Reproducibility of Estimates of Effective Area Fished by Antillean Fish Traps in Coral Reef Environments

ALEJANDRO R. ACOSTA[1], RALPH G. TURINGAN[1], RICHARD S. APPELDOORN[1], and CONRAD W. RECKSIEK[2]
[1]*Department of Marine Sciences*
University of Puerto Rico
Mayaguez, Puerto Rico 00709
[2]*Department of Fisheries, Animal and Veterinary Science*
University of Rhode Island
Kingston, Rhode Island 02881

ABSTRACT

Antillean, or arrowhead fish traps are the principal fishing gear used in coral reef environments throughout much of the Caribbean. We conducted four replicate experiments in 1987, 1989, and 1990 to estimate effective area fished (EAF) by the Antillean trap for the most abundant species. Site specific estimates of effective area fished were made for seven species: ocean surgeon *Acanthurus bahianus*, redband parrotfish *Sparisoma aurofrenatus*, stoplight parrotfish *S. viridae*, squirrelfish *Holocentrus ascencionis*, longspine squirrelfish *H. rufus*, French grunt *Haemulon flavolineatum*, and foureye butterflyfish *Chaetodon capistratus*. Estimates for ocean surgeon and redband parrotfish were obtained in all sample periods, and the effective area fished range from $25m^2$ to $300m^2$, and $18m^2$ to $156m^2$, respectively. Variations in estimates of effective area fished occurred among locations and time of year.

KEY WORDS: fish traps, effective area fished, reproducibility, reef fisheries.

INTRODUCTION

Fish traps are the principal fishing device for reef fish throughout the Caribbean. They are efficient and particularly useful in areas where coral formations prevent the use of trawls or nets (Munro, 1974; Stevenson and Stuart-Sharkey, 1980). However, despite this importance, assessment methods for reef fish stocks using fish traps are not well developed, and measurement of absolute abundance is difficult.

Methods of estimating abundance of reef fishes usually include some type of direct census. Visual census techniques have been used extensively in reef ecology, biomass, and abundance studies (Brock, 1982; Sale, 1978 ,1980; Bohnsack, 1983). Trapping studies are useful to obtain Catch-per-unit-effort (CPUE) data for those species caught in traps (Reese, 1973). Accordingly, trapping experiments coupled with visual census appears to be an appropriate approach for stock assessment in tropical areas (Ferry and Kohler, 1987).

The principal limitation of traps as a survey tool is that they provide only a relative index of fish abundance, and this is only if one assumes that the fishing area of a trap is similar for different locations and times included in the surveys (Miller and Hunte, 1987).

Few studies have been concerned with the estimation of effective area fished or `calibration' of fish traps. Two exceptions are the work of Miller and Hunte (1987) and Recksiek et al. (1991). Both studies estimated effective area fished using visual counts and trap catches. The results of those studies are within the same order of magnitude for target species in similar habitats, even though the study areas were different. Both studies reported that the use of the concept of `effective area fished' for calibrating fish traps works, but it is species and habitat dependent. Results from calibration studies need to be tested for consistency over time, however, and factors such as seasonality that may affect variation between estimates need to be evaluated.

The objectives of this study were: (1) The estimation of effective area fished per fish trap using visual counts, and (2) to investigate the validity of fish trap calibration for estimating fish density by comparing the reproducibility of catchability estimates obtained at four times from 1987 to 1989.

METHODS

Studies were conducted in a shallow reef known as "Corona de Laurel" off the South coast of Puerto Rico (Fig 1). The physiography and hydrography of this reef has been described by Glynn (1973). The estimation of effective area fished in this area has been fully dealt with previously (Recksiek et al., 1991); only an outline of the method will be provided here. Five stations were used for the first two surveys, one additional station was added for the last two surveys (Figure 1). The stations were set at locations which appeared to represent different habitats within the Corona de Laurel. Station 1, characterized as a high relief site, was set on the southwest corner of the reef.

The average depth at this site was 7 m and the substratum consisted almost entirely of dead coral boulders and rubble and numerous holes and crevices. Station 2 was set on the eastern edge of the reef where the substrate is similar to Station 1 except that corals abundance and relief were slightly reduced. Station 3 was on Laurel reef proper, the substrate was sand with soft corals. Stations 4 to 6 were set on the reefcrest, where the substrata consisted mainly of soft coral colonies and small patches of corals Visual counts and trapping experiments were conducted during March 1987, February-March 1989, August-September 1989, and February 1990. A total of 30 transects and 30 traps haul were made in each transect during each of the four sampling periods.

Visual and Trapping census

Divers surveyed 50 m by 4 m transects, for a total of 200 m^2 at each station. Diver swam each transect once slowly while attempting to record all fish greater than 5-cm total length over the transect. Fishes were categorized by size class

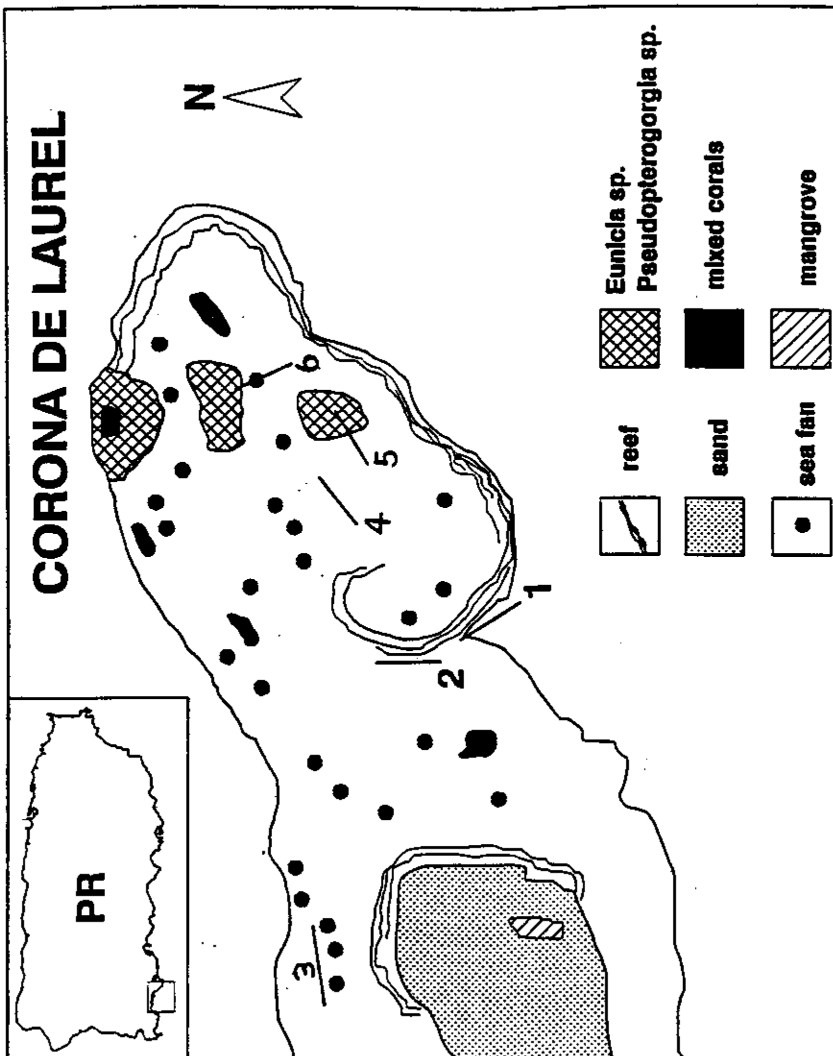

Figure 1. Map of study area showing sampling stations.

ranging from 5 cm to 30+ cm, with a size interval of 5 cm. One trap was deployed along each transect. Traps were of arrowhead design, 1.2 m x 1.2 m x 0.4 m, with a mesh of 1 and 1/4 inch. Traps were set unbaited for three-day soaks. Each three days the transects were surveyed and traps hauled. All fish caught were identified, and total length and standard length were measured.

Effective area fished

The approach used was similar to that of Miller and Hunte (1987) and Recksieck *et al.* (1991). To convert trap catches to absolute fish abundance requires a trap to be calibrated for effective area fished (EAF) (Miller, 1975). This is simply the ratio of catch per trap haul (c/f) and fish density (D):

$$\text{EAF}(\text{m}^2/\text{trap haul}) = \frac{\text{c/f (number fish/trap haul)}}{\text{D (number fish/m}^2)}$$

where D, is the density estimated from diver counts. Median transect count/station was the measure of fish density, and c/f was mean catch per trap haul. Reproducibility was determined by comparing replicate estimates of EAF over time.

RESULTS

Table 1 presents the total number of individuals and the total number of species per station for the visual counts and trap catches. As expected more species (72) were seen in the transects than in the trap catches (24). There were a few species present in both visual counts and trap catches with median values greater than zero. These were ocean surgeon, *Acanthurus bahianus*, redband parrotfish, *Sparisoma aurofrenatum*, stoplight parrotfish, *S. viride*, squirrelfish *Holocentrus ascencionis*, longspine squirrelfish *H. rufus*, foureye butterfish *Chaetodon capistratus*, and French grunt *Haemulon flavolineatum*. Table 2 gives the effective area fished and the density for these species by station and sampling period. Effective area fished was estimated for ocean surgeon in five of six stations; it ranged from 25 to 300 m^2. Densities for ocean surgeon range from 0.005 to 0.025 fish/m^2.

DISCUSSION

Species composition for traps and transects has remained fairly stable during the four sampling periods, but abundance per species by sampling period, has changed considerably. Little similarity existed, however, between the visually censused population and the trapped component of the population. This may be due to size selectivity of traps.

The data presented in Table 2 indicate that EAF estimates are variable among locations and time periods. For example, EAF for ocean surgeon ranged

Table 1. Total number of individuals and total number of species by station and year for the trap catches and visual counts.

		Stations					
		1	2	3	4	5	6
Trap Catches							
1987	No. Ind.	13	46	14	0	112	
	No. Species	5	9	10	0	15	
1989a	No. Ind.	27	36	14	32	21	
	No. Species	16	10	8	12	10	
1989b	No. Ind.	-	-	-	25	48	77
	No. Species	-	-	-	11	5	13
1990	No. Ind.	15	51	-	14	53	7
	No. Species	8	10	-	4	12	6
Visual Counts							
1987	No. Ind.	2191	812	343	495	455	
	No. Species	40	28	21	20	21	
1989a	No. Ind.	187	139	117	97	96	
	No. Species	27	20	14	18	18	
1989b	No. Ind.	965	304	-	189	108	822
	No. Species	38	25	-	13	11	30
1990	No. Ind.	804	211	-	100	56	828

from 25 to 100 during February 1989 for five different stations, and over time ranged from 25 to 300 m^2. This contrasts with the studies of Chittleborough (1979) and Morgan (1974), who found estimates of EAF for spiny lobster were in close agreement among locations during he same month of the year (*e.g.*, 144, 164, and 174 m^2/trap), but among years results ranged from 25 to 174 m^2. However, in their studies, habitat was the same for all locations. The resultsin our study indicate that EAF varies over time and by habitat.

Part of the variability seen is due to the relatively small number of samples used (maximum of 6) for each estimate. Additional variation may result if observed density of trap catches are low. For example, the data for ocean surgeon (excluding Station 1, which differ markedly in habitat type) seems to show an inverse relationship between density and EAF (Figure 2), although this is somewhat confounded by possible station effects. If true this would suggest

Table 2. Calculation of Effective Area Fished (EAF) and Density (D) per station and year using fish traps and visual counts.

		Stations									
		1		2		4		5		6	
Species	**Year**	**EAF**	**D**	**EAF**	**D**	**EAF**	**D**	**EAF**	**D**	**EAF**	**D**
Ocean surgeon	87							89	0.045		
Acanthurus bahianus	89a	25	0.02	80	0.025	67	0.015	100	0.015		
	89b							125	0.02	160	0.012
	90			40	0.025						
Redband parrotfish	87			18	0.11			71	0.04		
Sparisoma aurofrenatus	89a					50	0.02				
	89b							156	0.023		
	90			62	0.033						
Stoplight parrotfish	87			14	0.07						
S. viridae	89a										
	89b										
	90										
Squirrelfish	87										
Holocentrus ascencionis	89a										
H. rufus	89b										
	90			150	0.010					200	0.013
French grunt	87										
Haemulon flavolineatum	89a										
	89b										
	90	600	0.003								
Foureye butterflyfish	87										
Chaetodon capistratus	89a										
	89b										
	90									25	0.04

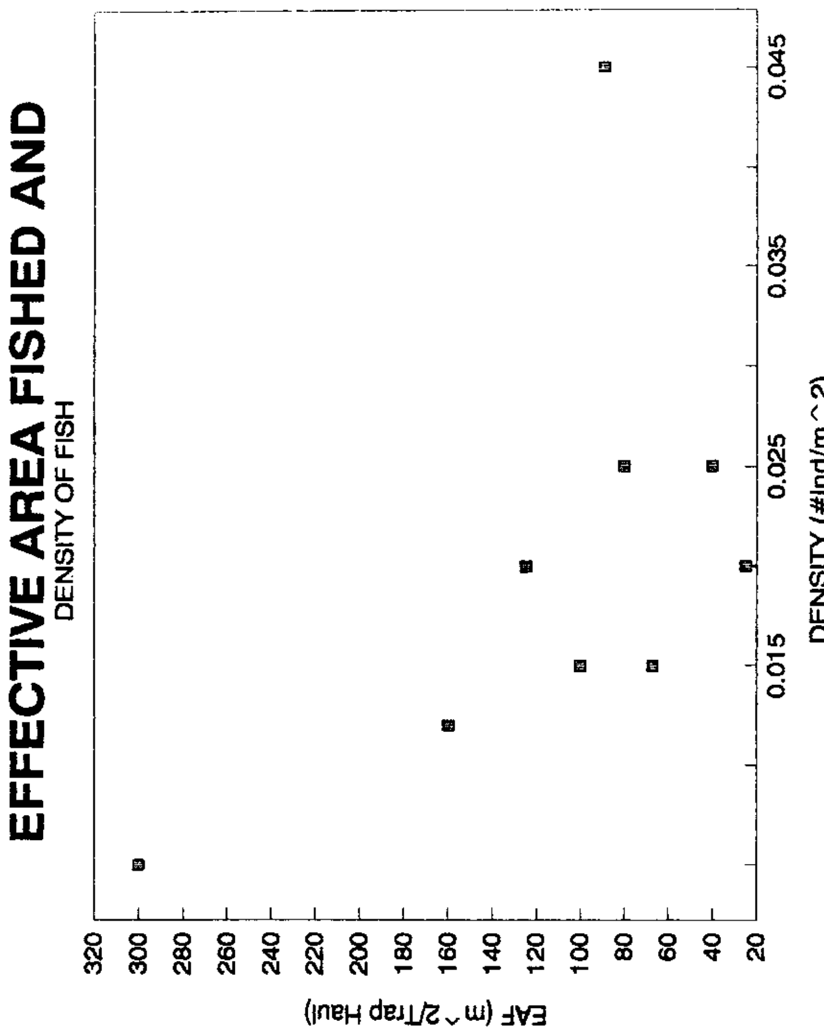

Figure 2. Effective area fished (m2/trap haul) versus Density (# Ind/200 m2)

that EAF estimates based on or applied to areas of extreme low densities are not generally applicable.

ACKNOWLEDGEMENT

Our sincere gratitude goes to Steve Tuleveck for his assisstance during one phase of the data collection and to Dave Jones for drawing Figure 1. Partial funding for this research was made available through Sea Grant research grants from the University of Puerto Rico (Projecr Number R/RR-30-10) and University of Rhode Island (Project Number M/PD-8716).

REFERENCES

Brock, R.E. 1982. A critique of the visual census method for assessing coral reef fish populations. *Bull. Mar. Sci.* **32**: 269-276.

Bohnsack, J.A. 1983. Species turnover and order versus chaos controversy concerning reef fish community structure. *Coral Reef* **1**:**223**-228.

Chittleborough, R.G. 1979. Studies on recruitment in the western Australian rock lobster, *Panulirus logipes cygnus* George: density and natural mortality of juveniles. *Aust. J. Mar. Freshwat. Res.* **21**: 131-148.

Ferry, R.E. and C.C. Kholer. 1987. Effects of trap fishing on fish populations inhabiting a fringing coral reef. *North American Journal of Fisheries Management* **7**: 580-588.

Glynn, P.W. 1973. Ecology of a Caribbean coral reef. The *Porites* reef-flat biotope: Part I. meteorology and hydrography. *Marine Biology* **20**: 297-318.

Miller, R. J. and W. Hunte. 1987. Effective area fished by Antillian fish traps. *Bull. Mar. Sci.* **38**(1): 89-110.

Miller, R. J. 1975. Density of commercial spider crab, *Chionoecetes opilio*, and calibration of effective area fished per trap using bottom photography. *J. Fish. Res. Board Can.* **32**: 761-768.

Morgan, G. R. 1974. Aspects of the population dynamics of the western rock lobster, *Panulyrus cygnus* George. II: Seasonal changes in the catchability coefficient. *Aust. J. Mar. Freshwat. Res.* **25**: 235-248.

Munro, J. L. 1974. The mode of operation of Antillian fish traps and the relationships between ingress, escapement, catch, and soak. *J. Cons. Int. Explor. Mer.* **35**(3): 337-350.

Recksiek, C.W., R. S. Appeldoorn, and R. G. Turingan. 1991. Studies of fish traps as stock assessment devices on a shallow reef in south-western Puerto Rico. *Fisheries Research* **10**: 177-197.

Reese, E.S. 1973. Duration of residence by coral reef fishes on `home' reefs. *Copeia* **145**-149.

Sale, P. F. 1978. Coexistence of coral reef fishes a lottery for living space. *Environmental Biology of Fishes* **5**: 243-249.

Sale, P. F. 1980. Assemblages of fish on patch reef predictable or unpredictable? *Environmental Biology of Fishes* **5**: 243-249.

Stevenson, D. K. and P. Stuart-Sharkey. 1980. Performance of wire fish traps on Western Coast of Puerto Rico. *Proc. Gulf. Carib. Fish. Inst.* **32**: 173-193.