Assessment of Island and Habitat-Specific Reef Fish Assemblages in The Bahamas using Fisheries-Independent Data

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ABSTRACT

Coastal fisheries in The Bahamas face a variety of threats from over-fishing, loss of near shore habitats, changing water quality and possibly invasive species. The lack of quantitative historical data and fisheries independent information makes change detection for individual species and fish assemblages difficult. This research documents reference conditions for fish assemblages based on island-to-island and habitat specific surveys. A synoptic survey method was used to: a) characterize fish fauna, b) evaluate reference conditions, and c) look at intra and inter-island and habitat-specific relationships to establish indicators to detect changes over time throughout the archipelago. Roving diver visual surveys were used to gather fish abundance data from four large islands (Andros, New Providence, Abaco and Great Exuma), and from specific sites and habitats around a small cay (Great Guana Cay, Abacos). Four characteristics were evaluated from these surveys: 1) the ecological similarity between islands and between habitats, 2) rank-order abundance for the top 65 species, 3) rank-order abundance of indicator species, and 4) the proportion of species in trophic guilds in specific habitats. The results showed significant inter-island differences when sufficient observations were available; thus island group comparisons must be analysed independently for change detection. Small scale, intra-island habitat analyses allowed for reference characterization of the area, which can be critical for detecting localized community changes over time. As threats to coastal fisheries continue to increase, identifying reference conditions and island patterns is critical for better management and to detect changes over time or space.

KEY WORDS: reef fish the Bahamas, visual fish surveys, change detection.

Evaluación de Ensamblajes de Peces de Arrecife Isla y Hábitat Específicos en las Bahamas utilizando Datos Independientes de las Pesquerías

Las pesquerías de la zona costera del archipiélago de Las Bahamas afrontan diversas amenazas tales como la sobrepesca, la destrucción del hábitat, y los cambios en la calidad del agua. Ya que las islas de Las Bahamas han sido expuestas a diferentes estresores ambientales, evaluamos si existen diferencias en la abundancia y en los ensamblajes de peces en las diferentes islas (los cayos Andros, Bimini, Exuma, and New Providence), y dentro de los diferentes habitas dentro de una isla (Great Guana Cay, Abacos). Todos los datos fueron colectados buceando. Analizamos los tres siguientes aspectos de los datos: 1.) el rango de abundancia de las 100 primeras especies de peces observadas, 2.) el rango de abundancia de cinco especies indicadoras, y 3.) la proporción de peces, de las 60 especies más abundantes, que se pueden agrupar en un nivel trofico similar. Nuestros resultados muestran que existen diferencias en la abundancia y en los ensamblajes de peces en las diferentes islas de Las Bahamas, cuando más de cuarenta horas de observación son completadas. También encontramos diferencias en la abundancia y ensamblajes de peces en los diferentes hábitats de una isla pequeña. Estos datos pueden ser útiles para estudios básicos y para detectar cambios en los ensamblajes de peces causados por diferentes estresores ambientales.

PALABRAS CLAVES: peces de arrecife, Las Bahamas, detección de cambios

INTRODUCTION

Caribbean coastal fisheries suffer from various anthropogenic stressors such as overfishing, destructive fishing practices, loss of habitat from coastal development, declining water quality and likely invasive species (Hughes and Connell 1999, Jackson *et al.* 2001, Newman *et al.* 2006). The lack of quantitative historical data and fisheries independent information makes defining baseline reference conditions and identifying ecological indicators related to the structure of fish assemblages crucial (Bozec *et al.* 2005). However, the logistics of assessing and monitoring disturbances to coastal fisheries is challenging because these fisheries consist of multiple targeted species, which respond differently to various stressors and are harvested by a diverse group of fishers. Thus, with expertise and resources often lacking for large-scale stock assessments, there are few large-scale surveys and monitoring programs.

In consideration, throughout the Caribbean, marine resource managers have employed indicator-based monitoring program using simple synoptic census techniques to determine reference conditions. (e.g. Pomeroy *et al.* 2004).

Once reference conditions are determined for coastal fisheries, indicators can be developed to assess biological community health and detect then direct management options to address anthropogenic impacts on fish communities. By definition, indicators must be characteristic of an ecosystem and derived from biotic or abiotic measures of attributes that can provide quantitative information on ecological condition, structure and function (USEPA 2005). Large-scale and small-scale attributes such as target species relative abundance, assemblage composition, trophic structures, and ecological similarity allow scientists to characterize a particular fish assemblage and can be used as indicators and to detect community changes over space and time (Chabanet *et al.* 2005). When compared among regional locations and habitats, indicators can also assess management strategies.

The scale of analyses is dependent upon the monitoring objective and stressor. In the Bahamian archipelago, large-scale analyses may be required to assess the status of a nationally important species, while small-scale analyses may be used to detect the effects of land-based sources and land-cover changes. Thus, large-scale fish assemblage analyses can be used to: a) characterize fish assemblages over large areas, b) detect trends in the overall relative abundances of target species between islands with different population densities or land cover change, and c) discern the similarity or dissimilarity of assemblages between island systems. Small-scale analyses can be combined with habitat-specific variables to: a) define habitat specific fish assemblage characteristics, b) elucidate variables that are structuring the fish communities, and c) analyze the impacts of stressors at a finer scale.

The latitudinal and longitudinal expanse of the Bahamian archipelago mandates the need for simple, accurate marine census techniques to assess and monitor large-scale (intra-island) and small-scale (inter-island) shallow-water fish attributes. The Roving Diver Technique (RDT), developed by the Reef Environmental Education Foundation (REEF), Univeristy of Miami and the National Marine Fisheries Service, is an synoptic monitoring technique employable by experts and as well as trained volunteers. The on-line REEF database now has over 10,000 fish surveys from the wider Caribbean. This technique has been widely used to evaluate patterns in species occurrence, to assess the status of target species and invasive species, and to monitor fisheries (Auster *et al.* 2005, Semmens *et al.* 2004, Whaylen *et al.* 2004, Schmidtt *et al.* 2001).

We utilized REEF RDT data from The Bahamas to identify intra-island (large-scale) and inter-island (small-scale) reference conditions and to identify indicators. First, we identified island and habitat fish assemblage relationships using similarity indices and ordination analysis. We then identified the most abundant species and the species primarily providing discrimination between sites and habitats. Finally, we binned species into trophic guilds to determine the trophic structure of individual habitats. These results outline reference conditions and indicators and provide the basis for continual monitoring of near shore fish assemblages for in The Bahamas.

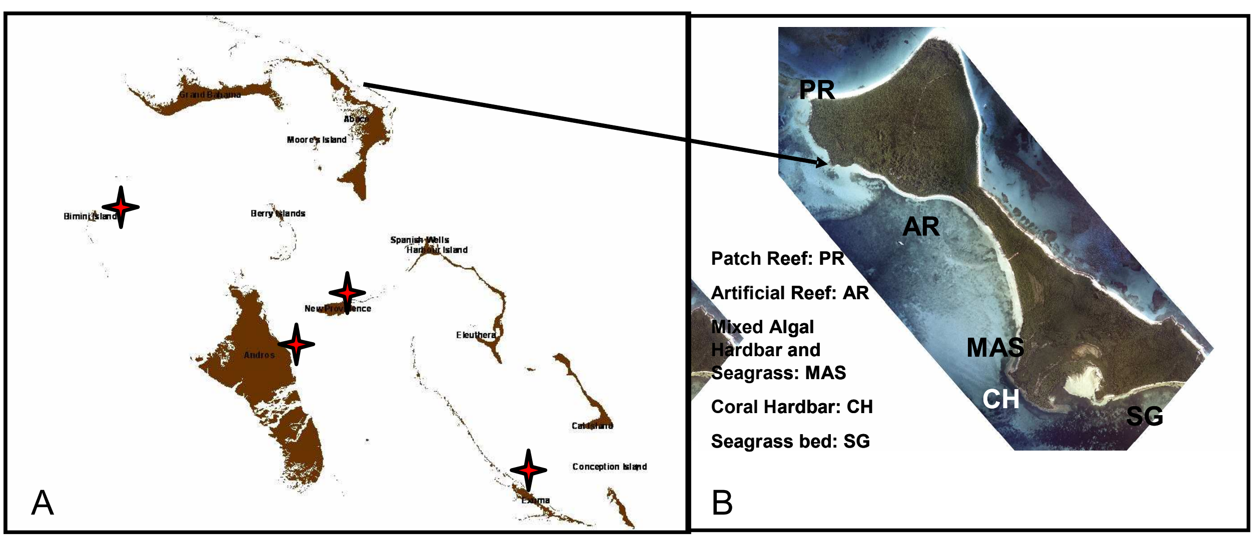

Figure 1 (A & B). (A) The Bahamian archipelago and island- survey location sites: North to South (Bimini, New Providence, Andros, Exuma) (GIS files from the National Center for Coral Reef Research: www.ncoremiami.org), (B) Habitat survey sites for northern end of Great Guana Cay, the Abacos.

LOCATION AND METHODS

Location

The islands of The Bahamas lie between 20 and 27°N latitude and 72 and 79°W longitude. The Bahamas stretches over a distance of some 1200 kilometers from northwest to southeast, and includes 30 inhabited islands, 661 cays, and about 2,387 exposed reefs. The total land area is approximately 3934.14 square kilometers with the majority of the land considered coastal (Figure 1) (Sullivan-Sealey 2004). Data from the large island families of Andros, Bimini, New Providence, Exuma and the small cay, Great Guana Cay (GGC) in the Abacos, were used in analyses. The near shore habitats adjacent to the northern end of GGC were characterized using classifications from Allee *et al.* (2000) as modified for the Bahamas in Sullivan-Sealey et al. (2002). Five main near shore habitats were classified as: 1) patch reefs (PR): 3-dimensional accretions and alleviate wave disturbance, 2) seagrass beds (SG): sandy substrate dominated by marine plants, 3) mixed algal hardbar and seagrass (MAS): rocky, flat substrate, often with rooted *Sargassum sp.*, 4) coral hardbar (CH): rocky, flat substrate, often subject to wave scouring disturbance, and 5) artificial reef (AR): wrecks or human-made structures (Figure 1B).

Methods

Inter-island analyses

Data from the REEF database were used for the inter-island analyses (the islands of Andros, Bimini, New Providence, Exuma). Data from the years of 1997-2006 were included. Using the RDT (i.e., a random swim approximately confined to an area with a radius of 100 m), divers and snorkelers collected data on reef fish species composition and abundance (www.reef.org). During each swim, all positively identified species were recorded in four broad categories (i.e., single=1, few=2– 10, many=11 – 100, and abundant >100). For inclusion of a site into analyses, a prerequisite of greater than_20 hrs of bottom time had to have been completed. Using the compiled expert and novice sighting frequency dataset, the bottom times for each individual site on an island were sorted such that the eight sites with the greatest amount of survey bottom times were selected for further analysis.

The individual site data were pooled for each island and species-time curves were constructed. This was done to ensure a minimum of 80% of the total species were represented. Type II errors were minimized by discarding sighting frequencies below 20%. The top 65 most abundant species from rank-order abundance were extracted per pooled island dataset for analyses. The data was square root transformed and Bray–Curtis similarity coefficients were computed for the individual island sites using the multivariate software program PRIMER (Clarke and Warwick 2001). The Bray–Curtis similarity procedure provides a method of quantifying the similarity of species occurrences within sets of samples. A value of 0 indicates total dissimilarity in species co-occurrences (e.g., the species at site A never occur at site B) while a value of 100 indicates total similarity in distribution (e.g., the species at site A always occurs at site B) (Clarke and Gorley 2001a). SIMPER analysis was used to obtain a site similarity ranking. The value allows for comparison and discernment of

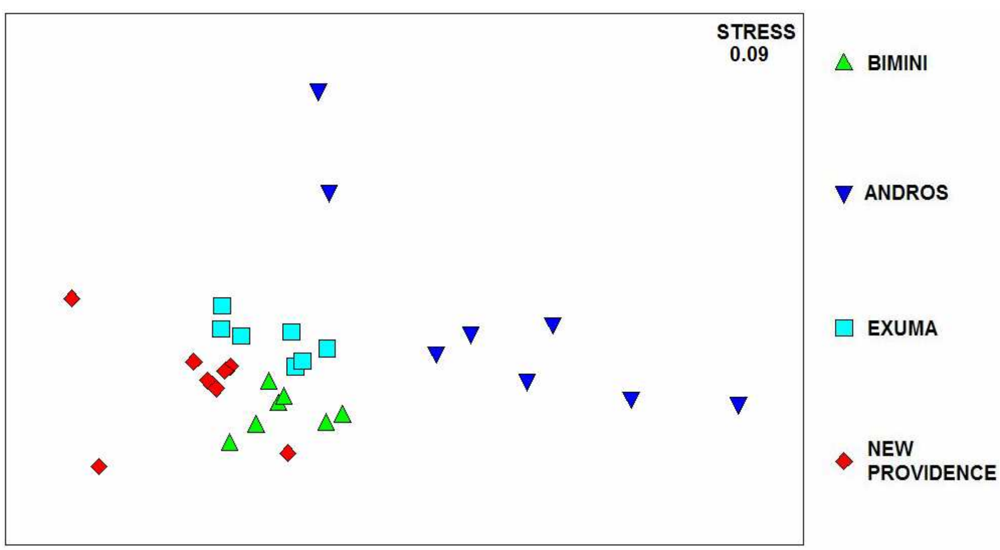

Figure 2. A MDS plot of fish sighting frequency for the islands of Exuma, Andros, Bimini and New Providence (data were square root transformed). The plot shows strong clustering of specific islands, indicating a distinctness in fish assemblages between islands. The stress value of 0.09 indicates good ordination between the sites. ANOSIM revealed a Global R value of 0.563, indicating significant differences in the fish species compositions between the islands.

the relative strengths of relationships between the sites. Non-metric multidimensional scaling (MDS) was used to validate patterns in site relationships found and to illustrate the relationships between sites in two-dimensional space. The MDS procedure was computed with 10 random re-starts to reach a minimum stress value. Analysis of Similarity (ANOSIM) was conducted to test the null hypothesis that there are no differences in community composition among the sites. SIMPER analysis was used to determine the rank-order abundance of species per site. To further explore the relationships observed from the previous ordinations, Principle Component Analysis (PCA) was completed in order to determine which factors and species made the greatest contribution to the dissimilarities seen among sites and habitats.

Intra-island analyses

Fish species relative abundance and substratum composition (habitat) data collected during March 2004-July 2006 were used for GGC intra-island analyses. For sites to be incorporated, a prerequisite of greater than 10 hrs bottom time was established. For each habitat, the independent surveys were pooled and averaged by survey times. Data was fourth root transformed, and the multivariate analyses completed were similar to those done on the inter-island sighting frequency data. Each fish species was placed into a trophic guild (i.e., herbivore, planktivore, macroinvertivore, carnivore) based on the diet composition of primary sub-adults/adults (data from reefbase.org).

RESULTS

Inter-island

Prior to multivariate data reduction, Bimini had the greatest species richness (282 species) followed by Exuma (276), New Providence (253) and Andros (222). Assemblages of fishes among the islands exhibited consistent regional patterns. This is indicated by the MDS ordination (Figure 2), where data for each point represents a survey site, and distance between the points reflects species similarity based on the Bray-Curtis similarity matrix. The stress value of 0.09 indicates good ordination between the sites (Clarke and Gorley 2001b). The null hypothesis of "no difference in community composition between the islands" was tested with a one-way Analysis of Similarity (ANOSIM). The Global R value generated was 0.563, indicating that there are significant differences between the islands.

For island pair-wise comparison, SIMPER analyses demonstrated that Andros and New Providence were the most dissimilar with an average value of 41.87 (Table 1). Many species contributed marginally to the dissimarilty, with no particular species dominating. The cleaning goby (*Elacatinus genie*) was the greatest contributor (1.7%), the beaugregory (*Stegastes leucostictus*) second greatest (1.6%). Bimini and Andros were the second most dissimilar with an average of 37.35 (unit), with the longspine squirrelfish (*Holocentrus marianus*) contributing the greatest to the dissimilarity (1.99%). A similar trend of no specific species heavily contributing to the dissimilarity was found for the other island pair-wise comparisons (Table 1). SIMPER analyses were also used to determine the rank-order abundance of the ten most abundant species per island. The bluehead wrasse (*Thalassoma bifasciatum*), blue tang (*Acanthurus coeruleus*) and stoplight parrotfish (*Sparisoma viride*) were ranked within the top-ten for all four islands. Commercially important species in the top-ten included the bluestriped grunt (*Haemulon sciurus*) (Andros), bar jack (*Caranx ruber*) (Bimini and New Providence) and yellowtail snapper (*Ocyurus chrysurus*) (Andros, Exuma and New Providence) (Table 2). The re-

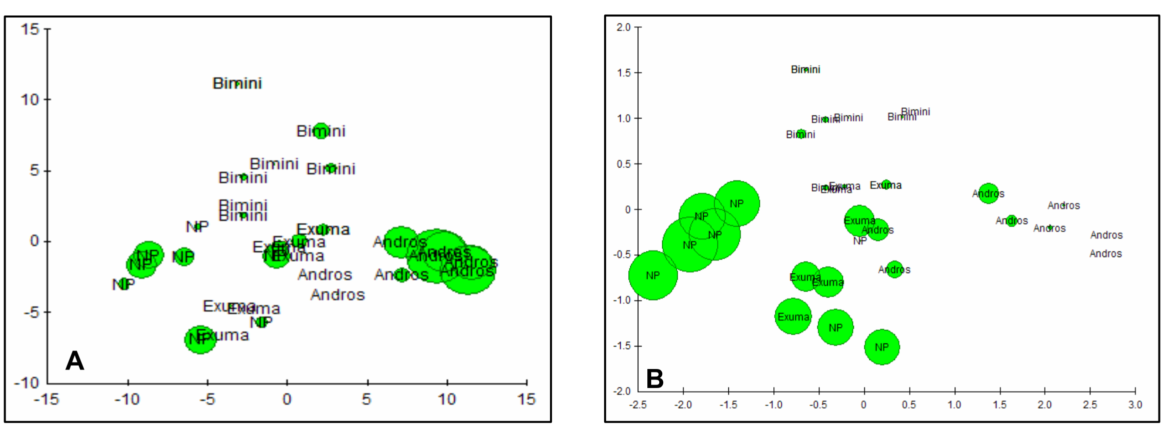

Figure 3. (A and B) PCA analysis found the % variation to be: 17.7% (PC1), 10.5% (PC2), and 8.5% (PC3). PC1 was factored strongly by the absence/ presence of species. Figures A&B depict the influence of commercially valuable species. (A) shows the sighting frequency and proportion of contribution of *Lutjanus analis* (mutton snapper) between the islands. (B) shows the sighting frequency and proportion of contribution and tiger grouper (*Mycteroperca tigris*).

sults of the PCA showed that PC1 accounted for 17.7% of the variation, PC2 10.5% and PC3 8.5%. Investigations into commercial fish abundances found differences between the islands. Figure 3 (A&B) depicts the dissimilarity between the islands in the proportion of the commercial fish mutton snapper (*Lutjanus* analis) and tiger grouper (*Mycteroperca tigris*).

Intra-island (habitat)

The seagrass, mixed algal hardbar and seagrass and the coral hardbar habitats largely consisted of juveniles, while the windward patch reef and artificial reef habitats were comprised primarily of adults (personal observations). The very pronounced influence of habitat on the number of species present was highlighted by the fact that the overall mean number of species observed was three times greater on the artificial reef than over the seagrass habitat. Assemblages of fishes between the habitats exhibited consistent clustering. This is indicated in the MDS plot of Figure 4, where data for each point represents a habitat and the distance between points reflects species similarity based on a Bray-Curtis similarity matrix. The stress value of 0.00 indicates the MDS plot depicts an extremely accurate spatial representation of the similarities and dissimilarities of the species between habitats (Clarke and Warwick 2001b).

SIMPER analysis revealed that the mixed algal hardbar and seagrass habitat and the artificial reef shared the greatest similarity of species. The artificial reef and the natural patch reef were the second most similar (Table 1). The rank order abundance of the ten most abundant species revealed the bluehead wrasse (*T. bifasciatum*) was the only species in the top-ten ubiquitous in all of the habitats (Table 2). Commercially important species (juveniles and adults) in the top-ten included the bluestriped grunt (*Haemulon sciurus*) (seagrass, coral and mixed algal seagrass), white grunt (*Haemulon plumieri*) (seagrass, coral hardbar, artificial reef), and yellowtail snapper (*Ocyurus chrysurus*) (patch reef and artificial reef). Other prominent species outside the top-ten, but within most habitats included the bucktooth parrotfish (*Sparisoma radians*) and damselfish (*Stegastes sp.*). PCA analysis found PC1 accounted for 40.7% of the variation, PC2 accounted for 29.7% and PC3 accounted for 17.3% of the variation; cumulatively accounting for 87.7% of the variation. Data inspection identified *Haemulon flavolineatum* (French grunt) and *Ocyurus chrysurus* (Yellowtail snapper) as dissimilar/outlier species between the habitats. Figure 4 (A&B) depicts the dissimilarity in proportion of these two commercial species.

When binned into trophic guilds, the percentage of species in the particular trophic guilds differed between sites (Table 3). The proportion of carnivores and omnivores was relatively consistent across the habitats. The percentage of benthic invertebrate and crustacean feeders was the greatest in the mixed algal hardbar and seagrass habitat, with less than 1% herbivores. Planktivores and herbivores were greatest on the high-energy, patch reef. There was a general trend of increasing benthic invertebrate and crustacean feeders with a decrease in habitat complexity in terms of 3-d dimensionality, algal and inver-

Table 1. SIMPER analysis. Pair-wise comparisons of fish species for the islands of Andros, Bimini, Exuma and New Providence and the near shore marine habitats adjacent to Great Guana Cay, the Abacos. The average dissimilarity between islands and habitats is ranked.

Average Dissimilarity			
Inter-island		**Intra-island, habitats**	
1. Andros /New Prov	41.87	1. Mixed algal seagrass/ Art Reef	40.79
2. Bimini /Andros	37.35	2. Patch reef/ mixed algal seagrass	40.62
3. Andros/Exuma	37.3	3. Seagrass/Art Reef	34.89
4. Exuma/New Prov	26.64	4. Coral/ mixed algal seagrass	31.2
5. Bimini/New Prov	26.27	5. Seagrass/coral hardbar	31.67
6. Bimini/Exuma	24	6. Seagrass/mixed algal seagrass	34.7
		7. Seagrass/patch reef	36.78
		8. Coral hardbar/ Art Reef	28.93
		9. Patch reef/coral hardbar	28.26
		10. Patch reef/Art Reef	23.69

tebrate species richness (unpublished data).

DISCUSSION

The differences observed in fish assemblages among islands of The Bahamas indicate that each land-bank system is comprised of unique ecological characteristics. A classification of bank systems provided in Sullivan-Sealey

Table 2. Rank-order abundances of near shore fish from SIMPER analysis. The ten most abundant species per island group and per habitat are listed.

	Bimini	Andros	New Providence	Exuma	Seagrass	Coral hardbar	Mixed algal hardbar & seagrass	Artificial Reef	Patch reef
1	*Acanthurus coeruleus*	*Thalassoma bifasciatum*	*Thalassoma bifasciatum*	*Sparisoma viride*	*Haemulon sciurus*	*Haemulon chrysargyreum*	*Halichoeres bivittaus*	*Abudefduf saxatilis*	*Acanthirus bahianus*
2	*Stegastus partitus*	*Acanthurus coeruleus*	*Acanthurus coeruleus*	*Acanthurus coeruleus*	*Thalassoma bifasciatum*	*Haemulon plumieri*	*Abudefduf saxatilis*	*Thalassoma bifasciatum*	*Acanthurus coeruleus*
3	*Thalassoma bifasciatum*	*Acanthurus chirurgus*	*Ocyurus chrysurus*	*Haemulon flavolineatum*	*Haemulon flavolineatum*	*Thalassoma bifasciatum*	*Acanthirus bahianus*	*Acanthurus chirurgus*	*Thalassoma bifasciatum*
4	*Haemulon flavolineatum*	*Halichoeres bivittaus*	*Sparisoma viride*	*Chaetodon capistratus*	*Halichoeres bivittaus*	*Gerres cinereus*	*Thalassoma bifasciatum*	*Ocyurus chrysurus*	*Abudefduf saxatilis*
5	*Chaetodon capistratus*	*Sparisoma viride*	*Caranx ruber*	*Ocyurus chrysurus*	*Stegastes leucostictus*	*Holocentrus adscensionis*	*Holocentrus adscensionis*	*Acanthirus bahianus*	*Halichoeres bivittaus*
6	*Caranx ruber*	*Ocyurus chrysurus*	*Stegastus partitus*	*Thalassoma bifasciatum*	*Haemulon plumieri*	*Acanthurus chirurgus*	*Stegastes leucostictus*	*Haemulon plumieri*	*Acanthurus chirurgus*
7	*Chromis cyanea*	*Acanthirus bahianus*	*Scarus croicensis*	*Gramma loreto*	*Lutjanus griseus*	*Stegastes leucostictus*	*Gerres cinereus*	*Gerres cinereus*	*Ocyurus chrysurus*
8	*Abudefduf saxatilis*	*Haemulon flavolineatum*	*Holacanthus ciliariars*	*Holocentrus marianus*	*Lutjanus mahogoni*	*Haemulon sciurus*	*Lutjanus apodus*	*Lutjanus griseus*	*Chromis cyanea*
9	*Holacanthus tricolor*	*Chaetodon capistratus*	*Chromis Cyanea*	*Holacanthus ciliars*	*Mulloidichthy s martinicus*	*Pomacanthus paru*	*Acanthurus chirurgus*	*Pomacanthu s paru*	*Caranx ruber*
10	*Sparisoma viride*	*Haemulon sciurus*	*Acanthurus chirurgus*	*Stegastus partitus*	*Halichoeres garnoti*	*Haemulon flavolineatum*	*Haemulon sciurus*	*Mulloidichth ys martinicus*	*Chromis multilineata*

et al. (2002) outlines the differing characteristics of the archipelago, in particular the unique geomorphic and oceanographic differences that exist between island groups. Thus, it is not surprising that fish assemblages were unique between the islands, in terms of community assemblages. The patterns between the islands may also be reflective of spatial scale. Particularly, the assemblages of New Providence and Bimini, the smallest of the four islands, showed high similarity between sites. While for Andros, the largest island, there was notable dissimilaries from the other islands, as well as, between the independent sites.

It is critical to determine baseline conditions in order to understand inter island differences in reef fish assemblages before addressing the impacts of anthropogenic activities such as habitat alterations with coastal development or over-fishing. Sullivan-Sealey (2004) conducted a large-scale comparison of near shore habitats of developed and relatively undeveloped areas in central Bahamas. Unlike the near shore habitats of the underdeveloped areas, there was lower coral diversity, lower coral cover, and higher incidence of coral lesions in sites adjacent to developed islands. In addition, differences were found in the relative abundances of commercially important species between the islands. Thus, this study highlights the potential need for "control sites" or marine protected areas located on all islands or bank systems since the ecological processes, degree of stressors and community assemblages that are unique to particular island systems may not be easily replicated on other islands or bank systems.

Tropical near shore habitat characteristics do influence the associated fish communities and spatial proximity of certain habitats to coral reefs and other habitats can shape the assemblage structure (e.g. Dahlgren and Marr 2004, Nero and Sealey 2005). Such characteristics will determine the overall assemblage by influencing growth, recruitment and mortality processes of individual species within the community assemblage. In this study, the pronounced differences in fish assemblages amongst the habitats are likely a reflection of the presence/absence of conspicuous epifauna, algae and seagrasses, and abiotic factors (wave energy, temperature and salinity). The patch reef on the Atlantic side of Great Guana Cay is a high-energy site, with the greatest algal and coral species richness. The artificial reef is the most topographically complex, which may account for the comparatively high fish species richness and the large amount of adult fish. Algae, invertebrate and fish species richness was second most in the coral hardbar site. The low-energy mixed habitat had notably high algal

Table 3. The percentage of fish in five trophic guilds for the habitats adjacent to Great Guana Cay, the Abacos

	Benthic Inverts/crust	Carnivore	Herbivore	Omnivore	Planktivore
Windard patch reef	37.64	19.63	25.06	9.01	8.66
Nearshore coral hardbar	40.06	22.76	20.83	13.78	2.56
Art Reef	45.50	26.70	17.25	9.28	1.58
Nearshore seagrass	50.52	20.28	16.72	11.80	0.69
Nearshore mixed algal seagrass	56.62	26.37	0.28	12.00	5.01

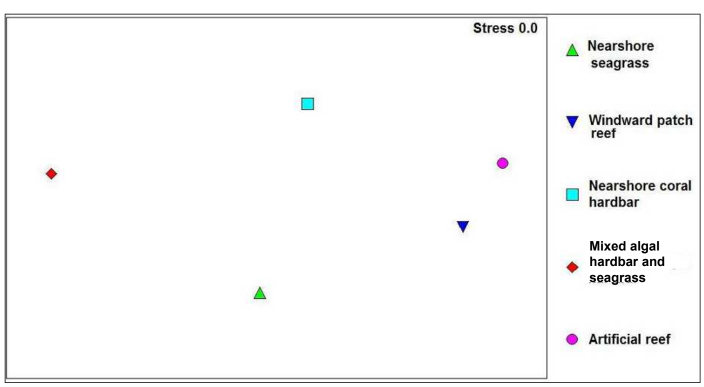

Figure 4. A MDS plot of relative fish abundances for individual habitat (pictured) surveys of Great Guana Cay, the Abacos (data were 4th root transformed). Strong dissimilarity between the fish assemblages of the different habitats is evident.

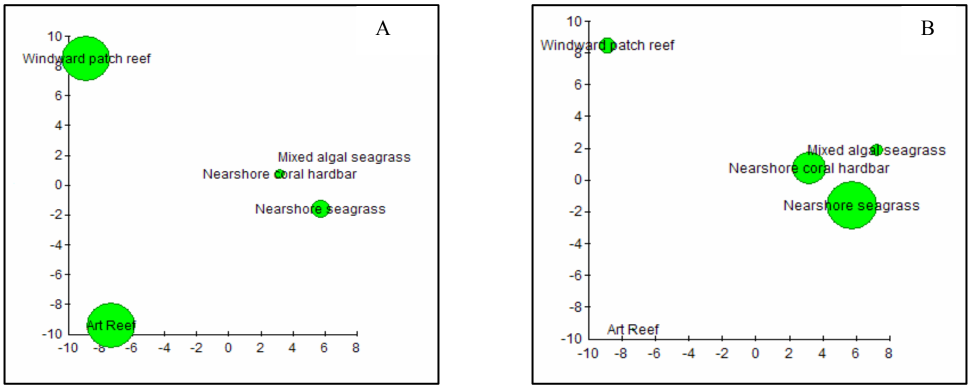

Figure 5 (A and B). Simper analyses identified *Ocyurus chrysurus* (Yellowtail snapper) and *Haemulon flavolineatum* (French grunt) as dissimildar/outlier species. PCA analysis found PC1 accounted for 40.7% of the variation, PC2 accounted for 29.7% and PC3 accounted for 17.3% of the variation, cumulatively accounting for 87.7% of the variation (Figure 3). PC1 was factored strongly by the absence/ presence of species, and PC2 by the factor of habitat. PCA plot (A) shows the differing relative abundance of *H. flavolineatum*, (B) shows the differing relative abundance of *O. chrysurus* between the different

species richness, but low coverage and the seagrass habitat had the lowest fish species richness. These habitat characteristics are reflected in the habitat SIMPER dissimilarity analyses and trophic percentages. For example, the percentage of herbivores is greatest at the patch reef and the percentage of invertebrate/crustacean feeders is greatest in the mixed habitat.

Nero and Sealey (2006) also found intra-island differences in the Bahamas when comparing fish and habitats adjacent to Andros Island. Using beach seines, the intra-island characterization of near-shore fish communities allowed for the assessment of not only species composition but biomass as well (beach seines allowed the collection of lengths as well as species identification). The study found environmental characteristics deemed to be most important in influencing fish species patterns were benthic flora canopy height, extent of invasion by exotic terrestrial plants, cover of *Batophora oerstedii*, cover of *Thalassia testudinum*, turf cover, water temperature, micro-crustacean diversity, and micro-crustacean density. While Breitburg (1998) in an Australian study, found that changes in species composition from land-based source pollution (eutrophication) may be indicated by a shift in the relative abundance of species, the loss or gain of specialized feeders and/or trophic structures. Hence future intra-habitat monitoring will seek to co-evaluate and quantify fish assemblages and environmental characteristics.

The goal of this paper was to document reference conditions of fish assemblage indicators with a view to develop baseline characterizations by island group (or bank system) throughout the archipelago and within individual near shore habitats. A noteworthy finding of this study is a synoptic method of recording only species and relative abundances, such as the REEF RDT is sufficient to begin to define indicators and detect patterns in fish assemblages, and thus can provide initial steps in first a characterization and later in a monitoring program. REEF RDT data can be used to establish baseline conditions and to monitor fish community health over time when an adequate amount of bottom time has been accumulated over different seasons and years. Changes in fish assemblage indicators such as loss of commercially valuable species, diversity, abundance, trophic structure or ecological composition can be indicators of underlying ecological change from anthropogenic stressors. The notable difference found in inter-island and intra-island (habitat) fish assemblages in The Bahamas outlines the need for island and habitat-specific analyses to detect changes in community health.

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LITERATURE CITED

Allee, R. J., Brown, D., Deegan, L., Dethier, M., Ford, R.G., Hourigan, T.F., Maragos, J., Schoch, C., Sealey, K., Twilley, R., Weinstein, M. P., Yoklavich, M. 2000. Marine and estuarine ecosystem and habitat classification. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-F/SPO-43. pp. 43.

Auster, P.J., B.X. Semmens and K. Barber. 2005. Pattern in the co-occurrence of fishes inhabiting the coral reefs of Bonaire, Netherlands Antilles. *Environmental Biology of Fishes* **74 (2)**: 187-194.

Bozec Y, Kulbicki, M., Chassot, E. striatus, Gascuel, D. 2005. Trophic signature of coral reef fish assemblages:

Towards a potential indicator of ecosystem disturbance. *Aquat. Living Resour* **18**: 103-109.

Breitburg, D.L. 1998. Scaling eutrophication effects between species and ecosystems: the importance of variation and similarity among species with similar functional roles. *Australian Journal of Ecology* **23**:280-286.

Chabanet, P., Adjeroud,M., Andréfouët, S., Bozec, Y., Ferraris, J., Garcìa-Charton, J., Schrimm, M. 2005. Human-induced physical disturbances and their indicators on coral reef habitats: A multi-scale approach. *Aquat. Living Resour* **18**: 215–230.

Clarke, R., Gorley, RN. 2001a. PRIMER v5: User manual/tutorial. PRIMER-E, Plymouth, UK, 91pp.

Clarke, R., Gorley, RN. 2001b. Change in Marine Communities: An Approach to Statistical Analysis and Interpretation, 2nd edition. PRIMER-E, Plymouth, UK, 172pp.

Dahlgren, C., Marr, J. 2004. Back reef systems: important but overlooked components of tropical marine ecosystems. *Bulletin of Marine Science* **75(2)**: 145–152.

Dulvy, N., Freckleton, R., Polunin, N. 2004. Coral reef cascades and the indirect effects of predator removal by exploitation. *Ecology Letters* **7**: 410.

Feeley, K. 2003. Analysis of avian communities in Lake Guri, Venezuela, using multiple assembly rule models. *Oecologia*

Ferreira, C., Floeter, S. Gasparini, J. Ferreira, B. Joyeux, J. 2004. Trophic structure patterns of Brazilian reef fishes: a latitudinal comparison. *Journal of Biogeography* **31**: 1093–1106.

Hughes, TP., Connel, JH. 1999. Multiple stressors on coral reefs: A long-term perspective. Limnology *and oceanography* **44**: 3. 932-940.

Jackson, J. *et al.* 2001. Historical Overfishing and the Recent Collapse of Coastal Ecosystems. *Science* **293**:5530, 629.

Nero, V.; Sullivan-Sealey, K . 2006. Fish–environment associations in the coastal waters of Andros Island, The Bahamas. *Environmental Biology of Fish*es **75**:223–236.

Newmanm M., Paredes,G., Sala, E., Jackson. J. 2006. Structure of Caribbean coral reef communities across a large gradient of fish biomass. *Ecology Letters* **9**: 1216–1227.

Pomeroy R.S., Parks J.E., Watson L.M. 2004. How is your MPA doing? A Guidebook of Natural and Social Indicators for Evaluating Marine Protected Area Management Effectiveness. IUCN, Gland, Switzerland and Cambridge, UK.

Reef base. www.reefbase.org.

Schmitt, E. F., T. D. Sluka, and K. M. Sullivan-Sealy. 2002. Evaluating the use of roving diver and transect surveys to assess the coral reef assemblages off southeastern Hispaniola. *Coral Reefs* **21**: 216-223.

Semmens, B.X., E.R. Buhle, A.K. Salomon, and C.V. Pattengill-Semmens. 2004. Tankers or fish tanks: what brought non-native marine fishes to Florida waters. *Marine Ecology Progress Series* **266**:239-244.

Sullivan-Sealey, K., B. Brunnick, S. Harzen, C. Luton, V. Nero, and L. Flowers. 2002. An Ecoregional Plan for the Bahamian Archipelago. Taras Oceanographic Foundation, Jupiter, FL.

Sullivan-Sealey, K. 2004. Large-scale ecological impacts of development on tropical islands systems: comparison of developed and undeveloped islands in the central Bahamas. *Bulletin of Marine Science* **75(2)**: 295–320.

US. EPA. 2005. Aquatic Resource Monitoring – Indicators. www.epa.gov/nheerl/arm/indicators/indicators.htm

Whaylen, L., Pattengill-Semmens, C.V., Semmens, B.X., Bush, P.G. and M.R. Boardman. 2004. Observations of a Nassau Grouper (*Epinephelus striatus*) Spawning Aggregation Site In Little Cayman, Including Multi-Species Spawning Information. *Environmental Biology of Fishes* **70**: 305-313