M/V Wellwood Grounding Restoration Fish Assemblage Monitoring Year 1 Report

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Executive Summary

Under contract with National Oceanic and Atmospheric Administration (NOAA) to evaluate the effect of restoration on the fish assemblages at the *Wellwood* grounding site in the Florida Keys, the Reef Environmental Education Foundation (REEF) conducted 267 roving fish surveys and 246 belt transect surveys during the first year of a five year monitoring project. Surveys were conducted at the *Wellwood* Restoration Site and two nearby Reference Sites. Total species richness at each site during Year1 surveys was 145 at the Restoration Site, 165 at the North Reference and 176 at the South Reference. Average species richness per monitoring event was 83 at the Restoration Site, 119 at the North Reference and 125 at the South Reference. The top 25 species from each of the reference sites were also recorded at the Restoration Site; however there were several species of grunt and snapper that were in high abundance at the reference sites that were rare at the Restoration site. The average size of surgeonfish and parrotfish increased over time at the Restoration Site. The proportion of surgeonfish at the Restoration Site greater than 20cm, increased to 17% after one year, up from 4% in the months immediately following restoration. Similarly, while large parrotfish were rare during the first 5 monitoring events, 23% of the individuals recorded at the Restoration Site during the July 2003 (one year) effort were greater than 30cm.

Background


Figure 1. The *M/V Wellwood* aground on Molasses Reef. Photo courtesy of the FKNMS

The *M/V Wellwood*, a 122-meter Cypriot-registered freighter, ran aground on August 4, 1984, on Molasses Reef off Key Largo, Florida (Figure 1). The ship impacted the reef's upper forereef and remained aground for 12 days. The grounding destroyed 1,285 square meters of living corals and injured 644 square meters of coral reef framework. Prior to the grounding, the area was a transition zone with high relief coral formations. The grounding transformed the area into a flattened, barren pavement covered with coral rubble.

Between 1986 and the present, several monitoring efforts have been conducted to document the recovery and status of the impact area. While most of the monitoring focused on the benthic condition, two studies have included the fish assemblage (Dennis and Bright 1990 and NURC 1997).

Nineteen years after the grounding, the area resembles nearby hard ground habitat with little structure and the benthic community is dominated by gorgonians (Gittings 2002). Natural recovery to a state similar to the pre-grounding condition is unlikely within a reasonable time frame. In an effort to restore habitat structure and stability to the grounding site, habitat restoration was initiated in May 2002. Limestone reef modules were placed in the injured area to provide substrate for new coral colonization.

The Reef Environmental Education Foundation (REEF) is a 501 (c)(3) non-profit organization dedicated to protecting the marine environment. REEF coordinates the Fish Survey Project, an ongoing effort that enables volunteer divers to collect fish sighting information during recreational dives. The project originated in 1993, and to date has gathered more than 62,000 surveys throughout the Caribbean, Gulf of Mexico, west coast of the US and Canada, the tropical eastern Pacific, and Hawaii. The focus of the Fish Survey Project is on training divers to collect fish data, and then managing this information, including annual reporting and website display. In the Summer of 2002, REEF was contracted by the National Marine Sanctuary Program to begin a long-term monitoring project on the fish assemblages at the *Wellwood* grounding site and two references areas. This project is set to run for 5 years, with quarterly monitoring in Year 1 and yearly monitoring for Years 2 through 5. This will provide temporal documentation of fish composition changes over time. The value of the information collected during this project will specifically aid in the assessment of restoration sites as effective replacements for natural habitat.

This report includes a summary and analysis of data collected by REEF during Year 1 (May 2002 – July 2003).

Study Area

The study area of this project included a portion of the grounding area that is being restored and two adjacent reference sites (Figure 2). The restoration area surveyed included restoration modules and contiguous low profile hardbottom areas adjacent to and in between the restoration modules. Nearby high profile reef, ledges, and undamaged/unrestored reef were not included as part of the Restoration Site (Figures 3, 4).

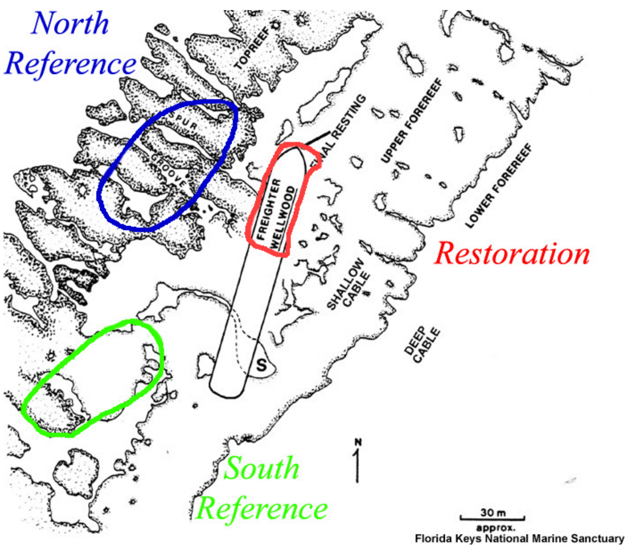

Figure 2. Location map showing areas of fish monitoring effort.

The reference sites were chosen to include areas that were closest in proximity to the grounding area while remaining undamaged and unrestored. It is anticipated that these sites will allow seasonal and temporal comparisons and will serve as a benchmark to measure and compare change over time at the Restoration Site. The reference areas were within nominal distance (25-75m) from the restoration area and all three sites could be visited during a normal recreational dive.

Figure 3. A bathymetric map showing the placement of the restoration modules. The area within the red line denotes the area surveyed; high profile, undamaged areas were avoided.

The North Reference site was slightly shoreward of the restoration area and was comprised of unimpacted high profile spur and grove reef areas. Depth was similar to the restored area.

The South Reference site was located SSE of the Restoration Site and was composed of both high relief spur and groove as well as hard bottom structure (Figure 5). Depth of this site was similar to that of the other two sites; however, it was slightly deeper at the base of the spurs than that of the Restoration Site.

Figure 4. The Restoration Site, with several restoration modules in view. This picture was taken in October 2002.

Figure 5. A large school of snapper and grunt at the South Reference site.

Method

A team of Advanced Assessment Team REEF Experts conducted Roving Diver Technique (RDT; Schmitt and Sullivan 1996) and belt transect surveys on the *Wellwood* restoration site and two adjacent natural reef sites seven times during Year 1 (Figure 2). The team visited the sites once prior to restoration (May 2002) and 6 times after restoration was complete- monthly for the first three months and quarterly for the following three quarters. An average of 12 surveys of each survey type were conducted during each survey effort.

The RDT is a non-point survey method and involves divers moving freely about a defined survey area of no more than 100 m radius. During a survey dive, all positively identified fish species are recorded. Cumulative log scale abundances of each species are also estimated during the dive and updated at the conclusion of the dive. Categories of abundance are Single (1), Few (2-10), Many (11-100), and Abundant (> 100). Each RDT survey is approximately 60 minutes, depending on safe diving limits. The RDT methodology provides a detailed species list and an estimate of categorical abundance.

Figure 6. A REEF AAT member conducting a visual belt transect at the Restoration Site.

In order to document size frequency shifts and more quantitative shifts in density of key taxa, belt transects were conducted (Figure 6). The AGRRA protocol for fish transects was followed (AGRRA 2001). The transect locations were randomly selected. The diver swims the length of the belt transects (2 m x 30 m) and records all species of the following groups: grouper (Serranidae), snapper (Lutjanidae), grunt (Haemulidae), parrotfish (Scaridae), surgeonfish (Acanthuridae), leatherjacket (Balistidae), angelfish (Pomacanthidae), butterflyfish (Chaetondontidae), and five additional species: yellowtail damselfish (*Microspathodon chrysurus*), hogfish (*Lacholaimus maximus*), Spanish hogfish (*Bodianus rufus*), barracuda

(*Sphyraena barracuda*) and bar jack (*Caranx ruber*). The size of each fish is estimated and assigned to a size category (<5 cm, 5-10, 10-20, 20-30, 30-40, >40 cm) using a 50 cm bar with 5 and 10 cm increments for scale. Grunts and parrotfishes less than 5 cm in length are not recorded.

Year 1 Results

A total of 267 RDT surveys and 246 belt transects were conducted by the REEF team during Year 1 (Table 1). The May 2002 effort was conducted prior to the installation of the restoration modules. Without the modules as a reference, the team had some difficulty defining the Restoration Site boundaries and some surveys during this effort probably included portions outside of the damaged area. Because of this, the August 2002 data is the best representation of the baseline condition.

Table 1. REEF monitoring effort during Year 1.

		May 2002	August 2002	September 2002	October 2002	January 2003	April 2003	July 2003
Restoration Site	RDT	12	12	12	16	9	12	16
25.0105N, 80.3728W	Transects	10	12	12	12	12	12	12
North Reference Site	RDT	12	12	12	15	10	12	16
25.0112N, 80.373W	Transects	10	12	12	12	12	12	12
South Reference Site	RDT	12	12	12	15	10	12	16
25.0102N, 80.3733W	Transects	10	12	12	12	12	12	12

All RDT data were processed and loaded into REEF's database. Data summaries by site for each monitoring effort are available online through the REEF Wellwood Project page (http://www.reef.org/data/wellwood.htm).

The RDT data provide a relatively complete inventory of fishes for each of the three study sites. Total species richness, based on all RDT surveys conducted during Year 1 (n=89 at each site), was 145 (Restoration Site), 165 (North Reference), and 176 (South Reference). To estimate species richness for each monitoring event, it was necessary to compensate for uneven effort between monitoring efforts. Species accumulation curves were generated using Monte Carlo randomization (1,000 runs) and the Michaelis Menten Mean estimator was used to estimate richness based on 9 surveys (the minimum number of surveys during a given effort). Richness estimates by site and monitoring effort are shown in Figure 7. At all three sites, richness was lower during the September 2002 event and again during the winter months of 2003. Richness was consistently lowest at the Restoration Site. The relatively high number of species reported at the Restoration Site during May 2002 was probably due to the lack of defined boundaries prior to the installation of the modules and therefore likely contains species that were sighted outside of the damaged area. Average post-restoration species richness per event (excluding the May 2002 data) was 83 (Restoration Site), 119 (North Reference), and 125 (South Reference).

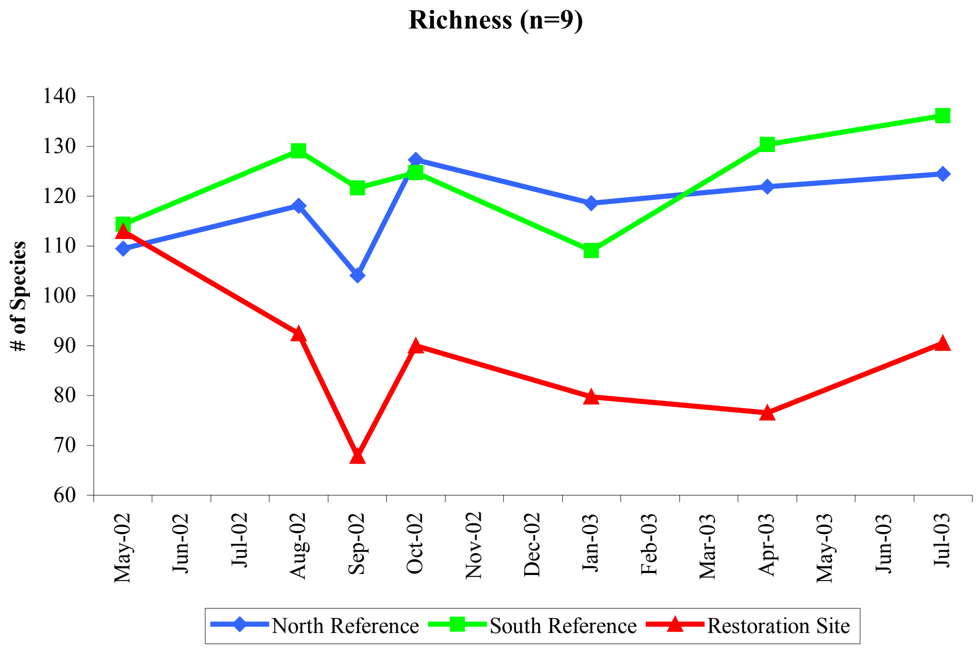

Figure 7. Species richness estimates, based on 9 RDT surveys. Estimates are based on species accumulation curves.

Using all RDT data collected post-restoration during Year 1, the 25 most frequent species for each site were compiled (a total of 38 species). Table 2 compares the dominant species at each site, listing the abundance score. Several species that were high in abundance at the reference sites were rare at the Restoration Site, including several grunts and snappers.

The biomass of fish taxa recorded during the visual transects was lower at the Restoration Site than at either reference site (Figure 8). Winter attrition was evident at all three sites (Figure 8). Densities of the four major families are given in Table 3. As noted previously, snapper and grunt, families that dominated the two reference sites, were essentially absent from the Restoration Site. The Restoration Site transects were dominated by herbivorous parrotfish and surgeonfish; these families were present in similar abundances at the reference sites. Grouper, angelfish, and butterflyfish were rarely documented during transect surveys (although certain species of butterflyfish and angelfish were frequently sighted during the RDT surveys; Table 2).

The size frequency distributions of parrotfish and surgeonfish during each of the monitoring events are shown in Figures 9 and 10. On average, fish were smaller at the Restoration Site than at either of the reference sites. Surgeonfish were slightly larger at South Reference (77% were larger than 10cm vs. 66% and 58% at North Reference and Restoration Site, respectively), whereas parrotfish were larger at North Reference (57% were larger than 20cm vs. 48% and 36% at North Reference and Restoration Site, respectively). The average size of surgeonfish and parrotfish increased over time at the Restoration Site. The proportion of surgeonfish greater than 20cm increased to 17% one year after habitat restoration, up from an average of 4% in the months immediately following restoration. Similarly, while large parrotfishes were rare during the first five monitoring efforts, 23% of the individuals documented at the Restoration Site during the July 2003 effort were greater than 30cm.

Table 2. The 25 most frequently sighted species at each site. Abundance score*, based on post-restoration RDT data collected during Year 1 (August 2002 – July 2003) of the project (n=77 at each site), is shown. The species list is ranked according to the Restoration Site abundance score.

Common Name	Scientific Name	Restoration Site	North Reference	South Reference
Bluehead	*Thalassoma bifasciatum*	3.61	3.70	3.56
Bicolor Damselfish	*Stegastes partitus*	3.55	3.65	3.71
Sergeant Major	*Abudefduf saxatilis*	3.00	3.27	3.32
Clown Wrasse	*Halichoeres maculipinna*	2.87	2.75	2.46
Ocean Surgeonfish	*Acanthurus bahianus*	2.85	2.98	2.85
Striped Parrotfish	*Scarus croicensis*	2.66	2.64	2.53
Blue Tang	*Acanthurus coeruleus*	2.63	2.86	2.70
Redband Parrotfish	*Sparisoma aurofrenatum*	2.60	2.86	2.66
Yellowtail Snapper	*Ocyurus chrysurus*	2.59	2.98	3.06
Yellowhead Wrasse	*Halichoeres garnoti*	2.57	2.56	2.73
Stoplight Parrotfish	*Sparisoma viride*	2.50	3.00	2.80
Blue Chromis	*Chromis cyanea*	2.22	2.53	2.50
Doctorfish	*Acanthurus chirurgus*	1.84	1.87	1.81
Bar Jack	*Caranx ruber*	1.81	1.60	1.91
Goldspot Goby	*Gnatholepis thompsoni*	1.79	1.11	1.14
Yellowtail Damselfish	*Microspathodon chrysurus*	1.73	2.57	2.50
Yellowtail Parrotfish	*Sparisoma rubripinne*	1.70	1.82	1.61
Roughhead Blenny	*Acanthemblemaria aspera*	1.65	1.31	1.14
Spotfin Butterflyfish	*Chaetodon ocellatus*	1.53	1.51	1.69
Bridled Goby	*Coryphopterus glaucofraenum*	1.52	1.19	1.44
Slippery Dick	*Halichoeres bivittatus*	1.52	2.21	1.76
Queen Parrotfish	*Scarus vetula*	1.51	2.14	2.02
Harlequin Bass	*Serranus tigrinus*	1.51	1.68	1.83
Princess Parrotfish	*Scarus taeniopterus*	1.45	1.48	1.82
Sharpnose Puffer	*Canthigaster rostrata*	1.42	1.69	2.00
Bermuda/Yellow Chub	*Kyphosus sectatrix/incisor*	1.32	2.67	2.83
French Grunt	*Haemulon flavolineatum*	1.32	2.55	2.66
Puddingwife	*Halichoeres radiatus*	1.17	2.14	1.90
White Grunt	*Haemulon plumieri*	1.13	2.21	2.57
Creole Wrasse	*Clepticus parrae*	1.01	2.52	2.93
Bluestriped Grunt	*Haemulon sciurus*	0.52	3.31	3.51
Brown Chromis	*Chromis multilineata*	0.29	2.55	2.91
Smallmouth Grunt	*Haemulon chrysargyreum*	0.16	2.78	3.38
Caesar Grunt	*Haemulon carbonarium*	0.13	2.36	2.37
Gray Snapper	*Lutjanus griseus*	0.06	2.22	3.41
Schoolmaster	*Lutjanus apodus*	0.05	0.88	2.66
Yellow Goatfish	*Mulloidichthys martinicus*	0.04	1.78	3.10
Glassy Sweeper	*Pempheris schomburgki*	0.04	2.30	2.31

*Abundance Score = $[(n_S x1)+(n_F x2)+(n_M x3)+(n_A x4)] / (n_S + n_F + n_M + n_A)$ * percent sighting frequency, where n is the number of times each abundance category was assigned

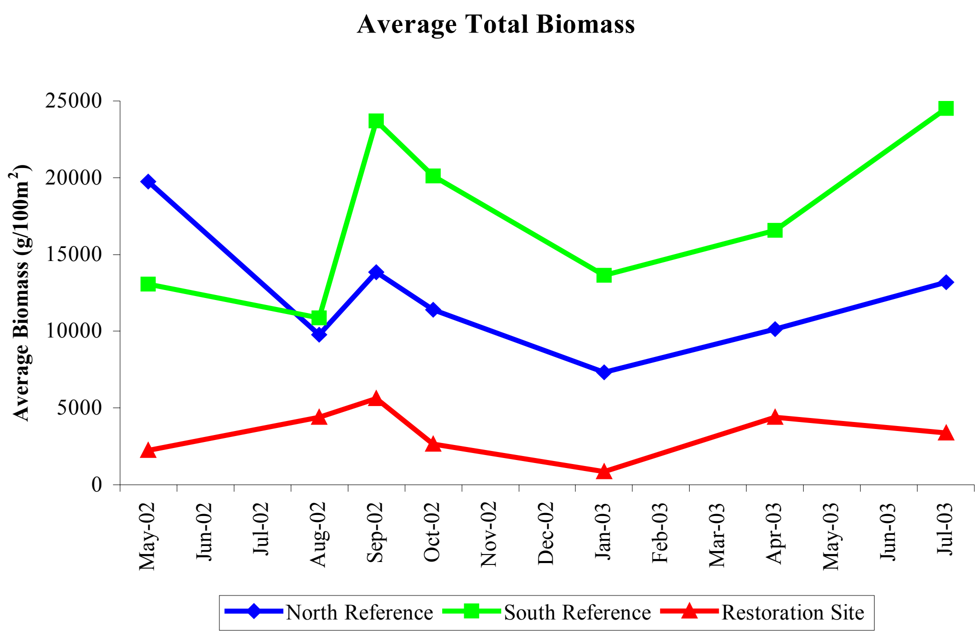

Figure 8. Average biomass per transect over time for all fish documented.

Table 3. Density (#/100 m^2) and standard deviation (in parentheses) of 4 major taxa, based on transect data.

	May 2002	August 2002	September 2002	October 2002	January 2003	April 2003	July 2003
PARROTFISH							
Restoration Site	4.3 (6.7)	8.1 (5.7)	13.6 (12.1)	3.6 (3.7)	4.5 (4.4)	4.9 (2.7)	11.7 (10.6)
North Reference	8.5 (7.2)	7.0 (4.0)	7.1 (2.7)	5.8 (4.5)	5.1 (5.0)	5.8 (2.9)	12.6 (15.0)
South Reference	6.8 (5.0)	9.9 (5.1)	8.1 (6.9)	6.9 (5.1)	5.2 (4.5)	3.9 (5.8)	6.8 (4.8)
SNAPPER							
Restoration Site		5.4 (8.2)	0.8 (1.1)	1.0 (1.6)		0.6 (1.1)	
North Reference	23.5 (45.6)	4.2 (7.1)	5.6 (9.4)	7.4 (13.6)	0.8 (2.6)	0.8 (1.5)	5.8 (12.0)
South Reference	17.8 (25.1)	5.8 (5.9)	33.8 (50.8)	18.2 (25.1)	14.2 (16.7)	8.9 (14.0)	23.9 (23.0)
GRUNT							
Restoration Site	2.6 (3.9)	0.6 (1.1)	0.6 (1.1)	0.8 (2.1)		0.8 (2.4)	0.10
North Reference	31.7 (34.8)	28.01 (35.0)	34.6 (68.8)	22.1 (27.9)	9.7 (14.3)	16.5 (17.2)	44.7 (58.7)
South Reference	27.9 (42.7)	12.2 (20.6)	30.0 (28.6)	45.3 (43.1)	41.7 (44.0)	35.8 (56.7)	42.8 (55.4)
SURGEONFISH							
Restoration Site	6.5 (6.2)	18.3 (16.1)	18.1 (9.0)	12.6 (5.8)	10.5 (4.1)	7.8 (3.7)	8.1 (6.9)
North Reference	9.2 (6.4)	8.1 (4.7)	22.1 (23.3)	10.0 (4.9)	8.7 (7.4)	6.0 (5.7)	22.2 (47.0)
South Reference	8.8 (5.2)	9.7 (5.3)	8.1 (4.5)	6.5 (5.1)	4.3 (3.7)	7.4 (6.0)	8.1 (7.4)

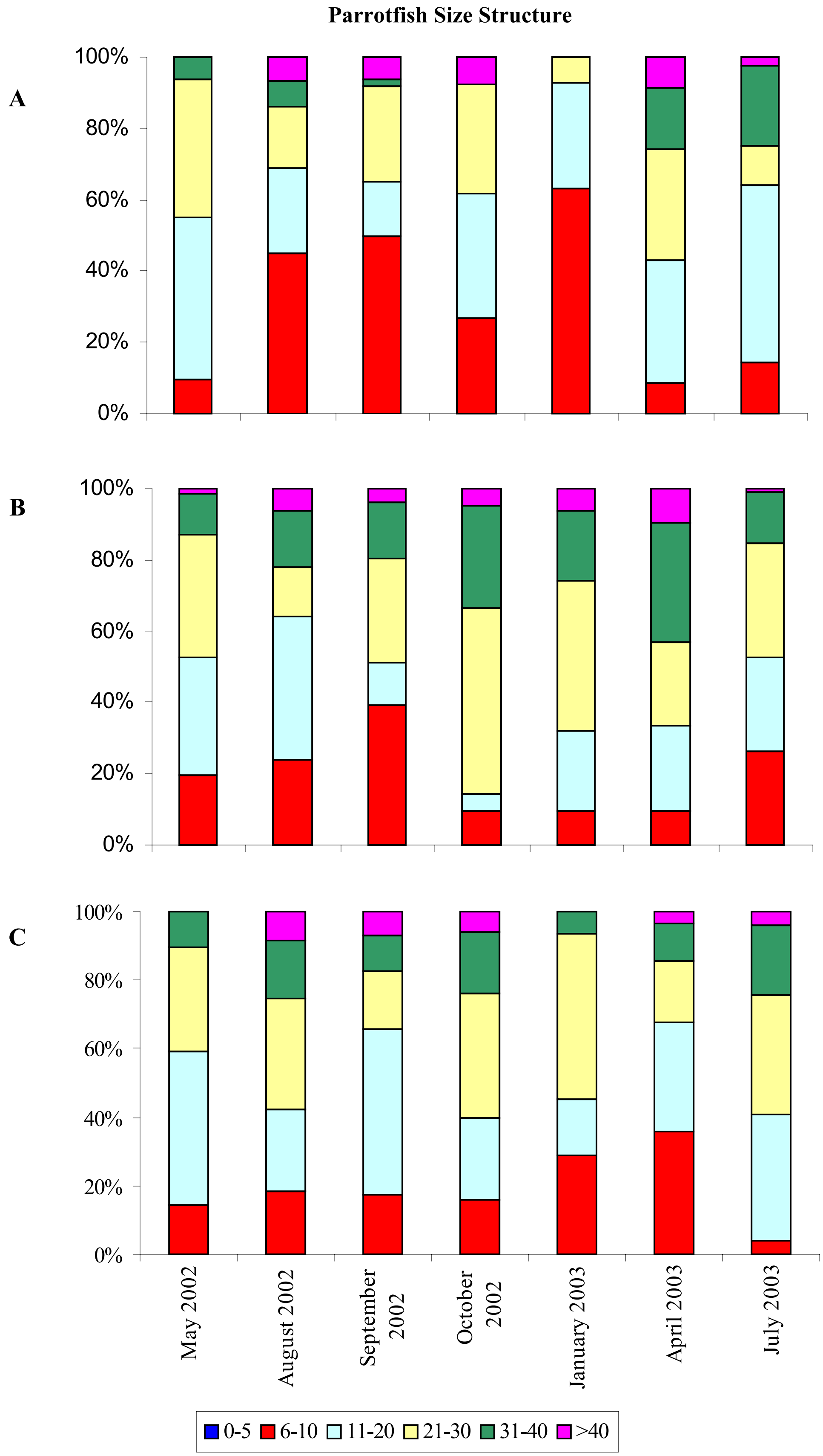

Figure 9. Size frequency distribution of parrotfish at (A) Restoration Site, (B) North Reference, and (C) South Reference. Values are proportion of total individuals in each size category; size ranges are in centimeters (cm).

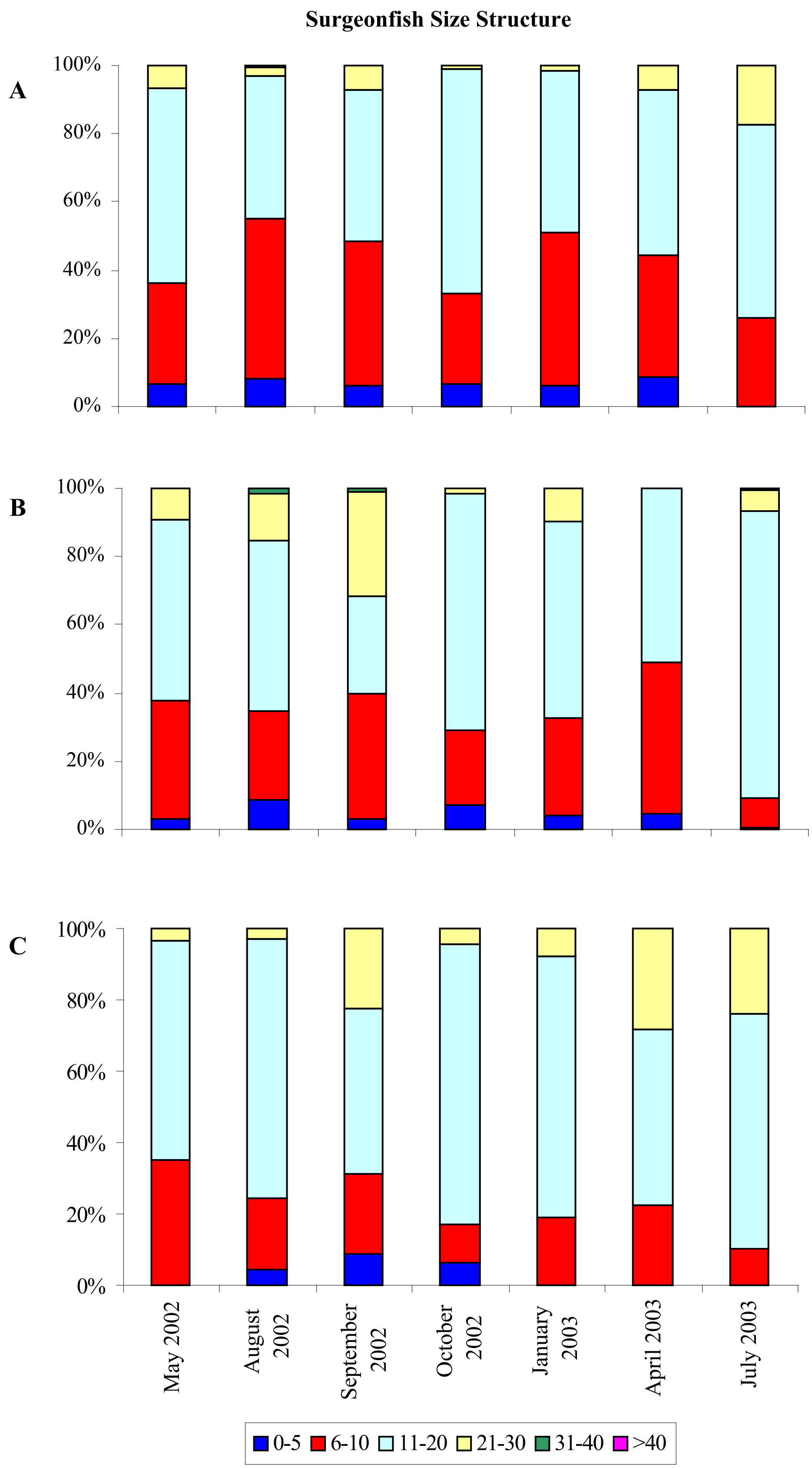

Figure 10. Size frequency distribution of surgeonfish at (A) Restoration Site, (B) North Reference, and (C) South Reference. Values are proportion of total individuals in each size category; size ranges are in centimeters (cm).

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