NOAA Coral Reef Conservation Program
FY2010 Final Report

Performance Evaluation of Marine Zoning in the Florida Keys National Marine Sanctuary

Project_ID: 10007 – 2010

January 19, 2011

Florida Fish and Wildlife Conservation Commission
Fish and Wildlife Research Institute
South Florida Regional Laboratory
2796 Overseas Highway, Suite 119
Marathon, FL 33050 2

Abstract

This multi-year project has used a multi-tiered approach to evaluate Marine Protected Areas in the Florida Keys National Marine Sanctuary. During the Federal Fiscal Year 10 (Oct. 09- Sept. 10), spatial and temporal rates of movement of acoustically tagged snappers and groupers were measured in the Tortugas region, including annual spawning migratory movements between Riley's Hump the Tortugas Ecological Reserves, and the Dry Tortugas National Park, including the Research Natural Area. In addition, the abundance and size-structure of spiny lobsters in and adjacent to the Western Sambo Ecological Reserve were surveyed. Results will be used to assess the importance of habitat linkages between adjacent marine protected areas and provide information for an ecosystem-based approach to management of marine resources.

Background

This multi-year project uses a multi-tiered approach to evaluate Marine Protected Areas (MPAs) in the Florida Keys National Marine Sanctuary (FKNMS). The FKNMS MPAs were established to resolve user conflicts, to protect critical coral reef ecosystems from exploitation, and to insure the sustainability of valuable marine resources. In past years, our research focused on the efficacy of one of the largest ecological reserves in the FKNMS, the Western Sambo Ecological Reserve (WSER). We continue to evaluate the efficacy of this reserve design relative to habitat use, population structure and animal movement, recognizing the potential need to alter MPA boundaries to include additional habitat for spawning of species such as lobsters, snappers and groupers. The present project builds on past research and monitoring in the FKNMS by the Florida Fish and Wildlife Conservation Commission and focuses on connectivity between the network of marine reserves in the Dry Tortugas region, including the connections between populations of fish in the Dry Tortugas National Park (DRTO), the DRTO Research Natural Area (RNA, a type of marine reserve), the Tortugas North Ecological Reserve (TNER) and spawning habitat at Riley's Hump (RH), located within the Tortugas South Ecological Reserve (TSER). The following submission summarizes annual progress on the *Performance Evaluation of Marine Zoning in the Florida Keys National Marine Sanctuary* project (ID: 10007 – 2010) for October 2009 to October 2010 in three parts: 1) Dry Tortugas Finfish project; 2) Dry Tortugas Lobster project and 3) WSER Lobster project.

DRY TORTUGAS FINFISH

Introduction

The TSER, TNER and RNA create a network of no-take reserves that protect 600 km^2 of coral reef habitat, adjacent to and within the DRTO, 70 miles west of Key West, FL (Figure 1). The Dry Tortugas coral reef ecosystem is unique in terms of the variety and complexity of available habitat, the diversity of biological resources, and the presence of key spawning locations that hypothetically supply larval/juvenile recruits to the Florida Keys and south Florida (Domeier, 2004; Burton et al., 2005; Ault et al., 2006). The TSER and TNER were established in the Tortugas region in 2001 and the no-take RNA was established within the DRTO in 2007. The established marine reserves and adjacent open fished areas of the Tortugas region provide an excellent system for empirical studies on habitat utilization, spillover, broad scale movements, residence times on aggregation sites, and the efficacy of a network of MPAs in protecting marine resources and conserving marine biodiversity.

This network is designed to enhance biodiversity and sustainability throughout the Tortugas and the Florida Keys coral reef ecosystem by creating refuge for various life history stages of numerous exploited fishery resources, including snappers and groupers. The purpose of our CRCP telemetry project was to determine regional connectivity and test the hypothesis that fish move from foraging grounds (RNA, TNER, and DRTO) to spawning sites in the TSER. Data will be used to assess the size, shape and site selection of the Tortugas marine reserves and their efficacy as an ecosystem-based management tool. For example, changes in reserve boundaries may be implemented to enhance or reduce spillover of key species, based on observed home ranges and movement patterns of snappers and groupers during the spawning season.

In addition, we began the effort to determine residence times and behavior of snappers and groupers in spawning aggregation areas. Snappers and groupers migrate long distances to specific sites to form spawning aggregations of 100 – 1000s of individuals at specific times of the year. Unfortunately, traditional fishery management strategies have not always accounted for the vulnerable nature of spawning events and these prime fishery targets are rapidly overfished. Recent changes in fishery regulations have placed greater emphasis on marine protected areas to preserve reef habitat, enhance reef fish production, conserve functional ecosystem processes, and protect a certain proportion of the population. After years of overexploitation, the TSER was established to protect the most important known multi-species aggregation site in the southeastern United States (Lindeman et al., 2000). Re-formation of the mutton snapper spawning aggregation has been documented since closure of the TSER to fishing, but little is known about adult reef fish movements in the region or the characterization of transient reef fish spawning aggregations at Riley’s Hump.

Materials and Methods

Finfish – Acoustic Array

The acoustic receiver array was first deployed in three phases between May and July 2008. The array covers approximately 800 km^2 and is designed to capture small scale movement and long range migrations of fishes in water 5 – 50 meters deep. In the first phase, 33 VR2 receivers were placed within the DRTO, including within and outside the borders of the RNA. This work was funded by our USGS research grant: *Efficacy of a newly-established RNA for protecting coral reef fishes within DRTO*, but is complementary to the objectives of our CRCP grant. The second phase was completed in June 2008, with an additional 23 acoustic receivers placed throughout DRTO, the TNER and open use areas of the FKNMS. The final nine receivers were set up during July 2008 at RH in the TSER. The coverage of our array is complemented by two collaborative acoustic projects: Mote Marine Laboratory's Nurse shark project (PI: Wes Pratt) and a USGS sea turtle study (PI: Kristen Hart).

The receivers were secured to a PVC stand attached to a concrete platform that functioned as ballast and provided stability. The VR2 receivers were positioned "tip up" approximately 1 meter above the seafloor inside a PVC pipe sleeve (63.5 or 76.2 mm) and secured by a tie wrap. Each receiver tip was protected by a coat of antifouling paint. A 3 m subsurface buoy was attached to a stainless steel I-bolt at the base of each receiver stand with a 6.35 mm polypropylene line. Prior to deployment, each VR2 sonic receiver was initialized in the laboratory with a personal computer and VUE software provided by the manufacturer (VEMCO; AMIRIX Systems Inc.). Receiver sites were preselected based on reef fish population structure, habitat type, rugosity, depth, and reserve boundary locations. The VR2 receiver stand and a surface marker were dropped together from the research vessel when it was determined by a fathometer reading that the vessel was over sand substrate and site coordinates were immediately recorded upon deployment. A team of divers immediately confirmed the position and placement of the receiver stand on the seafloor. Receivers were serviced for maintenance twice per year in the field. Individual receivers were brought to the surface and data was uploaded to a personal computer using VUE software with an upload cable or by Bluetooth® technology. If the receiver required a battery replacement, the battery was replaced and the receiver was reinitialized. In addition, the subsurface buoy and line were scraped clean of fouling organisms.

Finfish – Acoustic Tagging

All fish captured at RH were surgically implanted with VEMCO V16-4H coded transmitter tags *in-situ* at 33 – 40 m. This avoided exposure of fish to barotrauma induced mortality associated with the capture of fish from relatively deep water. Fish were caught in fish traps baited with threadfin herring and sardines soaked 3 – 12 hrs. Traps were set on the south slope of RH in an area identified by Burton et al. (2005) as the focal point of the aggregation zone. Rather than hauling traps to the surface, fish were transferred from a trap to a catch bag by divers at depth. Each fish was positioned ventral side up in a V-cradle surgery station and a 2.5 cm incision was made along the midline, posterior to the pelvic girdle. Scales were removed on either side of the incision to expose the skin. The tag was implanted within the peritoneal cavity and the incision was closed with three hand tied sutures. Sterile synthetic absorbable braided sutures (VICRYL Plus; Ethicon, Inc.) with an antibacterial coating and a size 0 cutting needle were used. The entire underwater surgical procedure took approximately 3 – 6 minutes. Standard, fork and total lengths were recorded and the fish were immediately released.

Progress and Results

Finfish

During FY 2010, VR2 receivers were successfully downloaded, redeployed and are operational on or near their originally proposed locations (Figure 1). All receivers were serviced during April/May 2010 and September 2010**.** Sixty-four VR2 stations have recorded more than 1.3 million detections since May 2008 (Table 1). Stations 20, 35, 35A, and 37B have large numbers of detections (> 50,000) because of one or two fish in residence near these inshore sites. The numerous detections at stations 2 and 48 are from multiple individual fish because of the proximity of these stations to spawning habitat along the southern slope of RH All VR2s in the array are currently in deeper water (>15 m) to avoid storm surge in the future.

Selected reef fish species were acoustically tagged inside the TSER during May/June 2010. Five mutton snapper *Lutjanus analis*, 6 black grouper *Mycteroperca bonaci*, and two goliath grouper *Epinephelus itajara*, were acoustically tagged from the M/V Spree. This effort brings the cumulative number of acoustically tagged fish in the TSER to 28 mutton snapper, 10 black grouper, 2 Nassau grouper, 2 goliath grouper and 3 red grouper **(**Table 2). Additionally, 4 black grouper and 1 yellowfin grouper *Mycteroperca venenosa* were tagged in the TNER and DRTO/RNA, potentially contributing to telemetry data collected at RH. During our spring 2010 RH trip strong southerly current of 3-4.5 kts hampered our fish tagging effort. Approximately 40 % of fish tagged within the TSER have been successfully tracked greater than 20 days since the inception of the study. Preliminary results indicate a possible corridor exists for the seasonal movements of mutton snapper between the DRTO/RNA and the TSER, providing a link between marine protected areas (Figure 2 and 3). Individual mutton snapper were documented making repeated migratory round trips (up to 3 trips/fish) to spawning grounds during the spawning season (May to August). Individual fish stay on the spawning grounds for up to 10 days surrounding the full moon phase before returning to the DRTO/RNA. Limited movement has been detected to the east or directly north to the TNER, however one mutton snapper tagged at RH was detected near the TNER and later at Pulaski Shoals, a movement of 40 km in 2 days. Mutton snapper appear to emigrate from RH by the end of August, although possible residential mutton snapper have been observed there as late as October. Below find a preliminary description of the spatial and temporal movement of acoustically tagged snappers and groupers in the Dry Tortugas. In 2010, preliminary results of our research was presented at the National Park Service/Florida Fish and Wildlife Conservation Commission RNA Workshop on January 12th 2010 and at the Florida Keys Science conference (October 2010).

Mutton Snapper

Exploited-phase mutton snapper crossed reserve boundaries several times annually, especially during the spring/summer spawning season. Figure 2 illustrates the routes traveled by four mature mutton snapper (*L. analis*) between their apparent "home" area and the spawning grounds in the TSER. Fish 2167 repeated this route three times during the spring/summer of 2009 (May 5th – July 15th). This fish arrived at Riley's Hump (RH), near the full moon period and spent as many as 10 days at RH before returning to its home area within the RNA. Fish 2170 utilized the same route traveled by fish 2167 but rounded Fort Jefferson to the North during the return trip in May. Fish 2198 was captured in October of 2008, (tag active until approx. 1/11/2011). The latest detection was made in August, 2010 on RH after traveling from its home area within the RNA. During the summer of 2009, fish 2198 made trips to RH during the full moons of both June and July, and on the return trip in July, avoided detection until being picked up within the DRTO, possibly indicating an easterly exit from RH in deeper water south of the route taken by other muttons. After spending the winter months in the RNA, fish 2198 made three more trips to RH during the summer of 2010, but appeared to return along the same path taken in July 2009. Fish 49589 was tagged at RH during the full moon of July 2008. This fish remained at RH for over a month, until the second week of August when it exited RH and was not detected until reaching the northern boundary of the RNA. The last detection of this fish was recorded near Pulaski Shoals on August 13, 2008. The large circle around RH denotes the general area in which this fish was detected.

Figure 3 also represents the paths traveled by four individual mutton snapper. Fish 49591 was tagged at RH in early July 2008, and spent the entire month moving around on the hump. In the late afternoon of July 31st, this fish disappeared from detection for an entire month and was next detected on the western edge of the Tortugas Bank shown by the red arrow on figure 3. Over the next five days this fish was documented swimming into the TNER along the high relief reef ledge, at approximately 100-150ft. depth, then retracing its path to the south, and finally disappearing from detection on the 5th of September 2008. Fish 52507 was tagged within the RNA, in May 2009, and was first detected on RH in July 2009. After spending one week at RH (coinciding with the July full moon), this fish disappeared from our array, and reappeared in October to the west of Fort Jefferson (RNA). Fish 52507 appeared to reside in the RNA from October to the end of June near a single receiver before returning to Riley's Hump at the end of June 2010, during the full moon. After two weeks at RH, fish 52507 took a detour from its prior return path and traveled east, likely remaining south of the park boundaries, before heading north to its home area within the RNA. On the eve of the full moon in July, 52507 made another trip to RH, returning along the same detour recorded in June. Any new data on this fish will become available during the next downloading trip in the spring of 2011.

Another fish of particular interest was mutton 61851, tagged on RH near the end of May in 2010. Fish 61851 spent the month of June and the first week of July on RH before heading to the

Northeast, along a path common to several other tagged mutton snapper. After passing northwest of Fort Jefferson fish 61851 appeared to spend most of July, the entire month of August, and all but a few days of September at this site within the RNA. Fish 52504 was first detected on the 16th of October 2008 near its tagging site within the RNA just northwest of Fort Jefferson. It stayed near this site until May of 2009, when it made its first documented trip to RH. The fish appeared to remain at RH for two weeks, and then made a return trip to its apparent home area near the Fort. Fish 52504 made this trip three times during the summer of 2009, each trip corresponding to the full moon period. In October of 2009, fish 52504 made a trip to the northeast edge of DRTO where it remained until January 2010. This fish was not detected in the array during the October 2010 downloads.

Black grouper

Grouper movements were small and infrequent, whereas mutton snapper and other species tagged moved more frequently. Figure 4, shows the movement and detection by site of three large, >920 mm, black grouper tagged at RH, and one 618 mm black grouper tagged in DRTO. The majority of black grouper detections were picked up by a single VR2 receiver, but vary substantially in frequency across seasons. Detection frequency for the 3 RH groupers was lowest during the summer period of July to September and highest during the period of October to March. Detection frequency drops drastically in early July for the largest fish (#21, 1069mm) and increases dramatically in early October, (sta.2, top figure), while detection of grouper #29 (sta. 2, 3, &48) is a more gradual decline, also beginning in early July, and like #21, frequency dramatically increases in October. Detection of grouper #23 at station 4 is more frequent during the same summer period without a dramatic decline, but detections do increase rapidly in early September. The pattern of detection frequency may suggests vertical movement, possibly indicating preference for cooler temperature and/or change in food availability. The smaller DRTO grouper does not show an obvious pattern. To date, no black grouper have been detected moving across reserve boundaries. Four large grouper tagged in the TNER and RNA last October were the first large adult black grouper to be tagged outside of RH, and may be more likely to be detected by the array while moving to and from the shallower reefs, and possibly to RH during the winter/spring spawning period.

Future Work

Finfish

Our Tortugas Regional Array covering TNER, TSER, RNA, DRTO and open use areas of the FKNMS is continuously collecting data. We will continue to coordinate and share data with other regional telemetry projects (Pratt-Mote; Hart-USGS). These concurrent studies provide additional receiver coverage along the north side and central portion of the RNA.

Fishes that are tagged at the spawning aggregation site may be detected at stations established by these research groups and vice versa, providing invaluable data on the connectivity of this coral reef ecosystem. All VR2s will be serviced and downloaded during May 2011 & October 2011.

These data will include fish tagged in 2008, 2009, 2010, and those to be tagged in 2011.
A cruise to RH will be scheduled for March 2011 (peak spawning period for black grouper) to search for deep water snappers and groupers at RH.
During this trip we will pair with the University of Puerto Rico (UPR) Coral Reef Institute to conduct surveys in deeper water (>150'). Technical divers from UPR will set VR2 stations in deeper waters and conduct video transects of reef fishes in this areas of RH. A group of shallow divers (100') will download and service the nine VR2 set in RH. In addition, we will use a remotely operated vehicle (ROV) to survey for coral and hard bottom areas at RH at depths of 45 to 200 feet. While SCUBA divers are only able to reach depths of 110 feet, the ROV provides data on areas that are too deep to monitor with SCUBA surveys. Specific areas to be covered by the technical divers and ROV include the deep water TSER habitat (Miller's Ledge) and deeper water west of RH.

During the CRCP timeframe, we will continue to tag the snapper/grouper complex of fish on our RNA project (FWC/USGS), which focuses on immigration and emigration of targeted reef fishes in and near the RNA, potentially contributing to information collected at RH. Data downloaded will yield time, location and depth, and will provide species-specific information on fish movement rates and spawning activities. This information will be analyzed to examine movement and core habitat utilization areas of snappers/groupers and determine long range movement between MPAs. All data collected will be entered into an FWC Access data base with statistical analyses using SPSS or SAS. Spatial and temporal data will be processed using Arcview GIS and Tracking Analysis software to examine movement patterns in association with habitats and MPA boundaries. A peer review manuscript using all the data downloaded up to October 2010 is currently underway. Dr. Feeley is leading this task.

Lobster

Acoustic tagging of spiny lobster at DTRO (pilot study)

Methods:

A total of 17 lobsters (12 in Oct 2009; 5 in May 2010) (Table 3) were tagged with acoustic transmitters for an exploratory project to determine the feasibility of detecting long range movements. The May tagging concentrated on female lobsters (4 of 5) because reproductive migrations were recently discovered in Florida Keys lobsters. Tags were affixed to the carapace of lobsters using epoxy putty and released within an hour of capture back to the location where they were captured. For receiver locations and downloading dates, please refer to the finfish component.

Results

All but three of the seventeen tagged lobsters were tagged within 2 km of Garden Key (Figure 5). Part of the rationale for tagging lobsters close to Garden Key was the concentration of acoustic receiver in the area. Not only were there many FWC receivers in deep water within 10 km of Garden Key, but also Wes Pratt (Mote) has been maintaining a set of receivers in shallow water near the coral exclusion zone just south of Garden Key (Figure 2).

Local movements
Seven of the seventeen tagged lobsters were detected by receivers during this pilot study. This low ratio was expected as the positioning of receivers was optimized to detect fish. There were a total of 62633 detected transmissions by seven receivers. The vast majority of these receptions (97.4%) were from nearby receivers placed in shallow water south of Garden Key by Wes Pratt (Mote). These receptions represent local den shifting movements and foraging movements common to spiny lobsters.

Long distance movements
In addition to the receiver data, we received one report of a Garden Key tagged female lobster captured in a lobster trap south of the DTRO southern boundary during mid-August of 2010. We were unable to get specifics regarding the location and timing; nonetheless, this result demonstrates the great mobility potential of lobsters in the DTRO region.
Two lobsters; one male from the Oct 2009 tagging and one female from the May 2010 tagging, were found at distances greater than 11 km. The male lobster (90mm CL / tagged 10/08/09) passed a receiver 7 km to the southwest on 10/18/09 then arrived in the vicinity of a receiver in 150 ft of water near Riley's Hump and 14 km southwest of Garden Key on 10/28/09. This doubles the longest previous distance we have tracked a lobster in the DTRO region where a female lobster was tracked from Loggerhead Key to near TERN during 2005. This male lobster movement is consistent with what are called nomadic movements which are undirected movements of many kilometers that do not have a return leg. The straight-line distance of 14 km over 20 days is within the capability of lobsters (Figure 3). The female lobster (85mm CL / tagged 05/03/10) was detected by a receiver off Pulaski Shoal on 06/06/10. This movement is consistent in timing and depth with a reproductive migration as found in female lobsters in the WSER (Figure 3). Both this female and the female that was captured in a commercial trap (see above) were probably reproductive migrations.

Lobster

Western Sambo Ecological Reserve

Introduction
Lobsters were re-surveyed in WSER, Eastern Sambo Special Use Area (ESSUA), Middle Sambo, and Pelican Shoal during 2010 (Figure 8). Both WSER and ESSUA are no-take reserves and Middle Sambo and Pelican Shoal are open to fishing. Additionally, for a second year we surveyed lobsters in the outlier reef just beyond the WSER boundaries, where lobsters appear to release their eggs (Bertelsen et al. 2010) To determine lobster size, sex, and abundance inside

FKNMS marine reserve zones and their exploited reference areas, we used size distribution surveys and 500 m^2 belt transect surveys during the closed fishing season. Sampling was designed to test the hypothesis that currently established no-take zones sufficiently protect lobsters so that lobsters in these areas become larger and more abundant than those in unprotected areas.

Methods

Lobster - Size distribution surveys

Four hundred and ten lobsters were captured for size structure estimates (Tables 4 and 5). We measured lobsters and examined them for molt condition, sex, reproductive status (females), and evidence of disease. We stratified sampling by habitat type because we expected each habitat to shelter a different size range of spiny lobsters (Hunt et al., 1991). Strata included reef crest, patch reef, and outlier reef. We attempted to capture at least 50 spiny lobsters per stratum in the reserves and at reference areas.

Lobster Monitoring - Area Surveys

To compare abundance, we searched for lobsters in reserves (WSER and ESSUA) and reference areas (Pelican Shoal and Middle Sambo) using area-based surveys. Divers counted all lobsters in 139 transects (500 m2) on the reef crest, outlier reef (no reference area), and patch reefs of reserve and reference areas (Table 6). Divers searched a 5 m wide area on each side of a 50 m tape and replicated this measure at each site.

Lobster Monitoring - Statistics

Mean size of lobsters from the reef crest was compared using ANOVA. Size data on males and females were separated to control for the different ratios of males to females in our samples, since males are usually larger. The mean size for both males and females on the patch reef sites were compared with independent samples t-tests. We did not include the outlier reef since it did not have a comparable reference area. Differences in lobster size between habitat types were compared using independent samples t-tests. Tests of sexual dimorphism (male - female size) for the reef crest comparing reserves to reference areas were conducted using a multiple t-test assuming unequal variance due to the unequal sample sizes. Differences in lobster density between regions were evaluated using ANOVA and independent samples t-test. Again, we did not include the outlier reef, since it did not have a reference area. Differences in lobster density between habitat types were evaluated using ANOVA.

Results and discussion

Lobster - Inside and outside the Marine Reserves

There were no significant differences in size of male or female lobsters from each of the reef crest regions (Pelican Shoal, WSER, Middle Sambo and ESSUA) (Table 5, males: ANOVA, d.f. = 3, F = 2.68, P = 0.052, females: ANOVA, d.f. = 3, F = 1.29, P = 0.280). The results for size difference in males for 2010 starkly contrast previous years. Typically, males from WSER are significantly larger than males from Pelican Shoal and the size of males from Middle and Eastern Sambo fall somewhere in between WSER and Pelican Shoal. The 2010's mean male size for all regions is much smaller than the average for 2004-2010 (Maxwell et al. 2010), which may account for the lack of significant differences between regions.
For patch reefs there was no difference in the size of males between regions (t test, d.f. = 62, t = -1.743, P =0.086), but there was a difference in the size of females between regions (t test, d.f. = 57, t = -3.113, P =0.003). Females from WSER were larger than females from Pelican Shoal. These data are also atypical. Differences in size between regions are usually more obvious in males than in females, since female growth slows down upon maturation (Lipcius and Herrnkind 1987; Bertelsen et al. 2004).

Lobster- habitat type

There were significant differences in the size of lobsters between habitat type for male and female lobsters at Pelican Shoal (Table 5, males: t test, d.f. = 60, t = 2.403, P =0.019 females: t test, d.f. = 54, t = 4.088, P =0.000). Females and males caught on the patch reefs were significantly smaller than those caught on the reef crest. There were no significant differences in the size of lobsters caught in any of the three habitats (patch reefs, reef crest, and outlier reef) at WSER.

Lobster - Sexual dimorphism

A comparison of mean carapace length (CL) between male and female lobsters is presented in Table 7. A functional marine protected area should retain mature animals, and since adult male lobsters are likely growing faster than adult female lobsters (Lipcius and Herrnkind 1987, Bertelsen et al. 2004), significant differences in size between males and females should be an indicator of an effective marine protected area. The average size difference between sexes for the past 6 years indicates sexual dimorphism is generally greatest in the large reserve, WSER, and decreases with distance from WSER (Maxwell et al. 2010). This year, however, there was no significant difference in size between sexes, and at both WSER and Pelican Shoal reef crest and patch reefs, the mean female size was actually greater (not significantly) than the mean male size. This result is very unusual, and appears to be due to smaller than average males, rather than larger than average females (Bertelsen et al. 2004, Maxwell et al. 2010). The smaller than average male lobsters could also indicate an influx of new recruits, rather than a marine protected area that is ineffective at retaining large male lobsters.

Lobster - Density

Lobster densities per 500 m2 transect are reported in Table 8. There were no differences in density of lobsters between any of the reef crest locations (Pelican Shoal, WSER, Middle Sambo and Eastern Sambo) (ANOVA, d.f. = 3, F = .794, P = 0.501) or patch reef locations (Pelican Shoal and WSER) (*t* test, d.f. = 37, $t = -.429$, $P = 0.671$). There were also no significant differences in density between the habitat types (ANOVA, d.f. = 2, F = 2.604, P = 0.078).

Lobster – Outlier reef

The sex ratio at the outlier reef was slightly more skewed towards females than at other locations (Table 4). This result is consistent with FWC's observations of lobsters tagged with sonic tags. The outlier reef appears to be where a number of females go to release their eggs (Bertelsen et al. 2010). The influx of migrating females could account for the skewed sex ratio during the breeding season (Mar-Sept).

Future Work

Lobster

We will continue annual surveys of spiny lobster in and adjacent to the WSER and incorporate sonic tagging of spiny lobsters in the Tortugas region. We will continue to use a combination of belt-transects and the capture, measurement and release of at least 50 spiny lobsters per stratum to estimate abundance and size structure inside and outside the ERs. We will also continue to focus on the outlier reef. We propose to incorporate habitat assessments into our surveys so that we can relate lobster size and abundance to habitat quality. Differences in the surveyed habitat could explain some of the annual variability in lobster size and abundance.

We can't fully explain this year's unusual results. The value of the WSER is usually very obvious by the presence of large males, indicating a protected resident population (Maxwell et al. 2010). It will be interesting to see if next year's data are more consistent to data collected in previous years.

References

Ault, J.S., Smith, S.G., Bohnsack, J.A., Luo, J., Harper, D.E. and McClellan, D.B. (2006) Building sustainable fisheries in Florida's coral reef ecosystem: positive signs in the Dry Tortugas. Bull. Mar. Sci. 78(3):633-654.

Bertelsen RD, Cox C, Beaver R, Hunt JH (2004) A re-examination of south Florida spiny lobster monitoring projects from 1973–2002: the response of local spiny lobster populations, in size structure, abundance, and fecundity, to different sized sanctuaries. In: Shipley JB ed. Aquatic protected areas as fisheries management tools. American Fisheries Society, Symposium 42, Bethesda, Maryland. Pp. 195–210.

Bertelsen RD, Maxwell KE, , Matthews TR, Hunt JH (2010) Caribbean spiny lobster (*Panulirus argus*) movement and population metrics at the Western SAmbo Ecological Reserve (Florida USA) Talk for: Linking Science to Management- A Conference & Workshop on the Florida Keys Marine Ecosystem.

Burton, M.L., Brennan, K.J., Munoz, R.C., Parker, Jr. R.O. (2005) Preliminary evidence of increased spawning aggregations of mutton snapper (*Lutjanus analis*) at Riley's Hump two years after the establishment of the Tortugas South Ecological Reserve. Fish. Bull. 103:404-410.

Domeier, M.L. (2004) A potential larval recruitment pathway originating from a Florida marine protected area. Fish. Oceanogr. 13(5):287-294.

Heyman, W.D. and Kjerfve, B. (2008) Characterization of transient multi-species reef fish spawning aggregations at Gladden Spit, Belize. Bull. Mar. Sci. 83(3): 531-551.

Hunt JH, Matthews TR, Forcucci D, Hedin B, Bertelsen RD (1991) Management implications of trends in the population dynamics of the Caribbean spiny lobster, *Panulirus argus*, at Looe Key National Marine Sanctuary. Final Report to NOAA. Florida Marine Research Institute, Marathon, FL.

Lindeman, K.C., Pugliese, R., Waugh, G.T. and Ault, J.S. (2000) Developmental patterns within a multispecies reef fishery: management applications for essential fish habitats and protected areas. Bull. Mar. Sci. 66(3):929-956.

Lipcius RN, Hernnkind WF (1987) Control and coordination of reproduction and molting in the spiny lobster *Panulirus argus*. Marine Biology 96: 207-214.

Maxwell KE, Bertelsen RD, Snook JL, Hunt JH (2010) Evaluation of marine reserves for spiny lobsters, *Panulirus argus*, using transect surveys in the Florida Keys National Marine Sanctuary, USA. Poster for: Linking Science to Management- A Conference & Workshop on the Florida Keys Marine Ecosystem.

Projects

Fish Telemetry Team
Alejandro Acosta, FWC, Principal Investigator
Paul Barbera, FWC
Benjamin Binder, FWC
Rodney Bertelsen, FWC
Michael Feeley, FWC, Principal Investigator/ currently with NPS
Michelle Dancy, FWC
David Hawtof, FWC
Danielle Morley, FWC
Bill Sympson, FWC
Marie Tellier, FWC

Spiny Lobster Marine Reserves Team
Sara Bergeron, FWC
Rodney Bertelsen, FWC
Ben Binder, FWC
Dave Eaken, FWC
Michelle Dancy, FWC
Nick Corby, FWC
Carrollyn Cox, FWC
Dave Hawtof, Volunteer
Sarah Maschal, FWC
Kerry Maxwell, FWC
Danielle Morley, FWC
Bill Sharp, FWC
Jessica Snook, FWC

Progress Report Submission
Alejandro Acosta, FWC
Rodney Bertelsen, FWC
Kerry Maxwell, FWC

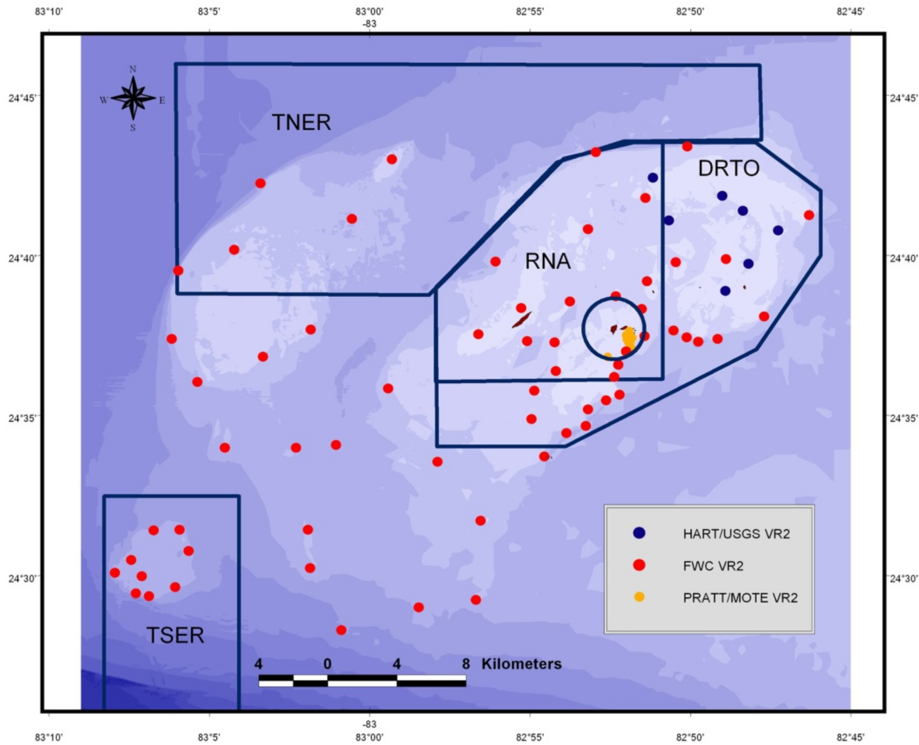

Figure 1. The TSER, TNER, DRTO and RNA create a network of no-take reserves that protect 600 km^2 of coral reef habitat in the Dry Tortugas. Location of FWC VR2 receivers are indicated for FY 2009. The FWC array is complemented by two collaborative telemetry projects: the Mote Marine Laboratory nurse shark project (PI: Dr. Wes Pratt) and USGS sea turtle project (PI: Dr. Kristen Hart).

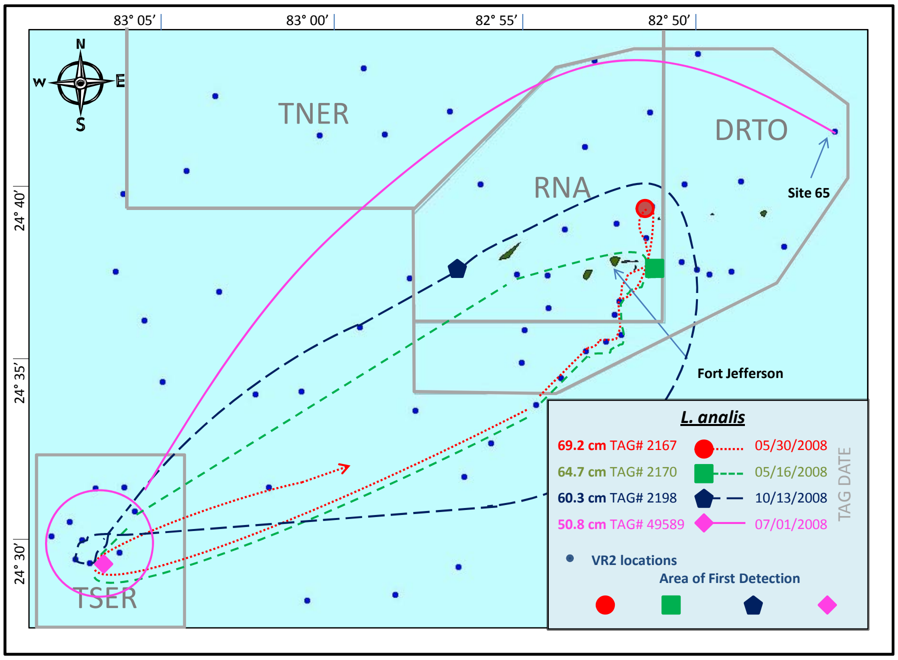

Figure 2. Tagging sites and preliminary spawning migratory movements of four mutton snapper in the Dry Tortugas.

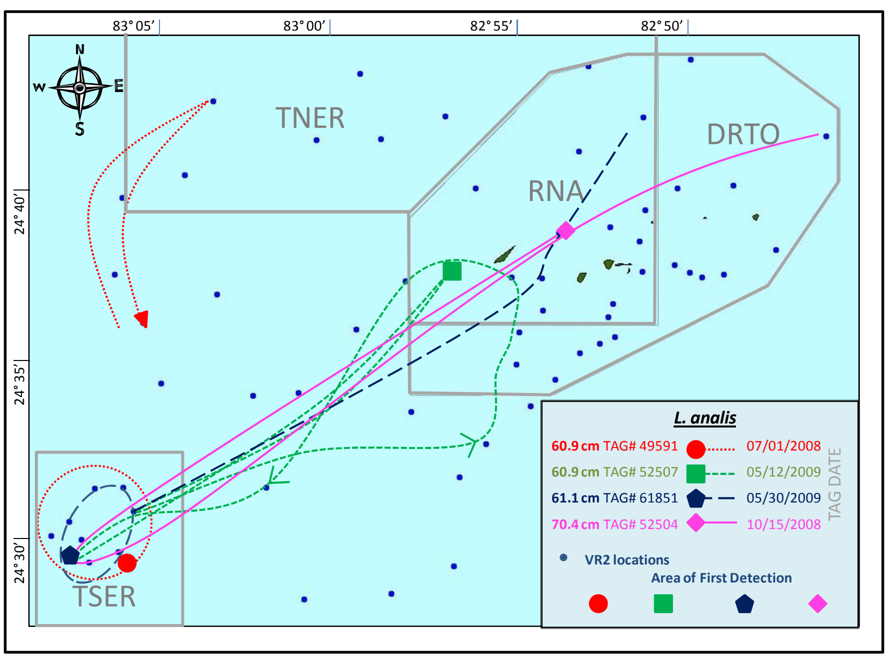

Figure 3. Tagging sites and preliminary spawning migratory movements of four mutton snapper in the Dry Tortugas.

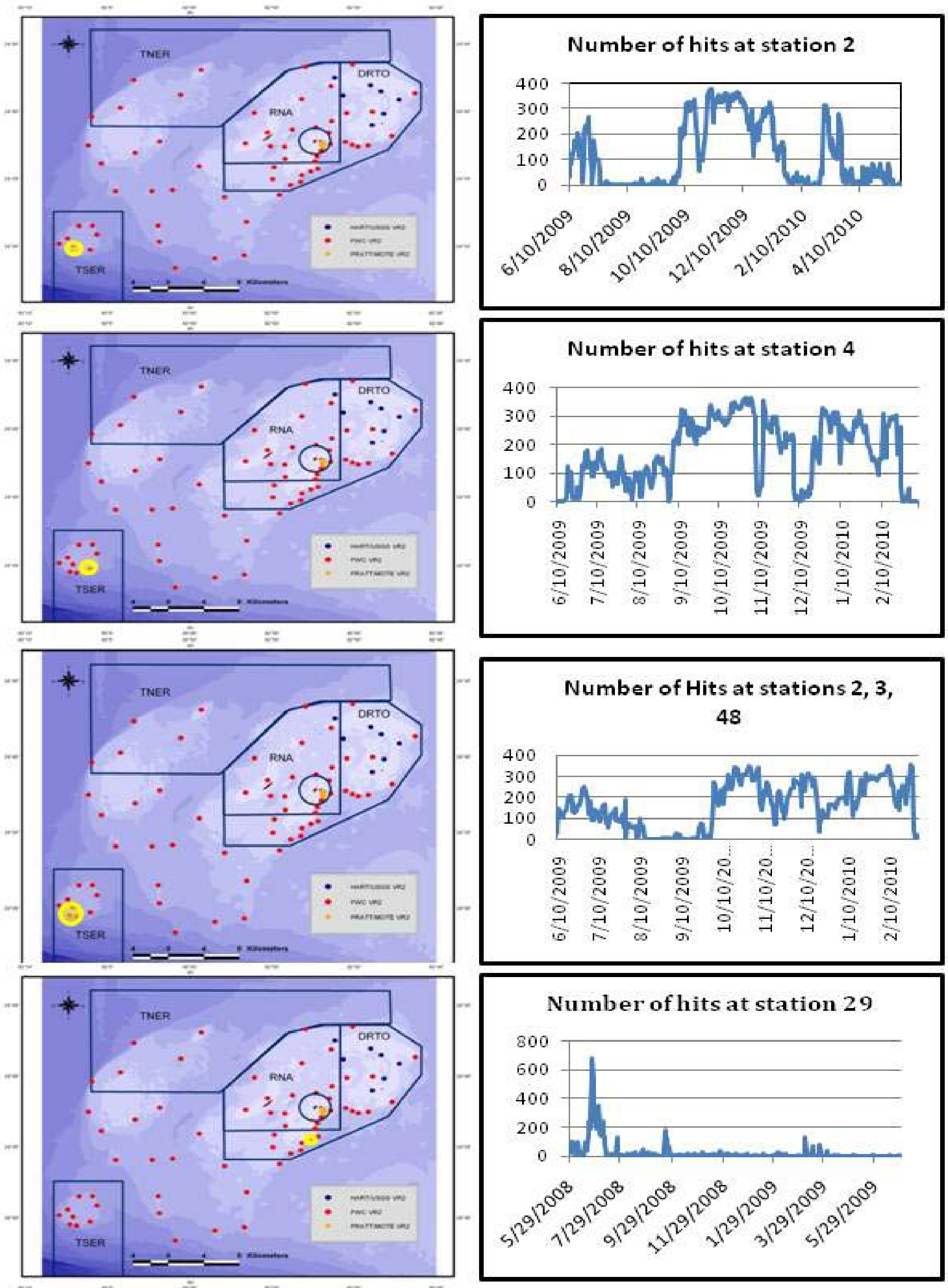

Figure 4. Tagging sites and movement detection of black grouper in the Dry Tortugas.

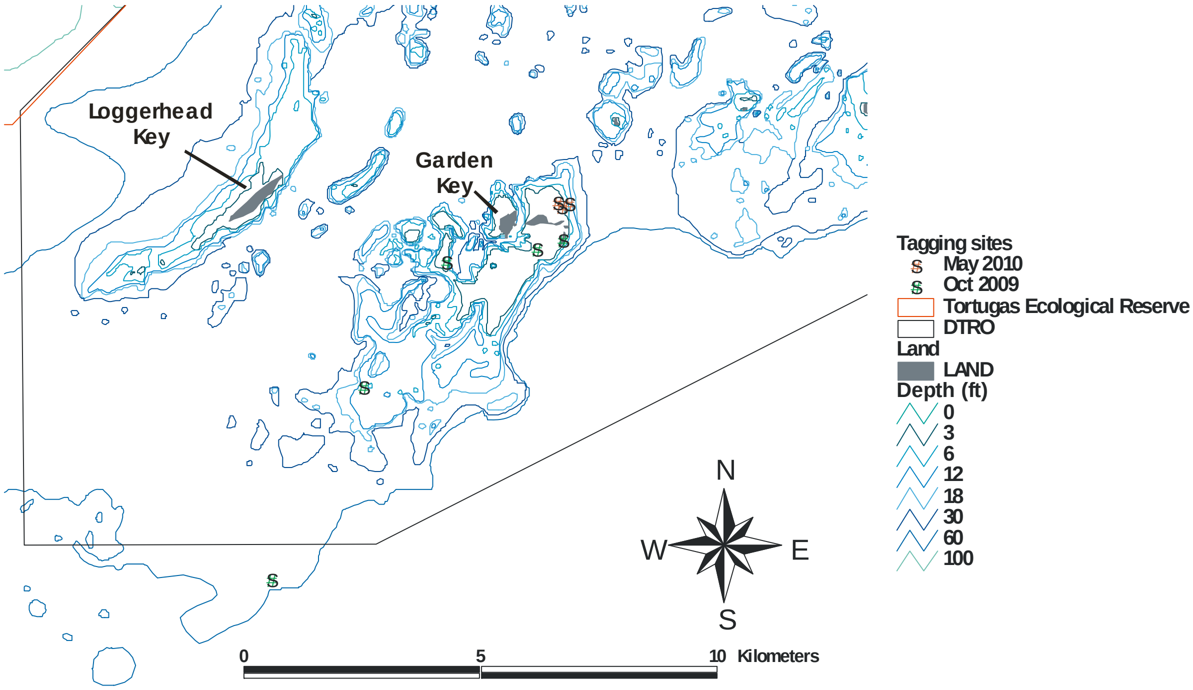

Figure 5. Tagging sites (green circles = Oct 2010; brown circles = May 2011)

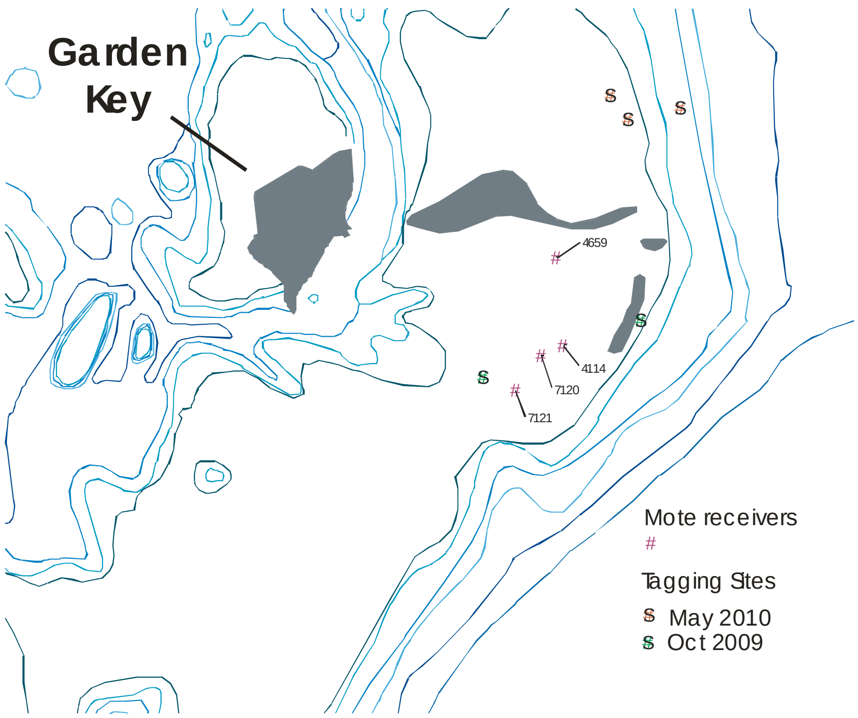

Figure 6. Local (Mote/ Pratt) receivers (purple circles) that detected lobsters tagged around Garden Key.

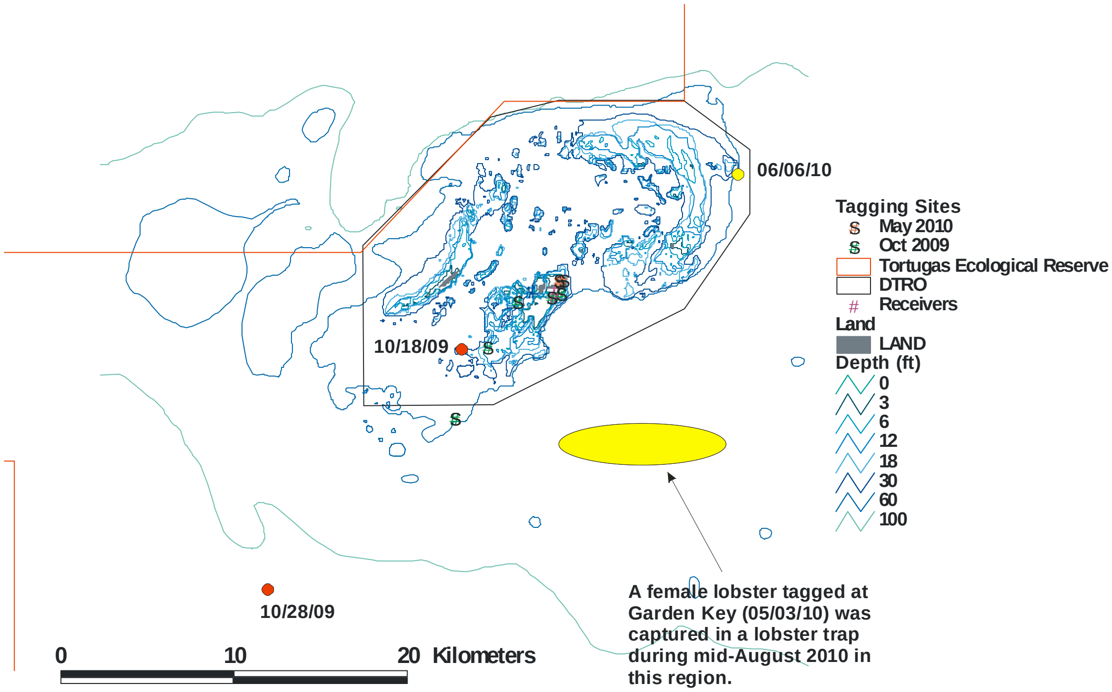

Figure 7. Long distance movements of spiny lobsters tagged at DTRO 2009-2010. The yellow ellipse and circle represent destinations of female lobsters (see text) and red circles indicate movements of a male lobster (see text).

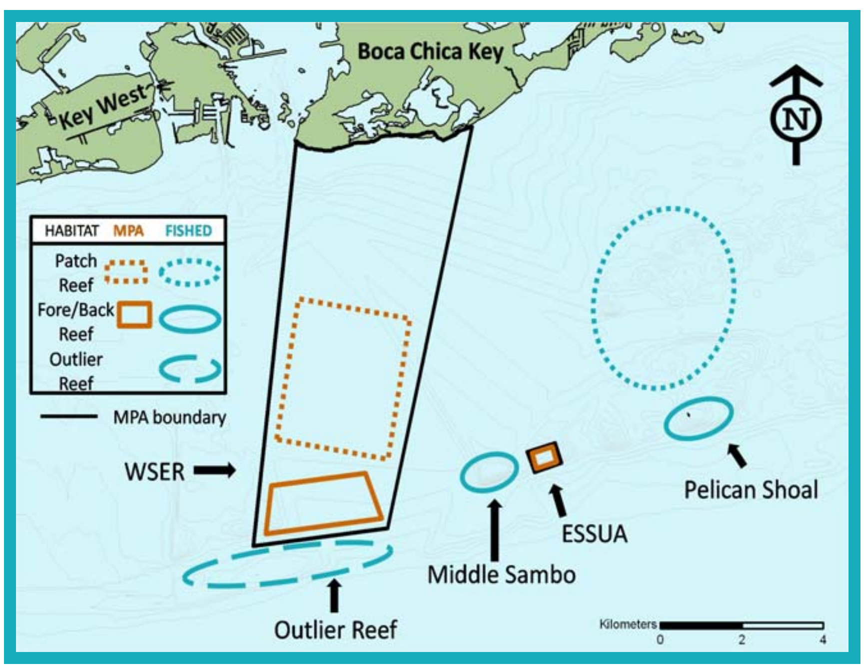

Figure 8. Study Area. Four regions were surveyed for lobster abundance and size distribution. Two regions are MPAs (WSER and ESSUA) and two are fished areas (Middle Sambo and Pelican Shoal). WSER and Pelican Shoal were surveyed across habitat types.

Table 1: Location of VR2 receivers in the Dry Tortugas region (September 2010). The management zone and cumulative number of detections is included for each station. Tortugas South Ecological Reserve (TSER), Tortugas North Ecological Reserve (TNER), Dry Tortugas National Park (DRTO), Research Natural Area (RNA), Florida Keys National Marine Sanctuary (FKNMS) and open waters (OPEN).

STATION	LATD	LATM	LOND	LONM	DEPTH (M)	ZONE	Number of Detections
1	24	30.077	83	7.943	2.4	TSER	2661
2	24	29.435	83	7.291	2.2	TSER	237747
3	24	29.968	83	7.103	2.2	TSER	6445
4	24	29.631	83	6.065	1.8	TSER	57796
5	24	30.478	83	7.431	2.3	TSER	29
6	24	31.408	83	6.732	2.1	TSER	1510
7	24	31.422	83	5.926	1.8	TSER	1142
8	24	39.520	83	5.966	1.8	TNER	143
9	24	36.036	83	5.371	1.6	OPEN	252
10	24	36.824	83	3.325	1.0	FKNMS	115
12	24	42.994	82	59.301	18.1	TNER	723
15	24	35.839	82	59.420	18.1	FKNMS	533
16	24	33.551	82	57.880	17.6	FKNMS	28
17A	24	33.710	82	54.547	16.6	FKNMS	495
18	24	31.424	83	1.927	0.6	FKNMS	77
19A	24	28.452	82	58.434	17.8	OPEN	3
20	24	39.185	82	51.348	15.7	RNA	127158
22	24	38.316	82	51.514	15.7	RNA	1594
26	24	36.572	82	52.246	15.9	RNA	4345
27	24	36.198	82	52.366	16.0	RNA	17425
28	24	35.638	82	52.200	15.9	DRTO	11133
29	24	35.462	82	52.619	16.0	DRTO	22402
41	24	39.778	82	50.450	15.4	DRTO	453
44	24	37.642	82	50.522	15.4	DRTO	6211
45	24	37.428	82	50.112	15.3	DRTO	32395
46	24	37.293	82	49.749	15.2	DRTO	9589
47	24	37.387	82	49.150	15.0	DRTO	761
48	24	29.346	83	6.878	2.1	TSER	56283
49	24	30.762	83	5.647	1.7	TSER	4543
50	24	37.387	83	6.165	1.9	OPEN	207
51A	24	34.332	83	4.879	1.5	OPEN	New Station
52	24	40.172	83	4.219	1.3	TNER	85
53	24	42.242	83	3.407	1.0	TNER	153
54	24	33.986	83	2.295	0.7	FKNMS	56
55	24	34.076	83	1.046	0.3	FKNMS	40
56	24	41.128	83	0.546	0.2	TNER	138
57	24	29.234	82	56.686	17.3	FKNMS	167
59	24	37.313	82	55.082	16.8	RNA	6005
60	24	40.814	82	53.187	16.2	RNA	42781

Table 1. (continued).

61	24	41.786	82	51.397	15.7	RNA	6539
62A	24	43.393	82	50.089	15.3	DRTO	895
63	24	39.872	82	48.885	14.9	DRTO	507
64	24	38.083	82	47.692	14.5	DRTO	1171
65	24	41.251	82	46.291	14.1	DRTO	3178
66	24	31.710	82	56.535	17.2	FKNMS	151
67	24	43.217	82	52.946	16.1	RNA	1328
68	24	37.533	82	56.605	17.3	RNA	10513
69	24	39.800	82	56.073	17.1	RNA	43
70	24	32.642	82	55.796	17.0	OPEN	132
24A	24	37.467	82	51.426	15.7	RNA	3925
30A	24	35.182	82	53.185	16.2	DRTO	9326
32A	24	34.441	82	53.863	16.4	DRTO	1305
33A	24	34.878	82	54.950	16.7	DRTO	80
34A	24	35.764	82	54.858	16.7	DRTO	308
35A	24	36.377	82	54.195	16.5	RNA	306798
36A	24	37.274	82	54.230	16.5	RNA	486
37B	24	38.549	82	53.753	16.4	RNA	330845
40A	24	38.719	82	52.321	15.9	RNA	549
14A	24	28.287	83	0.885	0.3	OPEN	1777
71	24	25.878	81	55.865	17.0	OPEN	1
72	24	37.202	82	58.051	17.69394	OPEN	92
73	24	25.291	82	26.511	8.080553	OPEN	70
74	24	41.168	82	58.748	17.90639	TNER	New Station
75	24	41.803	82	56.943	17.35623	TNER	New Station

Table 2. All acoustically tagged fish captured and released in the Dry Tortugas between May 2008 - October 2010.

Pinger code	Species	Date Tagged	Zone	Latitude	Longitude	Depth ft	TL inches	TL mm	Tag life days	Days of tag activity	% of Days Detected	Total Detections
27	*Epinephelus itajara*	6/13/2009	TNER	24 46.002	82 59.433	158	58.465	1485.0	1160	475	0.0	13
2577	*Epinephelus itajara*	6/13/2009	TNER	24 46.002	82 59.433	158	77.835	1977.0	1160	475	0.0	0
2576	*Epinephelus itajara*	6/1/2010	TSER	24 29.435	83 7.291	114	65.200	1656.1	450	122	28.7	2362
2572	*Epinephelus itajara*	6/1/2010	TSER	24 29.435	83 7.291	114	49.400	1254.8	450	122	39.3	832
2153	*Epinephelus morio*	7/3/2008	TSER	24 29.367	83 6.863	85	27.000	685.8	1160	820	0.5	4
2166	*Epinephelus morio*	7/3/2008	TSER	24 29.543	83 7.349	88	23.000	584.2	1160	820	1.5	56
2154	*Epinephelus morio*	7/6/2008	TSER	24 29.432	83 7.288	123	16.000	406.4	370	817	0.0	63187
49585	*Epinephelus striatus*	7/5/2008	TSER	24 29.43	83 7.322	110	23.000	584.2	1160	818	5.4	3715
52510	*Epinephelus striatus*	6/11/2009	TSER	24 29.438	83 7.298	105	26.000	660.4	1157	477	99.0	54187
49601	*Haemulon plumieri*	5/19/2008	DRTO	24 38.553	82 48.909	21	11.378	289.0	470	865	0.0	0
49595	*Haemulon plumieri*	5/27/2008	RNA	24 37.758	82 52.981	33	9.961	253.0	470	857	0.0	0
49602	*Haemulon plumieri*	5/27/2008	RNA	24 37.75	82 52.949	15	10.709	272.0	470	857	0.0	0
2170	*Lutjanus analis*	5/16/2008	DRTO	24 35.583	82 52.687	32	25.500	647.7	450	475	20.8	9293
2175	*Lutjanus analis*	5/17/2008	DRTO	24 35.628	82 52.674	28	24.000	609.6	450	450	5.1	611
2176	*Lutjanus analis*	5/17/2008	DRTO	24 35.625	82 52.673	28	21.700	551.2	450	450	12.4	2204
2174	*Lutjanus analis*	5/22/2008	RNA	24 34.332	82 54.639	40	18.425	468.0	470	470	0.0	0
2185	*Lutjanus analis*	5/24/2008	DRTO	24 36.138	82 56.951	49	24.016	610.0	470	470	1.3	987
2168	*Lutjanus analis*	5/26/2008	RNA	24 36.384	82 54.141	15	22.283	566.0	470	470	79.6	443749
2167	*Lutjanus analis*	5/30/2008	RNA	24 38.853	82 51.419	24	27.244	692.0	470	470	65.1	127054
2177	*Lutjanus analis*	5/30/2008	RNA	24 38.853	82 51.419	24	25.394	645.0	470	470	61.7	7438
49589	*Lutjanus analis*	7/1/2008	TSER	24 29.475	83 7.264	95	20.000	508.0	820	820	3.9	960
49590	*Lutjanus analis*	7/1/2008	TSER	24 29.45	83 7.307	107	25.000	635.0	500	500	8.8	1099
49591	*Lutjanus analis*	7/1/2008	TSER	24 29.475	83 7.264	95	24.000	609.6	1160	822	3.9	1933
13675/ 55	*Lutjanus analis*	7/2/2008	TSER	24 29.492	83 7.25	90	18.500	469.9	1160	821	0.5	62
13674/54	*Lutjanus analis*	7/5/2008	TSER	24 29.432	83 7.288	120	18.000	457.2	1160	818	2.4	405
13677/ 57	*Lutjanus analis*	7/5/2008	TSER	24 29.432	83 7.288	120	19.000	482.6	1160	818	0.5	1866
13678/58	*Lutjanus analis*	7/5/2008	TSER	24 29.43	83 7.322	110	19.000	482.6	370	370	15.4	1510
13679/ 59	*Lutjanus analis*	7/5/2008	TSER	24 29.43	83 7.322	110	22.750	577.9	370	370	5.9	667
2198	*Lutjanus analis*	10/13/2008	RNA	24 37.437	82 56.51	14	23.750	603.3	370	370	46.2	4371
2200	*Lutjanus analis*	10/13/2008	RNA	24 37.437	82 56.51	14	23.250	590.6	370	370	1.1	214

2201	*Lutjanus analis*	10/13/2008	RNA	24 37.437	82 56.51	14	22.500	571.5	1157	718	27.2	2715
49587	*Lutjanus analis*	10/13/2008	RNA	24 37.449	82 56.509	14	23.250	590.6	1157	718	0.3	8
49588	*Lutjanus analis*	10/13/2008	RNA	24 37.437	82 56.51	14	28.250	717.6	1157	718	6.8	1179
52502	*Lutjanus analis*	10/14/2008	DRTO	24 37.229	82 52.161	7	24.250	616.0	1157	717	0.3	4
52503	*Lutjanus analis*	10/15/2008	RNA	24 38.51	82 53.77	36	29.250	743.0	1157	716	0.6	31
52504	*Lutjanus analis*	10/15/2008	RNA	24 38.51	82 53.77	36	27.750	704.9	1157	716	60.6	120562
52505	*Lutjanus analis*	10/15/2008	RNA	24 38.51	82 53.77	36	21.000	533.4	1157	716	97.6	359043
56742	*Lutjanus analis*	5/9/2009	RNA	24 38.693	82 51.074	28	20.500	520.7	417	510	0.2	7
52507	*Lutjanus analis*	5/12/2009	RNA	24 37.55	82 56.207	15	24.000	609.6	417	507	46.7	4056
52508	*Lutjanus analis*	5/12/2009	RNA	24 37.55	82 56.207	15	23.000	584.2	417	507	15.2	938
52509	*Lutjanus analis*	5/13/2009	RNA	24 38.687	82 51.08	31	25.500	647.7	417	506	0.0	0
131/14805	*Lutjanus analis*	6/9/2009	TSER	24 29.399	83 7.24	112	24.000	609.6	417	417	0.2	27
13676/ 56	*Lutjanus analis*	6/9/2009	TSER	24 29.438	83 7.298	105	25.000	635.0	417	417	4.3	278
13680/ 60	*Lutjanus analis*	6/9/2009	TSER	24 29.438	83 7.298	105	25.000	635.0	417	417	1.9	376
13682/ 62	*Lutjanus analis*	6/9/2009	TSER	24 29.438	83 7.298	105	28.000	711.2	417	417	4.6	455
13683/ 63	*Lutjanus analis*	6/9/2009	TSER	24 29.399	83 7.24	112	24.000	609.6	417	417	5.0	94
52515	*Lutjanus analis*	6/10/2009	TSER	24 29.438	83 7.298	105	24.000	609.6	1157	478	3.3	461
52511	*Lutjanus analis*	6/11/2009	TSER	24 29.458	83 7.384	120	18.500	469.9	1160	477	15.3	5035
52512	*Lutjanus analis*	6/11/2009	TSER	24 29.438	83 7.24	105	26.000	660.4	1160	477	0.6	29
52513	*Lutjanus analis*	6/11/2009	TSER	24 29.438	83 7.24	105	24.500	622.3	1160	477	0.2	19
52514	*Lutjanus analis*	6/11/2009	TSER	24 29.399	83 7.24	112	29.000	736.6	1160	477	3.1	5451
52516	*Lutjanus analis*	6/11/2009	TSER	24 29.438	83 7.24	105	23.000	584.2	1160	477	21.0	2688
13681/ 61	*Lutjanus analis*	6/11/2009	TSER	24 29.438	83 7.298	105	26.500	673.1	1160	477	0.2	1
56746	*Lutjanus analis*	6/12/2009	TSER	24 29.458	83 7.384	120	26.500	673.1	1160	476	0.6	35
56747	*Lutjanus analis*	6/12/2009	TSER	24 29.438	83 7.298	105	28.500	723.9	1160	476	1.7	60
56748	*Lutjanus analis*	6/12/2009	TSER	24 29.438	83 7.298	105	28.000	711.2	1160	476	5.7	809
56744	*Lutjanus analis*	9/25/2009	RNA	24 40.583	82 53.208	41	30.000	762.0	1157	371	29.1	1182
14806/132	*Lutjanus analis*	9/27/2009	RNA	24 37.868	82 55.025	15	30.000	762.0	1122	369	0.0	0
14802/128	*Lutjanus analis*	9/28/2009	RNA	24 40.281	82 53.343	39	22.250	565.2	1122	368	0.8	29
14803/129	*Lutjanus analis*	9/29/2009	RNA	24 37.401	82 56.574	14	29.000	736.6	1122	367	0.0	0
14804/130	*Lutjanus analis*	9/30/2009	RNA	24 37.446	82 56.564	19	24.500	622.3	1122	366	29.8	450
61851	*Lutjanus analis*	5/30/2010	TSER	24 29.435	83 7.291	114	28.000	711.2	1157	124	95.1	8970
61849	*Lutjanus analis*	5/31/2010	TSER	24 29.435	83 7.291	114	28.000	711.2	1157	123	5.7	52
61853	*Lutjanus analis*	5/31/2010	TSER	24 29.435	83 7.291	114	29.500	749.3	1157	123	15.4	275
61852	*Lutjanus analis*	5/31/2010	TSER	24 29.435	83 7.291	114	27.000	685.8	1157	123	6.5	305

6	*Lutjanus analis*	6/1/2010	TSER	24 29.435	83 7.291	114	**35.300**	896.6	1157	122	15.6	355
2173	*Mycteroperca bonaci*	5/21/2008	RNA	24 39.027	82 51.022	35	23.976	609.0	470	863	0.0	0
2169	*Mycteroperca bonaci*	5/26/2008	RNA	24 36.38	82 54.05	20	17.244	438.0	470	470	1.5	259
2171	*Mycteroperca bonaci*	5/29/2008	DRTO	24 35.6	82 52.695	33	24.331	618.0	470	470	50.6	8836
2172	*Mycteroperca bonaci*	5/29/2008	RNA	24 36.418	82 54.156	28	21.575	548.0	470	470	9.4	2874
2184	*Mycteroperca bonaci*	5/30/2008	DRTO	24 35.824	82 52.199	30	22.126	562.0	470	470	1.3	146
2165	*Mycteroperca bonaci*	6/3/2008	DRTO	24 35.513	82 52.372	49	25.197	640.0	820	820	0.4	421
49586	*Mycteroperca bonaci*	10/11/2008	RNA	24 38.912	82 51.003	24	17.000	431.8	370	370	0.8	29
52506	*Mycteroperca bonaci*	10/14/2008	DRTO	24 37.229	82 52.161	5	26.250	666.8	1157	717	15.9	4428
56751	*Mycteroperca bonaci*	5/8/2009	DRTO	24 37.433	82 49.872	34	21.000	533.4	1157	511	42.5	5044
56730	*Mycteroperca bonaci*	5/9/2009	DRTO	24 37.439	82 49.889	34	15.000	381.0	1157	510	0.4	2
56731	*Mycteroperca bonaci*	5/9/2009	DRTO	24 37.439	82 49.889	34	18.500	469.9	1157	510	0.0	0
56736	*Mycteroperca bonaci*	5/10/2009	DRTO	24 37.376	82 49.948	46	20.500	520.7	417	509	81.3	31286
21	*Mycteroperca bonaci*	6/10/2009	TSER	24 29.529	83 7.239	90	42.087	1069.0	1157	478	63.0	40190
23	*Mycteroperca bonaci*	6/10/2009	TSER	24 29.631	83 6.065	110	36.260	921.0	1157	478	54.2	48085
28	*Mycteroperca bonaci*	6/10/2009	TSER	24 29.631	83 6.065	110	36.260	921.0	1157	478	0.4	2
29	*Mycteroperca bonaci*	6/10/2009	TSER	24 29.399	83 7.24	112	38.386	975.0	1157	478	51.7	42789
56741	*Mycteroperca bonaci*	9/26/2009	RNA	24 40.583	82 53.21	42	18.000	457.2	1157	370	61.4	3018
61850	*Mycteroperca bonaci*	5/31/2010	TSER	24 29.435	83 7.291	114	29.000	736.6	1157	123	96.7	6082
61854	*Mycteroperca bonaci*	5/31/2010	TSER	24 29.435	83 7.291	114	26.500	673.1	1157	123	82.9	1732
24	*Mycteroperca bonaci*	6/1/2010	TSER	24 29.435	83 7.291	114	47.900	1216.7	450	122	19.7	748
22	*Mycteroperca bonaci*	6/1/2010	TSER	24 29.435	83 7.291	114	38.500	977.9	450	122	66.4	9741
2571	*Mycteroperca bonaci*	6/1/2010	TSER	24 29.435	83 7.291	114	42.100	1069.4	450	122	85.2	2476
2575	*Mycteroperca bonaci*	6/1/2010	TSER	24 29.435	83 7.291	114	42.100	1069.4	450	122	17.2	1029
62112	*Mycteroperca bonaci*	10/10/2010	RNA	24 38.478	82 51.092	26	24.000	609.6	1122	0	0.0	0
62111	*Mycteroperca bonaci*	10/10/2010	DRTO	24 38.922	82 50.992	21	22.500	571.5	1122	0	0.0	0
61858	*Mycteroperca bonaci*	10/11/2010	TNER	24 42.56	82 59.427	40	36.500	927.1	1157	0	0.0	0
61857	*Mycteroperca bonaci*	10/11/2010	OPEN	24 43.055	82 59.513	60	28.000	711.2	1157	0	0.0	0
61855	*Mycteroperca venenosa*	10/11/2010	DRTO	24 39.392	83 6.016	72	28.000	711.2	1157	0	0.0	0
49599	*Ocyurus chrysurus*	5/16/2008	DRTO	24 35.583	82 52.687	32	17.008	432.0	450	398	35.5	2129
49597	*Ocyurus chrysurus*	5/17/2008	DRTO	24 35.625	82 52.673	28	15.000	381.0	450	397	1.8	158
49598	*Ocyurus chrysurus*	5/17/2008	DRTO	24 35.625	82 52.673	28	17.008	432.0	450	397	5.8	148
49596	*Ocyurus chrysurus*	5/19/2008	DRTO	24 37.017	82 49.509	20	14.803	376.0	100	395	0.0	0
49600	*Ocyurus chrysurus*	5/19/2008	DRTO	24 37.017	82 49.509	20	15.787	401.0	470	395	0.3	1

52519	*Ocyurus chrysurus*	10/10/2008	DRTO	24 35.589	82 52.683	34	17.250	438.2	370	417	45.3	8736
52520	*Ocyurus chrysurus*	10/10/2008	DRTO	24 35.589	82 52.683	34	16.000	406.4	370	417	15.6	226
52521	*Ocyurus chrysurus*	10/10/2008	DRTO	24 35.589	82 52.683	34	17.500	444.5	370	417	12.5	190
52517	*Ocyurus chrysurus*	10/11/2008	RNA	24 38.912	82 51.003	24	16.500	419.1	370	416	0.0	0
52518	*Ocyurus chrysurus*	10/11/2008	RNA	24 38.912	82 51.003	24	20.250	514.4	370	416	2.9	601
56732	*Ocyurus chrysurus*	5/7/2009	DRTO	24 35.611	82 52.759	31	15.800	401.3	1157	512	11.1	575
56733	*Ocyurus chrysurus*	5/7/2009	DRTO	24 35.611	82 52.759	31	16.800	426.7	1157	512	46.3	4057
56734	*Ocyurus chrysurus*	5/7/2009	DRTO	24 35.611	82 52.759	31	14.750	374.7	1157	512	0.6	7
61844	*Ocyurus chrysurus*	9/24/2009	DRTO	24 35.509	82 52.628	39	17.300	440.0	417	372	53.2	4743
61845	*Ocyurus chrysurus*	9/24/2009	DRTO	24 35.509	82 52.628	39	16.000	406.4	417	372	89.0	10215
61843	*Ocyurus chrysurus*	9/25/2009	RNA	24 40.583	82 53.208	41	20.000	508.0	417	371	0.0	0
61841	*Ocyurus chrysurus*	9/25/2009	RNA	24 40.583	82 53.208	41	16.000	406.4	417	371	1.1	22
61842	*Ocyurus chrysurus*	9/25/2009	RNA	24 40.523	82 53.149	29	17.000	431.8	417	371	1.9	10

Table 3. Tagging schedule of spiny lobsters in DTRO. All lobsters were tagged within 2 km of Garden Key with the exception of 56642 which was tagged near the southern RNA border plus 56650 and 56648 which were tagged 4 km southwest of Garden Key.

tagCode	size	sex	Date	Time	lat	lon
56642	113	F	10/7/2009	15:37	24.56045	-82.9177
56646	123	M	10/8/2009	9:30	24.62512	-82.8624
56641	97	F	10/8/2009	9:30	24.62512	-82.8624
56649	74	F	10/8/2009	9:30	24.62512	-82.8624
56644	74	F	10/8/2009	9:30	24.62512	-82.8624
56645	156	M	10/8/2009	12:00	24.62095	-82.8847
56643	120	F	10/8/2009	15:10	24.62333	-82.8674
56647	87	M	10/8/2009	15:10	24.62333	-82.8674
56651	100	M	10/8/2009	15:10	24.62333	-82.8674
56650	90	M	10/8/2009	15:10	24.62333	-82.8674
56652	90	M	10/8/2009	15:40	24.59695	-82.9003
56648	97	F	10/8/2009	15:40	24.59695	-82.9003
37265	90	F	5/3/2010	19:00	24.63148	-82.8628
37261	112	F	5/3/2010	18:30	24.63227	-82.8634
37264	92	M	5/3/2010	19:30	24.63185	-82.8612
37267	87	F	5/3/2010	19:30	24.63185	-82.8612
37263	85	F	5/3/2010	19:30	24.63185	-82.8612

Table 4. 2010 Number of lobsters collected for size distribution analysis by region and habitat (males/females).

		Habitat		
Region **(Bold = reserve)**	Reef crest	Outlier reef	Patch reef	Total
Pelican Shoal	64 (24/40)		54 (38/16)	118(62/56)
Eastern Sambo (SUA)	55 (23/32)			55 (23/32)
Middle Sambo	56 (22/34)			56 (22/34)
Western Sambo (ER)	58 (29/29)		69 (26/43)	127(55/72)
Western Sambo		54 (18/36)		54 (18/36)
Total	233(98/135)	54 (18/36)	123(64/59)	410(180/230)

Table 5. 2010 Mean size of lobster by sex, habitat, and region.

Habitat	Region (**Bold = reserve**)	Males Mean ±SD	Females Mean ±SD	Overall Mean ±SD
Reef crest	Pelican Shoal	71.9±11.9	75.2±6.6	73.9±9.0
	Eastern Sambo SUA	75.2±10.7	77.2±9.6	76.4±10.0
	Middle Sambo	82.8±15.2	78.5±10.1	80.2±12.4
	Western Sambo ER	78.1±15.5	78.6±7.2	78.3±12.0
Patch reef	Pelican Shoal	62.9±15.8	63.7±14.5	63.1±15.3
	Western Sambo ER	71.0±21.2	75.2±11.8	73.6±16.0
Outlier reef	Western Sambo	82.3±9.6	78.3±5.5	79.7±7.3
	Overall	73.7±16.3	76.1±9.9	

Table 6. 2010 Number of transect (500m2) surveys conducted by region (note: Patch reef transects were stratified equally into 10 top and 10 side transects).

		Habitat		
Region **(Bold = reserve)**	Reef crest	Outlier reef	Patch reef	Total
Pelican Shoal	20		20	40
Eastern Sambo (SUA)	20			20
Middle Sambo	20			20
Western Sambo (ER)	19		20	39
Western Sambo		20		20
Total	79	20	40	139

Table 7. Results of multiple t-tests comparing mean size (CL) of male and female lobsters. Although none of the results are significant, females are larger than males in *italicized* locations.

Location(**bold = reserve**)	t	df	Sig. (2 tailed)	Mean difference
Pelican Shoal reef crest	*-1.23*	*31.68*	*0.229*	*3.3*
Eastern Sambo SUA reef crest	-0.74	53.00	0.461	2.0
Middle Sambo reef crest	1.28	54.00	0.206	4.3
Western Sambo ER reef crest	*-0.14*	*39.67*	*0.888*	*0.5*
Pelican Shoal patch	*-0.17*	*52.00*	*0.864*	*0.8*
Western Sambo ER patch	*-0.93*	*34.52*	*0.361*	*4.2*
Western Sambo outlier reef	1.63	22.78	0.116	4.0

Table 8. Number of lobsters per 500m^2.

		Habitat		
Region **(Bold = reserve)**	Reef crest Mean±SD	Outlier reef Mean±SD	Patch reef Mean±SD	Overall Mean±SD
Pelican Shoal	1.85±1.69		1.75±3.51	1.80±2.72
Eastern Sambo (SUA)	3.30±3.13			3.30±3.13
Middle Sambo	2.55±4.97			2.55±4.97
Western Sambo (ER)	2.00±2.33		2.16±2.27	2.00±2.24
Western Sambo		0.75±1.07		0.75±1.07
Total	2.43±3.27	0.75±1.07	1.95±2.94	2.28±2.42