Remote Sensing and GIS Applications: Advances in Fisheries Research and Management Based on the Proceedings of the Gulf and Caribbean Fisheries Institute

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ABSTRACT

This work presents a summary of the 41 presentations the GCFI annual meetings have contributed for the advance in fisheries management and stocks quantifications, based on Remote sensing products and GIS applications across the Caribbean. Beginning in 1950, presentations on this regard included the analysis of uses and benefits of oceanographic instruments for marine biology and fisheries management, all the way to the use of most sophisticated remote operated vehicles loaded with multiple sensors presented in 2003, during the Emergent Technologies Special Session. The 13 reports on the use of a wide variety of active acoustics transducers identify this technology as a real alternative for the advance not only of quantification of stock biomass, but also for detailed habitat mapping. Presented works on benthic mapping have included also the use of even higher diversity of passive sensors, beginning with color and infrared aerial photography to satellite imagery and video-recordings. Additional experiences registering the link between existing information and GIS platforms illustrates how isolate data can be easily located and integrated for better decision-taken process and dissemination of scientific information. Integration of different technologies and establishment of functional networking across the Caribbean are key factors to the improvement of remote sensing imagery and GIS applications through the GCFI forum.

KEY WORDS: Remote Sensing, GIS applications

Aplicaciones de Sensores Remotos y Aplicaciones de SIG: Avances de la Investigación y Manejo Pesquero basado en las Memorias del Instituto de Pesquerías del Caribe y el Golfo

Este trabajo presenta un resumen de las 41 presentaciones hechas en las reuniones anuales de GCFI para el avance de la investigación y el manejo pesquero, basado en productos de sensores remotos y aplicaciones de SIG a lo largo del Caribe. Iniciadas en 1950, las presentaciones en este sentido incluyen desde el análisis de los usos y beneficios de instrumentos oceanográficos en la biología marina y manejo pesquero, hasta el uso de vehículos operados remotamente llevando múltiples sensores, información presentada en el 2003, durante la Sesión Especial de Tecnologías Emergentes. Los 13 reportes sobre el uso de una variedad de transductores acústicos activos identificaron esta tecnología como una alternativa real, no solo para la cuantificación de la biomasa de recursos, sino también para el mapeo detallado de los hábitats. Los trabajos presentados sobre el mapeo bentónico han incluido el uso de una aún mayor diversidad de sensores pasivos, tales como fotografías aéreas de color e infrarrojo, imágenes satelitales y grabaciones de video. Experiencias adicionales que registran la vinculación de datos existentes con plataformas de SIG ilustrando como datos aislados pueden ser fácilmente localizados e integrados para el mejoramiento del proceso de toma de decisiones y diseminación de información. La integración de diferentes tecnologías y el establecimiento de redes funcionales en el Caribe son factores claves para el mejoramiento de las imágenes de sensores remotos y las aplicaciones SIG a través del foro del GCFI.

PALABRAS CLAVES: Sensores remotos, aplicaciones de SIG

INTRODUCTION

Efficient fisheries management is a complex process because it on requires one hand a bulk of scientific information on stocks living in a vast ocean, moving across patchy habitats and on the other hand the adoption of appropriate polices and regulations. Many times, the decision-taken process in fisheries management responds to these challenges in absence of information about fish biomass, and its relationships with the environment they live as well as the dynamics that allows for connectivity at the local and higher spatial scales. Through these 60 years of existence, the GCFI forum have contributed with the dissemination of experiences, techniques and tools on how remote sensing products and the GIS platforms can provide the needed information and analysis. The following table summaries each of the 41 works presented during the GCFI annual meetings including a variety of sensors, techniques, hardware and software across the many places. There is missing information on some reports, but most of the contributions identified: year, proceedings, authors, institutions, location, objectives, results, sensor/instrument, and language of the original publication (Table 1). However, the most valuable lessons from this retrospective is perhaps the one that found the establishment of a networking of existing information, remote sensing imagery, state of the art technology and people's inputs and analysis all together in order to look with different lenses the nearby ocean resources we the Caribbean inhabitants share.

CONCLUDING REMARKS

The retrospective presented above give us the opportunity to learn how the fisheries world have been integrating different remote sensing products, linking them into functional GIS to open a whole new way to perceive and analyze our complex and dynamic marine environment. The possibility to be able to see them at different spatial and temporal scales have facilitated the generation of functional networking across the Caribbean and proved to be key factors in the advance of fisheries research and management. The GCFI forum has harbored every initiatives and projects on this regard and supported in front of a new millennium.

Table 1. Summaries each of the 41 works presented during the GCFI annual meetings

Year	Proceeding	Authors	Institutions	Location	Objectives	Results	Sensor/Instrument	Language
1950	3:88-95	Lawrence E	Electronics Distributors	Florida	Uses and benefits of echo-sounding for fisheries	US Engineering and coastal applications and instrument benefits	Bendix fish finder, paper recording	English
1951	4:103-110	Anderson AW Lyman J	US Navy Hydrographic Office	Washington, D.C.	promising of oceanographic instruments for marine biology uses	salinity, temperature, depth,	Nansen bottles, current meter and bathythermograph	English
1966	19:58	Bates CC Martin JW Rockwell R	US Naval Ocean & Bureau of commercial fisheries		Investigating multiband photography to determination of upwelling, red tide and thermal sea surface		passive microwaves infrared radiometer, telemetry buoys	English
1967	20:40-43	Bullis HR	Bureau of Commercial Fisheries	Eastern Gulf MX	1963-1965 qualitative monthly movement of menhaden schools	Description of advantages of vertical aerial photography	Infrared ektachrome	English
1983	36:117-126	West N Richardson K Griffin J Tanis FJ	Geography and Marine Affairs Univ. Rode Island Landsat RSC Environmental Research Institute, Univ. Michigan		Comparison of different passive remote sensing imagery for terrestrial, coastal and near shore	Analysis of Landsat MSS, TM, GOES SMR, NOAA AVHRRS, CZCS for coastal and near shore applications		English
1985	38:387-404	Butler MJ McNeil JL Fay CB	Atlantic Coastal Information Center Maritime Research Service MRMS, Inc	Caribbean project based on Canadian Experiences	Implementation of fisheries resource mapping based on thematic and statistical data	Mini GIS for Caribbean Fisheries Management	Main frame work stations	English
	38:405-414	Gerlotto F	ORSTOM	Martinique	Hydroacoustic methods for fish biomass	Hydroacoustics for surveys on pelagic fishes and stock evaluation		French
	38:415-432	West N Richardson K	International Center for Marine Research Dpt. Geography, Marine affairs Landsat Remote Sensisng Lab.	Martinique	Information for fisheries management near shore and offshore based on temperature, chlorophyll, sedimentation, depth, bottom cover	Unsupervised classification on wetlands and mangroves 5 classes on water	Landsat MSS 84 ELAS	English

1986	39:208-217	Butler MJA Speight CA McCourt ML	MRMS Maritime Management Service, Inc	Passamaquoddy Bay, New Brunswick	Review of remote sensing application for fisheries	Case studies on vegetation distribution on the tidal zone Shore classification Assess of clams fishing effort Detection of oil spill and monitoring Red tide detection	CIR photography with Zeis RMK camera Color infrared photography Black & white filtered for UV radiation	English
1992	45:253	Licenga-Correa MA	CINVESTAV	Banco Chinchorro, MX	Summary of methods of remote sensing for fisheries management	Automatic classification	Landsat TM	Spanish
	45:254-268	Butler MJA Leblanc C	Council of Maritme Premiers, CA, ICOD, CIDA, CERMES	Trinidad & Tobago Barbados	Caribbean mapping Project for living and non living resources. Need of habitat mapping at different scales 500,000, 50,000, 5000 for inventories and conflicts.	GeoAxes Destop mapping IDRC's		English
	45:997-998	Carriquiriborde L Claro R Gerlotto F Hernández C	Centro de Investigaciones de Quintana Roo, Instituto de Oceanología Cuba, ORSTOM		Horizontal international cooperation for acoustic evaluation of shallow water stocks	Workshops reports from 1988-1991 hidroacoustic surveys for shallow reef fishes		Spanish
1996	49:125-138	Valdez-Pizzini M Posada JM Grove K Rosado M	Dpt. Marine Sciences, Univ. PR	PR insular shelf	Determination of spatial location and seasonal patterns of fishing grounds	GPS position of 345 fishing traps along 112 km2 plotted as Surfer maps Three months surveyed	GPS differential corrected	English
	49:523-530	Junes RL Stone AW	Caribbean Marine Research NMFS-NESC	Exhuma Banks, Bahamas	Mapping seagrass biomass to location of queen conch juvenile aggregations and identification of tidal circulation patterns	86% of seagrass between 1-5 m mapped Nursery area 111 ha, primary ones within or adjacent to tidal channels Seagrass biomass estimated	Landsat TM Multiyear conchs census	English

1997	50:191-205	Bello-Pineda J Licenga-Correa MA	CINVESTAV	Alacranes Reefs, MX	Use of a satellite image for mapping purposes	Unsupervised classification of Alacranes. Unable to assign classes into habitats. 4 major classes.	Landsat TM 1986	Spanish
1999	52:402-414	Appeldoorn RS Prada MC Rivera JA	University of Puerto Rico NMFS-SEFC PR Sea Grant	South West PR	Methods for detailed mapping (1:1000) of benthic habitats using side scan sonar	21 identified habitats from side scan sea floor mosaics	300 kHz Marine Sonic Technology Inc system	English
	52:415-427	Garcia-Perez JR Arias-Gonzalez JE	CINVESTAV	Mahagual, MX	Characterize coral reef changes between May 97, Jul 98 and Nov 98	50 non-overlay images analyzed. 31-25% reduction in coral cover Effects of Mitchell and El Niño	Video transects	English
	52:686-699	Ingram GW Patterson WF	Univ. South Alabama Coastal Fisheries Institute, CA	Gulf of MX	Seabass, Gag, red snapper Tagging and release in 1995 & 1998 and literature analysis	Seabass can move 47 to 136 m/day Red snapper 5,93 km, Gag high fidelity, MPA benefits		English
2002	55:757-764	Wilson CA Nieland DL	Coastal Fishery Institute Dpt. Oceanography and Coastal Science, Louisiana	Northern Gulf of MX	Quantitative estimations of fishes. Removing by explosives	521 to 8202 red snappers 1.2 to 7.2 million young red snapper	Hydroacoustic, video transects and fish landings	English
	55:395-402	Boswell K Wilson C	Dpt. Oceanography and Coastal Sciences, LSU	Bay Champagne, Port Fourlon, LU	Use of hydro-acoustics for effective fisheries management	Big biomass differences between day and night, but not between channel and Bay. Small size *Anchovia mitchilli* dominated (90-97%) at night.	30 min transects Biosonics DE 6000 Wing net trawls Acoustic noise from plankton and suspended sediments	English
	55:713-734	Grober-Dunsmore R Frazer TK Beets J Funicelli N Zwick PD	Univ. Florida Florida Caribbean Center Science and Math Jacksonville Tech.	St. John, USVI	Relationship between landscape metrics of benthic habitats and reef fish assemblages	Fish assemblage structure may not scale up landscape habitat diversity. Benefits and limitations of spatial index.	Benthic mapping from NOAA Aerial photograph and fish census	English

	55:777-790	Prada MC Appeldoorn RS Rivera JA	University of Puerto Rico NMFS-SEFC	South west PR	Mapping benthic habitats (1:1000) on the south-west section of the PR shelf using side scan sonar	25 seafloor mosaics visually interpreted for generation of detailed benthic map	300 kHz Marine Sonic Technology Inc system	English
2003	56:355	Kendall M	NOAA/NPS	Buck Island, USVI	Understanding fish abundance and seascape	More diverse reef fish within seagrass Fish species richness related to sand near hard bottom Relationship observed only at intermediate scales	NOAA habitat map Visual fish census	English
	56:395-410	Mills AP Eristhee N Llewellyn A	Conservation and Fisheries Dpt.	BBVI	Integrated resource management and GIS expansion	Improvement of data capture Conceptualization of spatial models	Existing data GIS	English
2003 Special publication	Emergent Technologies for Reef Fisheries & Management NOAA Professional Papers 5:4-9	Rand PS Taylor JC Eggleston DB	Center for Marine Science & Technology, and Dpt. Marine. Earth & Atm. Science North Carolina State University	Little Cayman, Cayman Islands	Fishery independent methods to quantify fish spawning aggregations for use in population assessments and provide baseline information on reproductive life history of exploited populations.	3d attributes for grouper aggregations from 0725 hours Maximum volumetric density 1.05 to 0.74 ind/m3	Streo-video Sony TVR-11system	English
	NOAA Professional Papers 5:10-17	Johnston SV Rivera JA Rosario A Timko MA Nealson PA Kumagai KK	Hydroacoustic Tecnology, Inc NOAA-SEFSC-Biodiversity and Protected species Division Dpt. Recursos Naturales PR	All around shelf break of PR	Hydro-acoustic evaluation of spawning red hind aggregations along the shelf edge of PR	Spatial location of fish aggregations along the PR shelf edge Density comparison between 2002 & 2003 Cage target strength calibration	Split beam hydroacoustic Technology system Model 243-200 kHz	English

	NOAA Professional Papers 5:18-25	Taylor JC Eggleston DB Rand PS	Center for Marine Science & Technology, and Dpt. Marine. Earth & Atm. Science North Carolina State University	Little Cayman, Cayman Islands	Hydroacoustic surveys to estimate densites, spatial extend and total abundance of Nassau grouper spawning aggregations	Overall densities three times higher than diver estimations Extended location of complete aggregations Most of the fishes were off the bottom Effective tool for monitoring, specially combines with diver observations	Split beam hydroacoustic Technology system Model 241-200 kHz	English
	NOAA Professional Papers 5:26-37	Glazer RA Delgado GA	Florida Fish & Wildlife Conservation Commission	French eef, Florida Keys, FL	Link life-history parameters with habitat utilization to design the extend of an optimal size of MFR to protect queen conch population	39 conchs tagged Preferred habitat was coarse sand and rubble Spatial probabilistic home range models produced	Acoustic tags and GIS habitat information	English
	NOAA Professional Papers 5:38-47	Gleason AC Ekland AM Reid RP Koch V	Div. Marine Geology and Geophysics, RSMAS, Univ Miami NOAA-SEFSC	Carysford Reef, Florida Keys, FL	Characterize acoustic signature of grouper spawning aggregations	Acoustic classification and variability were significantly different at sites with and without groupers Sites with groupers had hard bottom substrates and high acoustic variability	QTC View Series V	English
	NOAA Professional Papers 5:48-68	Weaver DC Naar DF Donnahue BT	Flower Garden Bank NMS, NOAA Col. Marine Science, Univ. South Florida	Rideley's Hump & Tortugas South Ecological Reserve, FL	Multibeam bathymetry and deep water reef fishes	50 deep water fishes reported Top ten were planktivores Many gropers observed Detailed deep water bathymetry maps	Scuba Phantom S2 ROV Simrad EM 3000 mutibeam echosounding	English

	NOAA Professional Papers 5:69-87	Weaver DC Naar DF Donnahue BT	Flower Garden Bank NMS, NOAA	Alderdice, McGrailo & Sonier Bank, NW Gulf MX	Multidisciplinary project to revisit the reefs and banks of the NWGOM and built on the description and characterization of past research programs	Six submersibles dives focusing on hard bottom communities and reef structure 120 fishes associated with reef communities, dominated by planktivorous fishes (81.4%) High resolution multibeam bathymetry Significant populations of black sea urchins (Diadema) and spiny lobsters	Nuuytco Research, Ltd Deepworker 2000 and Deep Rower submersibles	English
	NOAA Professional Papers 5:88-104	Rivera JA Prada MC Arsenault JL Moody G Benoit N	NOAA-SEFSC-Biodiversity and Protected species Division Geophysique GPR International, Inc	MCD, Lang Bank & Mutton Snapper closed fishing areas, USVI	Reports of fish aggregations signals from side scan sonar imagery	18 km2 of Federal managed areas with multibeam bathymetry and detailed habitat mapping Location of spatial distribution of fish aggregations Largest densities on MCD over coral communities Unidentified swimming objects found over sand areas at the shelf break	RTK GPS Multibeam Geosawth 250 kHz Side scan sonar Klein 595 dual frequency 100 and 500kHz	English
	NOAA Professional Papers 5:105-	Matson DM Nagy BN Butler M Larsen S Murie DJ Lindberg WJ	NOAA Great Lakes Environmental Research Laboratory Dpt. Fisheries and Aquatic Sciences, Univ. Florida	Suwannece regional reef system, offshore North Central Gulf Coast	Describe technologies and integration of these technologies for gaining NMFS EFH understanding habitats-fish production systems	In situ measurements of total metabolic expenditure of gag Abundance, behavior, prey abilities Quantification of functional relationship between reef habitat quality on gag grouper growth on shallow coastal reefs	120 kHz split beam Simrad EY 500 echosounder Fix array of two Biosonics transducers E 6000, 200 & 420 kHz Sony CCD-TR910 video camera Electron transport systems	English

2004	57:61-75	Rubec Lewis Shirley O'donnal Locker	FWCC Florida Dept. protected Resources USF	Rookery Bay, FL	Predicting suitability maps of estuarine species influenced by fresh water inflows	24 seasonal maps of salinity, temperature and Dissolved oxygen 1 habitat map Bathymetry 66 HSM predictions Of species distribution. Great effect of salinity	SSS QTC Furuno 520 ST DGPS	English
	57:621-632	Kraus RT Hill RI Rooker JR Dellapena TM	Texas A&M Univ. NOAA Fisheries-Galveston Gulf MX council Grant J.R.RX	Sonnier Bank, Gulf of MX	Quantify abundance of exploited species composition Fish age structure for two decades ago	2 dominant species in fish counts Bank between 18 and 30 m	Video ROV transects	English
	57:1-8	Smith A	UWI Canary Caribbean Natural Rsource Inst. COMARE	St. Lucia	Use of GIS to participatory process during MPA implementation. Increase ownership Share information Locate isolated sites	Participative process successful experience	Existing information and GIS	English
	57:9-30	Rowe JJ Sedbery GR	Applied Science Associated, Inc RI Marine Research Institute SC MARMAP	EEZ between south Cape Hatteras to Cape Canaveral	Distribution of fishing effort, habitats and ocean circulation to site MPA and sustainable fisheries	785,088 fishes, 70% of abundance of 12 species Max abundance at the upper slope Max. fish abundance in hard bottom	Existing information Interpolation 15˚ maps Index bottom type 10" grid Pearson correlation coefficient	English