Developing Management Tools to Enhance Efficiency of Marine Protected Areas Management in Honduras

Desarrollando Herramientas a Mejorar la Eficaz del Manejo de Los Áreas Marinas Protegidas en Honduras

Développer des Outils de Gestion pour Améliorer l'Efficacité de la Gestion des AMP au Honduras

ANDRZEJ NAROZANSKI[1], STEPHEN BOX[2], and GEORGE STOYLE[3]
[1]Centro de Ecología Marina, Edificio Florencia, Oficina 401-403, Blvd Suyapa, Tegucigalpa, Honduras. andrzej@utilaecology.org. [2]Smithsonian Institution, Fort Pierce Marine Station, Florida 34949 USA. steveinbox@yahoo.co.uk. [3]University of Newcastle, Newcastle, United Kingdom. gstoyle@gmail.com.

ABSTRACT

The effective management of MPAs in Honduras has been hampered by a lack of appropriate tools to assist managers in making decisions and measuring the effectiveness of their actions. Three specific tools were developed to help marine park managers measure the status of their reefs, log details of infractions from illegal activities within the park boundaries and collate landing information from fishers. As online tools (available at www.ourfish.org), the information once entered is automatically analyzed and displayed as a set of clear outputs, available in real time.

We tested this system with two marine parks in the Bay Islands Honduras. AGRRA data collected inside and outside two marine protected areas on Roatán and Utila found significant differences in the fish assemblages and greater biomass inside the protected areas. There was little variation in coral cover inside or outside either of the MPAs. The majority of animals confiscated from offenders during illegal activities were conch and lobster (70%) with an average of four conch and three lobsters removed per fisher. Illegal spearing targeted 33 species of reef fish, with snappers and grunts predominating. Seventy-two percent of offenders were from mainland Honduras, compared to Islanders who accounted for 23%. Tourists made up the remainder.

These tools provide local park managers with detailed information on which to base focused management decisions by measuring the impact the park is having on the ecology of the area whilst also being able to pin point enforcement priorities and targets for further education and outreach work.

KEY WORDS: Roatán, Utila, Bay Islands, AGRRA, monitoring, MPA

INTRODUCTION

Central to the ecosystem approach of coral reef management are marine protected areas (MPAs), which have been established globally as an important tool used for fisheries management, biodiversity conservation, habitat restoration and tourism development (National Research Council 2001). MPAs are one of the most favoured coral reef management tools to address issues of overfishing and habitat degradation, whilst also fostering alternative livelihoods (Christie and White 2007). MPAs continue to be implemented throughout tropical regions, as coral reef health declines worldwide (Hughes et al. 2003), impacting biodiversity, economies, and food security.

Although the number of coral reef MPAs has grown rapidly in recent years, their performance remains highly variable (Halpern 2003, Mascia 2003) and MPAs within these regions have yet to realize their full potential. The success of an MPA is at risk if managers cannot assess and monitor the biological, environmental and social factors that influence how the area's management objectives are being fulfilled. Social factors, not just biological or physical variables, have been identified to be the primary determinants of MPA success or failure (Kelleher and Recchia 1998, McClanahan 1999). Current approaches to MPA management emphasize that these criteria, that influence the efficacy of the areas management actions should be considered during management strategy planning and evaluation (Alder et al. 2002).

Successful management of MPAs requires continuous feedback of activities in order to successfully achieve its objectives. The evaluation process consists of reviewing the results of actions taken, and assessing whether these actions are influencing or producing the desired outcomes (Mascia 2003). Without the means to reflect on such actions, this leaves managers at risk of wasting resources, objectives not being achieved and a loss of faith from dependant stakeholders (Hilborn et al. 2004). Mistakes are part of the management processes, but without planning, monitoring and evaluation, managers are unlikely to effectively identify areas of strength and weakness, and understand achievements and failures as management becomes rigid and largely unsuccessful (Hilborn et al. 2004). Through analysing scientific data gathered across these variables, protected area management can improve its effectiveness and therefore progress towards the achievement of its required goals and objectives.

Effective management of MPAs in Honduras has been hampered by a lack of appropriate tools to assist managers in assessing, evaluating and measuring the effectiveness of their actions. With already limited resources available to them, the ability to evaluate management strategy performance is vital to facilitate structured planning and reduce the risk of wasting resources due to a lack of appropriate feedback. To address this issue a suite of specific tools were developed to help managers gather information in three key areas that impact local MPA management. Here, we present these tools, using two MPAs in the Bay Islands, Honduras managed by the Bay Islands Conservation Association (BICA) Utila, and Roatán Marine Park (RMP) to pilot their use.

METHODS

Tool Development

Three areas were identified where the development of tools could strengthen MPA management in Honduras:

i) Coral reef health,
ii) Illegal activities within the boundaries of the protected area, and
iii) Fisheries landing data.

Construction of the entry forms for the coral reef health tool was based on the Atlantic and Gulf Rapid Reef Assessment (AGRRA) protocol version 5.4 (Lang et al. 2010), designed to collate data on fish size and abundance, coral reef relief, benthic cover, coral recruitment and coral size and condition. The forms for the illegal activities tool were developed using information gathered by the RMP from previous infractions, in addition to information from the experiences of MPA patrol officers and managers. The following information was included in the forms; incident details (details of reporting management organisation, date of report, date of incident, boat type involved, time, names of rangers and police, location, latitude and longitude coordinates); type of illegal activity (anchoring, net fishing, fishing with no license, trap fishing, fishing species in moratorium, capturing turtles, fishing species out of season, capturing sharks, fishing in no take zone, collecting marine trinkets, taking undersize lobster, taking female lobster, collecting coral, spearfishing, other); fishing equipment confiscated (mask & snorkel, fins, sling, gaff, SCUBA equipment, nets, traps, lionfish sling, spearguns, knives, gloves, other); weapons confiscated (knife, machete, shotgun, pistol, rifle, other); offender details (full name, address, residency status, gender, date of birth, estimated age, ethnic group, national ID number, fishing license number, option to upload photo - max 2Mb); number of animals seized (lobster, fish, conch, sea star, shark, other); details of fish seized (family, species, number, size class (cm)); details of action taken against offender (date, gear confiscation, reported to local authorities, 24 hour jail term, fine, beach clean, prison term, other). The fisheries landing database forms were developed using the guidelines from the FAO Fish stock assessment Manual, (Cadima 2003) and information from Box and Canty (2010). Information in the forms included; date, facility name, names of fishers, number of fishers, location fished, departure and return time, number and types of gears used, number of casts, distance travelled, fuel used (litres), fish category (deepwater snapper, grouper, invertebrate, mixed reef fish, pelagic, shallow water snapper, tuna, yellowtail snapper), total weight of fish caught, price per pound (lb), fish species, and length.

Each tool was constructed as an online database by creating a series of data entry forms with associated analysis, featuring real-time visual representation of results. Databases were developed using a combination of client, server-side and database scripting languages running on an Apache server and a number of MySQL (version 5.5) databases. Dynamic elements and database integration was achieved using PHP (version 5.4.8), a server-side scripting language which is embedded into the HTML source document. Organisation and summarisation of data was achieved on the database server through the use of Views (SQL Server 2008) as stored queries, which are accessible to the server as dynamic, virtual tables. Real-time visual representation of data was achieved using PHP and FusionCharts (Suite XT), a cross-browser compatible chart rending software that uses a combination of Flash and Javascript. Validation and list filtering was achieved using a combination of PHP and client-side Javascript.

Tool Assessment

AGRRA fish, benthic and coral data were collected during quarterly survey expeditions (December, 2011 and March, June, September, 2012) on fringing reefs around Utila (N 16°5.817, W 86°55.933) and barrier reefs around Roatán (N 16°23.000, W 86°24.000). Three sites inside and outside the two MPAs (Figure 1) were chosen on the north shore of each island, based on homogeneity of reef habitat. Surveys were conducted on the fore reef at depths ranging from 3 – 15 m. AGRRA data collected from the 6 surveys sites from each island was used to test the coral reef health tool. Written reports and photographs from 115 incidents recorded by the RMP, dating from November 2006 to October 2010 were analysed and used to test the illegal activity tool. No data was available from these two locations to test the fisheries landing tool and therefore fisheries results will not be presented in this paper.

Data Analysis

Fish length data recorded during AGRRA surveys and length-weight relationship *a* and *b* constants from Froese and Pauly (2012) were used to calculate biomass. Fish biomass and abundance (log transformed data), coral and fleshy macroalgae (percentage cover data), and number of; coral density per $10m^2$, diseased corals, coral affected by bleaching, corals with new mortality and old mortality were analysed by performing one-way ANOVAs using inside or outside the protected area as explanatory variables, in order to detect the impact of the marine protected area on a suite of reef health parameters. Biomass of fish seized during illegal activities was calculated by estimating fish sizes from photographs and using length-weight *a* and *b* constants from Froese and Pauly (2012). Results in grams (g) were converted to pounds (lb).

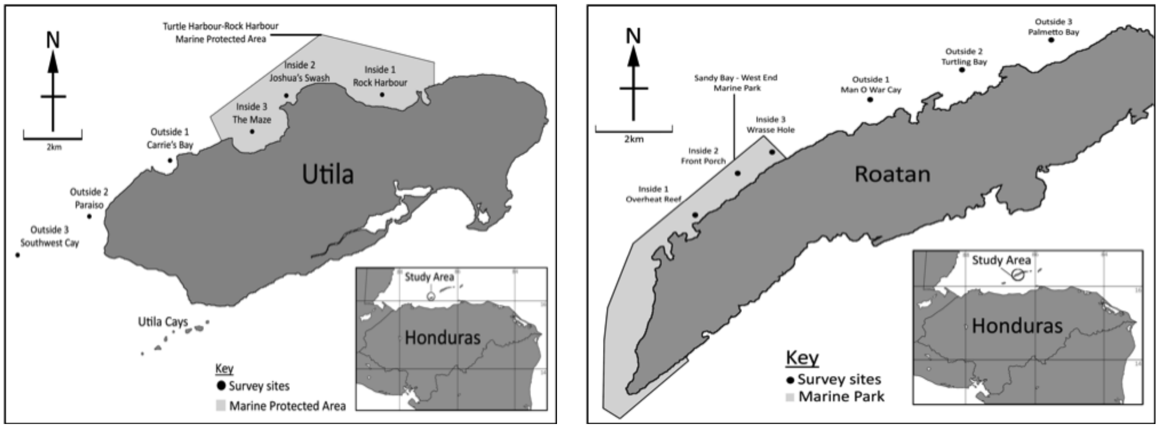

Figure 1. AGRRA survey sites inside and outside the Marine Protected Areas of Utila and Roatán.

RESULTS

Databases

Three database tools, AGRRA (coral reef health) (Figure 2), PATROL (illegal activities), CAPTURA (fisheries landing) are available online at www.ourfish.org, where each database can be accessed through a login page. Within each database users can navigate to the following options:

i) Enter new data,
ii) Review existing data,
iii) View outputs and products, and
iv) Manage database content lists.

On selection of the "Enter new data" option users are prompted to follow a sequence of pages allowing entry of information specific to each respective tool. For each database tool the entry form interface was designed to be user friendly, to make data entry simple and intuitive. Clicking the "Review existing data" directs the user to pages that present data already entered and provides the option to amend, add or delete data, allowing updates or corrections to be made. Data for each survey type is presented in tabular form in the "View outputs and products" section, with graphical outputs available based on spatial and temporal filters. Additional graphical outputs were developed for the AGRRA database that are aligned with the Healthy Reefs Initiative (HRI) report card, based on the Integrated Reef Health Index (IRHI) (Healthy Reefs Initiative 2010). The forth option, "Manage database content lists" allows administrators to amend, add or delete the contents of the lists that make up each data entry form.

Reef Health and Fish Assemblages

Herbivore abundance and biomass, total fish biomass and fleshy macroalgae cover were found to be greater inside the MPA on Roatán (Table 1). Parrotfish showed a greater abundance (p = 0.000) and biomass (p = 0.014) inside Roatán's MPA, while triggerfish showed the opposite (abundance p = 0.000, biomass p = 0.000). Snappers had a greater abundance outside (p = 0.017). For Utila herbivore biomass and macroalgae cover where greater outside the MPA (Table 1). Commercial species abundance and biomass, and total fish biomass was greater inside the protected area (Table 1). The following species; grunts (abundance p = 0.000, biomass p = 0.042), snappers (abundance p = 0.000, biomass p = 0.000) and triggerfish (abundance p = 0.000, biomass p = 0.000) showed a greater abundance and biomass inside the Utila MPA, however porgies had a greater abundance (p = 0.015) and biomass (p = 0.004) outside. Parrotfish were found to be more abundant outside (p = 0.000). There was no difference in coral cover, coral density, diseased corals, coral mortality or number of corals affected by bleaching inside or outside either of the MPAs (Table 1).

Illegal Activities

A total of 939 conchs (*Strombus gigas*), lobsters (*Panulirus argus* and *Panulirus guttatus*) and fish were confiscated by RMP patrol personnel over 115 reported illegal incidents. Conch was the most frequently confiscated item, accounting for 40%. Both lobster and fish accounted for 30%. An average of 4 conchs, 3 lobsters and 2 fish were confiscated during illegal activities inside the protected area boundaries. From thirty-three fish species caught bluestriped grunt was the most common species targeted, and had the highest mean weight overall caught by poachers, followed by schoolmaster snapper and stoplight parrotfish, bar jack and longspine squirrelfish (Table 2). Grunts dominated catches making up 35% of the fish families caught followed by snappers (28%).

One hundred and sixty individuals (some of these repeat offenders) were identified from the incident reports logged by the RMP. Seventy-two percent of offenders were from mainland Honduras, compared to Islanders who accounted for 23%. Tourists made up the remainder (5%). Snorkelling equipment (60% of incidents) was the most common item of equipment confiscated, followed by speargun (28% of incidents) and gaff (21% of incidents). Nets (6% of incidents), SCUBA equipment (4% of incidents), slings and traps (3% of incidents) were confiscated less frequently during illegal fishing incidents.

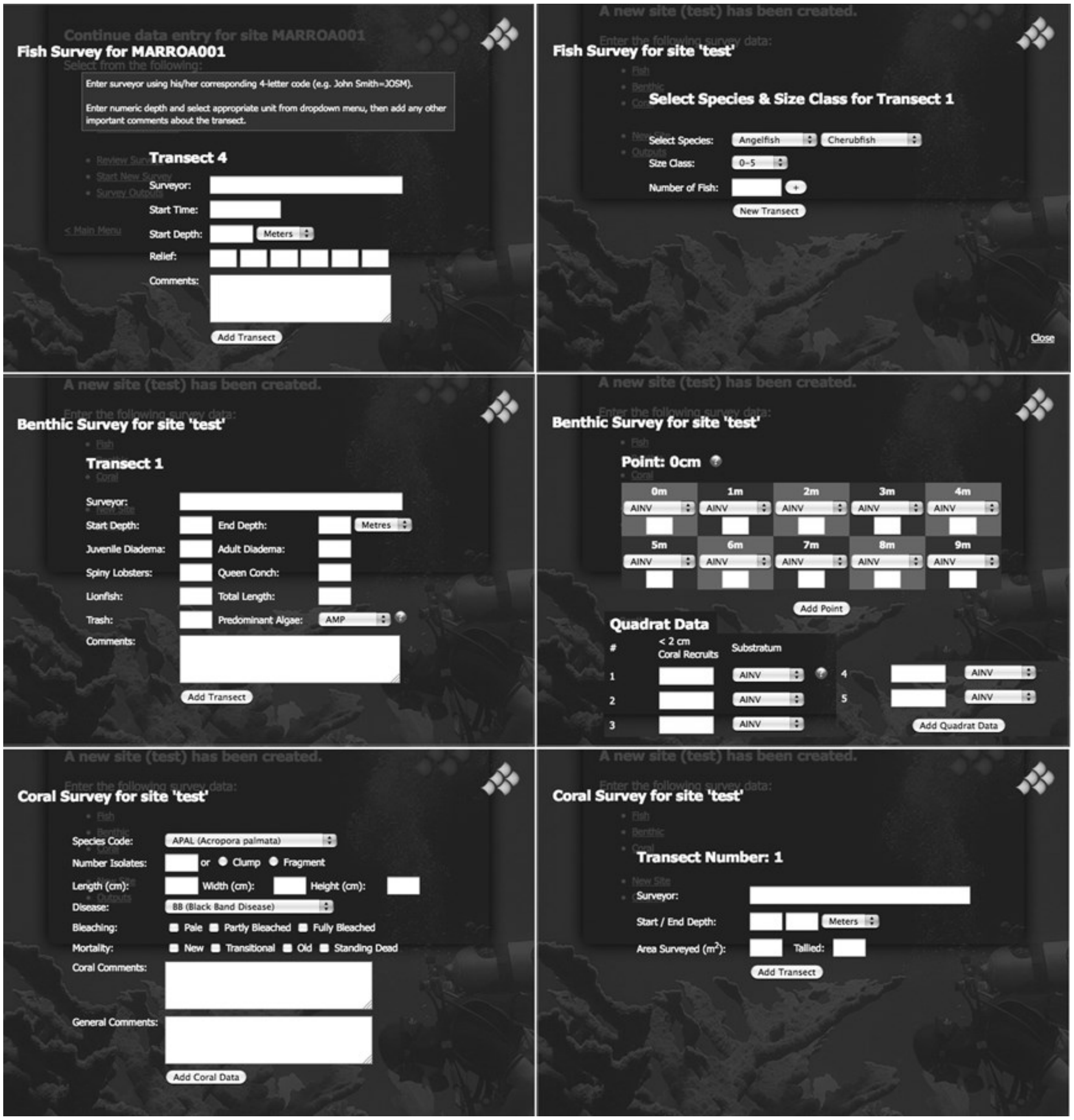

Figure 2. AGRRA database data entry forms fish (a), benthic (b) and coral (c).

Table 1. Reef health data for Roatán and Utila MPAs. Results of a one-way ANOVA testing variables against inside and outside MPAs.

	Roatán				Utila			
Variable	**Outside MPA**	**Inside MPA**	***F***	***p***	**Outside MPA**	**Inside MPA**	***F***	***p***
Total fish abundance (#/100 m^2)	42.8	44.5	0.570	0.450	46.2	57.3	3.520	0.062
Herbivores abundance (#/100 m^2)	24.9	32.8	8.870	0.003	30.3	19.8	22.930	0.000
Commercial sp. abundance (#/100 m^2)	3.9	2.7	2.720	0.101	3.0	10.2	26.630	0.000
Total fish biomass (g/100 m^2)	6737.9	9053.8	4.880	0.028	5936.1	8572.3	11.230	0.001
Herbivores biomass (g/100 m^2)	3527.8	5339.6	14.950	0.000	3643.3	2790.7	0.990	0.320
Commercial sp. biomass (g/100 m^2)	1041.6	1531.4	0.190	0.660	504.2	1782.4	17.230	0.000
Fleshy Macroalgae (%)	11.5	18.6	7.560	0.009	30.1	17.2	16.090	0.000
Coral cover (%)	15.7	14.3	0.360	0.554	16.9	14.8	2.040	0.158
Coral density (per 10 m^2)	52.7	61.0	2.500	0.189	64.3	61.3	0.330	0.594
Diseased corals (%)	38.1	16.7	7.692	0.051	2.1	0.0	2.290	0.205
Coral affected by bleaching (%)	21.3	13.0	0.614	0.477	31.7	20.3	2.790	0.170
Corals with new mortality (%)	5.2	5.8	0.200	0.678	4.2	2.7	1.800	0.251
Corals with old mortality (%)	35.7	21.3	4.050	0.114	46.6	35.6	5.040	0.088

Table 2. Fish species with the highest mean weights caught by poachers per incident and their corresponding total number caught by poachers.

English common name	Scientific name	Mean weight caught by poacher per incident (lbs)	Percentage of species caught by poachers (all incidents)
Bluestriped grunt	*Haemulon sciurus*	0.85	34
Schoolmaster	*Lutjanus apodus*	0.43	25
Stoplight parrotfish	*Sparisoma viride*	0.26	5
Hogfish	*Lachnolaimus maximus*	0.19	1
Bar jack	*Caranx ruber*	0.17	5
Mutton snapper	*Lutjanus analis*	0.14	2
Barracuda	*Sphyraena barracuda*	0.14	1
Longspine squirrelfish	*Holocentrus rufus*	0.08	5
French Angelfish	*Pomacanthus paru*	0.07	1
Black Margate	*Anisotremus surinamensis*	0.07	0
All fish species	- -	2.98	- -

DISCUSSION

The databases produced during this study represent the first MPA management tools of their kind to be developed in Honduras. These tools provide a mechanism to measure coral reef health data, log infractions from illegal activities within the park boundaries and collate landing data from fishers. Providing a means for managers to collate information and have it processed, receiving results instantaneously is a step major forward in how managers will be able to monitor these variables over time and assess how efficient current actions are.

An objective of the MPAs that were used to pilot this tool is to maintain (and increase) the natural resources within them. The coral reef health tool allows managers to assess if resources within the MPAs have increased, stayed the same or diminished, in turn providing a measure of the effectiveness of their resource management programme. In the case of assessing reef health data, being able to highlight certain variables such as high fleshy macroalgal cover or poor coral health can provide the prompt for further investigation, in order to determine root causes and improve strategies to mitigate further decreases and begin improvements. Data gathered during this study provides a baseline for the six survey sites around each island, which now represent permanent monitoring sites for each respective MPA management organisation. A number of attributes of reef health were identified to be significantly better inside the MPA than outside, while others were found to be the opposite. This identifies that there are key resources such as total fish biomass, which are being maintained by the presence of the MPA and their enforcement strategies, indicating that current management is having a positive impact on the resources inside, compared to outside. It also identified certain resources that are similar or worse than inside the MPA indicating where management actions need to focus to produce improvements. The outputs aligned with the HRI Integrated Reef Health Index, provides continuity in how certain metrics of reef health are measured, analysed and compared to other reefs in the region, further enhancing the analytical options available to managers.

The PATROL database provides a useful mechanism that allows a significant quantity of information to be collated and stored, providing easily accessible reports that can be produced as forms of evidence in the legal process towards prosecution of offenders. In addition, it provides a means to identify repeat offenders, allows improved planning of patrols to target poaching hotspots and times of day, as well as identifying trends in illegal activities taking place, the species and sizes targeted by poachers, the ethnicity and origins of offenders, and types of prosecution. The information directly analysed by this tool can help pinpoint enforcement priorities, assess and evaluate the success rate of the patrols over time through logging its patrol effort, as well as assist in directing outreach and education initiatives to target specific communities or demographics as a mechanism to reduce illegal activities. The level of illegal activities, particularly illegal fishing, is likely to be increasing as migration from the mainland increases to the island. The high proportion of mainland fishers caught in illegal activities suggests that it is this poorer demographic who are more prone to break the regulations because of their higher need to supplement their diet or their income. Running marine patrols to prevent this type of activity is one option, but is costly and time consuming. Alternatives to this top down enforcement by management agencies including the development of targeted outreach programmes on illegal fishing methods and equipment, closed season or restricted species, need to be developed to improve the adherence to fisheries laws around the island.

The production of the CAPTURA database represents an important tool for the future management of MPAs in Honduras. Fisheries management as a key component of MPA management is aimed at maintaining (and or recovering) fish stocks, a key factor in gaining community support for MPAs (Agardy 2000). The ability to evaluate whether fish stocks are productive and fishing is occurring at a sustainable level is a fundamental pre-requisite for the management of marine resources, for both fishers and other resources user such as SCUBA divers and snorkelers. It is essential that the total level of harvest is monitored and so that it can be linked to the total level of fishing effort directed at each target species in this area. Currently, MPA managers have minimal engagement with local fishers and there is little information available on the current status of fishing exploitation, the number of fishers active within the marine park boundaries or in adjacent areas in general, as no records of artisanal fishers or boats registered and licensed to fish locally are maintained by MPA managers or DIGEPESCA the Honduran fisheries department. The licensing of fishers is currently being undertaken within the Bay Islands region as part of wider strategy to legitimise and engage fishers (Stephen Box, Smithsonian Institute, Personal communication). The availability of the CAPTURA database tool for monitoring fishing activities, will allow a key component of fisheries management to be met, while providing a mechanism to link fishers to management authorities. Data which is stored is provided in the form of instant reports detailing the current status of their fishery, as well as providing information on CPUE, catch composition and size, size of fish, and income generated per fisher and fishing group. This information will help to determine suitable levels of exploitation which can be used to develop or amend MPA management strategy on sustainable quotas, closed seasons and sizes, as well as forming a direct link to engage fishers and fishers groups. This will help fishers to see how their actions change the status of the fisheries and therefore participate in how their local resources are monitored and managed.

These simple tools provide local park managers with detailed, locally derived information on which to base focused management decisions by measuring the impact the park is having on the ecology of the area whilst also being able to develop enforcement priorities, targets for further education and outreach work and assess fish stocks. A key part of a multidisciplinary approach to resource use management. These tools will be available for use by other MPAs in Honduras, the Mesoamerican region and beyond to assist management and conservation efforts.

ACKNOWLEDGEMENTS

The research leading to the production of these products and results received funding from the MAR Fund under grant agreement no HONI-4-007.

LITERATURE CITED

Agardy, T. 2000. Effects of fisheries on marine ecosystems: A conservationist's perspective. *ICES Journal of Marine Science* **57**:761-765.

Alder, J., D. Zeller, T. Pitcher, and R. Sumaila. 2002. A Method for Evaluating Marine Protected Area Management. *Coastal Management* **30**:121-131.

Box, S. and S. Canty. 2010. The long and short-term economic drivers of overexploitation in Honduran coral reef fisheries due to their dependence on export markets. *Proceedings of the Gulf and Caribbean Fisheries Institute* **63**:43-51.

Cadima, E.L. 2003. Fish stock assessment annual. FAO Fisheries Technical Paper. No. 393. FAO, Rome, Italy.

Christie, P. and A.T. White. 2007. Best practices for improved governance of coral reef marine protected areas. *Coral Reefs* **26**:1047-1056.

Froese, R. and D. Pauly (eds.). 2012. *FishBase*. Available: www.fishbase.org.

Halpern, B. 2003. The impact of marine reserves: do reserves work and does reserve size matter? *Ecological Applications* **13**(1):S117-S137.

Healthy Reefs Initiative. 2010. *Report Card for the Mesoamerican Reef*. Available: www.healthyreefs.org.

Hilborn, R., K. Stokes, J. Maguire, T. Smith, L.W. Botsford, M. Mangel, J. Orensanz, A. Parma, J. Rice, J. Bell, K.L Cochrane, S. Garcia, S.J Hall, G.P Kirkwood, K.Sainsbury, G. Stefansson, and C. Walters. 2004. When can marine reserves improve fisheries management? *Ocean & Coastal Management* **47**:197-205.

Hughes TP, A.H. Baird, D.R. Bellwood, M. Card, S.R. Connolly, C. Folke, R. Grosberg, O. Hoegh-Guldberg, J.B.C. Jackson, J. Kleypas, J.M. Lough, P. Marshall, M. Nystrom, S.R. Palumbi, J.M. Pandol, B. Rosen, and J. Roughgarden. 2003. Climate change, human impacts, and the resilience of coral reefs. *Science* **301**:929-933

Kelleher, G., and C. Recchia. 1998. Lessons from marine protected areas around the world. *Parks* **8**(2):1-4.

Lang, J.C., K.W. Marks, P.A. Kramer, P.R. Kramer, and R.N. Ginsburg. 2010. *AGRRA Protocols Version 5.4.* Available: www.agrra.org.

Mascia, M.B. 2003. The Human Dimension of Coral Reef Marine Protected Areas: Recent Social Science Research and Its Policy Implications. *Conservation Biology* **17**:630-632.

McClanahan, T.R. 1999. Is there a future for coral reef parks in poor tropical countries? *Coral Reefs* **18:**321-325.

National Research Council (NRC). 2001. *Marine Protected Areas: Tools for Sustaining Ocean Ecosystems.* National Academy Press, Washington, D.C. USA. 288 pp.