

Comparing Conch (*Strombus gigas*) and Lobster (*Panulirus argus*) Populations at Two Marine Protected Areas in Belize: Status and Lessons for the Future

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ABSTRACT

Understanding the complex dynamics and tracking changes of conch (*Strombus gigas*) and lobster (*Panulirus argus*) populations is crucial for sustainable fisheries and MPA management. In order for MPA managers to adapt management strategies to match resource availability managers must develop comprehensive systems to monitor key fisheries resources. In Belize, Friends of Nature (FoN)- a local NGO responsible for co-management of two marine protected areas has adopted the Long Term Atoll Monitoring Protocol (LAMP) to monitor these two commercially important invertebrates. FoN co-manages two marine protected areas one is completely no-take (Laughing Bird Caye National Park) and one is zoned for multiple use (Gladden Spit and Silk Cayes Marine Reserve) After almost five years of data collection FoN has been able to develop a greater understanding as to the status and the effects that different levels of management can have on populations. FoN has noted more stability in the populations of both conch and lobster at the completely closed site compared to the multi-use reserve. Although this data provides managers with a greater understanding of the status of the populations, there have been a number of important lessons learned about data collection and its application to management. At FoN, continued consistent monitoring is key for adaptive management, however the implementation of this monitoring has often yielded less than optimal results. By continuing to improve data collection efforts and understanding the strengths and weaknesses inherent in MPA monitoring FoN is working to ensure proper management of key commercial fishery stocks.

KEY WORDS: Marine Protected Areas, conch (*Strombus gigas*), spiny lobster (*Panulirus argus*)

Comparando las Poblaciones de Caracol (*Strombus gigas*) y Langosta (*Panulirus Aarhus*) en dos Áreas Protegidas Marina de Belice: La Condición y Lecciones para el Futuro

Para la pesca sostenible y el manejo de las áreas protegidas marinas (APM) es crucial el complejo dinámico de las poblaciones de caracol (*Strombus gigas*) y langosta (*Panulirus argus*) y los cambios en la pesquera comercial. Para los directores de APM adaptar las estrategias de manejo para la disponibilidad de recursos, es vital desarrollar sistemas comprensivos para monitorear los recursos de pesca. En Belice, Friends of Nature (FON), una organización no-gubernamental responsable para el co-manejo de dos APM, adopto el Long Term Atoll Monitoring Protocol (LAMP) para monitorear dos importante invertebra comercial. FON es responsable para dos APM, en cual uno es completamente no-extractivo (Laughing Bird Caye National Park) y el otro esta zonado para usos múltiple (Gladden Spit and Silk Cayes Marine Reserve). Después de recopilación de datos, FON ha desarrollado una gran comprensión en cuanto al status de las poblaciones y el efecto de diferente niveles de manejo en estas poblaciones. FON ha notado una estabilidad en ambos poblaciones en el área completamente cerrado que la reserva de multi-uso. Aunque los datos provee a los usuarios de la reserva con un gran entendimiento del status de las poblaciones, hay lecciones aprendidas sobre la colección de datos y sus aplicaciones al manejo. Un monitoreo consistente es la clave para un manejo adaptivo. Sin embargo, la implementación del monitoreo cede menos que optimo resultados. En mejorando los esfuerzos de recopilación de datos y entendiendo la potencia y debilidad inherente al monitoreo de las APM, FON está trabajando para asegurar propio manejo de las claves valores comercial de pesca.

PALABRAS CLAVES: Áreas Marinas Protegidas (AMP), caracol (*Strombus gigas*), langosta (*Panulirus argus*)

Comparaison entre les Populations de Lambis (*Strombus gigas*) et de Langoustes (*Panulirus argus*) dans Deux Aires Marinés Protégées a Belize, Etat de Lieux et Leçons pour le Futur

Comprendre la dynamique complexe et suivre l'évolution des populations de lambis *Strombus gigas* et de langoustes *Panulirus argus* est crucial pour des pêcheries durables et pour la gestion correcte des aires marines protégées. Pour la bonne adaptation des stratégies de gestion des aires marines protégées aux ressources existantes, les gestionnaires doivent développer des systèmes performants de suivi des pêcheries clefs. A Belize, une ONG locale, les Amis de la Nature (FoN), responsable de la cogestion de deux aires marines protégées, a adopté le protocole de surveillance des Atolls sur le long terme (LAMP) pour le suivi des populations de ces deux espèces d'Invertébrés d'importance commerciale. FoN co-gère deux aires marines protégées, dont une est une zone d'interdiction totale de toute capture (Parc national des Laughing Bird Cayes) et l'autre une zone à usage multiple (Réserve marine de Gladden Spit and Silk Cayes). Après quelques 5 ans de collecte de données, FoN a été capable de développer une meilleure compréhension de l'état des populations et de l'impact des différents niveaux de gestion sur celles-ci. FoN a noté une plus grande stabilité des populations à la fois des lambis et des langoustes dans la zone totalement interdite à la pêche par comparaison avec la zone d'usage contrôlé. Bien que ces données permettent une meilleure compréhension de l'état des populations, de nombreuses adaptations des collectes de données et de leur application à la gestion ont été réalisées. Pour FoN, un suivi continu régulier est un élément clef d'une gestion efficace, cependant la réalisation de ce suivi n'a pas toujours donné des résultats optimaux. En continuant à améliorer les collectes de données et en essayant de comprendre les points forts et les faiblesses inhérents au suivi des zones marines protégées, FoN travaille à réaliser la gestion correcte des stocks d'espèces marines d'intérêt commercial.

MOTS CLÉS: Lambi, langouste, Belize, Marine protected areas

INTRODUCTION

The 250 km Belize Barrier Reef System is of great cultural, ecological and economic significance to the small Central American country of Belize. In Belize, capture fisheries export earning amounts to US\$11.35 million. Of this, Spiny Lobster (*Panulirus argus*) and Queen Conch (*Strombus gigas*) are the two most important capture fisheries exports account for 8.6 million and 2.6 million US Dollars respectively in 2007 (Belize Fisheries Department Statistics 2007). Belizean fishing methods are artisanal in nature and confined primarily to the back reef lagoon and inside the atolls. Conch is harvested exclusively by skin diving while the lobster industry uses a mixture of traps and skin diving. The use of scuba equipment is not permitted in the industry. The targeted areas for conch and lobster are the back reef grass flats, patch reefs, reef crest and immediate fore reef slope to a depth of 15 m. Skin diving is concentrated in the southern portion of the country due to the substrate composition, which is not conducive to trap fishing.

Given the importance of the reef ecosystems the Government of Belize has declared an extensive system of marine protected areas (MPA) to safeguard these resources. Under the National Protected Areas System of Belize there are various categories of protection that are managed by two separate Government agencies. Marine Reserves, which fall under the jurisdiction of the Fisheries Department, are composed of a multi-use zoning scheme which allows for both extractive and non-extractive activities. The National Parks, governed by the Forest Department, allow only non-extractive activities including research and recreation. Although each of these MPAs has unique goals and management objectives, maintenance of sustainable fisheries is the overarching vision for most.

Friends of Nature (FoN), a Belizean non-governmental organization, is delegated co-management authority for two important marine protected areas: Laughing Bird Caye National Park (LBCNP) and Gladden Spit and Silk Cayes Marine Reserve (GSSCMR). LBCNP, encompassing 4,100 hectares of marine habitat, is entirely no-take (Figure 1), with only research and recreational activities allowed in the park. This park encompasses the entire Laughing Bird Faro and Laughing Bird Caye, a 0.58 Ha sand and shingle caye. The MPA is located entirely inside the back reef lagoon and includes shallow patch reefs in addition to deeper reef pinnacles. Due to its size and activities, compliance with regulations is more easily ensured. GSSCMR is a 10,500 hectare marine reserve that is zoned for multiple use. It includes a small no-take zone totaling 1.14% of the reserve, where only non-extractive activities are permitted. The remainder of the reserve is zoned for general and extractive uses, and is managed as such. GSSCMR protects an important stretch of the Belize Barrier reef and includes; deep and shallow fore reef habitat, the Silk Cayes, three sand and shingle cayes of about 0.75 – 1 Ha each in size); patch reefs and grass flats.

Both parks contribute to the maintenance of the conch and lobster fisheries but have very different management regimes. These MPAs provide benefits for eight coastal communities which represent a large percentage of the commercial fishers in Belize.

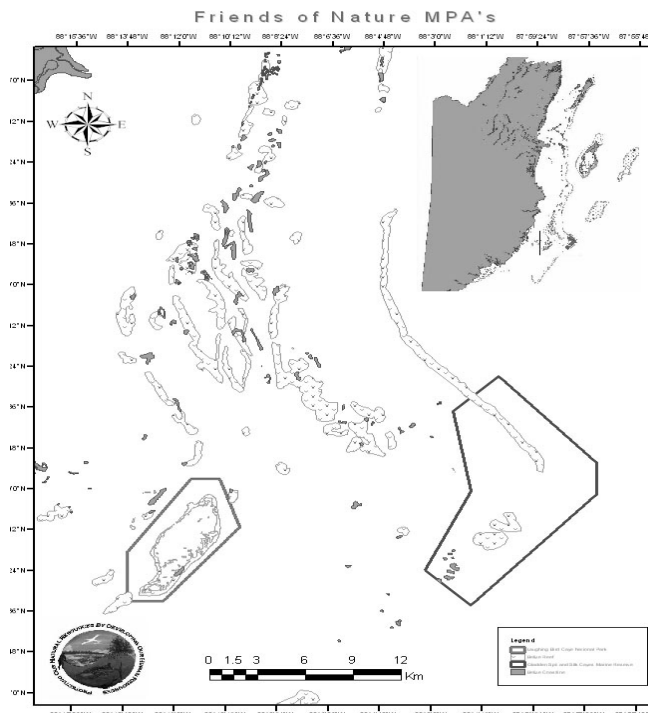


Figure 1. Map of FoN Managed Protected Areas showing Laughing Bird Caye National Park and Gladden Spit and Silk Caye Marine Reserve.

In order to understand management impacts and effectively adapt management strategies for fisheries, it is crucial to have a solid understanding of the current status of commercial fish stocks. FoN initiated a monitoring system for commercially exploited species in 2003 to determine the status of conch, lobster and finfish populations in the two parks. This monitoring follows the Long-term Atoll Monitoring Program (LAMP) developed for Glover's Reef Marine Reserve and used at most marine protected areas in Belize. The aim of this study is to provide preliminary analysis on the data collected to date, with the goal of gaining greater understanding into the status of the conch and lobster populations as well as the strengths, weaknesses and lessons learned from the monitoring program itself.

METHODS

Dr. Charles Acosta developed the Long-term Atoll Monitoring Program (LAMP) protocol for monitoring commercial species at Glover's Reef in 1996. This fisheries independent monitoring protocol is described in "Field protocol for monitoring coral reef fisheries re-

sources in Belize” (Acosta 2003) and is within the confines of the methodology described by the CARICOMP methods Manual Levels 1 and 2. It is based on the concept that approximately 90% of the users of the atoll (and other reef areas) are skin divers who target lobster and conch, and uses ‘encounters’ to simulate capture. Using this monitoring method encountered individuals are not removed from the population while in the case of fishing, they are. These encounters are then used to estimate a simulated Catch per Unit Effort (CPUE).

For Queen Conch (*Strombus gigas*) populations monitoring consists of timed swims. During these timed swims the researcher records the shell length and lip thickness for all conch encountered. Conch are also checked for egg masses. According to the LAMP protocol transects should also be used to estimate the density of queen conch at each site. Transect data was not included in the data set but will be included in further studies.

Sampling for Spiny Lobster (*Panulirus argus*) is very similar to that for Queen Conch. The researchers use timed swims to estimate population size at each site. During the timed swims the researcher uses a marked stick to estimate carapace length. Sex is determined and individuals are also checked for the presence of egg masses.

Sites were strategically chosen based on representative habitat for each MPA and distributed based on zonation at both LBCNP and GSSCMR. At LBCNP, 14 sites were chosen in both sea grass/sand algal flats and patch reefs. These sites are located at varying depths nine located within and five located outside the MPA boundaries. Similarly at GSSCMR twelve sites were identified in representative habitats and varying depths. At GSSCMR three sites are located within the no-take zone, six in the general use zone and three outside the reserve boundaries. (Figures 2 and 3). Six sampling events occurred at LBCNP while eight occurred at GSSCMR according to Table 1.

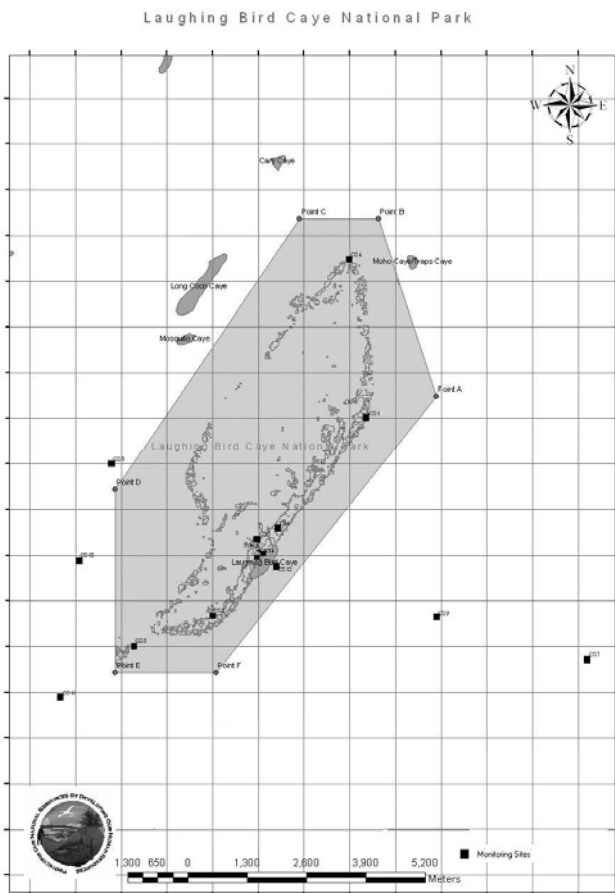


Figure 2. Map Showing Distribution of Commercial Species Sites at LBCNP.

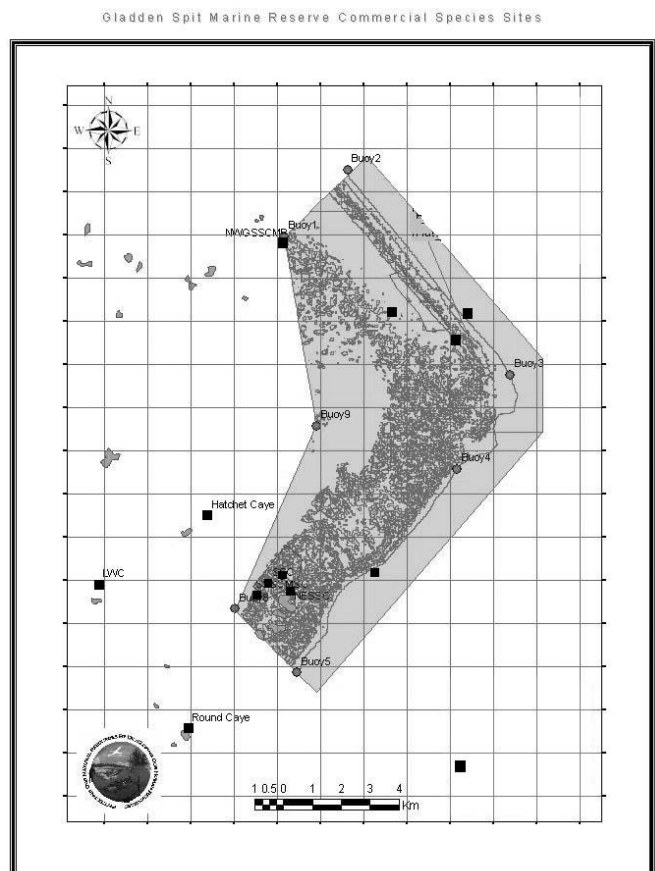


Figure 3. Map Showing Distribution of Commercial Species Monitoring Sites at GSSCMR

Table 1. Table showing sampling times for each MPA from March 2003 – May 2008.

Site	Mar 03	Oct 03	Feb 04	Oct 04	Feb 05	May 05	Aug 05	Dec 06	Apr 07	Nov 07	Feb 08	May 08
LBCNP				x	x	x	x				x	x
GSSCMR	x	x	x					x	x	x	x	x

RESULTS

The number of ‘encounters’ was used to calculate CPUE. Minitab 14 was used to calculate basic descriptive statistics for each location and species for both parks. A one-way ANOVA with unequal n was done to determine p and t values with 95% confidence intervals. This was done for each group of statistics in order to support the hypothesis that there was a significant difference in the mean CPUEs between parks as well as within and outside MPA boundaries.

Queen Conch

Overall for Queen Conch (*Strombus gigas*), the analysis indicates that there is a significant difference ($p = 0.036$) between LBCNP and outside the MPA boundaries, with F values of 4.55 calculated and 3.98 obtained from the statistical tables (Figure 4). There is also a significant difference ($p = 0.001$) between the zones of GSSCMR as indicated by the F values of 7.14 calculated and 3.11 from the tables (Figure 5). The figures presented here represent the overall average encounter rate over the entire study period (Figure 6). These averages give the best indication of trends between the parks. At both parks the number of conch encountered in the no-take zone showed significant difference from the number of conch encountered in the general use zone. Comparison of the no-take and general use zones in GSSCMR indicates that there is a difference

between the two, while a similar comparison between the general use zone of GSSCMR and outside the park indicates no difference. Table 2 gives statistical values for all the areas compared. As is expected, this seems to indicate that the population of conch within the non-extractive zones of the protected areas is higher than in areas where extraction is allowed. In addition, the number of conch encountered in the areas outside the MPAs was similar. The apparently low conch densities within the general use zone at GSSCMR, were unexpected as there were fewer conch within the MPA than were encountered in areas outside the boundaries.

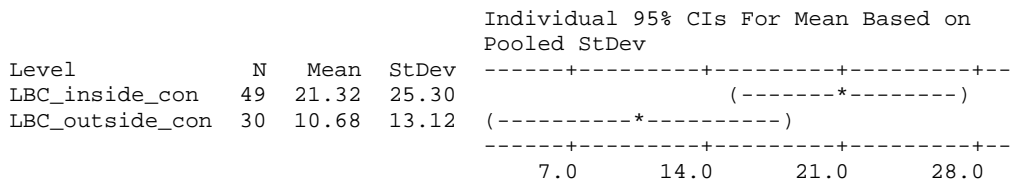
Spiny Lobster

The data set for Spiny Lobster (*Panulirus argus*), which compares overall encounter averages over the sample period, showed fewer similarities between the zones of the two MPAs (Figure 7). When comparing lobster encounters the only significant difference exists between the individual marine protected areas rather than between the zoning classifications. The comparison of all three areas in GSSCMR resulted in F values of 1.17 calculated and 3.11 from the table ($p = 0.314$), indicating that there is no significant difference between the three. In the case of LBCNP, comparison of areas inside and outside of the park indicates no difference between the two.

One-way ANOVA: LBC_inside_con, LBC_outside_con

Source	DF	SS	MS	F	P
Factor	1	2110	2110	4.55	0.036
Error	77	35711	464		
Total	78	37821			

S = 21.54 R-Sq = 5.58% R-Sq(adj) = 4.35%



Pooled StDev = 21.54

Figure 4. Results of One-Way ANOVA comparing conch CPUE inside and outside LBCNP

Table 3 provides a summary of the F and p values obtained. overall encounter rate for lobster was significantly lower in and around GSSCMR (1.002 lobster/hr) than corresponding sites in and around the LBCNP (4.06 lobster/hr). There appears to be a significant difference in encounter rate between the no-take zone at GSSCMR and inside Laughing Bird Caye National Park (p = 0.003), as well as between the areas outside the two MPAs (p = 0.001).

DISCUSSION

This paper represents the first attempt to collate and analyze the data collected over five years of monitoring by Friends of Nature at GSSCMR and LBCNP. The results from this analysis have given managers the opportunity to evaluate and compare the data collected and begin to understand the complex dynamics of the conch and lobster populations.

The monitoring strategy employed by FoN and by most organizations around Belize has yielded some valuable results. However, there is a strong need for

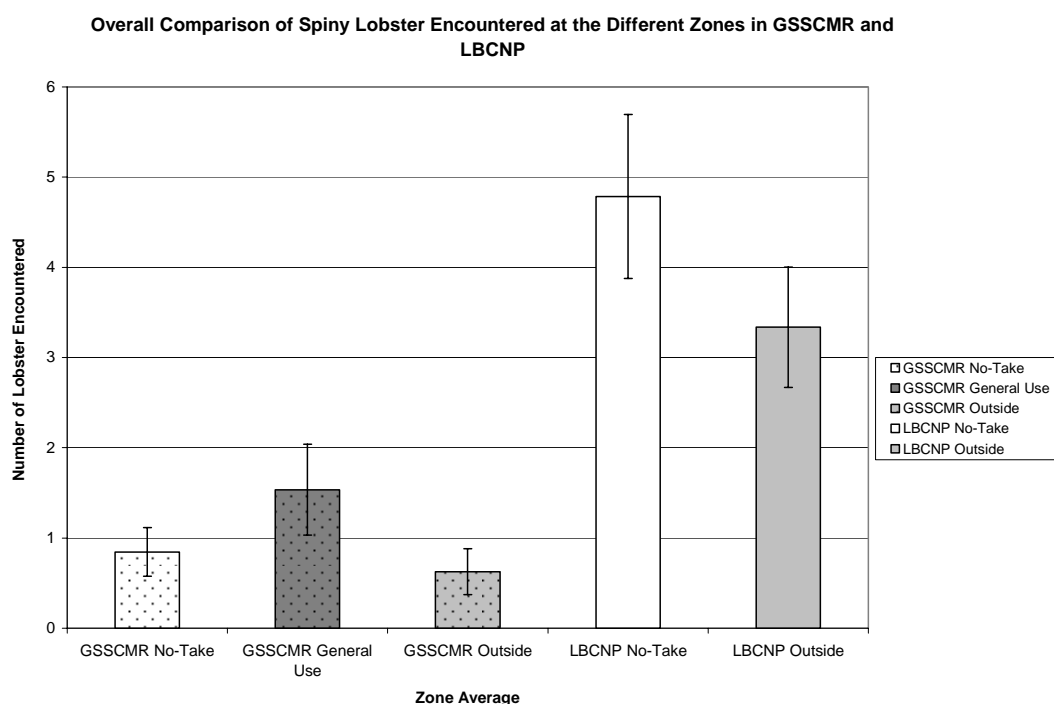


Figure 7. Graph showing comparison of lobster CPUE between the management zones at GSSCMR and LBCNP

Table 3. ANOVA values for Lobster (*Panulirus argus*) CPUE

Locations being compared	F _{calc}	F _{table}	p
GSSCMR - no-take, inside and outside	1.17	3.11	0.315
GSSCMR – no-take and inside	0.91	4.00	0.342
GSSCMR – inside and outside	1.55	4.00	0.218
LBCNP – inside and outside	1.33	3.98	0.253
GSSCMR no-take and LBCNP inside	9.31	4.00	0.003
GSSCMR outside and LBCNP outside	11.63	4.03	0.001

greater consistency in data collection and in the adherence to the collection protocols. High staff turnover at FoN over the past five years has led to questions regarding the consistency of monitoring methodologies. Until late 2007, monitoring was not conducted at regular intervals to allow for more rigorous comparison between years or seasons. This has been amended by the development of a monitoring plan complete with calendar for monitoring events. It is hoped that by adhering to this calendar and monitoring plan, it will be possible to look at yearly and seasonal fluctuations in population size.

When the monitoring programs at each MPA were originally established in 2003, great effort was made to ensure the selection of sites both within the different management zones as well as outside the protected areas. However, at both MPAs there were significant limitations on the number and location of these sites. At GSSCMR the no-take zone is extremely small (120 ha.), limiting the overall number of sampling sites as well as the habitat types. In addition, two of the three sites located outside the boundaries of the MPA are located in a high traffic area which deters illegal fishing activities and predisposes the data to be more similar to that of the general-use zone within GSSCMR. These two sites, which include one directly in front of the ranger station where the rangers are known to release confiscated undersized conch which has likely contributed to the higher numbers of conch observed outside the reserve compared to those seen in the general-use zone at GSSCMR. It is recommended that at least two new sites be identified at GSSCMR in conch habitat such as areas of seagrass beds and sand/algal flats, as well as the reevaluation of the inclusion of the sites now considered outside the reserve.

Overall sample size has a huge effect on the results shown here. At many of the sites very few individuals were encountered. This is especially true of lobster where only sixty individuals were observed over fifty-three hours of searching. In fact there were a number of sites where no lobsters were observed over repeated survey. These small sample sizes can lead to a great deal of fluctuation when making comparisons between monitoring dates. It also makes it difficult to pinpoint management zone effects.

The overall low rate of encounters for Spiny Lobster 2.2 /hour, indicate these populations levels are very low and likely not able to remain sustainable if different management regimes are not considered. The significantly higher rate of encounter at LBCNP (4.06/hour) shows that having a much larger non-extractive area might be directly related to higher population levels as opposed to 1.0/hour for GSSCMR. Given the results and the fact that GSSCMR has only 1.14% of its area designated for non-extractive uses, it is expected that encounter rates and population levels will be depressed. FoN is currently lobbying for the expansion of both the MPA and the non-extractive zone at GSSCMR which will likely lead to increased populations and a higher encounter rate.

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