Coral Reef Monitoring with Fishers Participation in Quintana Roo, Mexico: Building Social Capital to Preserve Marine Ecosystems

Monitoreo de Arrecifes de Coral con la Participación de Pescadores en Quintana Roo, México: Construyendo Capital Social para Preservar los Ecosistemas Marinos

La Surveillance des Récifs Coralliens avec la Participation des Pêcheurs en Quintana Roo, Mexique: Construction du Capital Social pour la Préservation des Écosystèmes Marins

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ABSTRACT

Since 2011 Comunidad y Biodiversidad has been working closely with fishing cooperatives in the central portion of Quintana Roo, Mexico to establish fully protected marine reserves to restore commercial fisheries and preserve coral reefs and associated habitats. The process to design, implement and monitor these reserves was developed in collaboration with the fishers and a multitude of other stakeholders, working under the Kanan Kay Alliance. The Alliance's main goal is to create a network of marine reserves along the coast of the state, which are co-managed by fishers and authorities, and eventually become essential tools in supporting ecosystem resilience and services. Although the project is very ambitious, both in terms of geographic coverage and timing (20% of territorial waters by 2015) and its collaborative approach (the Kanan Kay Alliance is made of 40 institutions), it has been discovered that the marine reserves are not only key to restoring the natural capital of the reefs, but also generate social capital particularly regarding the fishing cooperatives' organization, administration, leadership, marketing, law enforcement and governance skills. A package of incentives has also been generated to compensate some of the opportunity costs of the marine reserves. We conclude that this model of work can have dual results and that conservation projects can benefit greatly by considering both approaches even with controversial tools like fully protected zones.

KEY WORDS: Fully protected zones, co-management, fishers

INTRODUCTION

Bottom-up resource management has been gaining ground over the last decade with the human-environment interaction being recognised as a key part of the now more popular ecosystem-based management approach (Beger et al. 2004, Pikitch et al. 2004, Sáenz-Arroyo et al. 2005, McLeod and Leslie 2009, Zhou et al. 2010). The traditional ecological knowledge (TEK) of fishermen is also recognised as an important resource for conservation initiatives worldwide (Schafer and Reis 2008, Valdés-Pizzini et al. 2012, Butler et al. 2012). Combining these two resources provides additional environmental benefits but requires a cautious, participatory and transparent approach to establish successful conservation measures. No take zones (also called "fish refuges") have been shown to provide benefits both to the ecosystem (Roberts and Hawkins 2000, Williamson et al. 2004, Aburto-Oropeza et al. 2011) and to fisheries (Roberts et al. 2001, Gell and Roberts 2002), and currently represent one of the most popular tools for marine conservation with several initiatives promoting their use worldwide. The environmental and socioeconomic benefits of community-managed marine reserves have been documented in the literature (White and Vogt 2000, Johannes 2002, Basurto 2005, Sáenz-Arroyo et al. 2005).

The State of Quintana Roo is located on the Mexico´s Caribbean coast in an area of high marine biodiversity and anthropogenic pressure from coastal development, with both supporting some of the country´s leading tourist destinations (SECTUR 2011). Approximately 40% of the territorial waters of the state are located inside marine protected areas, but only 4% of this area is closed to fishing (representing 1.5% of the territorial sea), and many of the MPAs still suffer from underfunding and lack effective resources for successful law enforcement (Fraga and Jesus 2008). Legal commercial fishing is divided between three main groups; fishing cooperatives with exclusive use territorial concessions; fishing cooperatives with permissions (which may overlap neighbouring groups); and individuals with permissions (that can also overlap). There also exists a substantial amount of illegal, unreported and unregulated (IUU) fishing although its distribution is not homogenous in time or space throughout the state. Pressure is greater in remote areas such as Banco Chinchorro and during the tourist low-season (La Pancarta 2013) when fishers who turned to tourism return to fish to complement their incomes.

Until recently, Mexican fisheries law did not recognise fish refuges as a tool for protecting the marine environment, however in 2007 the Fisheries Law was reformed creating the figure of "fish refuges" and efforts were made to have more legal tools at national level to provide guidelines for the establishment of fish refuges in all coastal areas that are under the jurisdiction of the Mexican government (in Mexico states do not have jurisdiction over coastal waters). Taking into account the potential for marine conservation provided by the new regulations, the first community no-take zones were established the 16th of November 2012 in Baja California Sur. Soon after, the Kanan Kay Alliance, working closely with the state's fishing cooperatives, government agencies and NGOs succeeded in creating the first zones in the concession of the Cozumel fishing cooperative the 30th of November 2012 (Diario Oficial de la Federación 2012). Further areas in Punta Herrero and Banco Chinchorro were decreed on the 12th of September 2013 (Diario Oficial de la Federación 2013).

The declaration of the fish refuges in Quintana Roo has created the need for a large-scale, continuous monitoring programme to evaluate the effectiveness of the no-take zones and their effect on the surrounding area. Reef monitoring in the state has generally been conducted by professionals or students from Mexico´s many universities and research centres, or by volunteers participating in programmes such as AGRRA (Lang et al. 2010) or the no-longer active MBRS-SMP (Almada-Villela et al. 2003). In many coastal communities this has created conflicts or disconnection as scientists rarely share their data and results at the community level and top-down approaches to conservation initiated in the areas have rarely taken in to account the views and knowledge of the artisanal fishermen. Although this approach is slowly changing, it was thought that by the formation of groups of trained fishermen, they would provide more support to the project, develop new and transferable skills and be able to witness first-hand any changes in the ecosystem as a result of protection. A package of incentives was also offered to the fishing cooperatives to engage in the project, with goals to improve their socioeconomic standing and offset some of the opportunity costs of the fish refuges.

Taking into account the scale of the monitoring programme needed to effectively collect data in the fish refuges the best resource available is the fishers themselves. Whilst fishers´ TEK has been utilised in many areas for the study of fisheries, there are few areas where the fishers themselves have collected scientific data through underwater visual census techniques (Obura et al. 2002, Uychiaoco et al. 2005, Leopold et al. 2009) and only one report in the literature of fishers utilizing SCUBA to complete the surveys (Obura et al. 2002). Few studies have also quantitatively evaluated the accuracy and precision of the data collected (Leopold et al. 2009) with the majority of studies of this type being restricted to volunteer research programmes (Mumby et al. 1995, Darwall 1996, Harding et al. 2000, Pattengill-Semmens and Semmens 2003, Hassell et al. 2013). As professional monitoring programmes can be more costly, time consuming, and can exclude the community from the project (Danielsen et al. 2005), it was felt that, with adequate training and resources, fishers from the cooperatives that had created fish refuges in their concessions could collect data of sufficient quality to assess the function of the refuges and allow management decisions to be made in the future.

METHODS

Study Area

The creation of the Kanan Kay Alliance in 2011 has provided the initiative and backing for five of the most forward thinking cooperatives (Figure 1) to create no take zones in their concessions to help preserve marine biodiversity and support future fishing activities in adjacent areas. Through participatory meetings with the members of the cooperatives, areas of the concession were suggested by fishers as potential fish refuges. These areas were assessed for their suitability and counterproposals suggested to the cooperatives if thought necessary. The areas where then marked by GPS and technical studies developed in coordination with the fishers to present to the responsible government agencies for review.

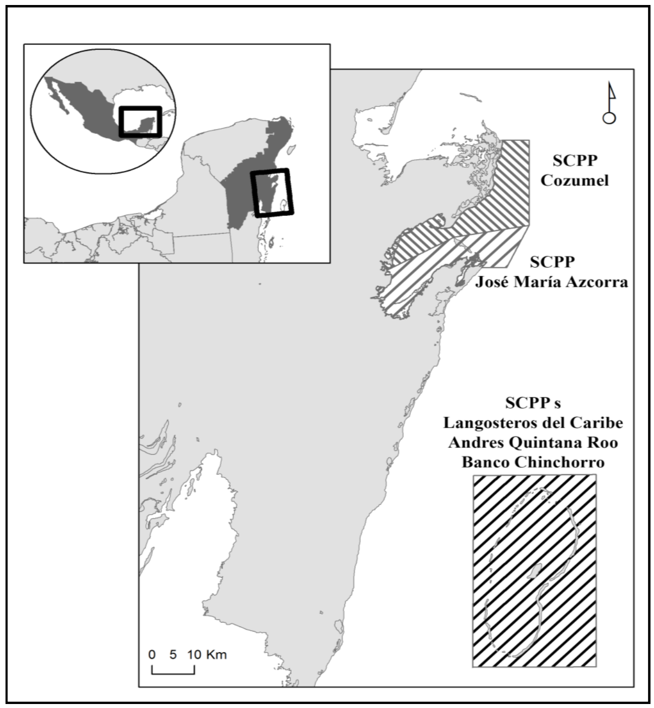

Figure 1. Study area and fishing concessions of participating cooperatives.

Sian Ka´an Biosphere Reserve

The two cooperatives operating out of the Bahía del Espíritu Santo proposed a network of no take zones protecting a range of environments. The Cozumel Cooperative initially suggested a network of nine small and one large area, although this was reduced to seven small (total area 50.3 Ha) and one large area (998 Ha) following revision of the existing marine zoning of the Biosphere Reserve and consultation with the National Park Commission (CONANP) (Figure 2). The José María Azcorra Cooperative initially proposed three large areas, which were later modified to three large (total area 1096.4 Ha) and one small area (29.1 Ha), with the smaller area restricting all fishing except lobster fishing (Figure 3).

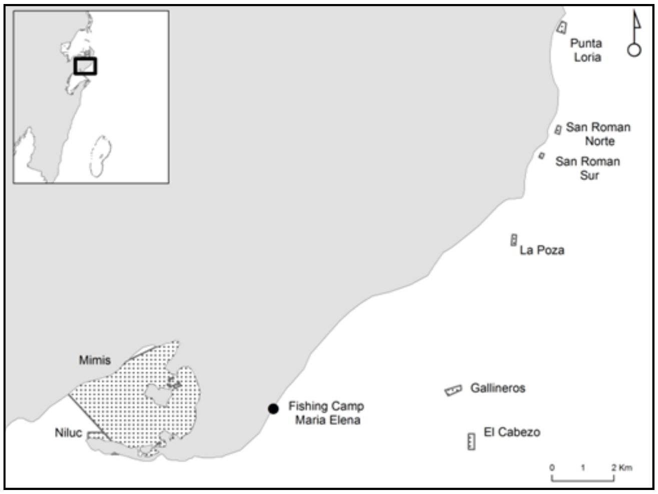

Figure 2. Location of fish refuges in the fishing concession of the Cozumel Cooperative.

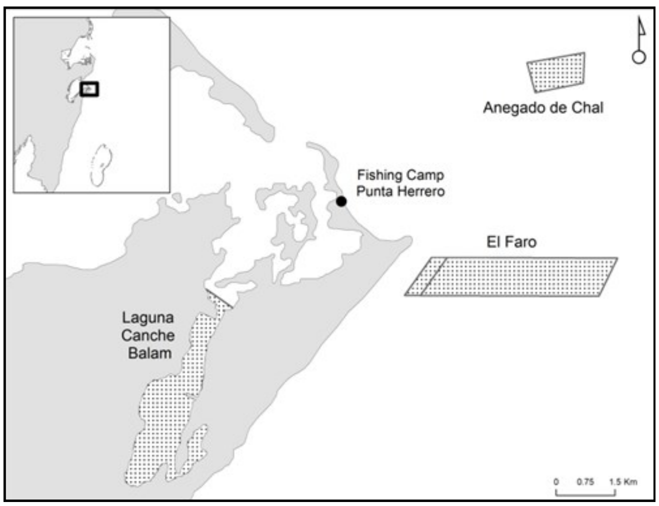

Figure 3. Location of fish refuges in the fishing concession of the Jose Maria Azcorra Cooperative.

Banco Chinchorro Biosphere Reserve

Initial discussions with the three fishing cooperatives that jointly use the waters of Banco Chinchorro produced three potential fish refuges with one each located in the north, centre and south of the atoll. However, persistent illegal fishing activities and the promise of improved surveillance by members of the Kanan Kay Alliance prompted the cooperatives to create one very large (12,257 Ha) no take zone located in the northwest of the atoll in an area strongly affected by the illegal activities (Figure 4).

Monitoring and Training

Whilst the final no take zones were being defined, each cooperative selected from their members a team of 6-12 fishers to undertake SCUBA diving training and a reef monitoring workshop. Fishers were trained to undertake coral, benthic cover, fish and invertebrate visual underwater censuses, with each fisher passing through a range of

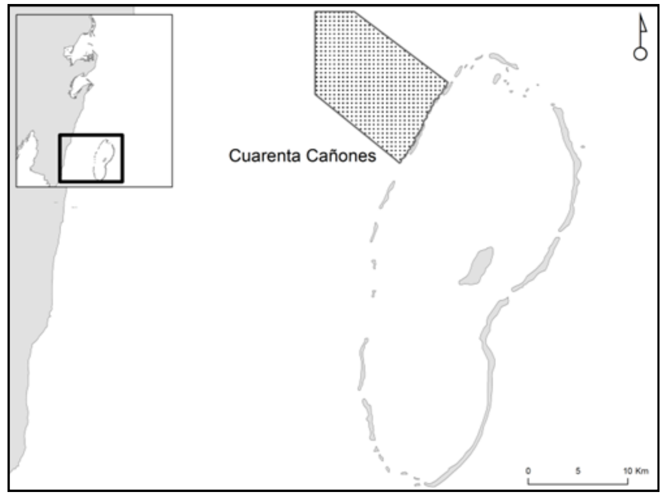

Figure 4. Location of fish refuges in the fishing concession of the three cooperatives of Banco Chinchorro.

assessments to ensure the data would be sufficiently accurate. The monitoring technique was designed to be sufficiently similar to regionally established scientific protocols to allow comparisons to be made whilst meeting the specific requirements of no take zones using a Before After Impact Control protocol (BAIC). Data quality was assured by contracting external evaluators to assess the fisher's ability to accurately record data and providing thorough training and in-house assessments before each monitoring period. Fish identification and methodology training was conducted with fisher´s surveying a section of reef with the instructor collecting data simultaneously from above the fisher. Coral and benthic cover evaluations were conducted using a leaded rope that remained stationary on the seafloor allowing the same point to be recorded by both the instructor and fisher. After several transects were completed the measure of similarity in the results was calculated using the Bray-Curtis Measure (Smith 2002):

$$BC_{ij} = \frac{\sum[p_{ik} - p_{jk}]}{\sum[p_{ik} + p_{jk}]}$$

Where:

p_{ik} and p_{jk} represent the proportions of individuals in census i and j respectively that belong to species k.

The index ranges from 0 where species in common and 1.0 where the distribution of species is identical. The data are then expressed as a similarity percentage.

Incentives

A range of incentives were offered to the fishers including direct compensation, business training and capacity building. Fishers taking part in the biological monitoring programme received a monetary compensation for their lost days fishing whilst they participated in the monitoring programme. This was calculated as the average between a good and a poor day´s fishing. Captains also received a compensation for their time, however, although the gasoline was provided, it was stressed that the use of the boats was not to be compensated as the cooperative should also assist with the financial burden of the monitoring programme. Training is provided without cost and opportunities for interchanges with fishermen in other areas made available.

Three fishing cooperatives from the Alliance were also selected to participate in the first round of business management training in 2013 with the aims of improving the competitiveness of the cooperatives in the market and increasing economic efficiency thus improving the economic standing of the fishers. The project is divided into three parts:

i) A diagnostic of the accounting, financial and leadership structure each fishing cooperative and its mode of operation,
ii) The development of a plan and tools to meet the specific business needs of each cooperative, and
iii) Implementation of the cooperative-specific products with the guidance and mentoring of professional consultants.

Two cooperatives from the Sian Ka´an Biosphere Reserve and one from Banco Chinchorro Biosphere Reserve were selected to take part in the first part of the project with the goal being to extend training to the other three cooperatives that have permission to fish in these reserves in the near future.

RESULTS

Biological Surveys by Fishers

Fishers from five fishing cooperatives took part in the reef monitoring training courses conducted in March and June 2012. Surveys were conducted after the initial training course although this data was not used to calculate the baseline as the locations and vertices of the final refuges were still being confirmed. Further surveys were undertaken at six month intervals with baselines completed for all sites by June 2013.

Fish biomass, calculated by means of size estimation, represents a key data for monitoring refuge effectiveness. Evaluation of the fishers by Comunidad y Biodiversidad staff showed the majority to be highly capable of underwater size estimation (Fisher ´A´, Figure 5.1) with Figures 5.2 and 5.3 showing the average size estimates for the fishing cooperative José María Azcorra and the three cooperatives of Banco Chinchorro respectively. Size estimates are classified as correct when they fall inside the binned size categories set out in the monitoring technique (0 - 5 cm, 6 - 10 cm, 11 - 20 cm etc.). Fishers who did not reach the necessary standards were not able to participate in the surveys without additional training.

Identification skills were tested using a combination of slideshow exams and in-water 1:1 ID dives. Bray-Curtis Similarity Measures were calculated for fish, coral and benthic cover data collected by the fishers when compared to those of the instructor and expressed as a percentage (Figure 6). The data suggests that the fishers who took part in the analysis can successfully identify coral and benthic

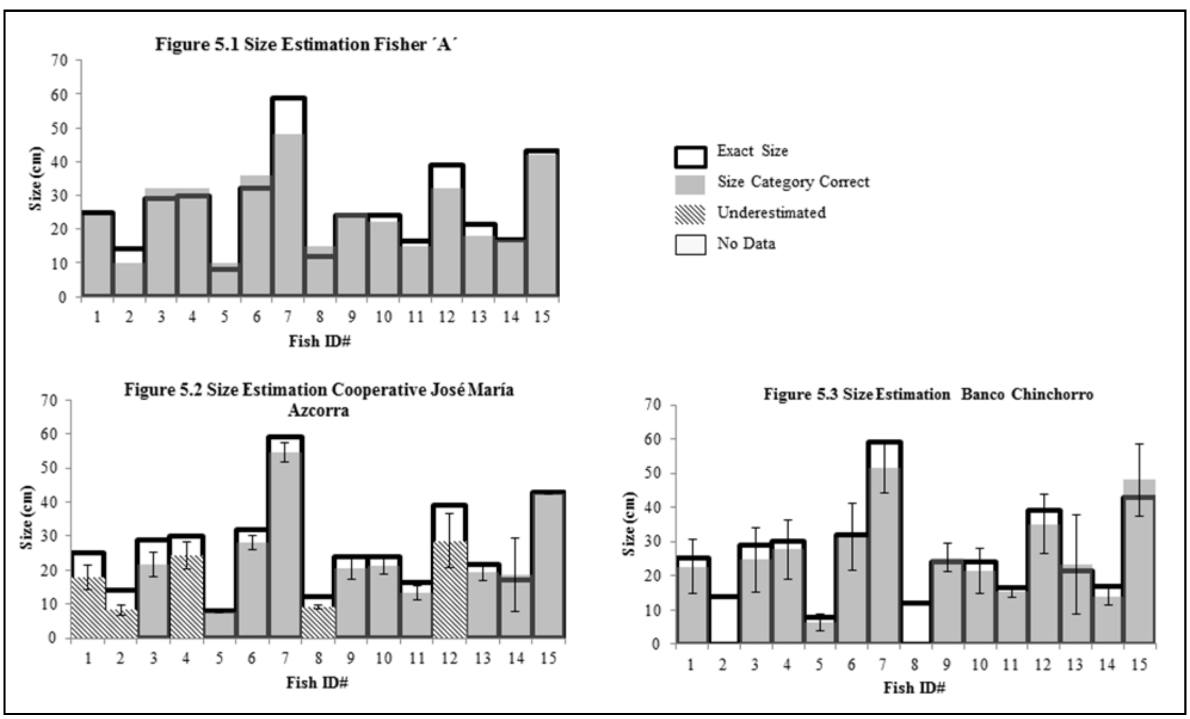

Figure 5. Size estimation by fishers using plastic fish of known sizes.

cover to levels very similar to the instructor (82.9% and 83.4% respectively). Fish data showed more differences from the instructor although some level of variation is expected due to the differing view point of the instructor and fisher and the constant movement of the fish. It was noted that smaller fish, generally of the family *Labridae*, were underrepresented in the data and when they were included in the analysis the measure of similarity was reduced.

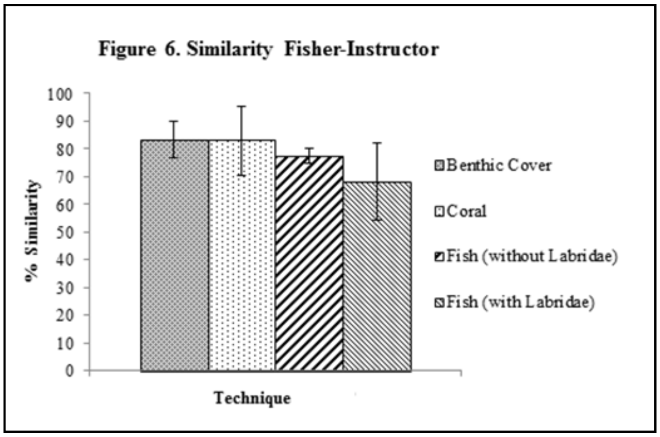

Figure 6. Similarity of species identification by fishers from Sian Ka´an Biosphere Reserve.

Incentives

A total of 28 fishers undertook PADI (Professional Association of Diving Instructors) SCUBA courses prior to the monitoring training programme, with 15 divers currently trained to Open Water level, and the remainder to Advanced level. Three other participants were already trained to higher levels. All participating fishers also received first aid training through the Emergency First Response Corporation before undertaking field activities. A PADI Distinctive Speciality Course was also developed to recognise the efforts of the fishers. The Fish Refuge Research Diver Distinctive Speciality course incorporates the theoretical and practical part of the monitoring training course, assessing the abilities of the fishers to correctly identify target species and safely conduct underwater surveys.

The first stage of the business management training project was completed with the results of the evaluation presented to the cooperatives during May 2013 (Flores and Wong 2013, QA Lab & Consulting Group 2013). The results of the diagnostic are confidential but show ample room for improvement and will be used to develop cooperative-specific tools to meets the needs of each cooperative before the tools are implemented in the final stage of the project in 2014.

DISCUSSION

The future success of the fish refuges created under the Kanan Kay Alliance and in collaboration with the fishing cooperatives relies heavily on two components. Firstly, biological data has to be collected to investigate whether the fish refuges are having their desired effect, and secondly, the opportunity cost to the fishers cannot be so large as to negate the positive effects inside the areas closed to fishing.

Biological data is necessary to establish if changes in the refuges occur, to what level, and to see if there is a potential benefit to the fishery (spillover). Whilst local scientists will be participating in the monitoring effort at more detailed levels, the fishers will collect the majority of the data. Doubts exist within the scientific community as to whether fishers can collect sufficiently robust data for the making of management-level decisions (Uychiaoco et al. 2005). Under the experimental conditions of this study the fishers proved themselves to be able to collected data of levels similar to volunteer-led monitoring efforts reported in the literature. Mumby et al. (1995) reported that volunteers identified corals correctly 52 - 70% of the time, and benthic cover correctly 70 - 90% of the time. The data from the fishers in the Sian Ka'an Biosphere Reserve, identifying the same species as the volunteers in the previous study, show values of 82.9% for coral and 83.4% for benthic cover. Similarly Harding et al. (2000) found that volunteer fish data was 75.27 % similar to the instructors after one week's training, rising to 78.52% after four weeks, whereas the data from fishers in this study, monitoring a similarly sized species list, was 77.4% similar to the instructor when small members of the *Labridae* family were excluded. The underrepresentation of some of the smaller fish families has been noted and will form part of future training efforts. Fishers also proved adept at the underwater size estimation. This is of little surprise as all the fishers work in a hand-caught lobster fishery (*Panulirus argus*) that operates a minimum capture size (13.5 cm TL) and as such underwater size estimation forms a part of their daily activity.

A further advantage of using fishers to collect biological data inside fish refuges is that they see first-hand the recuperation of the ecosystem when it is closed to fishing, and the community feels that they are part of the solution to the problem of overfishing. In many cases the local community grows suspicious of scientists who arrive and collect data, as they do not understand the process and it is rare that the scientists leave feedback or produce reports for the lay-audience (Danielsen et al. 2005). Winning the confidence of the community is vital to the buy-in for the fish refuge project and the community has to feel involved. The baseline data collected by the fishers has also taken place in relatively data-poor areas. This has provided the opportunity to contribute to regional databases (Healthy Reefs Initiative 2012) and to promote the use of the trained fishers for other conservation or restoration projects. It is hoped that other regional organisations will also train the fishers to meet their specific data collection needs and the fishers could even provide their services professionally as fishers from Sonora in Northwest Mexico have done

(Mario Rojo, Comunidad y Biodiversidad, personal communication).

The package of socio-economic incentives offered to the Kanan Kay Alliance members are one way to offset the opportunity costs of the fish refuges whilst simultaneously improving the economic wellbeing of individual fishers. More efficient fishing cooperatives result in better cash flow and higher economic stability at both organisational and individual levels. The fish refuges will not produce the desired results in the future without the support of the fishing cooperatives and are part of a wider scheme to show that a strong business model does not necessarily contradict good environmental practices.

Overall, this article highlights the importance of community participation at both biological and social levels when working with a potentially controversial tool like fully protected zones. Community buy-in has been vital to the success of the project and several incentives and tools can be used to improve participation. The fishers also proved that with adequate training and resources they can collect biological data of sufficient quality for the management of the fish refuges, and for the fishers who form the monitoring teams, the change in their perception of their resources has been remarkable as they are now aware of much more when they go out to fish; the "stones" have turned in to corals, they see all the fish, not just the antennae of lobster, and they understand how the ecosystem works and why they need to protect it.

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LITERATURE CITED

Aburto-Oropeza, O., B. Erisman, G.R. Galland, I. Mascareñas-Osorio, E. Sala, and E. Ezcura. 2011. Large recovery of fish biomass in a no-take marine reserve. *PloS ONE* **6**(8):e23601.

Almada-Villela, P.C., P.F. Sale, G. Gold-Bouchot, and B. Kjerfve. 2003. Manual of Methods for the MBRS Synoptic Monitororing Program. Mesoamerican Barrier Reef Systems Project, Belize City, Belize.

Basurto, X. 2005. How locally designed access and use controls can prevent the tragedy of the commons in a Mexican small-scale fishing community. *Society and Natural Resources* **18**(7):643-659.

Beger, M., A.R. Harbone, T.P. Dacles, J. Solandt, and G.L. Ledesma. 2005. A framework of lessons learned from community-based marine reserves and its effectiveness in guiding a new coastal management initiative in the Philippines. *Environmental management* **34** (6):786-801.

Butler, J.R.A., A. Tawake, T. Skewes, and V. McGrath. 2012. Integrating traditional ecological knowledge and fisheries management in the Torres Strait, Australia: the catalytic role of turtles and dugong as cultural keystone species. *Ecology and Society* **17**(4):34.

Danielsen, F., N.D. Burgess, and A. Balmford. 2005. Monitoring matters: examining the potential of locally-based approaches. *Biodiversity and Conservation* **14**:2507-2542.

Darwall, W.R.T. 1996. An evaluation of the suitability of non-specialist volunteer researchers for coral reef fish surveys. Mafia Island, Tanzania – a case study. *Biological Conservation* **78**:223-231.

Flores, E. and K. Wong. 2013. ¿Fortalecer empresas sociales para conservar recursos naturales? *Equilibrio* **59**:36-39.

Fraga, J. and A. Jesus. 2008. Coastal and marine protected areas in Mexico. India: International Collective in Support of Fishworkers, 2008.

Gell, F.R. and C.M. Roberts. 2002. The fishery effects of marine reserves and fishery closures. WWF-US, 1250 24th Street, NW, Washington, DC 20037, USA.

Harding, S., C. Lowery, and S. Oakley. 2000. Comparison between complex and simple reef survey techniques using volunteers: is the effort justified? *Proceedings of the 9th International Coral Reef Symposium*. Bali, Indonesia, 23-27 October 2000.

Hassell, N.S., D.H. Williamson, R.D. Evans, and G.R. Russ. 2013. Reliability of non-expert observer estimates of the magnitude of marine reserve effects. *Coastal Management* **41**:361-380.

Healthy Reefs Initiative. 2012. Report card for the Mesoamerican Reef 2012: An evaluation of ecosystem health.

Johannes, R.E. 2002. The renaissance of community-based marine resource management in Oceania. *Annual Review of Ecology and Systematics* **33:** 317–340.

La Pancarta. 2013. Esperan permisos para vender a mejor precio la escama. La Pancarta. 4th August 2013. Print.

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

Leopold, M., A. Cakacka, S. Meo, J. Sikolia and D. Lecchini. 2009. Evaluation of the effectiveness of three underwater reef fish monitoring methods in Fiji. *Biodiversity Conservation* **18**:3367-3382.

McLeod, K. and H Leslie. 2009. *Ecosystem-Based Management for the Oceans*. Island Press, Washington DC, USA. 392 pp.

Mumby, P.J., A.R. Harborne, P.S. Raines and J.M. Ridley. 1995. A critical assessment of data derived from Coral Cay Conservation volunteers. *Bulletin of Marine Science* **56** (3):737-751.

Obura, D.O., S. Wells, J. Church and C. Horrill. 2002. Monitoring of fish and fish catches by local fishermen in Kenya and Tanzania. *Marine Freshwater Research* **53**:215-222.

Pattengill-Semmens, C.V. and B.X. Semmens. 2003. Conservation and management application of the REEF volunteer fish monitoring program. *Environmental Monitoring and Assessment* **81**:43-50.

Pikitch, E.K., E.A. Santora, A. Babcock, A. Bakun, R. Bonfil, D.O. Conover, P. Dayton, P. Doukakis, D. Fluharty, B. Heheman, E.D. Houde, J. Link, P.A. Livingston, M. Mangel, M.K. McAllister, J. Pope, and K. Sainsbury. 2004. Ecosystem-based fishery management. *Science* **305**: 346-347.

QA Lab & Consulting Group. 2013. Producto No1. Informe Técnico – Documentos Resumen de la Aplicación del Due Diligience, PDAs y BSC. Resultados de Campo Gira del 4 al 14 de noviembre 2012.

Roberts, C. M. and J.P. Hawkins. 2000. Fully-protected marine reserves: a guide. WWF Endangered Seas Campaign, 1250 24th Street, NW, Washingon DC 20037, USA and Environment, University of York, York, YO10 5DD, United Kingdom.

Roberts, C.M., J.A. Bohnsack, F. Gell, J.P. Hawkins and R. Goodridge. 2001. Effects of marine reserves on adjacent fisheries. *Science* **294**:1920-1923.

Sáenz-Arroyo, A., J. Torre, L. Bourillon and M. Kleiberg. 2005. A community-based marine reserve network in North-western Mexico. *Proceedings of the Symposium and Workshop of the North American Marine Protected Areas Network*. Full documents available in Internet www.cec.org. Loreto, Baja California Sur, México. March 1 - 3. North American Commission for Environmental Cooperation. 19 pp.

Schafer, A.G. and E.G. Reis. 2008. Artisanal fishing areas and traditional ecological knowledge: The case study of the artisanal fisheries of the Patos Lagoon estuary (Brazil). *Marine Policy* **32**(3):283–292.

Secretaria de Gobernación, 2012. Diario Oficial de la Federación. Online: Accessed 17th October 2013. http://dof.gob.mx/nota_detalle.php?codigo=5280841&fecha=30/11/2012.

Secretaria de Gobernación, 2013. Diario Oficial de la Federación. Online: Accessed 17th October 2013: http://dof.gob.mx/nota_detalle.php?codigo=5313972&fecha=12/09/2013.

Secretaria de Turismo, 2011. Turismo en México en 2011. Online: Accessed: 3rd October 2013 http://datatur.sectur.gob.mx/work/sites/datatur/resources/LocalContent/310/33/tm2011.pdf.

Smith, E.P. 2002. Ecological Statistics. Pages 589-602 in: El-Shaarawi A.H. and W.W. Piegorsch (eds.) *Encyclopedia of Environmetrics*. John Wiley & Sons, Ltd, Chichester, United Kingdom.

Uychiaoco A.J., H.A. Arceo, S.J. Green, M. T de la Cruz, P.A. Gaite and P.M. Aliño. 2005. Monitoring and evaluation of reef protected areas by local fishers in the Philippines: tightening the adaptive management cycle. *Biodiversity and Conservation* **14**:2775-2794.

Valdés-Pizzini, M., C.G. García-Quijano and M.T. Schärer-Umpierre. 2012. Connecting humans and ecosystems in tropical fisheries: social sciences and the ecosystem-based fisheries management in Puerto Rico and the Caribbean. *Caribbean Studies* **40**(2):95-128.

White, A.T. and H.P. Vogt. 2000. Philippine coral reefs under threat: lessons learned after 25 years of community-based reef conservation. *Marine Pollution Bulletin* **40**(6):537-550.

Williamson, D.H., G.R. Russ, and A.M. Ayling. 2004. No-take marine reserves increase abundance and biomass of reef fish on inshore fringing reefs of the Great Barrier Reef. *Environmental Conservation* **31**(2):149-159.

Zhou, S., A.D.M. Smith, A.E. Punt, A.J. Richardson, M. Gibbs, E.A. Fulton, S. Pascoe, C. Bullman, P. Bayliss and K. Sainsbury. 2010. Ecosystem-based fisheries management requires a change to the selective fishing philosophy. *Proceedings of the National Academy of Sciences of the United States of America* **107**(21):9485-9489.