

Queen Conch Monitoring

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Goal

Effective evaluation of the Florida Keys National Marine Sanctuary marine zoning plan requires a well-conceived monitoring study to compare resources in fully protected marine zones (FPMZs) and reference areas. The goal of this project is to determine effects of FPMZs on the density, abundance, and area occupied by queen conch in the FKNMS. We surveyed queen conch aggregations by conducting belt-transect surveys at offshore reef aggregations within Sanctuary Preservation Areas (SPAs) and Special Use (Research Only) Areas. Additionally, reef areas without protective status were surveyed (reference areas). Aggregations were surveyed for juvenile and adult density, abundance, and overall aggregation size in order to evaluate patterns of abundance and recruitment. The results from these surveys will also be used to evaluate the effectiveness of the marine reserve concept as a means for protecting and restoring the Florida conch population to historic numbers. This is the sixth annual report on the results of these surveys.

Methods

Sampling occurred between May and October 2002 in order to ensure that the surveys were conducted during the period of maximal density associated with spawning. The surveys were conducted at FPMZ reef locations as well as reefs without restrictions (i.e., reference areas; Fig. 1). In many cases, the only conch aggregations at FPMZ reefs were located outside protected area boundaries. We defined aggregations as discernible clusters of adult and/or juvenile conch.

An initial survey of each site was made to determine the presence of conch, the approximate size of the aggregation, and an apical edge beyond which conch were infrequent or not observed. If a conch aggregation was estimated to be greater than approximately 100 m in length, a 100-m fiberglass tape (primary tape) was affixed at an apex and was deployed along the margin of the aggregation. Five secondary tapes (i.e., belts) were laid perpendicular to the primary tape at random intervals along the primary tape. Divers then recorded all conch within 1 m of each side of the belts. Densities were determined by dividing the number of conch counted by the area surveyed. Regional (i.e., Upper, Middle, and Lower Keys) and overall (i.e., Keys-wide) densities were calculated using all individuals sampled in the year divided by the total area sampled. Aggregations were mapped to determine overall abundance; we used GPS data to determine the periphery of aggregations. The area encompassed by each aggregation was estimated using ArcView GIS software.

In areas where conch were very sparse, direct counts were made of individuals and belts were not conducted. The counts of individual conch were used to estimate abundance for the aggregation, region, and overall Keys. However, these observations were not included in the subsequent calculations of regional and overall density because densities were not measured.

We examined the overall aggregation area, adult abundance, juvenile abundance, adult density, and juvenile density as a means to evaluate changes in FPMZs and reference areas. Two-way ANOVAs were used to compare FPMZs and reference areas over the period of record (i.e., 1997 to 2002). In addition, one-way ANOVAs were used to determine if there were differences in aggregation area, adult abundance, juvenile abundance, adult density, and juvenile density among regions of the Florida Keys.

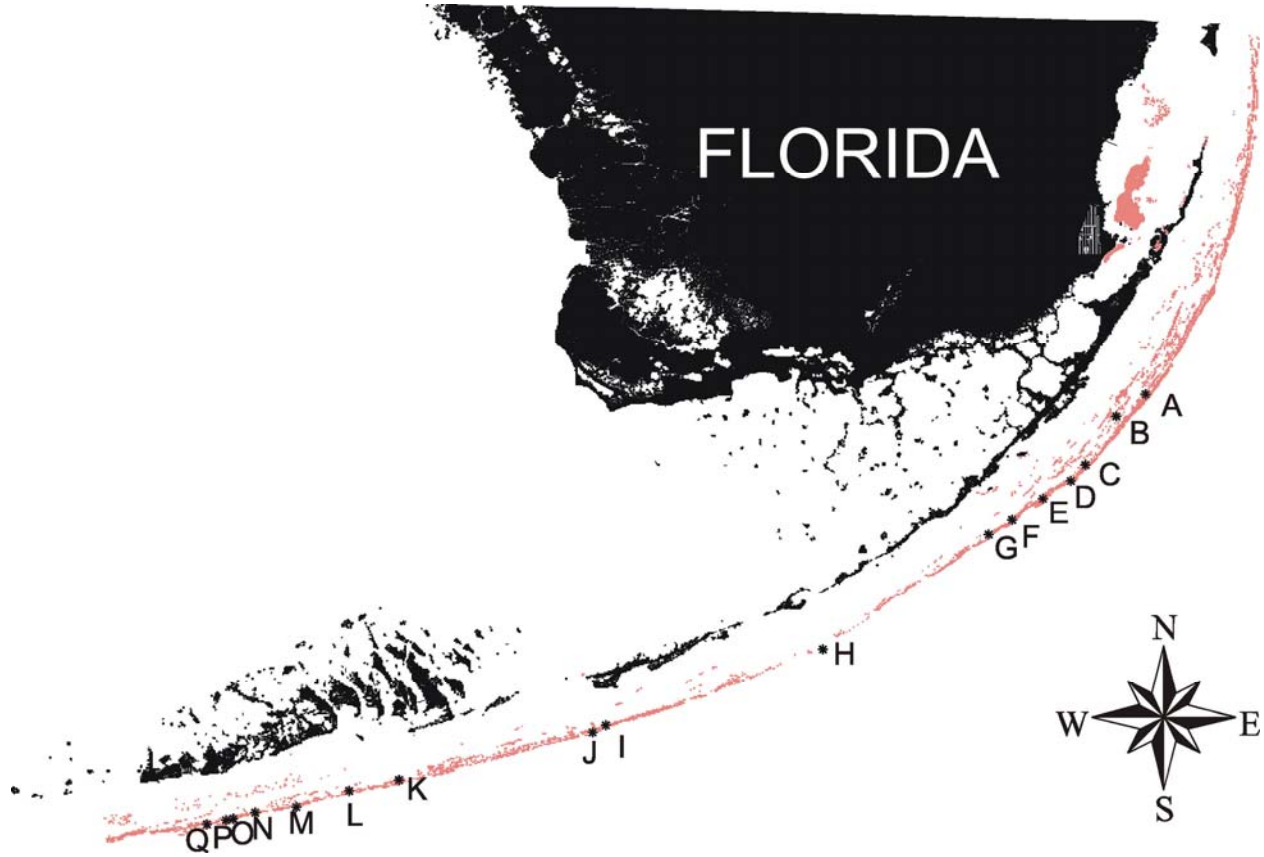


Figure 1. Sampling sites for queen conch monitoring project for 2002. The belt-transect sites included: (A) The Elbow SPA, (B) Grecian Rocks SPA, (C) French Reef SPA, (D) Sand Reef Ref., (E) Molasses Reef SPA, (F) Pickles Reef Ref., (G) Conch Reef SPA, (H) Alligator Reef SPA, (I) Delta Shoals Ref., (J) Sombrero Reef SPA, (K) Looe Key SPA, (L) American Shoal Ref., (M) Pelican Shoal Ref., (N) Eastern Sambo R-OA, (O) Middle Sambo Ref., (P) Western Sambo ER, and (Q) Eastern Dry Rocks SPA.

Findings to Date

A total of 27 aggregations were surveyed at 17 sites (Fig. 1). Densities were measured at 20 conch aggregations and direct counts were conducted at the other seven aggregations. In many cases, conch aggregations were located outside the boundaries of FPMZs.

Juvenile densities ranged from 0.000 individuals•m⁻² at an adult-only aggregation at Conch Reef to a maximum of 0.649 individuals•m⁻² at the Elbow (Tables 1-3). Excluding Conch Reef, where no juveniles were found within the belts, the lowest density of juveniles at an aggregation was at Eastern Dry Rocks where 0.001 individuals•m⁻² were observed (Tables 1-3). The highest abundance of juvenile conch by far was observed at the Elbow in the Upper Keys; approximately 12,102 juveniles were estimated to be present (Table 1). This one site alone had over a third of the total number of juveniles seen in the Florida Keys (Tables 1 and 4).

Table 1. Results of queen conch belt-transect surveys conducted in the Upper Keys at the beginning of the study (1997) and in 2002. Densities are reported in individuals•m⁻². Areas are for areas encompassed by the aggregations and are reported in m². The mean values reported for overall juvenile and adult densities were derived from the entire data set and not by averaging the mean densities of each aggregation.

Upper Keys										
SPA										
Site	Juv Abund (1997)	Juv Abund (2002)	Juv Density (1997)	Juv Density (2002)	Adult Abund (1997)	Adult Abund (2002)	Adult Density (1997)	Adult Density (2002)	Area (1997)	Area (2002)
Carysfort Reef	0	-	0.000	-	0	-	0.000	-	0	-
The Elbow	3,373	12,102	0.062	0.649	1,214	771	0.022	0.041	54,526	18,654
Key Largo Dry Rocks	0	-	0.000	-	0	-	-	-	0	-
Grecian Rocks	472	1,910	0.063	0.135	236	1,815	0.032	0.128	7,445	14,136
French Reef	56	10	0.003	-	992	55	0.054	-	18,422	-
Molasses Reef	130	1,235	0.006	0.074	2,152	1,407	0.105	0.084	20,480	16,732
Conch Reef	72	4	0.006	0.000	350	606	0.029	0.095	11,881	6,159
Mean			0.028	0.189			0.048	0.080		
Total	4,103	15,261			4,944	4,654			112,754	55,681
Reference										
Pickles	0	76	0.000	0.008	576	645	0.073	0.071	7,851	9,078
Mean			0.000	0.008			0.073	0.071		
Total	0	76			576	645			7,851	9,078
Overall - Upper Keys										
Mean			0.031	0.144			0.046	0.078		
Total	4,103	15,337			5,520	5,299			120,605	64,759

The Upper Keys had the highest juvenile conch densities with 0.144 juveniles•m⁻² (Table 1). The Middle Keys had similar juvenile densities with 0.135 juveniles•m⁻² (Table 2). The Lower Keys had the lowest densities (0.045 juveniles•m⁻², Table 3). Estimated regional abundance for juvenile conch ranged from approximately 15,337 individuals in the Upper Keys to 6,400 in the

Middle Keys (Tables 1 & 2). Like the Upper Keys, most of the juveniles in the Middle Keys were located at one site, Delta Shoal (Table 2). The Lower Keys had an estimated 12,322 juveniles, spread fairly evenly among seven sites (Table 3).

Table 2. Results of queen conch belt-transect surveys conducted in the Middle Keys at the beginning of the study (1997) and in 2002. Densities are reported in individuals•m⁻². Areas are for areas encompassed by the aggregations and are reported in m². The mean values reported for overall juvenile and adult densities were derived from the entire data set and not by averaging the mean densities of each aggregation.

Middle Keys										
SPA										
Site	Juv Abund (1997)	Juv Abund (2002)	Juv Density (1997)	Juv Density (2002)	Adult Abund (1997)	Adult Abund (2002)	Adult Density (1997)	Adult Density (2002)	Area (1997)	Area (2002)
Alligator Reef	48	107	0.010	-	86	59	0.018	-	4,791	-
Sombrero Key	4	870	-	0.045	0	659	-	0.034	-	19,384
Mean			0.01	0.045			0.018	0.034		
Total	52	977			86	718			4,791	19,384
Reference										
Delta Shoal	33	5,423	0.012	0.226	77	884	0.028	0.037	2,699	23,992
Mean			0.012	0.226			0.028	0.037		
Total	33	5,423			77	884			2,699	23,992
Overall - Mid Keys										
Mean			0.011	0.135			0.021	0.035		
Total	85	6,400			163	1,602			7,490	43,376

Adult conch density was highest at Eastern Sambo (0.129 adults•m⁻², Table 3) and was lowest at Sombrero Reef (0.034 adults•m⁻², Table 2). The highest estimated abundance was at Eastern Sambo with an estimated 12,560 adults (Table 3), representing over 40% of the total number of adult conch found in the Florida Keys. Of the sites where adult conch were surveyed within belt transects, Conch Reef had the lowest abundance with an estimated 606 conch present (Table 1). The region with the most adults by far was the Lower Keys (approximately 23,640) followed by the Upper Keys (approximately 5,299) and the Middle Keys (approximately 1,602) (Tables 1-3).

Table 3. Results of queen conch belt-transect surveys conducted in the Lower Keys at the beginning of the study (1997) and in 2002. Densities are reported in individuals•m⁻². Areas are for areas encompassed by the aggregations and are reported in m². The mean values reported for overall juvenile and adult densities were derived from the entire data set and not by averaging the mean densities of each aggregation.

Lower Keys										
SPA										
Site	Juv Abund (1997)	Juv Abund (2002)	Juv Density (1997)	Juv Density (2002)	Adult Abund (1997)	Adult Abund (2002)	Adult Density (1997)	Adult Density (2002)	Area (1997)	Area (2002)
Looe Key	1,349	2,484	0.021	0.063	2,501	939	0.049	0.042	56,451	29,076
Eastern Sambo	773	4,230	0.018	0.047	4,348	12,560	0.101	0.129	42,903	91,134
Western Sambo	411	1,190	0.008	0.026	2,765	2,285	0.055	0.049	50,252	46,460
Eastern Dry Rocks	2	19	-	0.001	21	991	-	0.062	-	15,967
Mean			0.016	0.042			0.066	0.092		
Total	2,535	7,923			9,635	16,775			149,606	182,637
Reference										
American Shoal	69	121	0.007	0.012	617	634	0.062	0.061	10,010	10,466
Pelican Shoal	2,455	3,399	0.061	0.075	944	1,835	0.023	0.047	40,533	48,005
Middle Sambo	767	879	0.014	0.035	3,987	4,396	0.072	0.174	55,370	25,277
Mean			0.030	0.051			0.054	0.078		
Total	3,291	4,399			5,548	6,865			105,913	83,748
Overall - Lower Keys										
Mean			0.023	0.045			0.060	0.088		
Total	5,826	12,322			15,183	23,640			255,519	266,385

The four aggregations at Eastern Sambo covered the most area; the extent of these aggregations was estimated to be 91,134 m² (Table 3). The three aggregations at Pelican Shoal encompassed 48,005 m² (Table 3). The single largest aggregation was at Western Sambo (46,460 m², Table 3). The Lower Keys region had the most area encompassed by conch aggregations (266,385 m², Table 3).

We estimated that there were approximately 30,541 adult conch within the offshore aggregations during 2002 (Table 4). In 1997, we estimated that there were approximately 20,866 adult conch (Table 4). We estimated that there were approximately 34,059 juveniles in the study area in 2002 compared with 10,014 in 1997 (Table 4).

Table 4. Summary of queen conch belt-transect surveys conducted in the Florida Keys in 2002.

	Juv Abund (1997)	Juv Abund (2002)	Juv Density (1997)	Juv Density (2002)	Adult Abund (1997)	Adult Abund (2002)	Adult Density (1997)	Adult Density (2002)	Area (1997)	Area (2002)
Mean			0.025	0.074			0.055	0.080		
Total	10,014	34,059			20,866	30,541			383,614	374,520

Two-way ANOVAs indicated that there were no significant differences between FPMZs and reference areas over the period of record for adult density (two-way ANOVA: $F_{\text{btwn SPA/reference}} = 0.08$, $P = 0.790$; $F_{\text{among years}} = 0.48$, $P = 0.781$), adult abundance (two-way ANOVA: $F_{\text{btwn SPA/reference}} = 2.91$, $P = 0.114$; $F_{\text{among years}} = \mathbf{7.16}$, $P = \mathbf{0.025}$), juvenile density (two-way ANOVA: $F_{\text{btwn SPA/reference}} = 1.66$, $P = 0.241$; $F_{\text{among years}} = \mathbf{20.01}$, $P = \mathbf{0.003}$), juvenile abundance (two-way ANOVA: $F_{\text{btwn SPA/reference}} = 0.02$, $P = 0.900$; $F_{\text{among years}} = \mathbf{12.50}$, $P = \mathbf{0.007}$), and aggregation area (two-way ANOVA: $F_{\text{btwn SPA/reference}} = 2.99$, $P = 0.132$; $F_{\text{among years}} = \mathbf{11.14}$, $P = \mathbf{0.010}$) (Fig. 2-4). However, there were significant differences in adult abundance, juvenile density, juvenile abundance, and aggregation area over time (indicated in **bold** above) (Fig. 2-4). None of the ANOVAs had any significant interactions.

A comparison among regions during 2002 indicated that there were no significant differences in adult density (one-way ANOVA: $F_{\text{among regions}} = 1.05$, $P = 0.381$), adult abundance (one-way ANOVA: $F_{\text{among regions}} = 0.90$, $P = 0.427$), juvenile density (one-way ANOVA: $F_{\text{among regions}} = 1.00$, $P = 0.401$), juvenile abundance (one-way ANOVA: $F_{\text{among regions}} = 0.24$, $P = 0.790$), and aggregation area (one-way ANOVA: $F_{\text{among regions}} = 2.27$, $P = 0.150$) (Fig. 5-7).

Discussion

The results of the sixth year of queen conch monitoring support those of earlier years: conch are recovering, albeit slowly, and aggregations are distributed in well-defined clusters that, in general, are not entirely encompassed by FPMZ boundaries. Additionally, many sites now have more than one aggregation, notably Eastern Sambo and Pelican Shoal. Conch are also distributed in marked regional patterns. For example, the Lower Keys region from Looe Key to Eastern Dry Rocks is a complex containing approximately 23,000 of the 30,000 adults located throughout the Keys. There were relatively few adult conch in the Middle Keys; however, the approximately 1,600 adults surveyed were a dramatic increase for the region. This increase was due to a large cohort of juveniles that recruited in 2000 and 2001 (Fig. 3) and have begun to reach maturity.

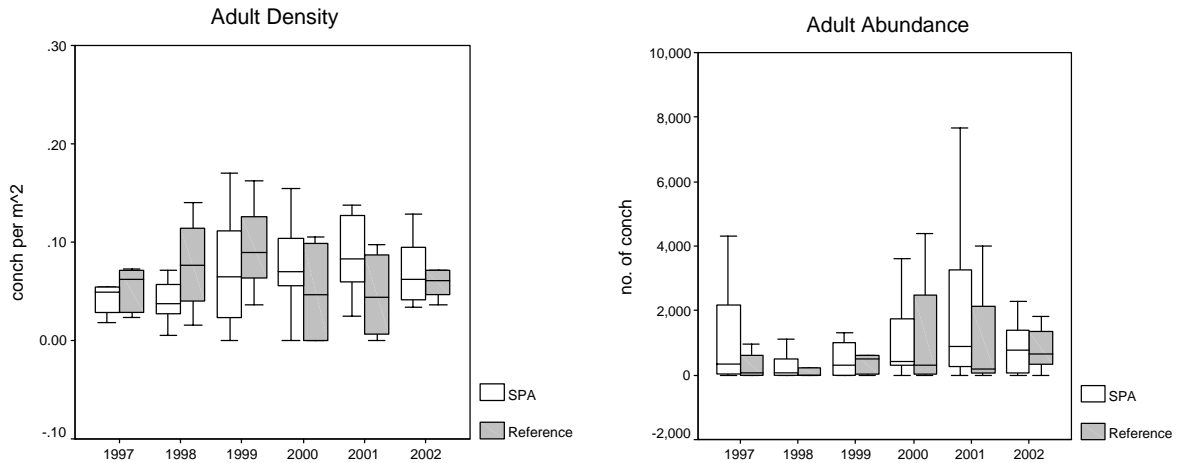


Figure 2. Box plots of the density and abundance of adult queen conch by protective status (i.e., SPA and reference areas) in the Florida Keys. The box represents the 25th and 75th percentiles. The horizontal line within the box indicates the median. The error bars represent the 10th and 90th percentiles.

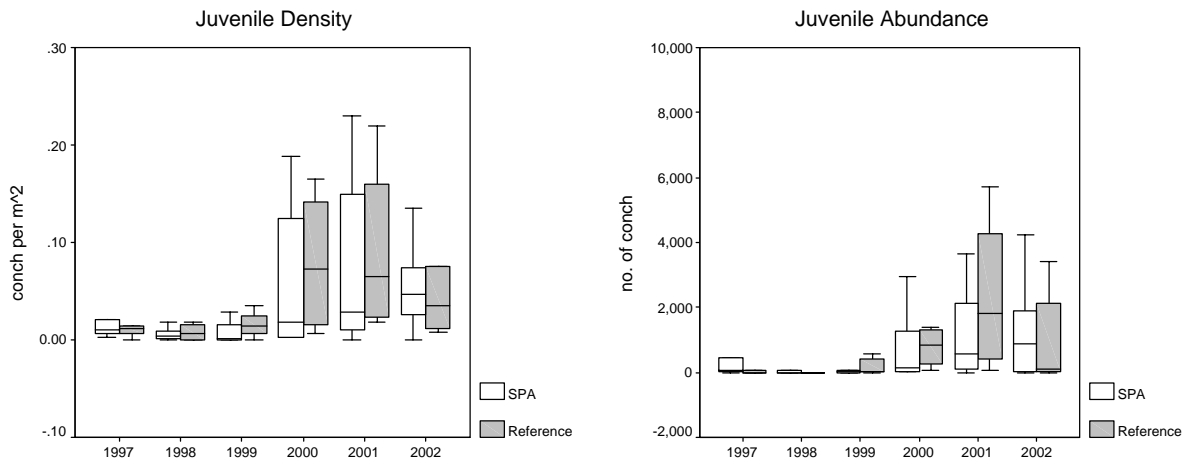


Figure 3. Box plots of the density and abundance of juvenile queen conch by protective status (i.e., SPA and reference areas) in the Florida Keys. The box represents the 25th and 75th percentiles. The horizontal line within the box indicates the median. The error bars represent the 10th and 90th percentiles.

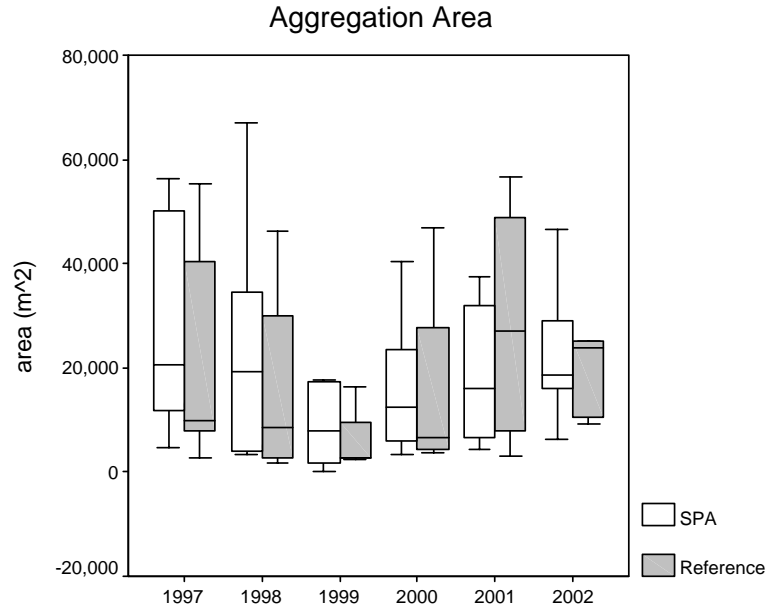


Figure 4. Box plot of queen conch aggregation area by protective status (i.e., SPA and reference areas) in the Florida Keys. The box represents the 25th and 75th percentiles. The horizontal line within the box indicates the median. The error bars represent the 10th and 90th percentiles.

We expect that the number of adult conch in the Middle Keys will continue to increase next year. Overall, adult abundance has increased from 1997 to 2002 while density has remained relatively stable during recent years (Fig. 2).

There was a large amount of recruitment in 2002 - not as much as in 2000 or 2001, but noticeably higher than from 1997 through 1999 (Fig. 3). In the Upper Keys, juvenile abundance increased from about 10,000 in 2001 to 15,000 in 2002. In the Middle Keys, juvenile abundance has remained fairly even over the last two years. In the Lower Keys, juvenile abundance has also increased to nearly match the number seen in the Upper Keys. This was due to the identification of new conch aggregations. We expect that as long as recruitment remains high and the population continues to increase, we will continue to find new aggregations next year as conch move into previously unoccupied areas.

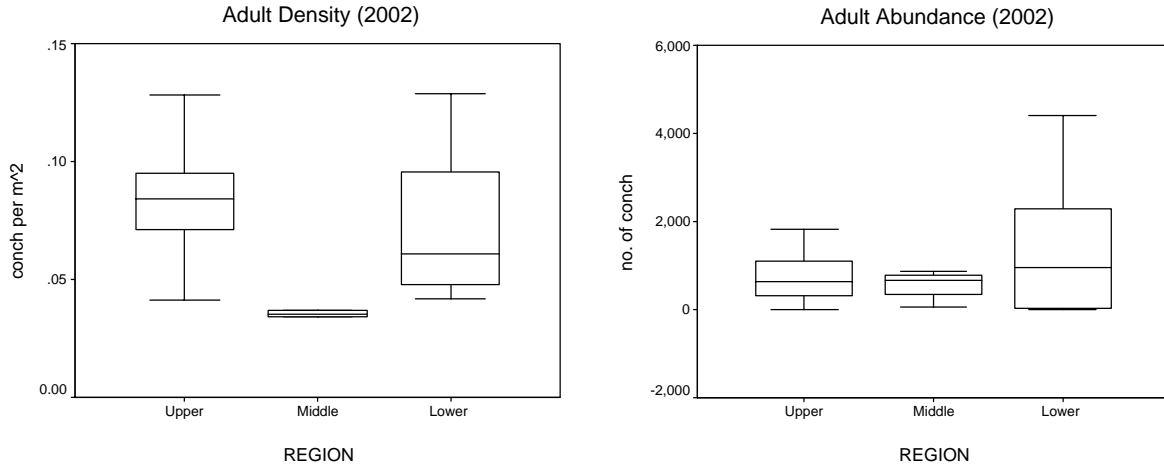


Figure 5. Box plots of the density and abundance of adult queen conch in 2002 by region in the Florida Keys. The box represents the 25th and 75th percentiles. The horizontal line within the box indicates the median. The error bars represent the 10th and 90th percentiles.

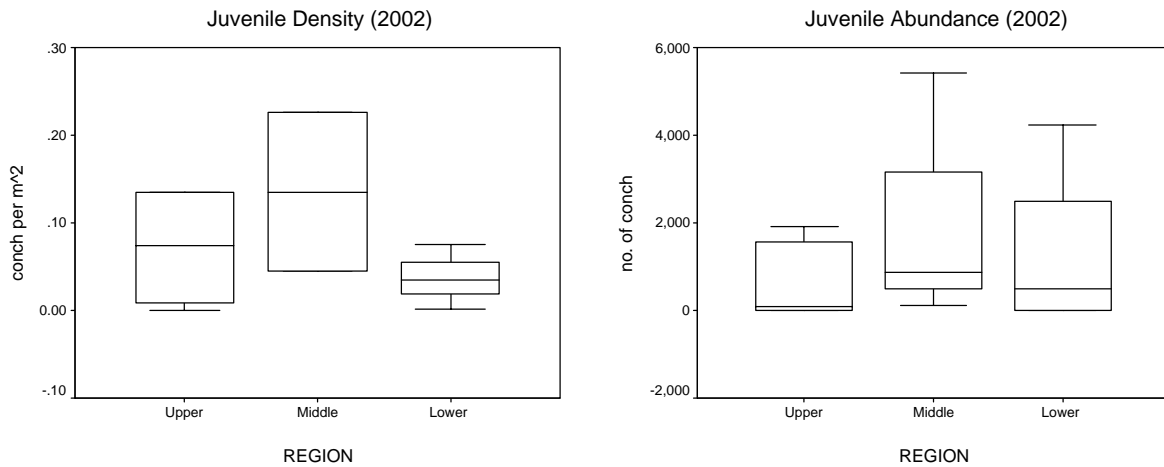


Figure 6. Box plots of the density and abundance of juvenile queen conch in 2002 by region in the Florida Keys. The box represents the 25th and 75th percentiles. The horizontal line within the box indicates the median. The error bars represent the 10th and 90th percentiles.

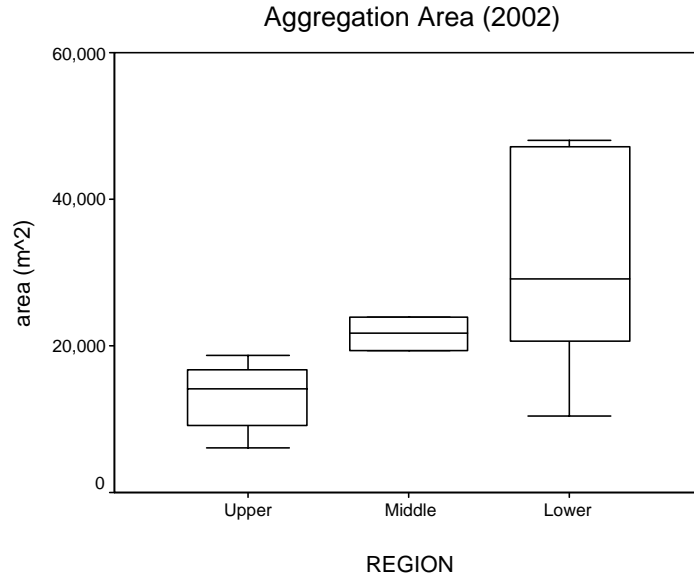


Figure 7. Box plot of queen conch aggregation area in 2002 by region in the Florida Keys. The box represents the 25th and 75th percentiles. The horizontal line within the box indicates the median. The error bars represent the 10th and 90th percentiles.