Mapping Fishing Grounds Using Global Positioning System (GPS) Technology

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ABSTRACT

The application of global positioning system (GPS), along with satellite or airborne imagery and digital mapping, is of increasing importance in the understanding of fishing behavior. This paper presents the preliminary results of an interdisciplinary project (fisheries biology, anthropology and popular knowledge) tracking the patterns of spatial and seasonal utilization of fishing resources in the insular shelf of southwestern Puerto Rico. In this particular case traps were used as indicators of overall spatial and seasonal use. Researchers employed GPS receivers (Trimble GeoExplorer) to rapidly record trap coordinates that were latter differentially corrected. Three observations (February, May, and October) were recorded. In each observation, the location of all fish traps in the area were logged. Each survey comprises from three to five outings to observe the location of the gears. Recorded data was posted in the SURFER mapping program using a bathymetric data set for the area. This paper analyzes the patterns of space use and territoriality. This project is funded by the University of Puerto Rico Sea Grant College Program under its Research Initiative for Marine Fisheries Reserves.

KEY WORDS: Fisheries, fishing grounds, fish traps, GPS, Puerto Rico.

INTRODUCTION

Geographic information, in the form of aerial photography and maps, has been widely used to detect the pattern of use of particular portions of land, waters, and their associated resources (Gibb, 1981; Magoon, 1989). A time series of such information allows us to monitor environmental impact and assist in establishment of adequate conservation strategies (Niedzwiedz and Ganske, 1991). However, analysis and interpretation of this information on paper-based products often proves to be tedious, thereby inhibiting the efficient achievement of such goals (O'Regan, 1996).

Global positioning system (GPS), along with satellite or airborne imagery and digital mapping, has improved our ability to rapidly capture and analyze environmental data (Everitt, *et al.* 1993; O'Regan, 1996). The digital format of the data enables it to be directly downloaded to a computer for processing and inclusion into a geographic information system (GIS) for subsequent analysis (Morton *et al.,* 1992).

GPS was developed by the U.S. Department of Defense as a worldwide, all-weather navigation and positioning resource for both military and civilian use. It is being used to survey everything from telephone poles to coastal erosion (Morton *et al.,* 1992) or to measure resource distribution in general (Myhre, 1992; Simons *et al.,* 1992; Everitt *et al.*, 1996). The objectives in the present study were to used GPS technology to rapidly map fishing grounds on the insular shelf of southwestern Puerto Rico and then, to use these maps to detect fishing activities (seasonal changes, patterns of territoriality, fishing pressure, conflicts with other stakeholders) and compare observed behavior with the culturally reported behaviors on fishing. The present paper covers some of these aspects using fish traps as a model. This paper is part of an interdisciplinary project (fisheries biology, anthropology and popular knowledge) funded by the University of Puerto Rico Sea Grant College Program under its Research Initiative for Marine Fisheries Reserves.

MATERIALS AND METHODS

Surveys were conducted during February, May and October of 1996 with the purpose of covering different periods of fishing activities. The field team was coordinated by two persons, one operating a boat equipped with a 140 HP outboard motor, while the other one was recording geographic coordinates using a GPS and taking notes on fish trap ownership. Ownership was established by distinguishable characteristics of each fish trap buoy (i.e., color, shape, material, marks) and it was later confirmed in interviews with their presumed owners. An attempt was made to locate all fish traps in an area of approximately 112 km^2 on the insular shelf of southwestern Puerto Rico, from Punta Jorobada, near Guanica, to Cabo Rojo (Figure 1). Each survey comprises from three to five outings, depending on weather conditions, and the area was covered by traversing between the coast and the shelf-edge and from east to west.

Fish traps, normally deployed in groups of three, were selected as the primary target of the study since most of them are buoyed. This makes them easier to locate and independent of fisherman's presence. The location of nearshore, unbuoyed fish traps were not recorded in the present study.

The coordinates of each fish trap were logged for one minute (one measurement/sec.) into a Trimble GeoExplorer GPS. Two GPS served as field receivers. These had sufficient memory to store a maximum of 80 different locations on each GPS. A third GPS was simultaneously recording positions and satellite pseudoranges at a known "benchmarked" antenna location (A Trimble community base station at the Laboratory for Applied Remote Sensing and Image Processing, Univ. of Puerto Rico, Mayagüez Campus).

At the laboratory, field and base station data were downloaded into a computer. This information permitted post survey differential correction of the trap positions. Differential correction eliminates error in data measurements due to satellite clock and orbit errors (Hurn, 1993). An accuracy of 2 - 5 meters is expected. The mean position for each trap was referenced to Puerto Rico 1927 datum and posted to a base map. The base map was created using SURFER, a commercially available mapping program and a bathymetric data set, from a National Ocean Survey, compiled and digitized by Mercado (1993). While SURFER is not a GIS, it allows users to display and analyze large volumes of spatially referenced data and their associated attributes (i.e., fish trap ownership).

The plotted maps, illustrating the distribution of the fish traps, were shown to the fishermen. Their explanations about fish trap locations, fishing dynamics and interactions were recorded.

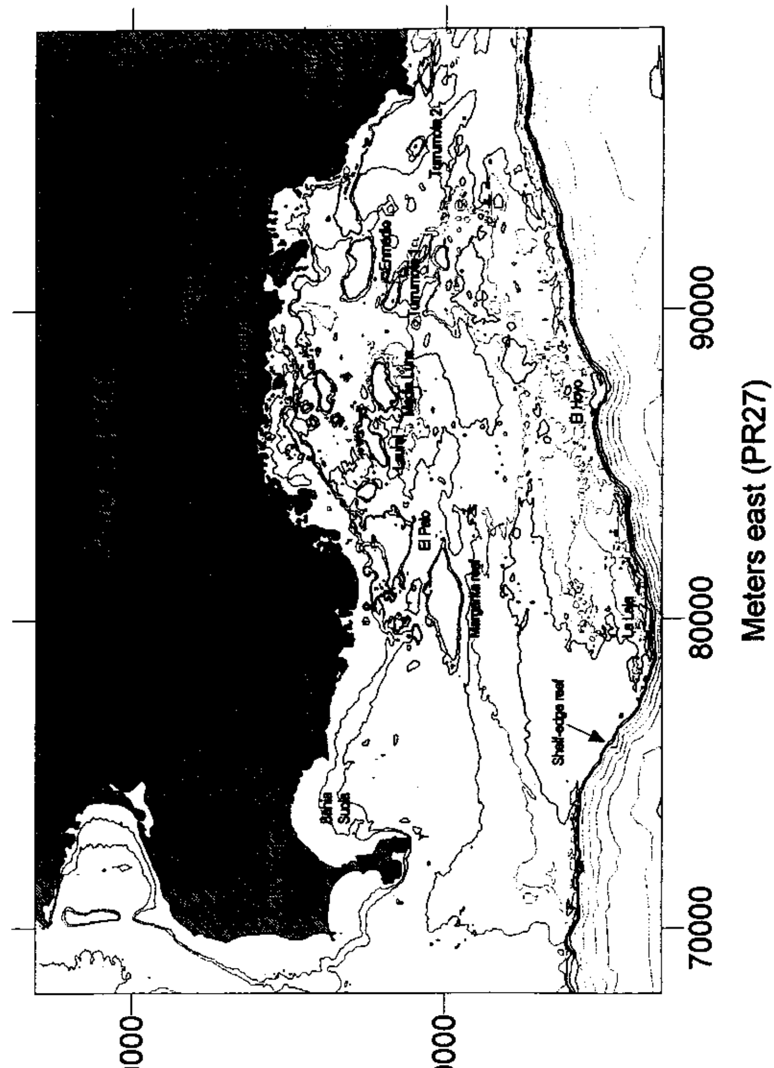

Figure 1. Map showing the insular shelf of southwestern Puerto Rico and its referential sites.

RESULTS AND DISCUSSION

Global Positioning System technology allows us to determine the actual distribution of fishing gear in a confident and precise manner, making it possible to follow their changes in distribution within space and time, to detect areas of possible overfishing due to a high concentration of fishing gear, and to avoid or solve conflict with fishing or other activities overlap.

The positions of 345 buoyed fish traps were recorded in February, 217 in May, and 352 in October. According to official statistics (Department of Natural Resources), the total number of fish traps operating in the area is around 900. Though our numbers could just reflect one third of the potentially active fishing traps, the fishermen agree that our maps properly mirror the main grounds of the fish trap fishery.

There are several features that characterize this fishery along the insular shelf of southwestern Puerto Rico. The main fishing grounds are the shallow and deep algal plains located seaward of the Margarita, Laurel, Media Luna, Turrumote I, and Turrumote II reefs (Figures 1, 2, 3, 4). There is a rich fish and invertebrate assemblage associated with the well-developed algal community and the hiding places provided by the complex relief of the surrounding reefs (Kimmel 1985).

There were not fish traps at the leeward side of most of the reefs (the lagoon), including the shelf-edge reef (Figures 1, 2, 3, 4). The substrate in most of these areas is sandy, muddy and relatively barren, providing little cover for fishes (Kimmel, 1985). An exception was observed at Enmedio reef, an area highly visited by nearshore water fishermen. Another area lacking of buoyed fish traps is in front of Bahia Sucia-La Pitahaya (Figures 1, 2, 3, 4). The substrate in this area is characterized by an homogeneous habitat of sea grass beds (*Thalassia testudinum*, *Syringodium* spp. and *Halimeda* spp.), considered by the fishermen as a poor fishing ground, especially for the spiny lobster, *Panulirus argus*, the main target of the fishery. This area is visited by nearshore fishermen with unbuoyed fish traps. In general, the fishermen avoid to deploy traps at the shelf-edge since this is a passed through area of medium scale vessels and there is a risk of haphazard damage of buoys or mutilation of the pulling rope.

In terms of seasonal patterns, the selected fishing grounds remain basically the same during the three surveyed periods (Figures 2, 3, 4). In February, fish traps appear to be more densely located in the main axis between Margarita and Media Luna reefs (Figures 1, 2). There is also a high csoncentration of fish traps in the adjacent areas at La Laja (Figures 1, 2). La Laja is a highly productive fishing spot and at this time of the year, a well known spawning aggregation site for the red hind, *Epinephelus guttatus.* In May, fish traps appear to be more dispersed, and most of those observed at La Laja in February, seem to be relocated westward of this point (Figure 3). The October survey was conducted one month afterhur ricane Hortense hit the southwestern corner of Puerto Rico, and the fishermen reported severe fish trap losses. However, the October map does not reflect it (Figure 4). Fish traps previously located seaward of Punta Jorobada (Figures 1, 2, 3, 4) and first thought were affected by the hurricane, to be relocated by their owner eastward of the surveyed area. On land, the senior author observed several fishermen devoted to the construction or repair of fish traps. This is a normal activity after the hurricane season and the fishermen indicated that the conditions are better for spiny lobster abundace (November to March). In the field, some of fish traps had new buoys and rope. It could reflect a new fish trap. A salient feature in the October survey was the presence of fish traps at the shelf-edge (east of El Hoyo; Figures 1, 4), clearly identified by several conspicuous bouys. These fish traps are dedicated to the capture of the silk snapper, *Lutjanus vivanus.* Some fishermen indicated that this species is spawning at this time of the year.

Figure 5 shows an overlay of the three previous maps (Figures 2, 3, 4). A slightly longitudinal movement can be observed, with fish traps in February located barely seaward. It was related by the fishermen indicating a regular pattern of fish trap movement in the search of productive fishing grounds, and the presence of favorable weather conditions (November to March), making easier their trips to offshore waters. Fishermen explained the shoreward movement of the fish traps between March and October as normal precautions within the hurricane season, to avoid conflicts with the recreational fishermen whose tend to cut their buoys and pulling lines during the fishing tournaments, and regular rotation of fishing grounds.

Figure 6 shows the distribution of fish traps during the October survey including reference to ownership. Twelve of the symbols represent a different fishermen and one (the half black-half white square) to unidentified owner. There is a certain fishing area overlap between La Parguera fishermen, while they voluntarily tend to avoid Salinas-Playa Santa and Cabo Rojo-Pitahaya fishing grounds. Interviews did not reflect any kind of conflicts between fish traps users. Separation appears to be related with accessibility to the fishing areas rather than a case territoriality. However, fish trap users perceive a conflict of interest with the divers and accuse them of stealing their catch.

The combined use of GPS, fisheries biology, popular knowledge and anthropology offers a unique opportunity to expand our knowledge of resource utilization and management. This combination, as shown in this paper, may be an useful tool for the understanding of the complexities of resource use. We cannot rely on one source of information, nor on the perceptions and constructions of the fishers, or the managers. Actual observation of practices mapped through this methodology is a critical step forward in building on such understanding. This study is a first step in that direction. Future studies must combine measurements and tracking of other recreational and commercial activities to have a broader picture of the complex seascape of uses and conflicts. Subtly, this paper proposes the use of this methodology for the monitoring of fishing activities, as a complement to other fisheries data gathering techniques.

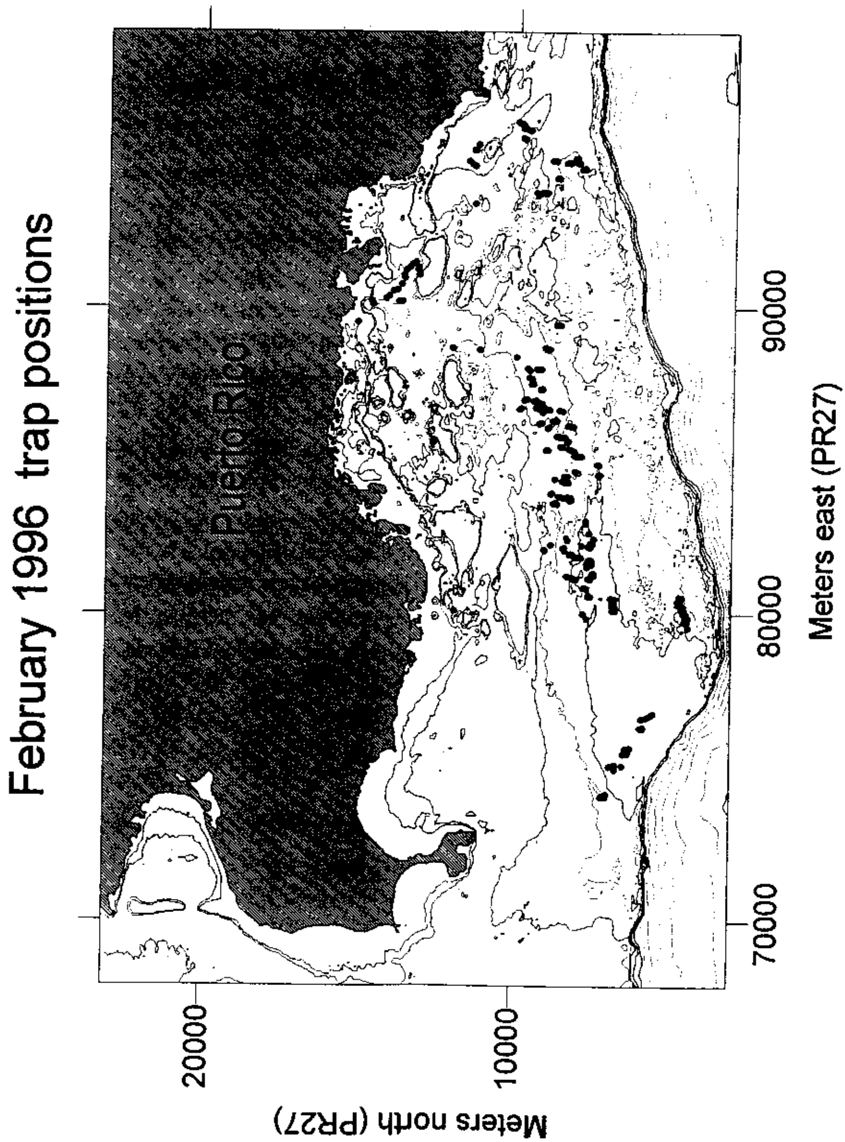

Figure 2. February 1996 fish trap positions on the insular shelf of southwestern Puerto Rico.

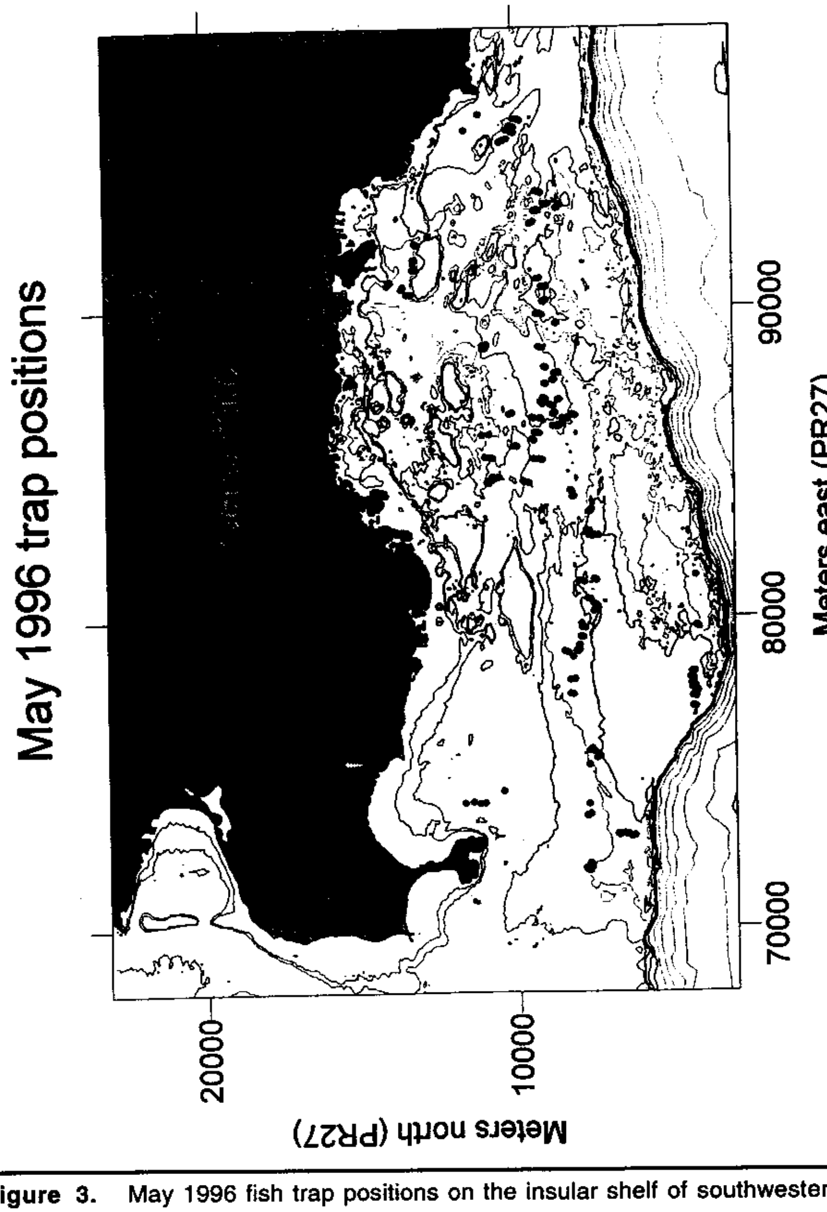

Figure 3. May 1996 fish trap positions on the insular shelf of southwestern Puerto Rico.

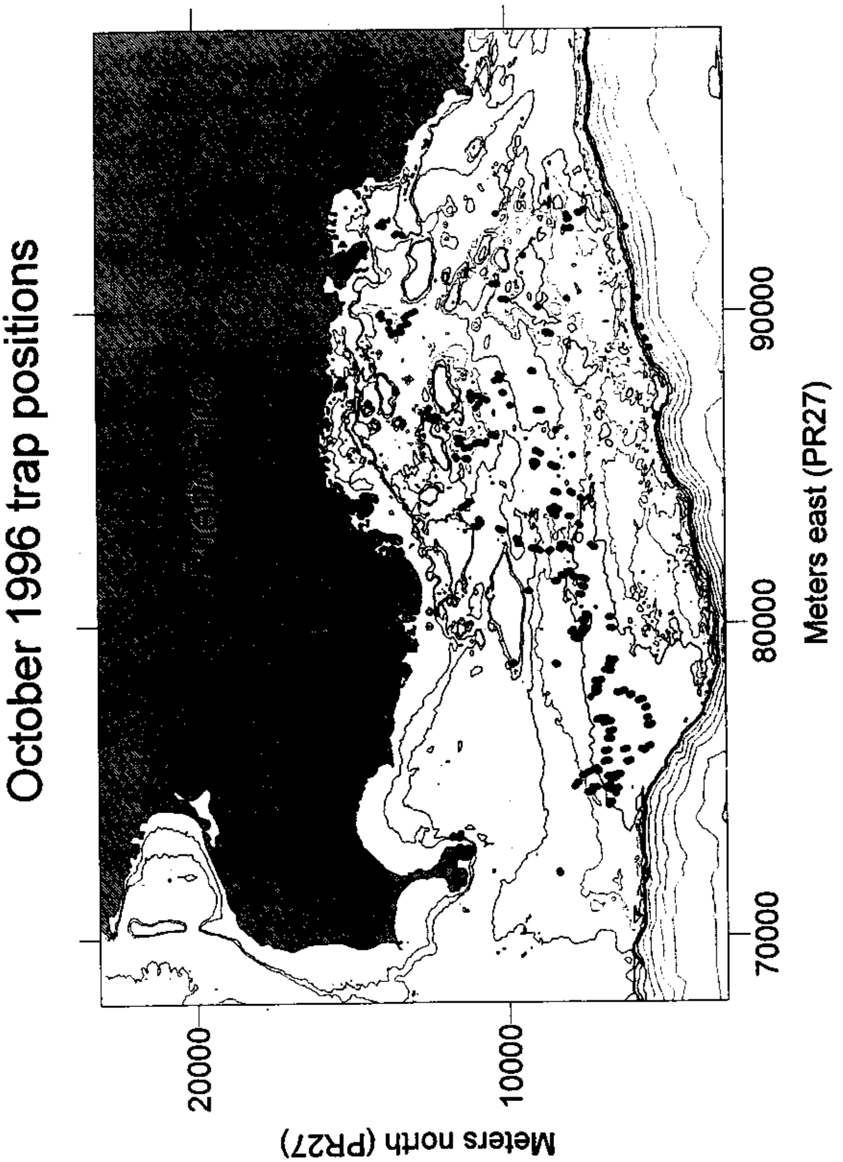

Figure 4. October 1996 fish trap positions on the insular shelf of southwestern Puerto Rico.

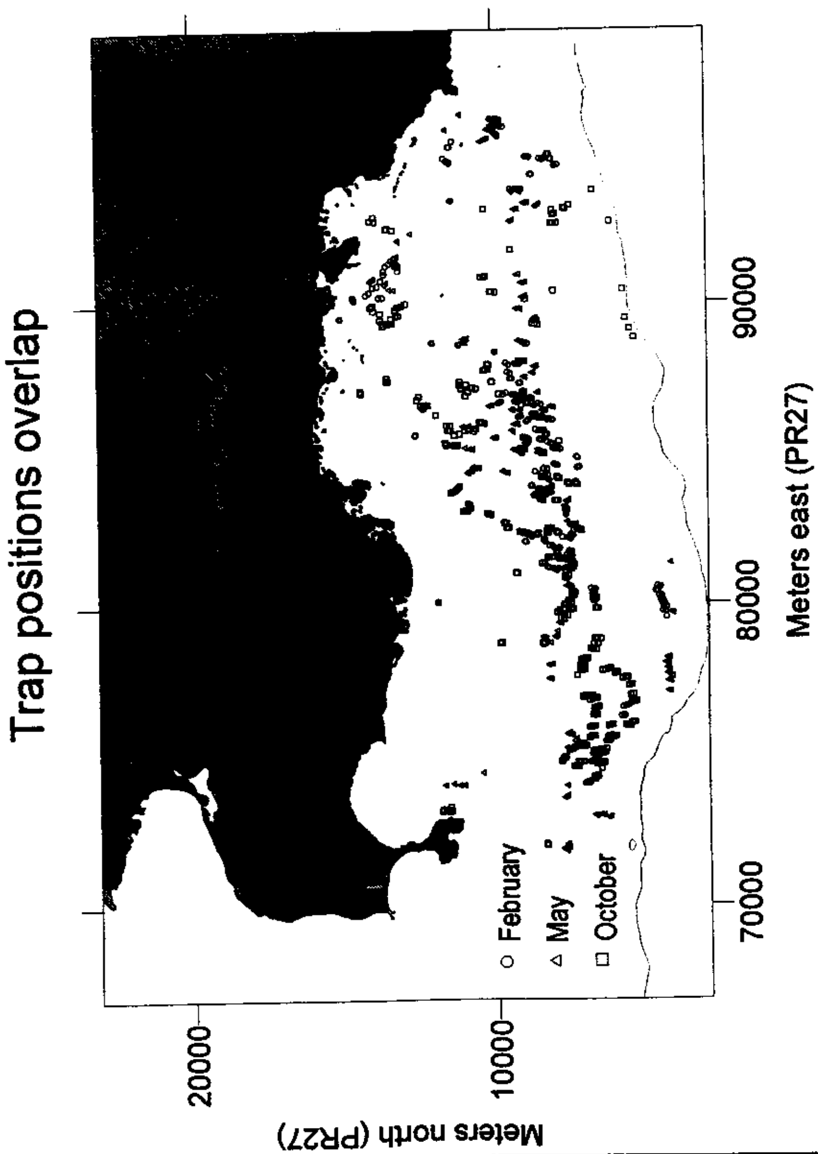

Figure 5. Fish trap positions overlayed on the insular shelf of southwestern Puerto Rico.

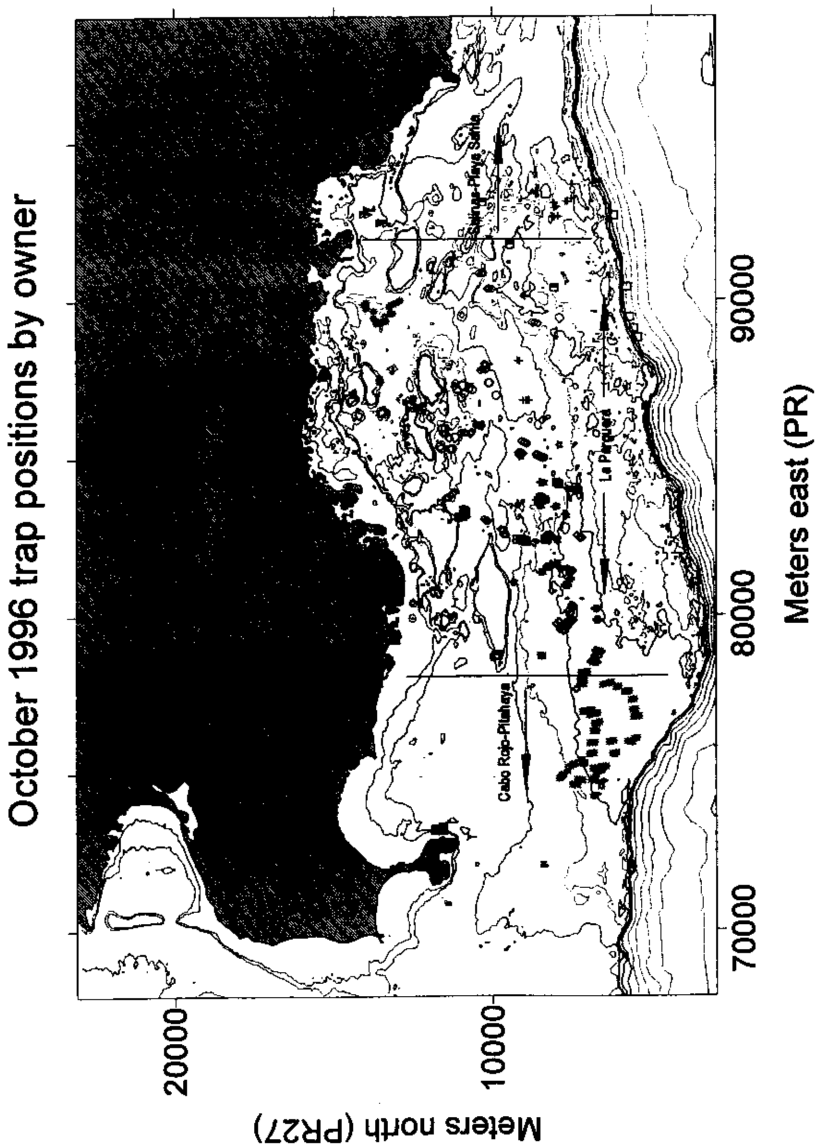

Figure 6. October 1996 fish trap positions by owner on the insular shelf of southwestern Puerto Rico.

LITERATURE CITED

Everitt, J. H., D. E. Escobar, R. Villareal, J. V. Richerson, M. A. Alaniz, M. R. Davis. 1993. Integration of airborne video-GPS-GIS technologies for detecting and mapping noxious plants on range-lands. Pages 436 - 445 in: C. D. Heatwole, ed. *Proceedings Symposium Application of Advanced Information Technologies*. (Amer. Soc. Agr. Eng., St. Joseph, Michigan).

Everitt, J. H., F. W. Judd, D. E. Escobar, and M. R. Davis. 1996. Integration of remote sensing and spatial information technologiesfor mapping black mangrove on the Texas Gulf Coast. *J. Coast. Res*. **12**(1):64 - 69.

Gibb, J. G. 1981. Coastal hazard mapping as a planning technique for Waiapu County, East Coast, North Island. NWASCO, Wellington:Water and Soil Tech. Publ. No. 21, 63 p.

Hurn, J. 1993. *Differential GPS explained.* Trimble Navigation. Sunnyvale, CA., 55 p.

Kimmel, J. J. 1985. *A Characterization of Puerto Rican Fish Assemblages..* Ph. D. Dissertation. University of Puerto Rico, Mayaguez, PR. 106 p.

Magoon, O. T. 1989. Resolution of coastal conflicts. *Shore and Beach* **57**(3): 6 - 9.

Mercado, A. 1993. Extreme wave heights in Puerto Rico and the U. S. Virgin Islands. Progress Report. Sea Grant Project Number R/OE-25-10. Mayaguez, PR., 96 p.

Morton, R. A. Leach, M. P., Paine, J. G., and M. A. Cardoza. 1992. Monitoring beach changes using GPS surveying techniques. *J. Coast.Res.* **9**(3):702 - 720.

Myhre, R. J. 1992. Use of color airborne videography in the U. S. Forest Service. *Proceedings Resource Technology 92, Sympos.Amer. Soc. Photogramm. and Remote Sensing* (Bethesda, Maryland), 145 - 152.

Niedzwiedz, W. R., and L. W. Ganske. 1991. Assessing lakeshore permit compliance using low altitude oblique 35mm aerial photography. *Photogramm. Engineering and Remote Sensing* **57**(5):511 - 518.

O'Regan, P. R. 1996. The use of contemporary information technologies for coastal research and management: a review. *J. Coast. Res.* **12**(1):192 - 204.

Simons, J. D., E. N. Powell, and T. M. Soniat. 1992. An improved method for mapping oyster bottom using a global positioning system and an acoustic profiler. Aquaculture' 92 (Orlando, Florida). 207 p. (summary only).