby the type of benthic cover is recorded every 25 cm along six to eight 30 m transects at each site. Mean benthic composition is calculated from these transects at each site.

In July 2019, the PHMR coral colonies showed early (pre-peak season) and widespread bleaching in the GUZ and RZs (The two monitoring sites OUT were not completed due to inclement weather.) The data showed bleaching levels even higher than the 2017 country-wide bleaching event with approximately 1 out of four corals identified as being affected (Fig. 13). The mean percentage of corals showing disease seemingly decreased from 2018 to 2019 with the biggest decrease seen in the RZs from 8% to 2% (Fig. 14). The mean coral colony planar area monitoring reflected the bleaching events coral health from 2017-2019 with the 2019 planar area decreasing from the 2017 levels by 40% and 30% in the RZs and GUZ, respectively. TIDE continued to monitor the 2019 bleaching event into the 2019 "bleaching season" which is October-December when water temperatures for the year reach its peak.

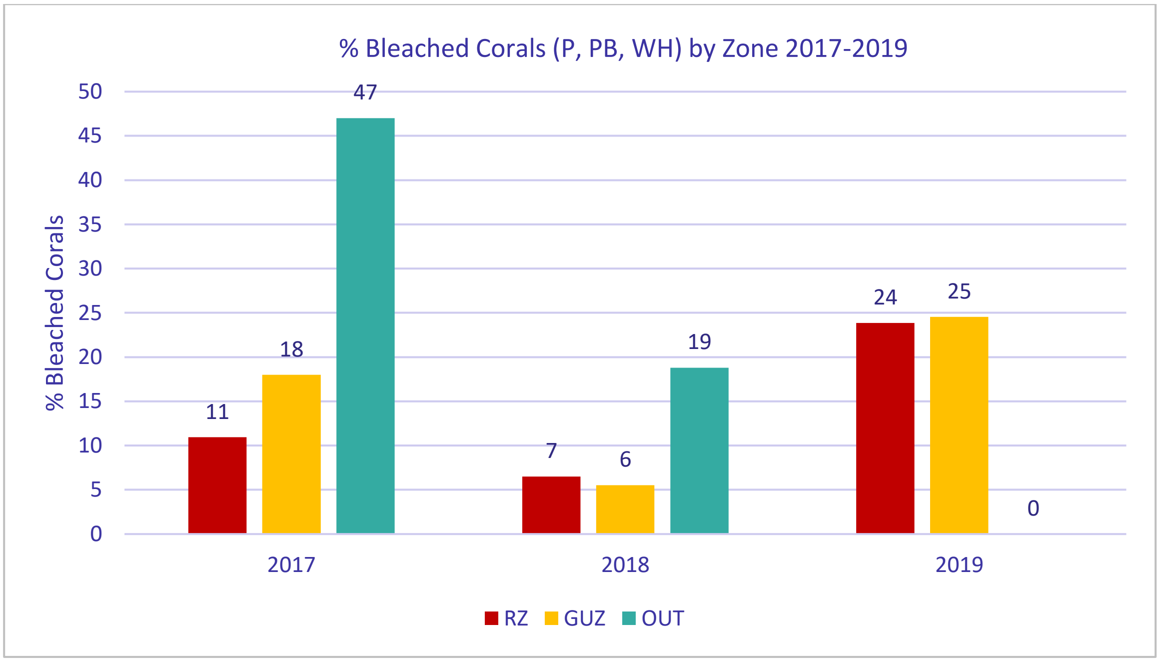


Figure 13. Mean percent (%) bleached corals (pale + partial bleaching + whole bleaching) by zone 2017-2019 [Replenishment Zone (RZ), General Use Zone (GUZ), Outside the Reserve (OUT)].

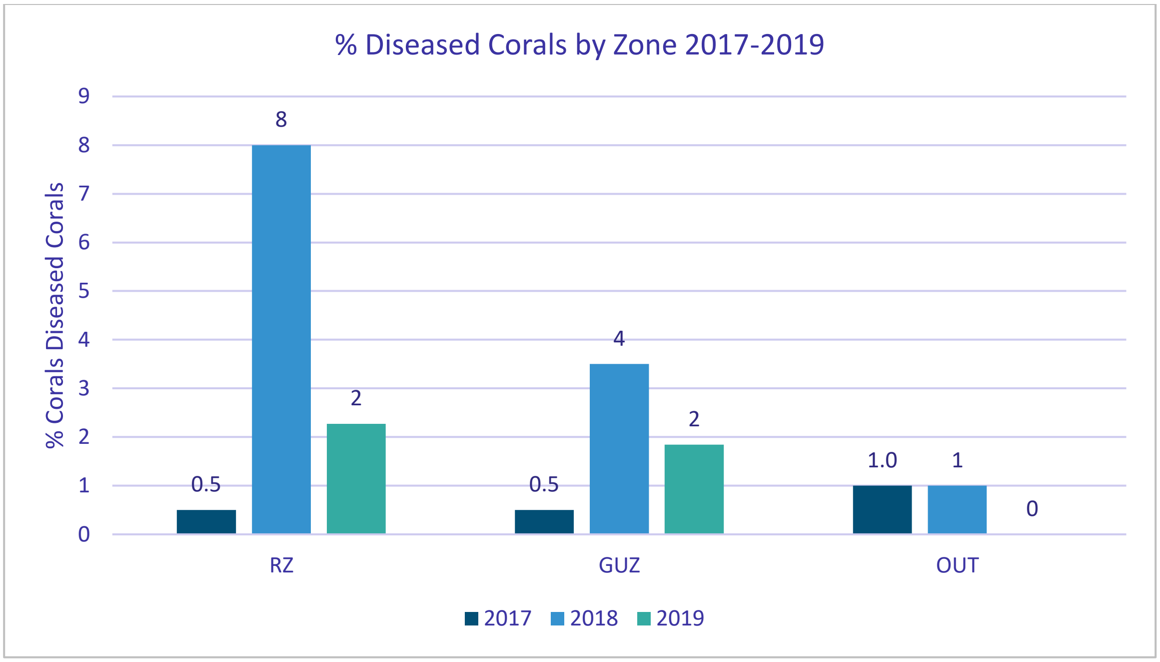


Figure 14. Mean percent (%) corals showing signs of disease by zone 2017-2019 [Replenishment Zone (RZ), General Use Zone (GUZ), Outside the Reserve (OUT)].

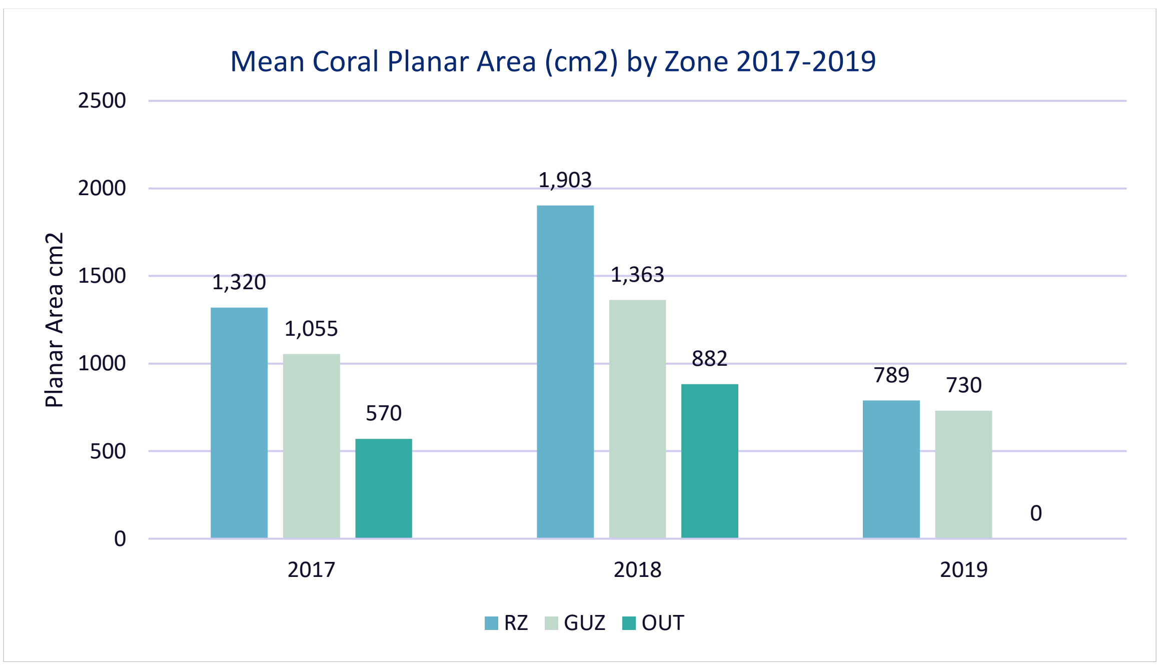


Figure 15. Mean coral colony planar area (length * width) by zone 2017–2019 [Replenishment Zone (RZ), General Use Zone (GUZ), Outside the Reserve (OUT)].

Coral Bleaching

Bleaching refers to a coral's loss of zooxanthellae, an organism that lives in symbiosis with coral colonies. Large spikes in water temperature, long durations of water temperature at the upper limits of the coral colony or even increases in light intensity can cause a coral colony to bleach. There was an unprecedented bleaching event throughout Belize in 2017. The severity of bleaching differed from North to South of Belize and inside and outside of PHMR (i.e. coral bleaching was more prevalent outside the marine reserve than inside.) The least affected corals country-wide in 2017 was in PHMR. Due to the 2017 unprecedented bleaching event throughout Belize, coral bleaching monitoring continued in 2018 and 2019 during "bleaching season" which is October-December when water temperatures for the year reaches its peak.

A total of six sites are monitored using the bar drop method developed as a bleaching assessment tool in 1995 by McField (1999). Four sites are in the replenishment zones, one in the general use zone, and one outside the reserve. The bar drop method or "weighted-bar swimming transect method", allows the observes to cover large areas of reef in shallow water. The method utilizes a one meter small diameter PVC tubing. Five markings spaced twenty-five centimeters apart were placed on the PVC. The observer swims in a straight line along a compass bearing or depth contour, holding the bar perpendicular to the line of the swimming transect. For every three kick cycles, the bar is dropped onto the substrate. The species and condition of coral equal to or greater than ten centimeters lying under the five marks are recorded. At each of the sites, 200 colonies are assessed for 3 levels of bleaching: pale, partial bleaching and whole bleaching (where >90% of colony bleached).

TIDE researchers a observed a substantial decrease in coral bleaching inside and outside PHMR in 2018, indicating coral recovery, and thus coral resiliency (Fig. 16). Spanish Bank, located outside the PHMR, showed the most significant recovery from 2017. However, in October 2019, the PHMR coral colonies again showed widespread coral bleaching, but not as severe as in October 2017 (Fig. 17). Both the RZs and the OUT showed corals affected (i.e. paling + partial bleaching + wholly bleach) at, or close to, 45%. None of the sites found whole bleaching (>90%) corals, but all showed partial bleaching (PB) with the highest seen at Barrow Bank (GUZ) and Spanish Bank (OUT) at 27% and 21%, respectively (Fig. 18). With coral bleaching events increasing in frequency throughout the Caribbean, TIDE will continue to work with the Belize Coral Reef Monitoring Network to monitor and assess coral levels of bleaching, recovery and mortality within PHMR.

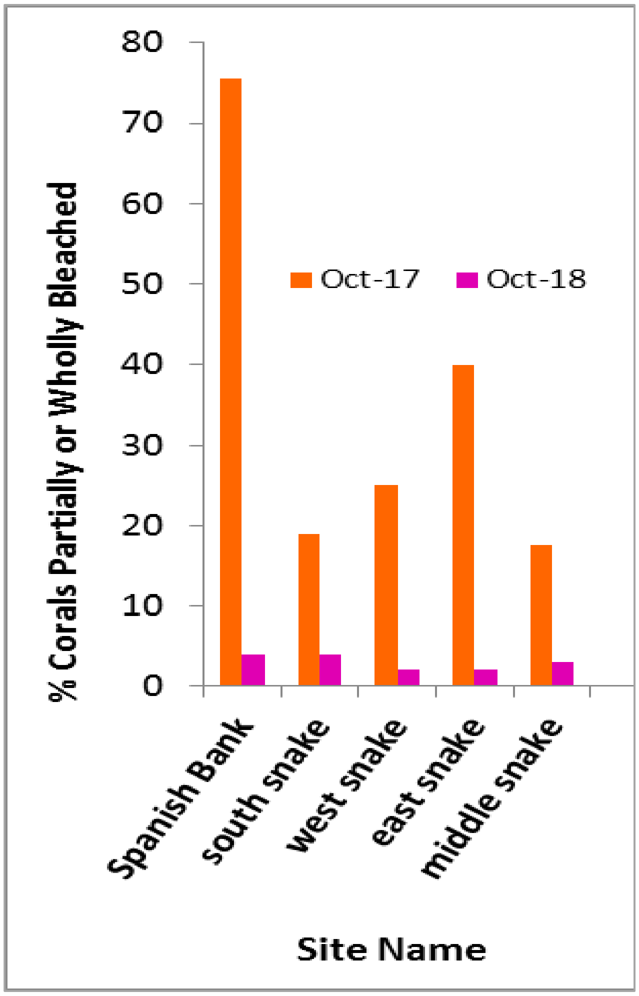


Figure 16. Percentage of corals partially or wholly bleached October 2017-2018 (graph courtesy of FOH).

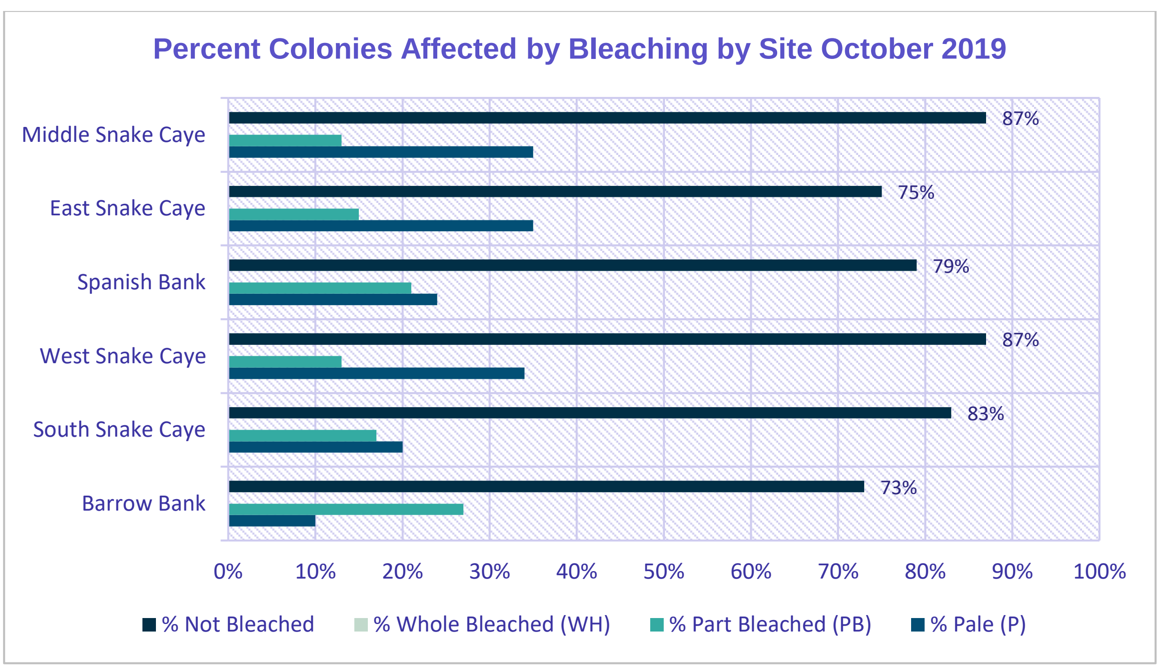


Figure 17. Percentage of colonies affected by bleaching by site in October 2019.

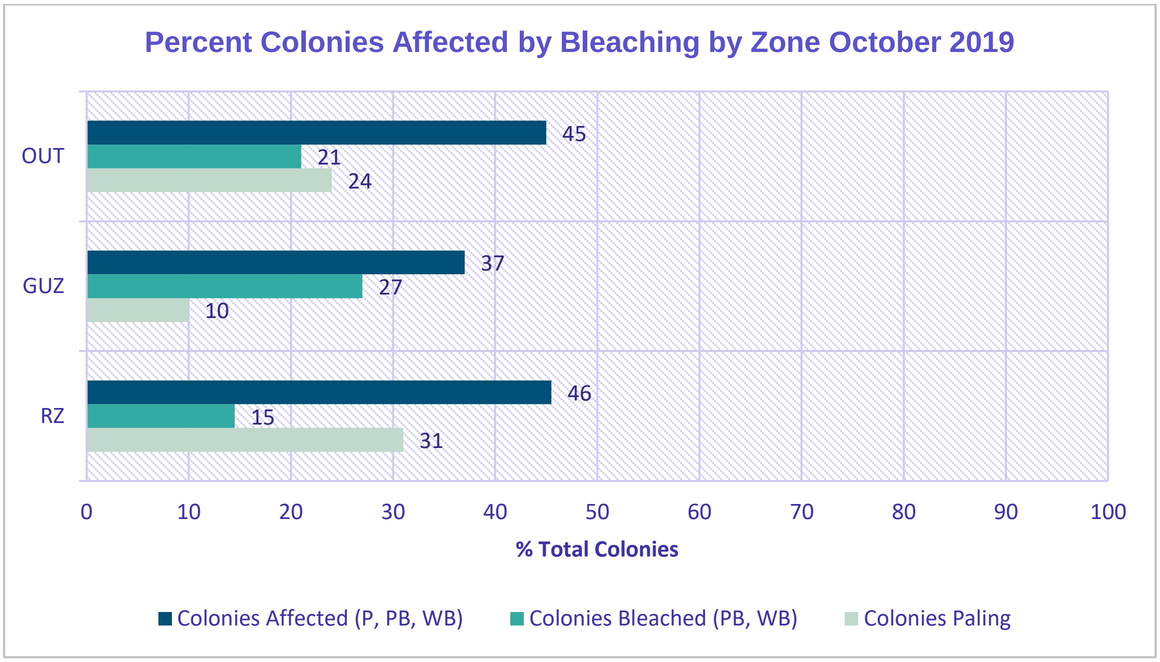
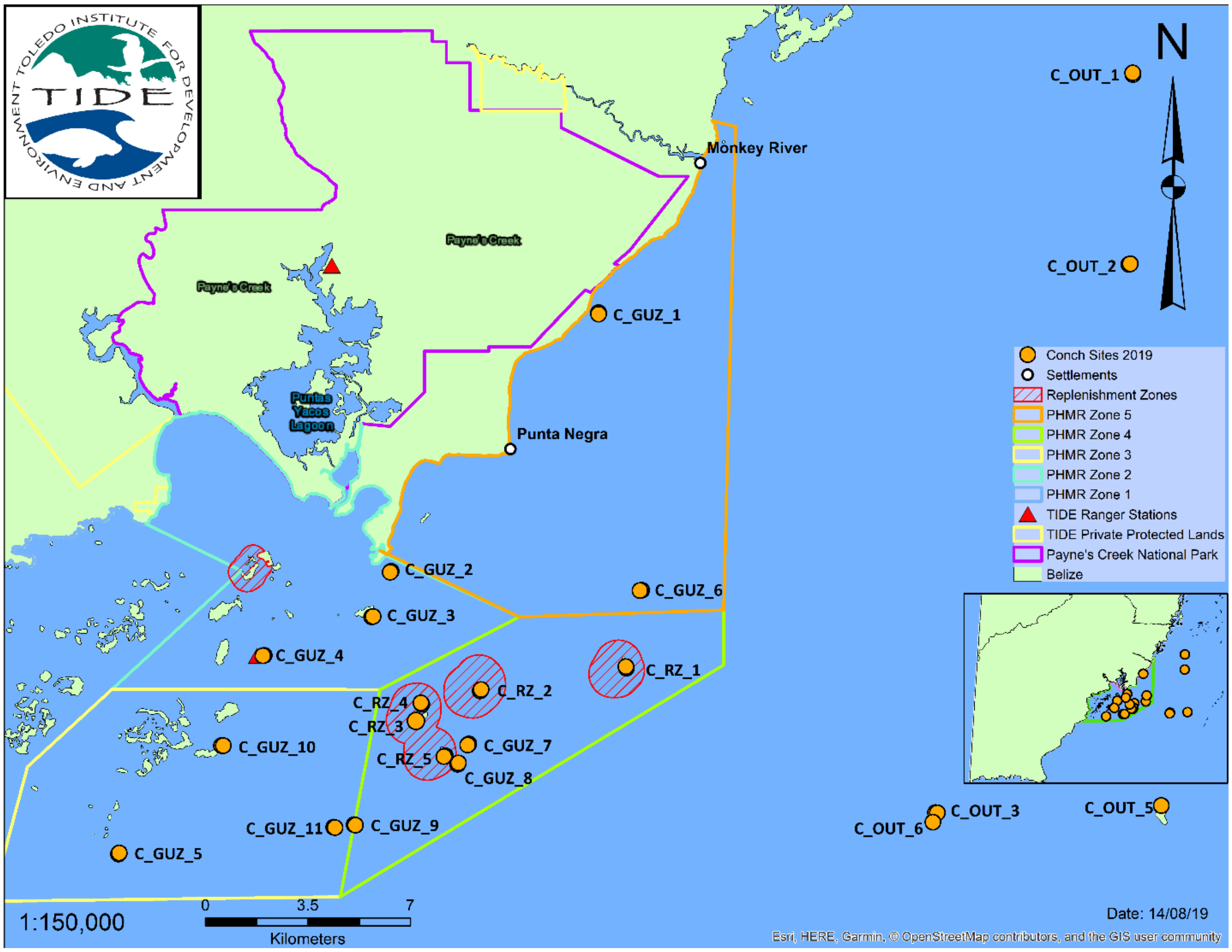


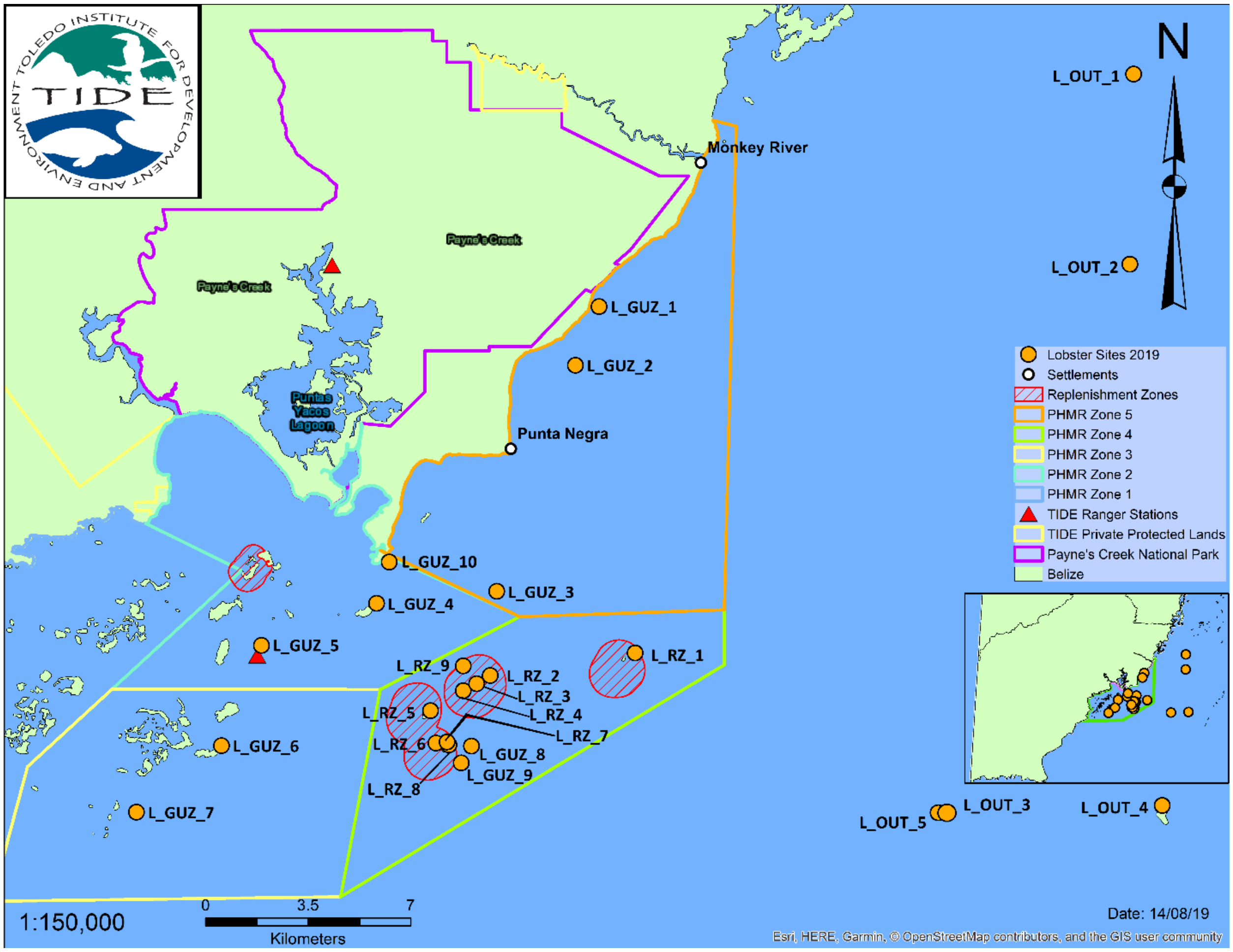
Figure 18. Percent coral colonies affected by bleaching by zone in October 2019 [Replenishment Zone (RZ), General Use Zone (GUZ), Outside the Reserve (OUT)].

Appendices

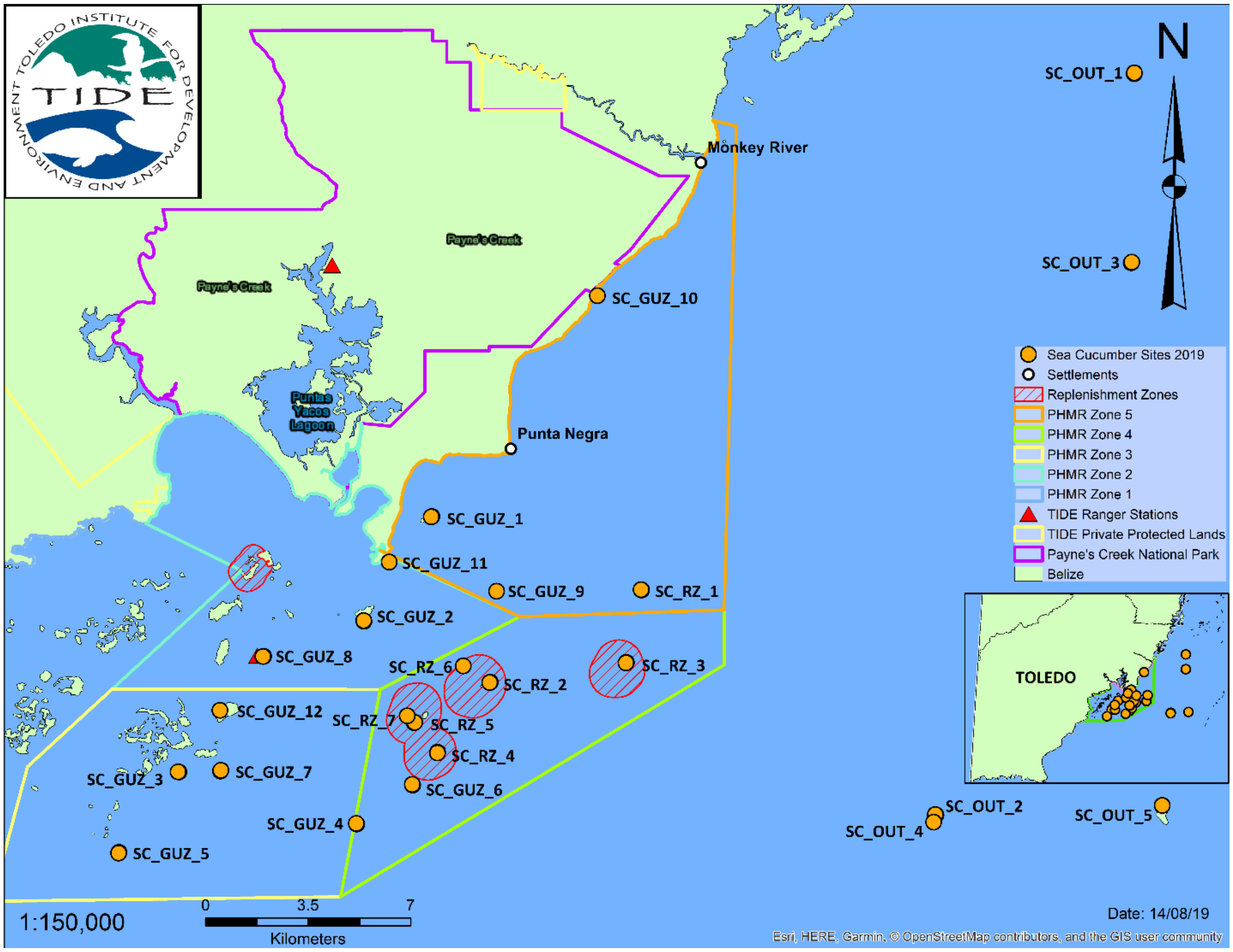
Appendix 1. Queen conch monitoring sites 2019.



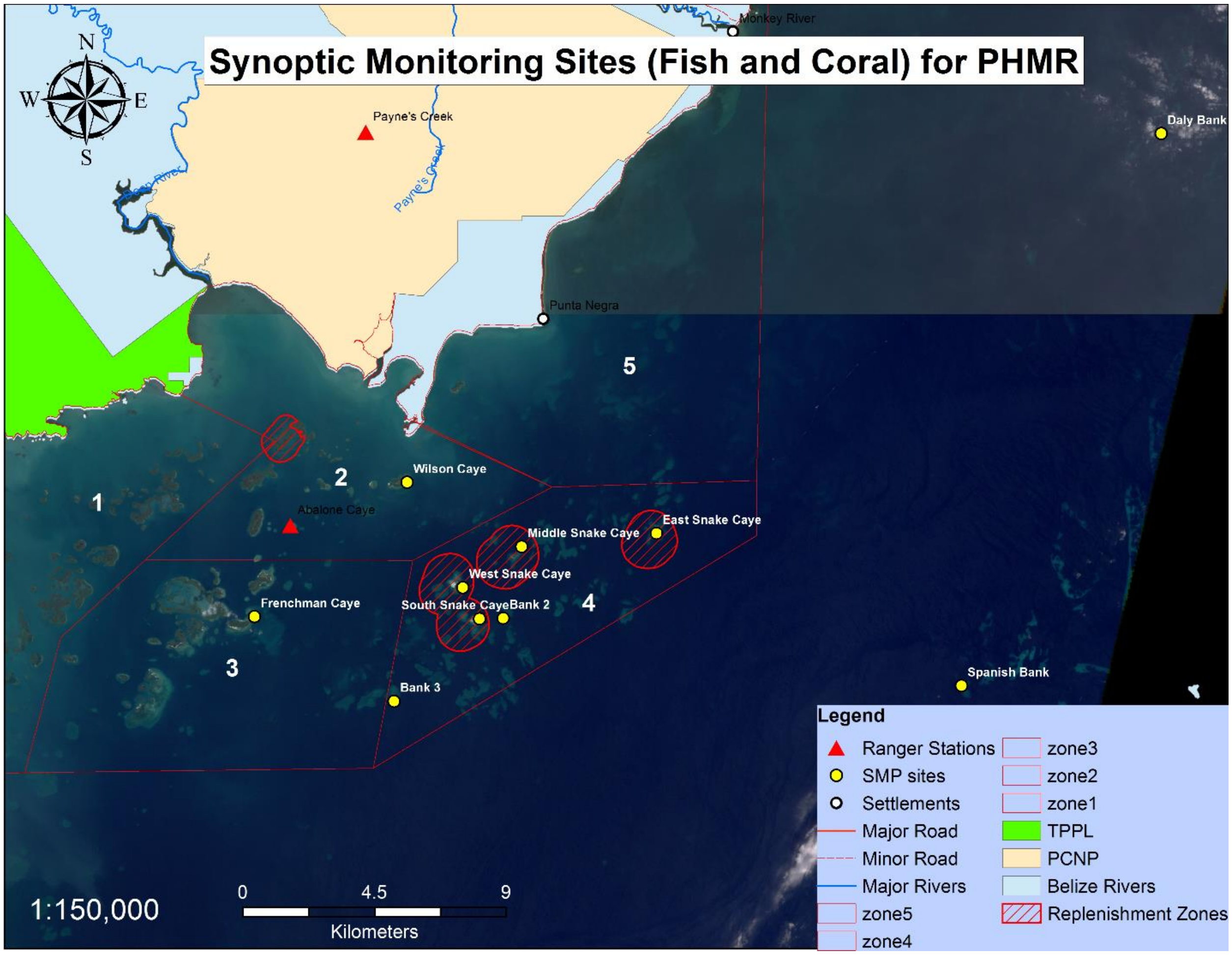
Appendix 2. Spiny lobster monitoring sites 2019.



Appendix 3. Sea cucumber monitoring sites 2019.



Appendix 4. MBRS coral monitoring sites 2019.



Appendix 5. Coral bleaching monitoring sites 2019.