Coral Reefs (2002) 21: 216–223
DOI 10.1007/s00338-002-0216-y

REPORT

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Evaluating the use of roving diver and transect surveys to assess the coral reef fish assemblage off southeastern Hispaniola

Received: 4 January 1999 / Accepted: 12 November 2001 / Published online: 9 May 2002

Abstract The relatively little-studied fish fauna off southeastern Hispaniola was rapidly assessed using a combination of visual survey techniques including transects and roving diver surveys. It was found that when combined, both methods provided a more complete overall species assessment than either method was able to provide in isolation. Being able to conduct rapid species assessments is becoming increasingly more important as a conservation tool. Data on species composition, sighting frequency, and abundance of all fishes were collected using both methods. Abundance was recorded in four logarithmic-based categories (roving diver method) while the number of fishes were counted within 40-m^2 transects (transect method). Both methods were similar in recording the most abundant species, while a greater number of rare species (especially fishery-targeted species) were recorded with the roving diver method. The most abundant groupers were *Cephalopholis cruentata* and *C. fulva*. The most abundant parrotfishes were *Scarus taeniopterus*, *Sparisoma aurofrenatum*, and *Scarus iserti*. The most conspicuous differences between fishes off southeastern Hispaniola and elsewhere in the tropical western Atlantic were the low abundance and smaller size of harvested species such as groupers, snappers (Fam. Lutjanidae), and grunts (Fam. Haemulidae). With the roving diver method, more time could be spent surveying (instead of placing transect lines), resulting in a greater number of species being recorded. Additionally, well-trained volunteers can adopt the roving diver method as part of their regular diving program. Transect surveys were able to provide information such as length (biomass) and actual density measures that were not recorded in roving diver surveys. Thus, these methods were complementary and should be used in conjunction when conducting rapid assessments of fish assemblages, especially to detect the effects of overfishing.

Keywords Fish assemblages · Survey methods · Hispaniola · Dominican Republic · Conservation · Coral reefs

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Introduction

Fishes are a conspicuous element of coral reef ecosystems in the tropical western Atlantic (Starck 1968; Bohlke and Chaplin 1993), and are often a focus of monitoring and management programs to evaluate the condition of reef communities (Hatcher et al. 1989). When the species composition, abundance, or size distribution of fish assemblages changes, this is often an indication of additional underlying ecological change on the reef (Reese 1977; Hughes 1996). Assessing variables such as species composition, sighting frequency, density, and length frequency distributions allows the characterization of a particular fish assemblage in space and time. When compared among regional locations, these characteristics, especially for fisheries-targeted species, can be monitored for changes from baseline values, and effects of various management strategies can be evaluated (Bohnsack 1982; McClanahan 1994; Jennings 1995). In this way, biological surveys and assessments of key reef taxa groups such as fishes are essential to management and conservation efforts (Goldsmith 1991; Pattengill-Semmens 1998).

Historically, fish inventories were carried out via the comprehensive but destructive technique of poisoning a given area of the reef (Randall 1963; Starck 1968). However, destructive methods cannot be repeated in the same area and result in the death of many fishes as well as other organisms. Visual surveys are repeatable and especially valuable since they minimize the impact of sampling on the environment. Visual surveys are highly effective in the clear water present on most coral reefs, but have the tendency to overlook or underestimate the abundance of cryptic reef fishes (DeMartini and Roberts 1982; Bortone 1991). Diurnally active species are reasonably well censused, but the most common species are often underestimated; nocturnal species are more difficult to survey due to restricted visibility (Brock 1982). For all visual surveys, fish sizes tend to be overestimated. However, this can be corrected with training and corrections for bias in length estimates (Bell et al. 1985; St. John et al. 1990). Transects have been traditionally used as one of the standard visual survey methods and the biases in this technique have been well studied (Brock 1954; Sale and Sharp 1983; Fowler 1987; Watson et al. 1995; Cheal and Thompson 1997; Sale 1997; and others). However, with the need for fish survey monitoring data to be conducted rapidly and at low cost, trained volunteer surveyors using the roving diver technique (RDT) are being increasingly employed (Pattengill-Semmens and Semmens 1998; Pattengill-Semmens 2001). In this study, we surveyed the relatively little studied fish fauna off southeastern Hispaniola using the transect and roving diver visual survey techniques. We compared the data generated by both methods. The results of this study should be useful in the continued monitoring of fishes in southeastern Hispaniola in an area where commercial fisheries collapsed in the early 1970s (Towle et al. 1973; Secretaria de Estado de Agricultura 1994; Vega et al. 1996) It is also hoped that this information will assist in the rapid assessment of fishes on reefs in other areas to document the effects of fishing and to assist in the development of more comprehensive management plans (Hatcher et al. 1989; Wilcox et al. 1989; MAMMA 1998).

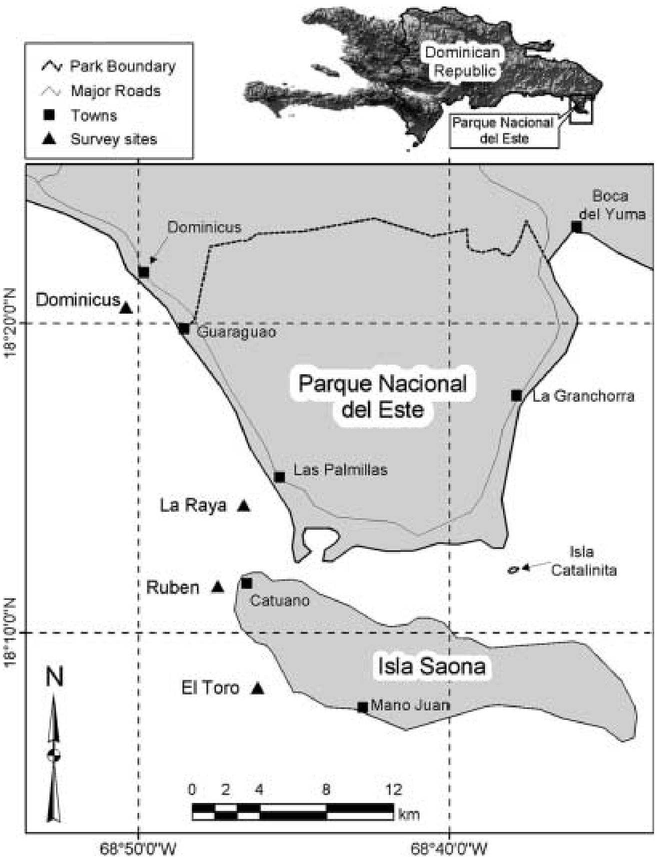

Fig. 1. Fish survey sites off southeastern Hispaniola. The boundaries of Parque Nacional del Este (PNE) are indicated. (Illustration by Brian K. Walker, National Coral Reef Institute, Dania Beach, Florida)

Methods

Fishes were surveyed using both the transect and roving diver methods at four reef sites in southeastern Hispaniola listed in order from north to south: Dominicus, La Raya, Rubén, and El Toro (Fig. 1). The more northern reef sites are closer to tourist areas (Bayahibe) and coastal cities such as La Romana. The most northern site examined, Dominicus, occurs just north of the boundary of Parque Nacional del Este (PNE), and offshore of a resort. The three other reef sites examined are offshore of the uninhabited coast of the Park along the western shore of southeastern Hispaniola. El Toro is both the southernmost and most exposed site off the southwestern shore of Isla Saona. The reef habitat at La Raya consists of deep rocky outcroppings and small, elevated patches separated by sand at a depth of 16–18 m. The reef habitats at Dominicus and Rubén are characteristic low-relief spur-and-groove systems (Shinn et al. 1977, 1981), at a depth of 15–17 and 18–20 m, respectively. El Toro is a low-relief, hard-bottom habitat with relatively little vertical relief at a depth of 16–18 m. All four sites have a similar depth range (15–20 m), vertical relief measured by the chain transect method, where values indicate the amount of chain overlain on the surface to cover a flat distance of 100 cm (119–129 cm/m), sediment cover (11.0–32.8%), algal cover (52.2–70.0%), sponge cover (4.6–15.2%), hard coral cover (5.2–20.2%), and octocoral cover (0.40–3.4%) as measured by percent composition of benthos within 20 (1-m^2) quadrats at each reef site (Table 1). Transect and roving diver surveys were conducted at each site and pooled from all sites in order to rapidly assess the overall fish assemblage structure and compare data gathered by the roving diver method with the transect method.

Survey methods

The transect method involved recording the presence and abundance of all fish species as well as their length (estimated to the nearest centimeter) present in a 40-m^2 strip transect (20 m long by 2 m wide). Observers were trained to estimate fish lengths by using models both on land and underwater. The distribution of each observer's estimated model sizes was compared to the known size distribution using a χ^2 test. The training exercise was continued until there was no significant difference between the observer's estimated size distribution and the known distribution (Bell et al. 1985). Transect widths were visually estimated and divers (using SCUBA) surveyed as they set the transect line to minimize disturbance to fishes (Fowler 1987). Transects were placed along the rocky outcroppings and spurs present at each reef site. Sighting frequency was determined as the number of times a species was observed divided by the total number of surveys (transects). A maximum of only one sighting of each species was possible per

Table 1. Summary of benthic characteristics at reef sites off southeastern Hispaniola. Means are based on a sample size of 20 1×1 m quadrats per site. Percent coverage of various benthos was estimated within each quadrat. Relief was measured via the chain transect method; values indicate the amount of chain overlain on the surface to cover a flat distance of 100 cm. Data are reported as mean (standard error). The number of each type of fish survey conducted at each site is also included

	Dominicus	La Raya	Rubén	El Toro
Depth range (m)	15–17	16–18	18–20	16–18
Relief (cm/m)	129 (3.4)	119 (3.7)	126 (3.6)	124 (5.6)
Sediment cover (%)	15.60 (3.07)	32.80 (5.76)	11.00 (4.52)	17.00 (3.69)
Algal cover (%)	55.60 (3.12)	52.20 (4.65)	62.20 (4.12)	70.00 (3.69)
Sponge cover (%)	7.00 (2.11)	7.80 (1.80)	11.40 (2.80)	5.20 (1.13)
Coral cover (%)	20.20 (2.29)	7.80 (1.80)	11.40 (2.80)	5.20 (1.13)
Gorgonian cover (%)	1.60 (0.61)	0.40 (0.28)	0.40 (0.28)	3.40 (0.93)
No. of transect fish surveys	15	12	11	22
No. of roving diver fish surveys	5	5	5	6

transect. Density for each species was calculated as the number of individuals observed per 40 m^2.

The roving diver visual survey method involved a diver swimming around a reef site for approximately 45–60 min and recording all fish species observed. This method included an assessment of both the spurs and grooves as well as some of the sandy area surrounding the actual reef site. Observers are free to search as they wish with few special restrictions: divers may not physically disturb the habitat and must have a buddy for safety. The length of the dive is allowed to vary, limited only by safe diving considerations usually determined by depth. At the end of the survey dive, each observer transfers data to a standard computerized scan form with pre-listed species available from the Reef Environmental Education Foundation (www.reef.org). Other data recorded include the observer's name, dive site name, navigational site coordinates, date, water temperature, duration of the survey, survey start time, estimated visibility, average depth, strength of the current, and habitat type where the survey took place (Schmitt and Sullivan 1996). Sighting frequency was calculated in the same manner as for the transect surveys. Species abundance was estimated in logarithmic-based categories as single (1), few (2–10), many (11–100), or abundant (> 100) for each survey. These data were summarized by using an index computed for each species as a weighted average of abundance categories recorded by all observers on the dive. The abundance index was calculated as:

$$\text{Abundance Index} = \frac{(S \times 1) + (F \times 2) + (M \times 3) + (A \times 4)}{n}$$

where S, F, M, and A were the number of observations in each of the abundance categories of single (S), few (F), many (M), and abundant (A) for each species, and n was the total number of surveys including surveys in which the species was not observed (Schmitt and Sullivan 1996). This index ranges from 0–4 and is indicative of the abundance category (including zero) most often recorded for each species.

Transect surveys took place during 5–9 March 1995 and roving diver surveys during 24–30 March 1995. Five observers collected data using the roving diver and four observers used the transect visual survey method. Total survey time for all reef sites combined was 31.5 h (43 surveys) for the roving diver method. For comparisons between the two methods, data collected by the roving diver visual survey method were randomly culled from all sites so there was a more equal sample time between the two methods. The adjusted roving diver survey time (used in the data analysis) was 16.1 h (21 surveys) while the transect method consisted of 15.5 h survey time (60 transects).

Analysis of survey methods

Similarity among species observed at all sites was compared for the two methods to determine if characteristics of the fish assemblage observed differed depending on the survey method used. Similarity in species presence–absence was determined by measuring the overlap in species lists using the Jaccard coefficient, which ranges from 0–1 (Ludwig and Reynolds 1988). A complete list of species observed by both methods along with their sighting frequency and abundance data was prepared.

Species with the highest and lowest sighting frequencies according to each method were compared. The 24 species with the highest sighting frequencies according to the transect method were compared with the 24 species with the highest sighting frequencies according to the roving diver method. The 29 species with the lowest (but not zero) sighting frequency values according to the transect method were compared with the 27 species with the lowest (but not zero) sighting frequency values according to the roving diver method. A different number of species were compared for each method due to tied frequency values.

In order to provide an evaluation of biases in the two methods, sighting frequency data and abundance data were compared. Sighting frequency data (percentages) were arcsine transformed before being plotted to achieve normality and homogeneous variances (Zar 1984). Density data from transects were log(x + 1) transformed (Zar 1984). Pearson correlation coefficients (r) were computed between sighting frequency and abundance measures collected via both methods.

Although we were primarily interested in comparing the overall assessments of the entire area for general trends in species distributions and abundance, we also compared site to site differences in clustering of abundance data from each survey method using the Bray-Curtis index and the Simclust program (Wolfe and Chester 1991). We used the abundance index measure from the roving diver method and the density measure from the transect method to compare abundance of haemulids, lutjanids, scarids, and serranids among the four sites.

Results

Analysis of survey methods

Similarity between the overall species lists derived from the roving diver and transect visual survey methods was 0.59. There were 36 species (29%) which were only recorded by the roving diver method (Table 2). Most of these species (35 out of 36) had abundance index values less than 1.0. Five of these species (yellow jack, *Caranx bartholomaei*; yellowtail snapper, *Ocyurus chrysurus*; porkfish, *Anisotremus surinamensis*; smallmouth grunt, *Haemulon chrysargyreum*; and cero, *Scomberomorus regalis*) were fisheries-targeted species. Many of the species recorded only by the roving diving surveys were found in grooves, reef edges, or were cryptic species. Fifteen species (12%) were recorded only by the transect

Table 2. Summary of fishes observed in southeastern Hispaniola according to both the roving diver and transect visual survey methods

	Roving	Transect	Total
No. of orders	8	7	8
No. of families	34	28	36
No. of genera	60	50	64
No. of species	110	89	125
No. of species uniquely recorded	36	15	–

method. These species also occurred in low abundance and were difficult to visually detect. Two of these species (yellowfin grouper, *Mycteroperca venenosa*, and blue runner, *Carnax crysos*) were fisheries-targeted species. More species were observed by the roving diving method (110 species) than the transect method (89 species). A complete list of species observed by both methods with their sighting frequency and abundance data is provided in Table 3. Fifty-five percent of the 24 most common fish species recorded from each method were the same between the two methods. Among these species, individual species were often recorded with very different sighting frequency values by each method, usually with a higher sighting frequency recorded by the roving diver method (Table 3). Among the species recorded as least common (but not with a sighting frequency value of zero) by each of the methods, only eight species (spotted eagle ray, *Aetobatus narinari*; redspotted hawkfish, *Amblycirrhitus pinos*; orangespotted filefish, *Cantherhines pullus*; southern stingray, *Dasyatis Americana*; shy hamlet, *Hypoplectrus guttavarius*; redtail parrotfish, *Sparisoma chrysopterum*; southern sennet, *Sphyraena picudilla*; and permit, *Trachinotus falcatus*) were present but least common by both of the methods. As we would expect, many species recorded as least common by one method were not recorded at all by the other method, and in a few cases, species that were recorded as least common (or not even recorded at all) by one method were actually more common according to the other method. Of these cases, it was more frequent for species to be more common according to the roving diver method even if they had been recorded among the least common species (or were not even observed) according to the transect method. Some examples of these species were garden eel, *Heteroconger halis*; colon goby, *Coryphopterus dicrus*; smallmouth grunt, *Haemulon chrysargyeum*; yellowtail snapper, *Ocyurus chrysurus*; spotted trunkfish, *Lactophrys bicaudalis*; and sergeant major, *Abudefduf saxatilis* (Table 3).

Sighting frequency values for each species tended to be higher using the roving diver method than the transect method (Fig. 2a). However, correlation between the two measures of sighting frequency was high (Pearson's $r = 0.746$, $n = 126$; $p < 0.05$). Several species had sighting frequency values that were nearly the same according to both methods, while some species had a high sighting frequency according to the transect and a low sighting frequency according to the roving diver method, and

Table 3. Composite species list for reef fishes off southeastern Hispaniola. Species are listed in alphabetical order by family. Abundance index/density and sighting frequency (%) values (as explained in the text) according to the roving diver and transect method are given, respectively, following each species name. Species that were recorded as common according to both methods (highest sighting frequency %) are indicated by *C*. Species that were listed among the least common (but not zero sighting frequency %) according to both methods are indicated by *R*. Cases where the species was not recorded are indicated by "–"

	Roving			Transect		
Acanthuridae						
Acanthurus bahianus[a]		1.2	51%	C	0.48	28%
Acanthurus chirurgus[a]		0.84	51%		0.79	28%
Acanthurus coeruleus[a]	C	2.5	40%	C	0.51	23%
Apogonidae						
Apogon towsendi[c]		–	–		0.10	5%
Aulostomidae						
Aulostomus maculatus[a]	C	1.8	88%	C	0.58	30%
Balistidae						
Balistes vetula[a]		0.21	14%		0.05	3%
Cantherhines macrocerus[a]		0.2	12%	R	0.07	2%
Cantherhines pullus[a]	R	0.02	2%	R	0.01	2%
Melichthys niger[a]		1.8	65%	C	1.9	27%
Monacanthus tuckeri[b]		0.14	9%		–	–
Bothidae						
Bothus lunatus[b]	R	0.02	2%		–	–
Carangidae						
Caranx bartholomaei[b]	R	0.1	5%		–	–
Caranx crysos[c]		–	–	R	0.02	2%
Caranx ruber[a]		0.71	42%	R	0.36	2%
Trachinotus falcatus[a]		0.02	2%	R	0.09	2%
Chaetodontidae						
Chaetodon aculeatus[a]		0.66	44%		0.39	20%
Chaetodon capistratus[a]	C	2.5	95%	C	2.5	67%
Chaetodon ocellatus[b]	R	0.08	5%		–	–
Chaetodon sedentarius[a]		0.44	26%	R	0.05	2%
Chaetodon striatus[a]	C	1.5	70%		0.23	15%
Cirrhitidae						
Amblycirrhitus pinos[a]	R	0.02	2%	R	0.03	2%
Clinidae						
Lucayablennius zingaro[c]		–	–	R	0.03	2%
Malacoctenus boelkiei[c]		–	–	R	0.02	2%
Malacoctenus triangulatus[a]	R	0.02	2%		0.02	3%
Congridae						
Heteroconger halis[b]		1.6	47%		–	–
Dasyatidae						
Dasyatis americana[a]	R	0.02	2%	R	0.01	2%
Echeneidae						
Echeneis naucrates[b]	R	0.02	2%		–	–
Gobiidae						
Coryphopterus dicrus[b]		0.81	37%		–	–
Coryphopterus eidolon[a]	R	0.10	5%		0.23	5%
Coryphopterus glaucofraenum[b]	R	0.06	2%		–	–
Coryphopterus lipernes[c]		–	–		0.17	7%
Coryphopterus personatus[a]		0.58	16%	C	91.3	58%
Gobiosoma dilepsis[b]		0.32	16%		–	–
Gobiosoma evelynae[c]		–	–		0.50	18%
Gobiosoma oceanops[b]	R	0.02	2%		–	–
Gobiosoma prochilos[c]		–	–	R	0.02	2%
Ioglossus helenae[b]	R	0.04	2%		–	–
Haemulidae						
Anisotremus surinamensis[b]	R	0.02	2%		–	–
Haemulon aurolineatum[a]	C	1.5	67%		0.60	18%
Haemulon carbonarium[a]		0.37	16%		0.12	7%
Haemulon chrysargyreum[b]		0.66	30%		–	–
Haemulon flavolineatum[a]		1.7	65%		0.71	22%
Haemulon sciurus[a]		0.73	28%	R	0.02	2%

Table 3. (Contd.)

	Roving			Transect		
Holocentridae						
Holocentrus adscensionis[a]	C	2.3	86%	C	0.58	25%
Holocentrus marianus[a]		0.14	9%		0.26	5%
Holocentrus rufus[a]		0.88	49%		0.07	8%
Myripristis jacobus[a]	C	2.7	88%	C	5.7	55%
Labridae						
Bodianus pulchellus[b]	R	0.02	2%		–	–
Bodianus rufus[a]		0.88	49%		0.07	8%
Clepticus parrae[a]		0.81	28%		2.2	22%
Halichoeres bivittatus[b]	R	0.13	5%		–	–
Halichoeres cyanocephalus[b]		0.19	7%		–	–
Halichoeres garnoti[a]	C	2.4	86%	C	5.6	77%
Halichoeres maculipinna[c]		–	–	R	0.04	2%
Halichoeres pictus[c]		–	–		0.07	3%
Thalassoma bifasciatum[a]	C	2.9	95%	C	8.3	62%
Lutjanidae						
Lutjanus mahogani[a]		0.48	21%	R	0.02	2%
Ocyurus chrysurus[b]		0.96	40%		–	–
Malacanthidae						
Malacanthus plumieri[a]		1.0	51%	R	0.01	2%
Myliobatidae						
Aetobatus narinari[a]	R	0.05	5%	R	0.05	2%
Mullidae						
Mulloidichthys martinicus[a]		1.4	63%	R	0.02	2%
Pseudupeneus maculatus[a]	C	1.9	74%		0.39	23%
Muraenidae						
Gymnothorax moringa[a]		0.25	21%	R	0.05	2%
Opistognathidae						
Opistognathus aurifrons[b]		0.14	12%		–	–
Ostraciidae						
Lactophrys bicaudalis[b]		0.07	7%		–	–
Lactophrys polygonia[b]		0.66	44%		–	–
Lactophrys quadricornis[b]	R	0.05	5%		–	–
Lactophrys trigonus[a]	R	0.02	2%		0.15	3%
Lactophrys triqueter[b]		0.95	63%		–	–
Pomacanthidae						
Holacanthus tricolor[a]	C	2.0	93%	C	0.74	38%
Pomacanthus arcuatus[b]		0.18	16%		–	–
Pomacanthus paru[a]		0.52	40%	R	0.02	2%
Pomacentridae						
Abudefduf saxatilis[b]		0.88	40%		–	–
Chromis cyanea[a]	C	3.5	100%	C	36.4	87%
Chromis insolatus[c]		–	–		0.09	3%
Chromis multilineata[a]	C	3.0	88%	C	16.7	53%
Microspathodon chrysurus[a]	C	1.6	67%		0.08	7%
Stegastes diencaeus[a]		0.12	7%		0.18	5%
Stegastes fuscus[b]		0.18	9%		–	–
Stegastes leucostictus[a]		0.44	21%	C	1.2	37%
Stegastes partitus[a]	C	3.0	88%	C	31.7	88%
Stegastes planifrons[a]		0.65	26%		1.3	22%
Stegastes variabilis[a]		0.63	37%		0.73	22%
Priacanthidae						
Priacanthus arenatus[b]	R	0.02	2%		–	–
Scaridae						
Scarus guacamaia[b]		0.14	7%		–	–
Scarus iserti[a]		1.2	49%	C	5.7	47%
Scarus taeniopterus[a]	C	2.2	93%	C	7.6	70%
Scarus vetula[b]	R	0.05	5%		–	–
Sparisoma atomarium[b]	R	0.02	2%		–	–
Sparisoma aurofrenatum[a]	C	2.1	93%	C	4.5	82%
Sparisoma chrysopterum[a]	R	0.1	5%	R	0.07	2%
Sparisoma rubripinne[c]		–	–	R	0.05	2%
Sparisoma viride[a]	C	1.9	74%		0.14	12%
Serranidae						
Cephalopholis cruentata[a]	C	2.0	95%	C	1.8	70%
Cephalopholis fulva[a]	C	1.6	72%		0.27	15%
Epinephelus guttatus[a]		0.07	17%		0.1	8%
Gramma loreto[a]		1.1	53%	R	0.11	2%

Table 3. (Contd.)

	Roving			Transect		
Hypoplectrus aberrans[a]		0.19	12%		0.19	5%
Hypoplectrus chlorurus[a]		0.23	9%		0.07	5%
Hypoplectrus gummigutta[c]		–	–		0.06	5%
Hypoplectrus guttavarius[a]	R	0.05	5%	R	0.03	2%
Hypoplectrus indigo[b]		0.24	12%		–	–
Hypoplectrus nigricans[a]		0.64	40%	C	0.5	30%
Hypoplectrus puella[a]	C	1.3	74%	C	0.88	38%
Hypoplectrus unicolor[a]		0.67	42%		0.49	22%
Liopropoma rubre[c]		–	–	R	0.06	2%
Mycteroperca tigris[b]		0.09	7%		–	–
Mycteroperca venenosa[c]		–	–	R	0.01	2%
Paranthias furcifer[b]	R	0.15	5%		–	–
Rypticus saponaceus[a]		0.07	7%		0.03	12%
Serrannus tabacarius[a]	C	1.7	79%		0.14	5%
Serranus tigrinus[a]	C	2.0	81%	C	1.7	68%
Sciaenidae						
Equetus punctatus[a]		0.26	26%		0.04	3%
Scombridae						
Scomberomorus regalis[b]		0.16	9%		–	–
Sparidae						
Calamus bajonado[b]	R	0.05	5%		–	–
Sphyraenidae						
Sphyraena barracuda[b]		0.28	14%		–	–
Sphyraena picudilla[a]	R	0.06	5%	R	0.23	2%
Synodontidae						
Synodus foetens[c]		–	–	R	0.02	2%
Synodus intermedius[a]		0.36	21%		0.05	5%
Tetraodontidae						
Canthigaster rostrata[a]		1.4	63%	C	1.2	48%
Chilomycterus atinga[b]	R	0.02	2%		–	–
Diodon holacanthus[a]		0.30	16%		0.03	3%
Diodon hystrix[b]		0.07	7%		–	–
Sphoeroides spengleri[a]		0.39	28%	R	0.02	2%
Urolophidae						
Urolophus jamaicensis[a]		0.23	19%	R	0.02	2%

[a]Species were observed by both methods
[b]Species were observed by the roving diver method only
[c]Species were observed by the transect method only

other species had a high sighting frequency according to the roving diver and a low sighting frequency according to the transect method (Table 4). The higher sighting frequency of the tobaccofish, *Serranus tabacarius*, and yellow goatfish, *Mulloidichthys martinicus*, from the roving diver method may be related to these species being more often observed on the sand adjacent to reefs. This area was surveyed via the roving diver but not the transect method.

Correlation between abundance measures from the two methods was moderate (Pearson's $r = 0.64$, $n = 126$; $p < 0.05$), although several species had similar abundance measures according to both methods (Fig. 2b). These species included (in order of highest abundance) striped parrotfish, *Scarus iserti*; creole wrasse, *Clepticus parrae*; and beaugregory, *Stegastes leucostictus*. Most species had higher abundance values according to the roving diver method. However, one species, masked goby, *Coryphopterus personatus*, had higher abundance values according to the transect method. This was probably related to this species also having a higher sighting frequency according to the transect method and its occurrence in small pockets with large numbers of

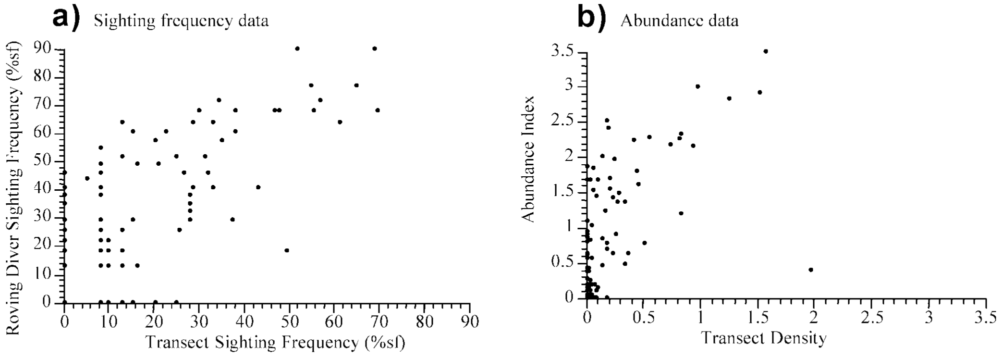

Fig. 2. Comparison of sighting frequency and abundance data among roving diver and transect visual survey methods. Transect data are log(x + 1) transformed for comparison to the logarithmic roving diver abundance index

Table 4. Summary of similarities and differences among percent sighting (%sf) data reported for various species according to the transect and roving diver survey methods. Species with similar %sf according to both methods are listed, followed by species with high %sf by the transect but low %sf by the roving diver method and then species with low %sf by the transect but high %sf by the roving diver method

Species with similar %sf by both methods (listed from high to low %sf)		Species with high %sf by transect but low %sf by roving diver method (listed in order of high %sf from transect method)	Species with low %sf by transect but high %sf by roving diver method (listed in order of high %sf from roving method)
Stegastes partitus	*Epinephelus guttatus*	*Coryphopterus personatus*	*Acanthurus coeruleus*
Halichoeres garnoti	*Hypoplectrus chlorus*	*Gobiosoma evelynae*	*Serranus tabacarius*
Scarus iserti	*Coryphopterus eidolon*	*Rypticus saponaceous*	*Microspathodon chrysurus*
Stegastes leucostictus	*Balistes vetula*		*Mulloidichthys martinicus*
Hypoplectrus nigricans	*Dasyatis americana*		
Hypoplectrus unicolor	*Caranx crysos*		
Stegastes variabilis	*Aetobatus narinari*		
Clepticus parrae			
Stegastes planifrons			
Gobiosoma dilepsis			

individuals in each pocket. However, it should be mentioned that the abundance index from the roving diver method was based on a logarithmic, categorical scale for fishes on the entire reef, while the density values from the transect method were based on the number of individual fish present in a 40-m^2 transect.

The abundance data for both survey methods provided similar clusters among the four sites for species of haemulids, lutjanids, scarids, and serranids. The two sites Rubén and Dominicus which are both low-relief, spur-and-groove habitats were the most similar, followed by La Raya, a deeper, patchy habitat, and El Toro, a low-relief, hard-bottom habitat.

Discussion

The two visual survey methods (roving diver and transect) were complementary in characterizing the fishes present on reefs off southeastern Hispaniola. The roving diver method was better able to synoptically record fishes present by ranging over an entire area and finding a greater number of uncommonly seen species in a shorter amount of time. The roving diver method can easily be adopted by well-trained volunteers as part of their regular diving program in order for fish surveys to be completed quickly and inexpensively (Schmitt and Sullivan 1996; Schmitt et al. 1998). However, as part of a resource management program, it is important to have length (biomass) and actual density measurements. For example, there may be the same abundance and sighting frequency of a commercially important species or group such as groupers, in areas both exposed to and protected from overharvesting. However, individuals of the species may be smaller in the areas where the species has been typically overharvested. This situation could be recorded by the transect but not by the roving diver method.

In general, species of the subfamily Epinephelinae were scarce from reefs off southeastern Hispaniola except for the small grouper species, graysby, *Cephalopholis cruentata*, and coney, *C. fulva*. Large groupers had a conspicuously low abundance off southeastern Hispaniola, as did large parrotfishes (personal observation). Another study confirmed a lack of fisheries-targeted species off southeastern Hispaniola and that these fishes had a tendency to be small (Pugibet et al. 2002). The lack of fisheries-targeted species seems to be more complicated than simply a disappearance of adults since a lack of juveniles of these species was found according to a trawling study in the area (Leon et al. 2002).

Species that were commonly observed and had a high abundance within the sampling area (such as blue chromis, *Chromis cyanea*, and bicolor damselfish, *Stegastes partitus*) were sampled equally well by both methods. However, there were more differences among the rare species. It is important to document the occurrence of rare or low-density species such as Nassau grouper, *Epinephelus striatus*, and other fisheries-targeted species that are declining region-wide and for which fishery landings data are unavailable, over relatively large geographical regions (Bohnsack 1996). Rare species may also be important for ecological and conservation-related reasons (Goldsmith 1991). Less commonly observed species (such as yellowtail snapper, *Ocyurus chrysurus*; spotted trunkfish, *Lactophrys bicaudalis*; and rainbow parrotfish, *Scarus guacamaia*) were better sampled by the roving diver method. However, some less commonly observed species such as golden hamlet, *Hypoplectrus gummigutta*, peppermint bass, *Liopropoma rubre*, and arrow blenny, *Lucayablennius zingaro*, were recorded by the transect method and not the roving diver method. Since, in this study, habitats adjacent to the reef were surveyed only using the roving diver method, species such as garden eel, *Heteroconger halis*, peacock flounder, *Bothus lunatus*, and yellowhead jawfish, *Opistognathus aurifrons*, which live in sand-dominated areas were recorded by the roving diver method, while these species were not recorded by the transect method. Although transects could have been conducted in all habitats, the roving method, by its very nature, is better able to survey a variety of habitats within a site (Schmitt and Sullivan 1996).

Species abundance recorded using the two methods depended on the sighting frequency (high or low) of a species within the sampling area. However, when a species was observed by both methods, it was usually recorded with a similar ranked abundance. For example, when queen triggerfish, *Balistes vetula*, was observed, it was recorded with a similar low abundance by both methods. This is related to the characteristic behavior of this species to occur singly. When blue tang, *Acanthurus coeruleus*, was observed, it was recorded with a similar high abundance by both methods. This is related to the characteristic behavior of *A. coeruleus* to occur in large schools that range throughout an area.

Through this survey work, two visual survey methods were used simultaneously to record species composition and abundance of the overall fish assemblage, including predators and herbivores. Through the transect method, data on fish size distributions were collected as well. These aspects of the fish assemblage on reefs off southeastern Hispaniola can continue to be compared over space and time. Such survey data will facilitate evaluation of the effects of increased levels of coastal fishing and assist in the development of management plans.

Acknowledgments This work was carried out at the Nature Conservancy's Marine Conservation Science Center at the University of Miami with support from the United States Agency for International Development "Parks in Peril" Program, International Development Bank, the Latin American and Caribbean Region of the Nature Conservancy, and the Dunn Foundation. The following people are greatly acknowledged for their field assistance: P. Buehler, J. Earnshaw, R. Grist, L. Hubert, B. Jacobsen, M. Jacobsen, R. Klocek, V. Kohn, C. Presperin, D. Probert, E. Pugibet, and L. Sang. M. Chiappone provided benthic summary data. The Reef Environmental Education Foundation (REEF) trained observers and developed the roving diver method. Comments from J. Bohnsack, P. Sale, and several anonymous reviewers improved the manuscript. The map illustration was created by Brian K. Walker, Biological and Geographical Information Specialist, National Coral Reef Institute, Dania Beach, Florida.

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