INTEGRATED WATERSHED RESOURCES

RESULT 2: PROTECTED AREAS MANAGED
REQUIREMENT 2.2: NATURAL RESOURCES IDENTIFIED, CHARACTERIZED AND MADE AVAILABLE

STANDARD 2.2.1: RAPID INVENTORY OF THE CARIBBEAN SPINY LOBSTER (PANULIRUS ARGUS) IN ROATAN, MESOAMERICAN REEF

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COVER PHOTO

Mesoamerican Reef, Roatan – Spiny Lobster
By Stephen Dunbar

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ACRONYMS AND ABBREVIATIONS

AFE	Administración Forestal del Estado
BICA	Bay Island Conservation Association
CBM	Corredor Biológico Mesoamericano
CCAD	Comisión Centroamericana de Ambiente y Desarrollo
CL	Carapace Length
COHDEFOR	Corporación Hondureña de Desarrollo Forestal
CURLA	Centro Universitario Regional de Litoral Atlantico
DAPVS	Departamento de Áreas Protegidas y Vida Silvestre
DIBIO	Dirección de Biodiversidad
DIGEPESCA	Direccion General de Pesca y Agricultura
GIS	Geographical Information System
GPS	Global Positioning System
IHT	Instituto Hondureño de Turismo
PMAIB	Proyecto de Manejo Ambiental de Islas de la Bahia
SAG	Secretaria de Agricultura y Ganadería
SCUBA	Self Container Underwater Breathing Apparatus
SERNA	Secretaria de Recursos Naturales y Ambiente
SPSS	Statistical Package for the Social Sciences
TIN	Transect Identification Number
UNAH	Universidad Nacional Autónoma de Honduras
UTH	Universidad Tecnológica de Honduras
UTM	Universal Transverse Mercator

ACKNOWLEDGEMENTS

USAID/MIRA (Manejo Integrado de Recursos Ambientales), in recognition of the importance of reliable and current information for use in environmental education and improved protected areas management, is supporting systematic inventories of flora and fauna species and natural communities in key protected areas in Honduras. The inventories carried out under USAID/MIRA are intended to generate empirical and scientifically-rigorous information on natural history, distribution, abundance, and species diversity for practical application in the management of Honduras' protected areas, with emphasis on improved management and monitoring of biodiversity resources and development of materials for environmental interpretation.

The principal investigators that conducted all field work, analysis and generated the report for this invertory were April D. Sjoboen and Stephen G. Dunbar from Loma Linda University, California. For fieldwork activities the principal investigators were assisted by Veren J. Perumal from Loma Linda University.

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EXECUTIVE SUMMARY

Throughout the Caribbean region, the spiny lobster, *Panulirus argus*, is a species of great commercial importance. Between 2000 and 2003, over 77,000 metric tonnes of lobster were exported from the Caribbean, indicating the potential economic value of the species for developing nations in the region. In the Bay Islands of Honduras, the harvest of *P. argus* plays an important role for both artisanal fishers and the tourist industry. While both indigenous fishers and tourist operators alike recognize that numbers of lobsters appear to be declining, little work has been done to identify population sizes, distributions and relative abundances, or to monitor their numbers on and around the island of Roatan. Therefore, there is a real need for a rapid assessment of the distribution and abundance of *P. argus* around Roatan. In addition, the characterization of this species' preferred habitat will provide critical information for local managers of Marine Protected Areas in the waters around Roatan.

INTRODUCTION

Throughout the Caribbean region, the spiny lobster, *Panulirus argus*, is a species of great commercial importance. In Belize, it ranks as the most valuable fishery (Gillet, 2003). Between 2000 and 2003, over 77,000 metric tons of lobster were exported from the Caribbean (FAO, 2005), indicating the potential economic value of the species for developing nations in the region. Despite their potential economic importance, Hodgson & Liebeler (2002) report that for some 49% of surveyed reefs in the Caribbean no records of the species exist. In the Bay Islands of Honduras, the harvest of *P. argus* plays an important role for both artisanal fishers and the tourist industry. While both indigenous fishers and tourist operators alike recognize that numbers of lobsters appear to be declining, little work has been done to identify population sizes, distributions and relative abundances, or to monitor their numbers on and around the island of Roatán. Environmental threats to *P. argus* around Roatán include rapid coastal development, human population growth, inadequate infrastructure for the growing tourist industry, over-fishing, illegal fishing and lack of regulation enforcement (Huitric, 2004). The purpose of the spiny lobster rapid assessment inventory was to estimate the distribution and abundance of *P. argus* around Roatán.

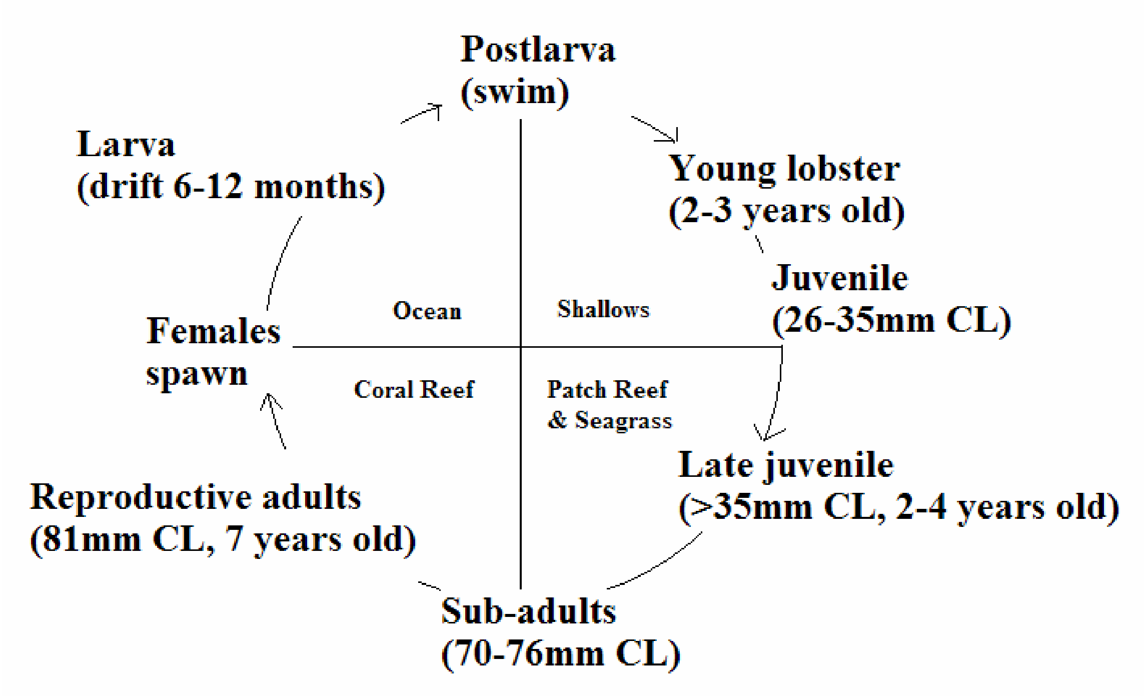
NATURAL HISTORY

Panulirus argus is a member of the family Palinuridae, which consists of lobsters lacking the characteristic chelipeds seen in most lobsters. They are called spiny lobsters due to their chitinous exoskeleton that is covered with hard spines. Their size ranges from 15-25 cm (head to tail), but they can be as large as 61 cm (Humann & DeLoach, 2003). Their average weight is 2 kg (Widmer, 2000). *Panulirus argus* also has two large, stiff antennae that are used as a defensive mechanism against predators.

LIFE CYCLE

The lifecycle of *P. argus* is complex, ranging over five distinct phases: larvae, post larvae, juvenile, sub adult and adult (Figure 1). Reproduction of *P. argus* occurs year round (Acosta *et al.*, 1997) in many parts of the Caribbean. The female releases eggs, which hatch into planktonic larvae (phyllosoma) and are carried along with surface currents for four to nine months. The Caribbean Current affects Roatán (Fonseca *et al.*, 2004), and may be an important factor in determining population connectivity between *P. argus* populations in the Caribbean Ocean. If the gyres and currents are only localized, fishing effects on the population are direct, whereas if there is a possibility for larval transport from other areas there will be a regular influx of new individuals. The early larval stages of *P. argus* undergo developmental changes during their first few months as plankton, eventually metamorphosing into the post larval stage (puerulus). During this stage the larva is transparent, motile and non-feeding. The puerulus enters an inshore current and settles into the benthos, generally settling into habitats near mangroves. Metamorphosis from the puerulus into the early juvenile stages occurs here. The juvenile phase of *P. argus* begins when it reaches a carapace length (CL) of 6-7 mm (Gillet, 2003; Lipcius *et al.*, 1997). Briones-Fourzán *et al.* (2003) categorizes their sizes into the following: algal juvenile (5-15 mm CL), postalgal juvenile (15-45 mm CL), sub adult (45-80 mm CL), and adult (>80 mm CL). As can be seen in Figure 1, the habitats they use throughout their lives range from ocean currents, shallow waters, patch reef and sea grass to coral reef.

Figure 1. Life cycle phases and habitat utilization of *Panulirus argus*.
Adapted from Huitric (2004).



SOCIAL BEHAVIOR

Panulirus argus is well known for its gregarious migratory nature and defensive positioning. Migration occurs in long queues of up to 65 lobsters in length, beginning in fall and winter. They travel in single file by keeping in contact with surrounding lobsters with their antennae and can walk as far as 15 km in one day (Widmer, 2000). These migrations lead the individuals into deeper water, presumably to escape the colder temperatures and receive protection from storms. There could be a correlation between environmental factors and their behavior.

METHODOLOGY

SURVEY[1]

Surveys were done within each site by randomly laying out a 30 m transect line. The line was weighted at both ends using four pound dive weights and marked with bright pink cord segments every meter. Laminated cards numbering from 1-15 were tied to the cord in two m increments to aid in identifying where individual organisms were located along the transect. The line was tucked gently under hard corals to prevent it from floating above the substrate. At each end a small buoy was tied to a rope so GPS readings could be taken from the surface while the transect line was anchored to the bottom. Universal Transverse Mercator (UTM) readings of most transects were recorded (Table 1) by a handheld Global Positioning System (GPS) unit (Garmin 72) so that they could be mapped in a Geographical Information System (GIS). Data were also collected on time of surveys, water and air temperatures, water salinity, tidal time and height prior to each dive. Transects were rapidly surveyed by a buddy team using scuba and all data recorded onto indestructible, underwater paper. Horizontal visibility was noted by using the transect line as a guide. The divers swam approximately one m above the bottom in a zigzag pattern, each surveying a three m swath on either side of the line. Each lobster was then recorded for location along the transect line, substrate depth, immediate micro-habitat and estimated carapace length and, if possible, entire body length using a 30 cm pre-marked measuring rod. These were made by tying two 12 in rubber rulers onto a 30 cm piece of ½ inch PVC pipe using plastic cable ties. Holes were then drilled into the pipe at random intervals in order to reduce floatation while under water. Carapace length (CL) categories were chosen using sizes from Briones-Fourzán *et al.* (2003) as previously stated. Micro-habitat was classified into seven categories:

- *Coralline Algae*: crusts or finely branched algae that are calcareous and extending less than two cm above the substrate.
- *Turf Algae*: a fleshy or filamentous mat of algae that does not rise more than one cm above the substrate.
- *Macro algae*: algae whose fronds extend more than one cm above the substrate.
- *Soft Coral*: identified to genus, if possible.
- *Hard Coral*: identified to species, if possible.
- *Sponges*: general life forms (i.e. basket, encrusting, coralline, boring).
- *Sand/Rubble*: sand or coral rubble substrates.

Substrate depth was estimated in feet using the depth gauge on the dive regulators and later converted into meters. Carapace and body length were taken in centimeters and later converted into millimeters. As each transect was completed the line was randomly relocated by two divers lifting the weights and swimming to the new location. A single dive consisted of surveying one-five transect lines before surfacing to exchange oxygen tanks. A digital camera with underwater housing was used to photographically record habitat details and individuals for later digital analyses and also as reference material for each site to be stored in the GIS. At day's end, all field data was transferred into the project database.

[1] Survey methods have been adapted from Walker, *et al* (2004).Walker, R., Taylor, J., Waska, H., Ponce-Taylor, D., Vause, B., Comley, J., Visvalingam, S., & Raines, P. (2004). Sian Ka'an coral reef conservation project Mexico 2003- final report. Coral Cay Conservation Ltd., London.

Table 1. GPS locations (in UTM) for transects. Readings were not taken for all transects. Where applicable, the accuracy was also recorded. The TIN (Transect Identification Number) represents the Zone, Site and Transect, respectfully.

TIN	Starting UTM	Ending UTM
1A1	16Q0555241-1804877	30m NE
1B1	16Q0548610-1802633 ACR: 11m	N/A
1B2	N/A	N/A
1B3	16Q0548618-1802627 ACR: 4.5m	16Q0548586-1802620 ACR: 4.9m
1B4	N/A	N/A
1B5	16Q0548559-1802606 ACR: 4.3m	16Q0548556-1802637 ACR: 4.3m
1B6	N/A	N/A
1B7	16Q0548549-1802681 ACR: 4.6m	16Q0548572-1802699 ACR: 4.6m
2A1	16Q0568055-1811602 ACR: 15.8m	16Q0568055-1811646
2A2	16Q0568055-1811646	16Q0568076-1811625
2A3	N/A	N/A
2A4	16Q0568119-1811652 ACR: 4.3m	16Q0568102-1811624 ACR: 4.3m
2A5	16Q0568085-1811655 ACR: 4.2m	16Q0568119-1811652 ACR: 4.3m
2A6	N/A	N/A
2A7	N/A	N/A
2A8	16Q0568124-1811715 ACR: 5.9m	16Q0568098-1811677 ACR: 11.9m
2B1	16Q0567749-1811555 ACR: 68.8m	16Q0567756-1811577
2B2	N/A	N/A
2B3	N/A	N/A
2B4	16Q0567740-1811595 ACR: 4.8m	16Q0567731-1811567 ACR: 5.1m
2B5	16Q0567759-1811599 ACR: 4.7m	16Q0567724-1811597 ACR: 4.7m
2B6	16Q0567452-1811365	16Q0567479-1811339
2B7	N/A	N/A
2B8	16Q0567531-1811337 ACR: 4.3m	16Q0567551-1811368 ACR: 4.6m
3A1	16Q0578797-1814331 ACR: 10.2m	16Q0578773-1814385
3A2	16Q0578797-1814331 ACR: 10.2m	16Q0578762-1814374
3A3	16Q0578797-1814331 ACR: 10.2m	16Q0578749-1814353
3A4	16Q0578797-1814331 ACR: 10.2m	16Q0578272-1814308 ACR: 4.1m
3A5	16Q0578771-1814322 ACR: 4.1m	16Q0578272-1814308 ACR: 4.1m
3A6	16Q0578771-1814322 ACR: 4.1m	N/A
3A7	N/A	N/A
3A8	16Q0578831-1814372 ACR: 6m	16Q0578856-1814345 ACR: 7.4m
3B1	16Q0578438-1814294	16Q0578474-1814312
3B2	N/A	N/A
3B3	N/A	N/A
3B4	N/A	N/A
3B5	16Q0578503-1814266 ACR: 5.5m	16Q0578518-1814239 ACR: 5.0m
3B6	16Q0578471-1814239 ACR: 4.3m	16Q0578482-1814205 ACR: 4.3m
3B7	N/A	N/A
3B8	16Q0578423-1814272 ACR: 4.3m	16Q0578402-1814255 ACR: 4.3m

LOCATION

Surveys were done at three Zones on the south side of Roatán (Figure 2). Two sites were randomly chosen from within each of those Zones, and 8 transects done in each site as weather permitted. Each transect covered approximately 180 m^2. Currents and storm conditions prevented a complete survey of Zone 1. The dive sites were representative of various marine habitats (shallow water, wall, sand, coral rubble). The sites were as follows:

Zone 1 (west)

- Site A— 40-Foot (1 transect; 180 m^2)
- Site B—Maurilio's Bank (7 transects; 1260 m^2)

Zone 2 (middle)

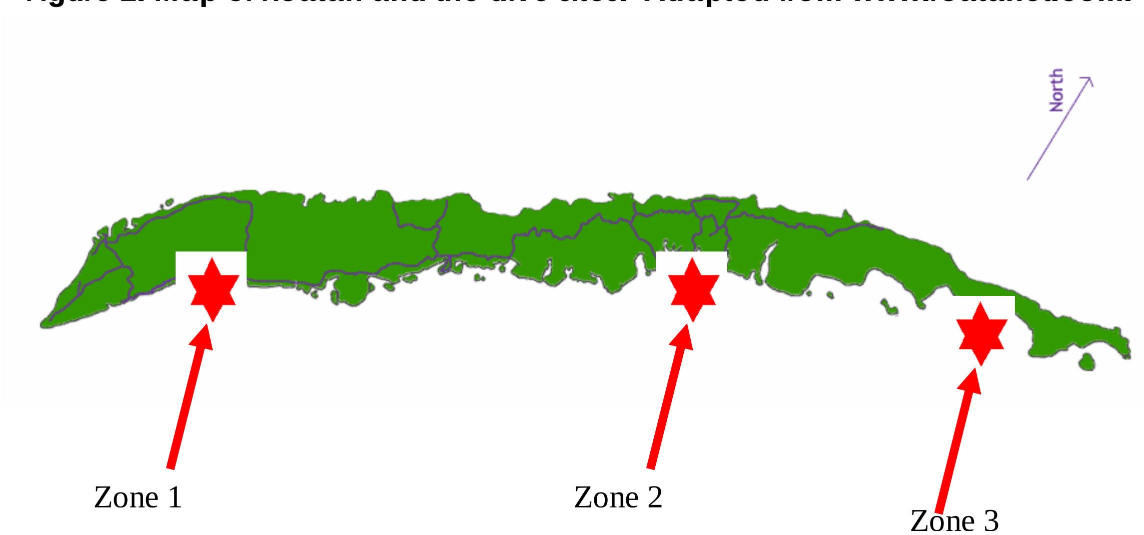
- Site A—Crab Wall (8 transects; 1440 m^2)
- Site B—Tortugas Reef (8 transects; 1440 m^2)

Zone 3 (east)

- Site A—Rocky Point (8 transects; 1440 m^2)
- Site B—Shrimp Boat (8 transects; 1440 m^2)

The dive site of the day was randomly chosen depending on daily weather conditions. All dives were done between 0900 and 1700 from October 25, 2005 to November 2, 2005.

Figure 2. Map of Roatán and the dive sites. Adapted from www.roatanet.com.



ANALYSIS

Data for temperature and salinity were compared among zones by ANOVA's with the computer program Statistical Package for the Social Sciences (SPSS). More detailed analyses consist of calculating the density of *P. argus* per fixed area (i.e. 10,000 m^2) for each site. Standing stock biomass was calculated by approximating the weights of animals observed in the field from recorded lengths. The calculations used were obtained from Briones-Fourzán and Lozano-Alvarez (2001). The equation used was: Log (total weight in g) = 2.7511 (Log (CL in mm)) – 2.6243. However, since only estimated lengths of animals were taken during the underwater visual surveys, such approximations for each site can only be viewed as relative estimates.

RESULTS

Over the two-week course of the assessment surveys, 18 lobster were encountered within the transects (Table 2). Four additional lobsters were seen on other dives but not included in the analyses: two juveniles in Zone 1, and two adults in Zone 2. Of the 18 lobster accounted for, all were found in the immediate proximity of a hard coral mound. Also, 33% of the lobsters (six individuals) were either on coral walls or very close to them. As can be seen from Figure 3, very few lobsters were found in Zone 1, possibly due to a smaller amount of area surveyed.

Salinity and temperature differences between all three Zones were compared and analyzed using Model-II, 1-way ANOVA's (Figures 4, 5). When salinity was compared among Zones, no significant difference was found between Zones 1 (n =8, mean =35.89 ± 0.46) and 2 (n =16, mean =35.73 ± 0.18). However, Zone 3 (n =16, mean =37.45 ± 0.19,) was significantly different ($F_{(2,39)}$ =17.08, P<0.001). When temperature was compared among Zones, no significant difference was found between Zones 2 (n =16, mean =27.58 ± 0.16) and 3 (n =16, mean =27.48 ± 0.16). However, Zone 1 (n =8, mean =28.80 ± 0.19) was significantly different ($F_{(2,37)}$ =13.795, P<0.001).

When lobster density was extrapolated to hectares for each zone, Zones 1 and 3 were similar in densities at 7 and 10 lobsters/hectare, respectively. Zone 2 had the highest density at 48 lobsters/hectare (Figure 6). Comparatively, a 2004 rapid assessment of Barbareta Island resulted in an average of 41.1 lobster/hectare (Fonseca *et al.*, 2004). Standing stock biomass was also estimated for each zone, with more lobster weight found in Zone 2 than in either Zones 1 or 3 and Zone 1 having the least amount (Figure 7). Abundance between Sites at each Zone also showed variation (Figure 8).

Ages of *P. argus* were estimated based on standards found in Briones-Fourzán *et al.* (2003) using carapace length (CL). Algal juveniles are those with a CL of 5-15 mm, postalgal juveniles with 15-45 mm CL, sub adults with 45-80 mm CL, and adults with >80 mm CL. This study showed that sub adults were the most abundant of all lobsters encountered (Figure 8).

Both days that Zone 1 was surveyed had strong currents despite partial protection by a reef wall. This area is characterized by abundant hard and soft corals, coral rubble and very little sand (Figure 10). The highest number of lobsters found was in Zone 2. This Zone is shallow, then drops off and is characterized by hard coral and sand, little coral rubble, sponges and soft coral. In this Zone, the shallower areas are abundant in fire coral (*Millepora* spp.) and soft corals, and not much sand and hard coral are present (Figure 11). Surveys were also done over the wall in Zone 2, where more lobsters were encountered. Zone 3 dives were done in fairly shallow water, though the area is bordered by a wall at the reef crest. Soft and hard corals are abundant, as are sponges, with small patches of sand throughout the Zone (Figure 12). A few of the dives went over the edge of the wall in Zone 3 as well (Figure 13).

Table 2. Results. Each row represents an individual *P. argus.* The TIN (Transect Identification Number) represents the zone, site and transect, respectively. The Quadrat number is the location along each transect line in which *P. argus* was found. The Water Depth and Microhabitat were recorded near each lobster. Age was estimated using carapace length, and it was noted whether each lobster was single, aggregated or molting.

TIN	Quadrat	Water Depth (m)	Microhabitat	Estimated Age	Notes
1A1	1	14.7	hard coral, coral rubble	adult	single

TIN	Quadrat	Water Depth (m)	Microhabitat	Estimated Age	Notes
2A2	1	4.6	hard coral	sub adult	single, molting
2A2	1	4.6	hard coral, sand	postalgal juvenile	single
2A4	10	10.7	hard coral, wall	sub adult	grouped
2A4	10	10.7	hard coral, wall	postalgal juvenile	grouped
2A4	10	10.7	hard coral, wall	postalgal juvenile	grouped
2A4	10	10.7	hard coral, wall	postalgal juvenile	grouped
2A5	2	3.7	hard coral	sub adult	single
2A7	1	4.6	hard coral	sub adult	single
2B2	5	6.1	hard coral	sub adult	single
2B2	4	8.2	hard coral, wall	sub adult	single
2B2	3	7.6	hard coral, sand	sub adult	single, molting
2B6	15	11.3	hard coral, wall	adult	grouped
2B6	15	11.3	hard coral, wall	sub adult	grouped
2B8	15	17.7	hard coral, wall	adult	single
3B1	14	6.7	hard coral, soft coral, sand	sub adult	single
3B4	6	9.8	hard coral, by wall	subadult	single
3B8	1	13.7	hard coral, coral rubble, wall	adult	single

Figure 3. Comparison of relative abundance among the three zones: 1=west, 2=middle, 3=east.

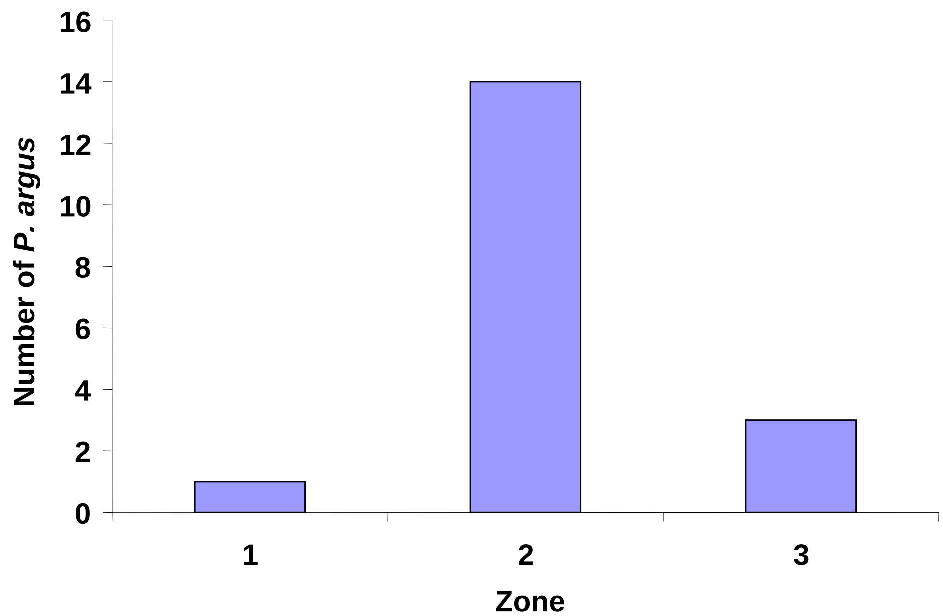


Figure 4. Comparison of mean salinities between the three Zones. Vertical bars represent ±1 standard error. * = P<0.001.

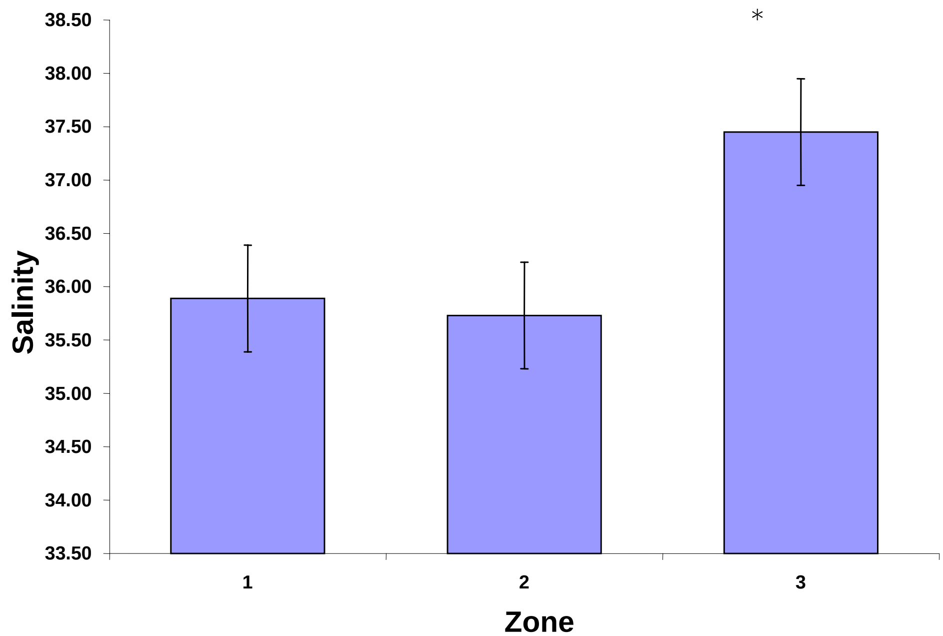


Figure 5. Comparison of mean temperatures between the three zones. Vertical bars represent ±1standard error. * = P<0.001.

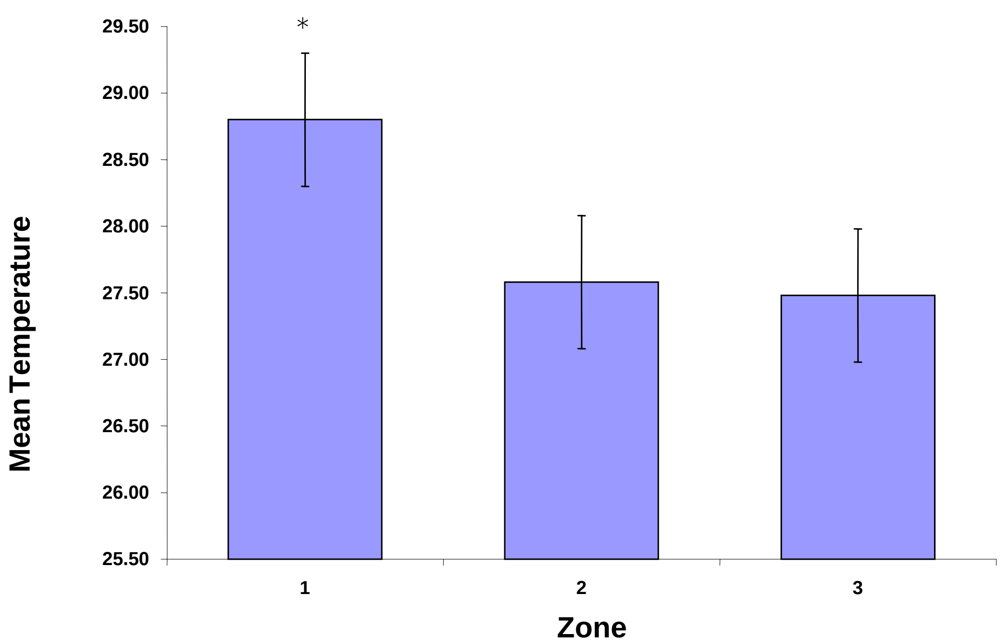


Figure 6. Extrapolated density of lobsters per hectare for each zone: 1 =west, 2 =middle, 3 =east.

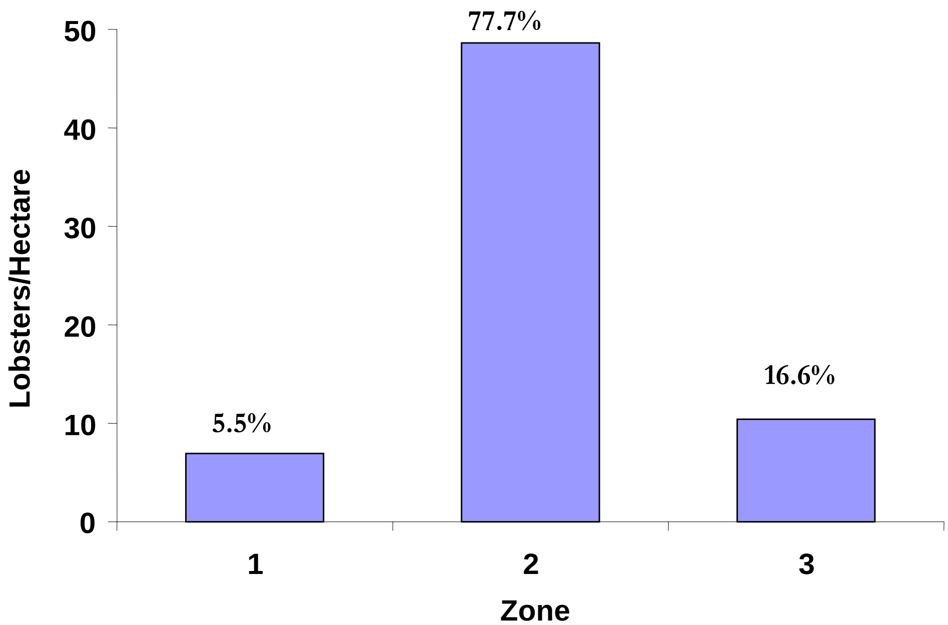


Figure 7. Estimated lobster biomass for each zone. Weight calculations were based on the equation (Log (total weight in g) = 2.7511 (Log (CL in mm)) – 2.6243) as found in Briones-Fourzán and Lozano-Alvarez (2001). Biomass was then estimated by dividing total weight of all lobsters found in the area by the surveyed area of each zone. Note: Zone 1=1440 m^2, Zone 2=2880 m^2 and Zone 3=2880 m^2.

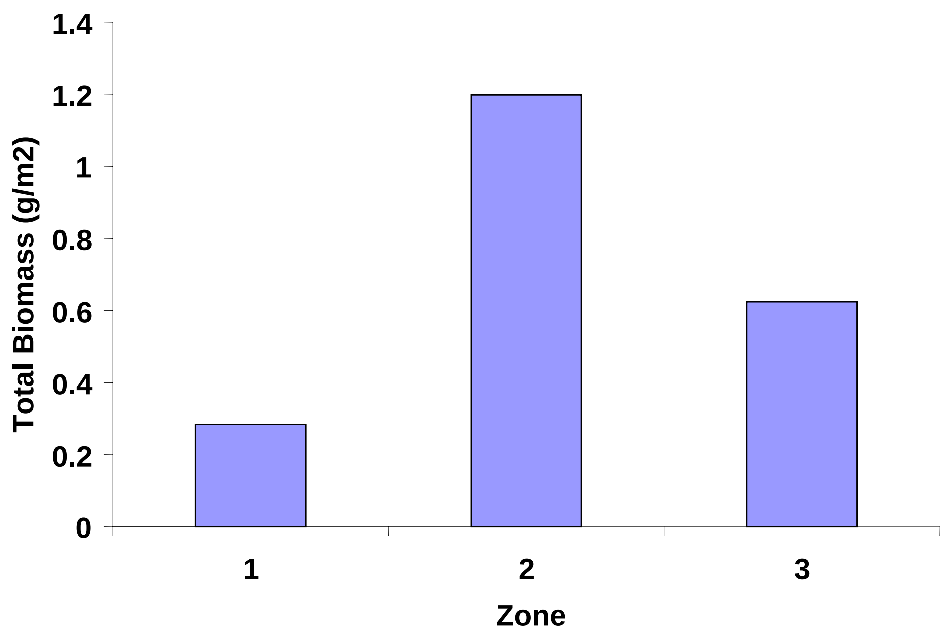


Figure 8. Comparison of abundance among sites: 1A=40-Foot, 1B=Maurilio's Bank, 2A=Crab Wall, 2B=Tortugas Reef, 3A=Rocky Point, 3B=Shrimp Boat.

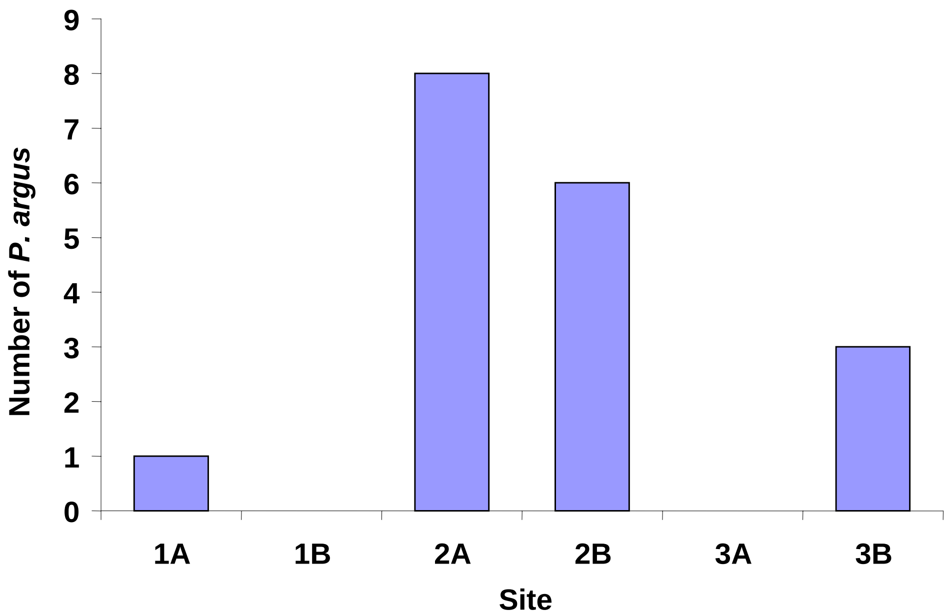


Figure 9. Life stages of *P. argus* estimated from carapace length. 1=algal juvenile, 2=postalgal juvenile, 3=subadult, 4=adult.

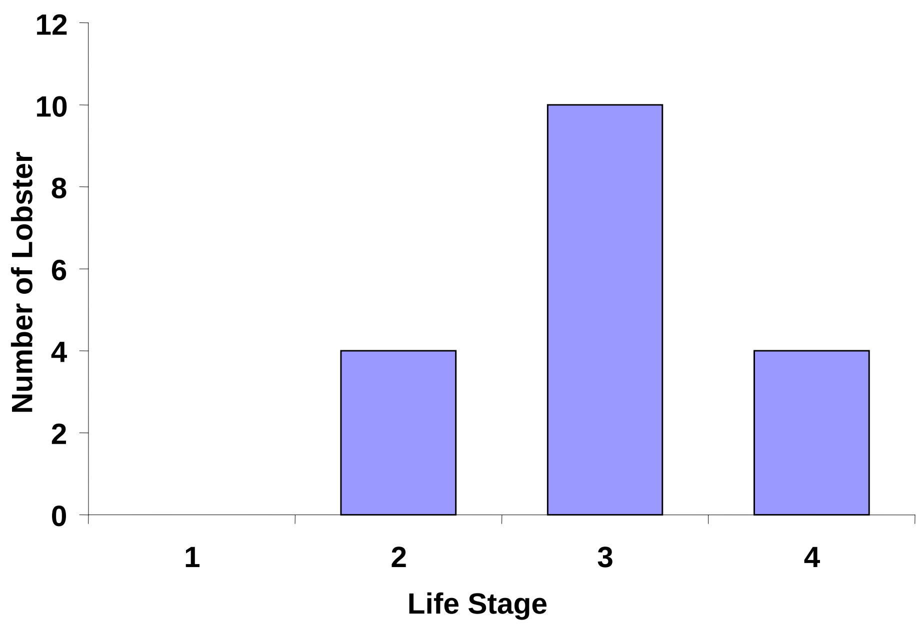


Figure 10. Typical representation of Zone 1.

Figure 11. Typical representation of Zone 2.

Figure 12. Typical representation of Zone 3.

Figure 13. Part of the wall in Zone 3.

DISCUSSION

CONSERVATION STATUS

While *Panulirus argus* is not in immediate danger of extinction in the Caribbean, numbers are declining rapidly. A cumulative comparison of *P. argus* fishery results from Cuba, the Bahamas, the United States, Brazil and Honduras over the last 55 years shows an increasing trend (Figure 14). More recently, catches have leveled off, possibly due to a combined effect of increased fishing regulations and declining numbers of lobsters. When comparing the fishing exports among 10 Caribbean fisheries, it can be seen that Honduras is not a major fishery in the region (Figure 15). However, when the fishing efforts are combined, each nation contributes significantly the depletion of *P. argus* in the greater Caribbean.

Besides the risk of recreational and commercial over-fishing, habitat destruction and pollution also contribute to declining populations. Activities that reduce and degrade habitats, such as mangrove destruction, sedimentation and destruction of sea grass beds and coral areas, mean a loss of important nursery and feeding grounds not only for the lobster but for many other species as well. Pollution from increased population density and unmanaged waste treatment cause decreased water quality that can discourage lobster settlement in those areas.

Figure 14. Comparison of the last 55 years of *Panulirus argus* capture for Cuba, the Bahamas, the US, Brazil and Honduras (FAO, 2005).

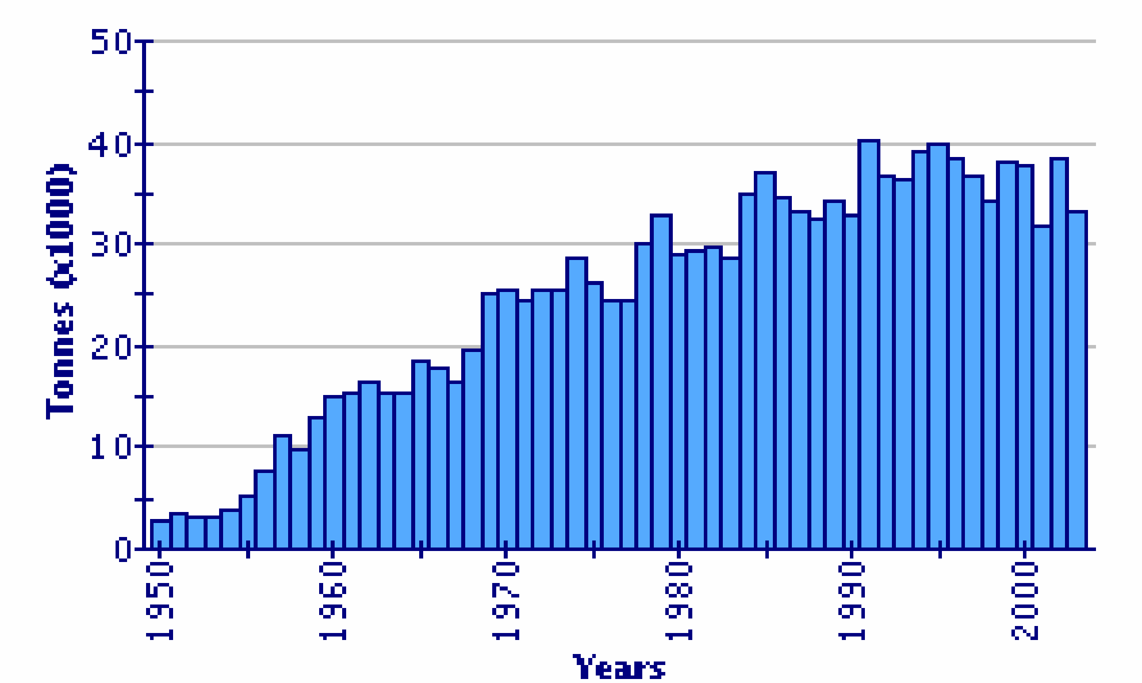
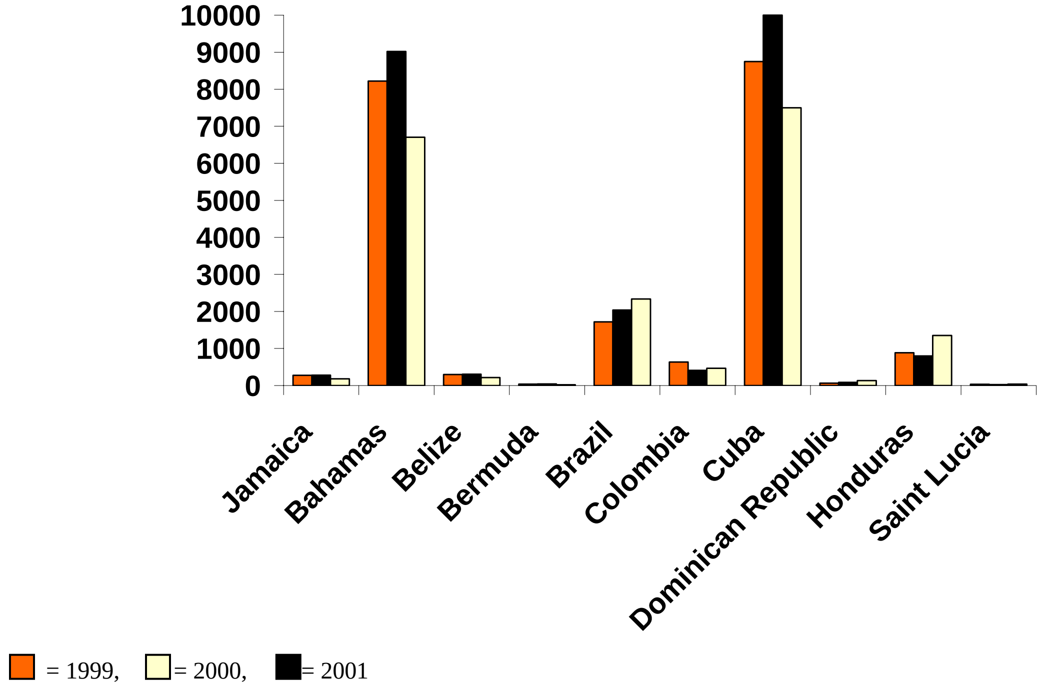


Figure 15. Comparison of commercial exports of *Panulirus argus* from 1999-2001. Adapted from http://www.fao.org/, 2005.



THREAT EVALUATION AND MANAGEMENT RECOMMENDATIONS

This is the first year that restrictions are being applied to the method of capture (David, pers. comm.). Scuba diving for lobsters is being banned and only fishers using skin diving or lobster traps will be allowed to commercially catch lobsters. These limitations will not only allow the lobsters to escape to deeper water to avoid fishing pressure, but will reduce the amount of scuba-diving-related accidents from fishermen who are not properly instructed in the use of the equipment.

Management regulations from the government do not always succeed. Fishermen may not realize where the enforcement is coming from and therefore may disregard it (Ester Lopez, pers. comm.). *Therefore, we recommend increased communication regarding fishing closures and restrictions, using posted notices or flyers and public announcements on the radio. These steps will help inform local fishermen of the current fishery status.*

Current management procedures generally consist of passing laws and regulations, but fail to include the participation of the fishermen. Huitric (2004) and Gillet (2003) recommend some form of education in which to alert the fishermen to the fact that their current fishing practices will affect their future yields. A management strategy should benefit all parties involved. Placing fishing regulations on lobster will financially harm those fishermen who depend on lobster for their livelihood. If they can be included in the enforcement process they are more likely to heed the advice of their peers than a management authority (Huitric, 2004) (Gillet, 2003). For example, the self-enforcing "harbor gangs" in Maine realize that they harm themselves by fishing more lobsters than those populations can handle, and by reducing fishing yields now they will have higher ones in the future (Huitric, 2004). If this awareness can be created among Honduran fishermen, lobster populations could potentially increase. Instructing not only the fishermen but those involved in enforcing regulations, fisheries managers and the general population regarding the lifecycle and overall biology of lobsters can aid in helping to protect not only the lobster, but the entire ecology in question (Huitric, 2004). If the fishermen are provided with other money-making options, tourist trade skills, for example, or provided with cash for every lobster they catch (alive) and report, there is a chance the populations may increase. *Therefore, we recommend that the fishermen of Roatan and the Bay Islands, be regularly informed about the importance of their impacts on both the current and future populations of lobster in Honduran waters. In addition, local fishermen should be kept current on the formation of enforcement groups or coalitions.*

Although bycatch, over fishing and habitat degradation are major factors in the reduction of worldwide marine biodiversity, many people remain uninformed of these issues. While people continue to consume seafood caught by both commercial and artisanal means, many are unaware of threat to future yields.. Programs that raise awareness of the plight of bycatch, destructive fishing methods used and the unsustainable harvesting of marine species with limited population sizes, can impact the food choices that people make.. *Therefore, we recommend that a Seafood Watch Guide, such as that put out by the Monterey Bay Aquarium in California (Monterey_Bay_Aquarium, 2005)(see also: http://www.mbayaq.org/cr/cr_seafoodwatch/sfw_issues.asp) be developed and distributed among local fishermen, tourist guide centers and restaurants throughout the country. This would alert both the local population and tourists to the status of many marine organisms and indicate those seafoods harvested in an environmentally friendly manner.*

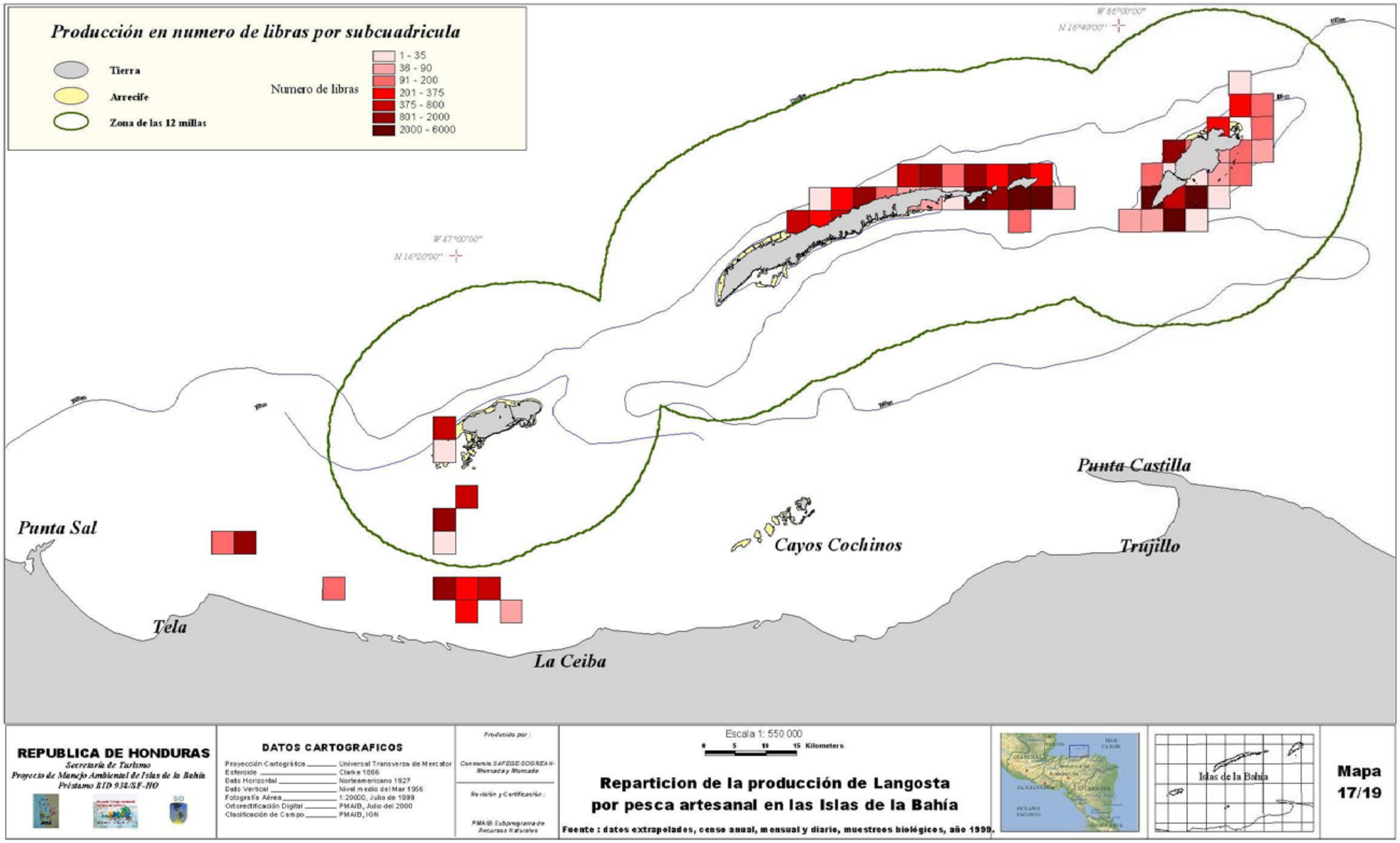
According to MacKenzie and Stehlik (1996), Honduras has a minimum catch-size requirement for lobster tail set at 5.5 in (13.97 cm), as well as a licensing fee. The closed season ranges from March 16 - July 31 (MacKenzie & Stehlik, 1996). Following the 1999 study by PMAIB, the enforcement of a minimum 14.5 cm tail length was recommended (Ester Lopez, pers. comm.). The minimum catch size in Puerto Rico and the US Virgin Islands is a CL of approximately 9 cm (Quinn & Kojis, 1997). *Therefore, we recommend imposing both upper and lower size limits for the CL of lobsters caught, allowing juvenile lobsters to reach a reproductive age and larger individuals to reproduce, since larger lobsters have a greater reproductive capability. Additionally, closure of the fishery during the main reproductive season and banning the catch of ovigerous females could aid in allowing populations to increase.*

Loss of mangroves due to coastal development threaten lobsters because of their importance as feeding grounds (Gillet, 2003) and recruitment sites. Coastal development inevitably results in waste accumulation and excess drainage, causing the water to be polluted and sedimentation to harm the young stages of lobsters. While in Roatán, we took note of the extensive coastal development occurring, particularly on the eastern side of the island. As a result, mangrove forests and terrestrial plants are being removed, resulting in sediment runoff into the ocean during heavy rains. Not only does the destruction of mangrove forests remove a primary location for young lobster settlement (as well as many other invertebrates), but the sedimentation from terrestrial runoff can destroy benthic habitats, such as sea grass beds, that are important foraging grounds for many species. Improper treatment of water run-off causes an influx of nutrients into the watershed environment, initiating algal growth, which leads to coral death (Goldberg & Wilkinson, 2004). How this is directly affecting *P. argus* populations in Roatán is unknown. *Therefore, we recommend the regulation of coastal development and waste disposal. These steps may help reduce negative impacts to key ecosystems.*

The establishment of protected corridors has been shown to aid conservation efforts for threatened species (Fonseca *et al.*, 2004). Although the establishment of marine reserves throughout the Bay Islands is in process, many have not been officially declared and boundaries have gone unenforced. Marine Protected Areas (MPAs) allow for recovery of stressed organisms. It is possible that by establishing a series of MPAs throughout the Bay Islands, new jobs could be created for displaced lobster fishermen in enforcement and management practices. A 1999 study by PMAIB collected data from fishers regarding the amount and location of lobster catches. The results of their study showed most lobsters being caught on the east end of the island, possibly as a result of the protected area on the west end (Figure 16). *Therefore, we recommend that more training be implemented for policy makers involved in MPAs to improve background of biodiversity knowledge and understanding. Increasing the information available could positively aid in establishing and enforcing subsequent MPAs* (Reid *et al.*, 2005).

In the future, the populations of *Panulirus argus* would benefit from further, more in-depth, long-term studies of both anthropogenic and environmental impacts. *Therefore, we recommend that investigations be carried out on the impacts of both local and commercial fisheries on spiny lobster populations in the Bay Islands. We further recommend studies into the relationship of habitat degradation and pollution on local populations of P. argus. Studies of the local marine environment would also be beneficial. Since the larval stage of P. argus is dependant on local marine currents for movement, the study of these currents, as well as specific genetic markers, could help determine the connectivity of lobster populations in the area and aid in decision-making for the establishment of Marine Protected Areas. Understanding Sea Surface Temperature (SST) fluctuations, as well as sedimentation rates could also provide valuable insights into how these factors affect local lobster populations around Roatan and the Bay Islands.*

Figure 16. Data from a 1999 study by PMAIB on abundance and location of the *Panulirus argus* fishery in the Bay Islands.



CONCLUSIONS

The results of this inventory provided data on 18 lobsters. The majority of *P. argus* found were sub adults and all were found in close proximity to a hard coral mounds. Most lobsters were found in Zone 2. Our results show that very few lobsters were found in Zone 1, possibly due to a smaller area surveyed. It is possible that most lobsters were found in Zone 2 because, according to casual observations, there may be lower diving pressure, less population density and lower commercial boat traffic than in the other Zones surveyed. Most of these pressures are found in Zones 1 and 3 and these factors may influence the numbers of *P. argus* found in these areas (Table 3).

Table 3. Comparison of major anthropogenic pressures among the three Zones based on casual observations between October 25 and November 2, 2005.

Region	Diving	Population Density	Fishing	Commercial Traffic
Zone 1 (West)	High	High	Low	High
Zone 2 (Middle)	Low	Low	High	Low
Zone 3 (East)	Low	Low	High	High

A number of additional factors might have contributed to the low lobster count for this assessment: weather, over-fishing (too many individuals being caught or fishing pressure causing a migration to deeper waters), location of survey transects, method of surveying, lack of law enforcement, and the limited time allotted to doing the surveys. Storm conditions at the time of surveying may also have resulted in the lobsters migrating to deeper waters.

Panulirus argus populations are declining due to artisanal and commercial fishing, habitat destruction and pollution. It is recommended that there be improved communication between fishery management and fishers, enforced regulations regarding tail size and seasonal closures, education of the general public on basic marine ecology and human impact, seafood watch guides, control of coastal development and waste disposal and the establishment of enforced Marine Protected Areas. If fishers and the public can realize the importance of their impact on the marine environment, positive results may ensue and *P. argus* populations may be able to increase.

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