Measuring Environmental, Economic, and Social Sustainability of Caribbean Fisheries through the Fishery Performance Indicators, an Innovative Rapid Assessment Tool

Evaluación de la Sostenibilidad Ambiental, Económica y Social de las Pesquerías del Mar Caribe por Medio de los Indicadores de Desempeño Pesquero, un Nuevo Instrumento de Valoración Rápida

Mesure de la Durabilité Environnementale, Economique et Sociale des Pêches des Caraïbes Grâce aux Indicateurs de Performance de la Pêche, un Outil D'évaluation Rapide Innovant

JORGE MARCO[1] and DIEGO VALDERRAMA[2]*
[1]*University of los Andes, Bogota, Colombia.*
[2]*George Mason University*
4400 University Drive, MS 5F2 Fairfax, Virginia 22030 USA.
*dvalder@gmu.edu

ABSTRACT

Designed by researchers affiliated primarily with the University of Florida, University of Washington and The World Bank, the FPIs are a broadly applicable and flexible tool for assessing performance in individual fisheries and for establishing linkages between enabling conditions, management strategies and the outcomes of sustainability-based indicators. The FPIs include 67 measures to assess wealth accumulation on 11 dimensions of stock and harvest/post-harvest industry performance, and 54 measures of enabling factors — including management and governance — to associate with variation in outcomes. A major advantage of the FPIs is their ability to establish meaningful comparisons across fishery systems characterized by different species, management regimes and socio-economic contexts. They are also ideal for cross-country comparisons of fishery systems that exploit biological resources sharing similar characteristics. Consisting initially of 61 case studies drawn from industrial and developing countries around the world, the FPI database has expanded considerably in the last few years. In addition, the FPIs are currently being used by institutions such as The World Bank to evaluate the impact of fishery management reform in recipient countries. More recently, the FPIs were adopted by the Environment for Development (EFD) Collaborative Program on the Sustainable Management of Marine Resources to evaluate a new set of fisheries around the world, including the Caribbean region. The goal of this study is to introduce the FPIs to the Caribbean context and to explain the potential for collaborative partnerships with managers and academics from the region in order to carry out joint evaluations of the most important Caribbean fisheries. As an example of potential applications, we evaluate the case of artisanal queen conch fishery in the Colombian Caribbean.

KEYWORDS: Sustainability indicators

INTRODUCTION

Fishery Performance Indicators (FPIs

Commercial fishing is a business and should create sustainable positive net income and create wealth. Although biological sustainability is a necessary condition for sustainable livelihoods, it is not sufficient for commercial fisheries to generate sustainable income and create wealth. The Fishery Performance Indicators (FPIs) are a rapid assessment instrument for measuring economic, community and ecological outcomes (triple bottom line) from fishery management systems. Thus, FPIs can be understood as a set of metrics designed to measure the fishery's degree of social responsibility, its economic value and its environmental impact. Rather than imposing a single notion of socio-economic sustainability, the FPIs provide a broad range of metrics, organized into a framework that provides components and keys dimensions within each component, of environmental and socio-economic impacts (outputs) and of factors that may enable such impacts (inputs). This framework is envisioned primarily to support analysis linking sustainable livelihoods and ecosystem health with specific inputs (Ostrom 1990, 2009, Agrawal 2002, Cinner et al. 2012). Therefore, metric scores are to be provided on each key dimension and weighted neutrally (equally) to produce indicator scores. The resulting ranking will highlight particularly strong and weak-performing fisheries, and draw attention to commonalities and differences among their input scores. When implementing the FPIs, 122 individual metric are scored from 1 to 5 using level criteria that are designed to be easy to score across a wide range of fisheries, and that are generally chosen to reflect significant industry standards or the quintiles of performance on the metric globally. They rely on a basic set of data that should be available in all significant fisheries (e.g., volumes and prices) and expert assessment of qualitative indicator levels; it requires no primary data collection. Outputs and inputs indicators are broken into key dimensions, each of which is reflected in several specific metrics. Although individual metrics may be imprecise, using multiple metrics for each performance dimension leads to an accurate impression of what is and is not working. In this manner, the FPIs are robust to being employed in data poor fisheries and sectors. In addition, each metric is also given a quality score to indicate how confident the scorer is regarding the accuracy of the chosen bin (Anderson et al. 2016).

Case study: Artisanal Queen Conch Fishery in the Colombian Caribbean

Queen conch is endemic to the Caribbean, with Bermuda at the northmost edge of the species' distribution, Panama at the southwestern and Barbados at the eastern edge. Most islands located between these extremes have reported queen

conch populations and production. Areas with current or historic populations of queen conch in Colombia are San Andres, Providence and banks of the San Andres archipelago (composed of Quitasueño, Serrana, Serranilla and Roncador). The fishery shifted towards these northern archipelagos in the 1970s after San Bernardo and Rosario in the southern Caribbean were fished to local extinction and subsequently closed in 1977 (Mora 1994). In 1987, Colombia began establishing management regulations, and as a result, the Quitasueño area was closed to fishing (Prada et al. 2008). Currently, the Serrana Bank is the most productive bank in the country. Since 2015, the total catch is devoted to local consumption (Colombia has eliminated industrial fishing because queen conch stocks and traditional fishery were at risk). The fishery represents an important activity as it provides employment and income in remote coastal communities, contributes to increase earnings as well as to food security and poverty alleviation. Unfortunately, there have been no major studies to determine the benefits and dependency of local communities on artisanal queen conch fishing. Nowadays, many fishers need to explore further and deeper fishing grounds in search of sufficiently high queen conch abundance, resulting in increased production costs, especially because of the high price of the fuel and the substantial fuel consumption levels by outboard engines in artisanal fisheries. As a result of an overall decline in queen conch production (because of, among others, overall diminishing queen conch abundance, closed geographical areas and/or periods and reductions in annual catch), there are fewer jobs in the artisanal queen conch fishery. The closed areas and closed seasons for queen conch usually overlap with similar measures for other stocks (spiny lobster, several reef fish), with negative consequences for fishers' income.

METHODOLOGY

The FPIs fall into two categories. The first category is of indicators or outputs that identify and measure whether the fishery is delivering economically viable and socio-ecologically sustainable results. In accordance with the triple bottom line, each FPI outcomes corresponds with environmental, economic, or community well-being. Additionally, each FPI output metric corresponds to the environmental, harvest, or post-harvest sector. The FPIs include metrics that address important agendas in global development such as gender, equity, risk, and climate change. The second category is of input factors, or enabling conditions, that contribute to the process of incentivizing socio-ecologically sustainable use of fish resources. By analyzing relationships among the output and input metrics, the FPI dataset can be used to understand the causes, correlations and paths toward successful and sustainable development. This will give stakeholders who are reliant on fisheries for their livelihood critical information to make a case for better fisheries management based on a broader set of criteria incorporating governance and economic factors, many of which are currently being ignored (Anderson et al. 2016).

Outputs: Measuring Performance by Sector Outcomes and Sustainability Outcomes

Table 1 presents an overview of the 68 output metrics, divided in 14 dimensions. An essential feature for inclusion is that the metrics must be relevant, relatively easy to estimate, either quantitatively or qualitatively; and they must be comparable across regions and systems. The triple bottom line partitioning, with indicators for performance on Ecology, Economics and Community outcomes, is represented on the far left. The Ecology indicator is captured in a single dimension composed of a relatively small number of metrics that summarize scientific assessment work, but with coding guidelines that facilitate accurate scoring based on the information available where formal stock assessments do not exist. The Economics indicator measures whether the fishery is effectively generating market benefits and is reflected in six distinct dimensions. The Harvest dimension captures landings and revenue levels, and whether rent is dissipated through inefficiencies of excess capacity or derbies. Economic gains accumulate within the harvest sector through vessel profits and the value of permits, and to the post-harvest sector in the form of processing capital; these are captured in the Harvest Assets and Post-Harvest Assets dimensions. The Risk dimension captures several sources of volatility that affect business value. Finally, the Trade and Product Form dimensions assess the extent to which the product is reaching markets that yield the greatest potential profit (Anderson et al. 2016).

Inputs: Enabling the Creation of Sustainable Incomes and Ecosystem Health

Table 2 presents an overview of the 54 input factors, which are thought to enable generation of the socioeconomic prosperity. Importantly, the structure of the FPIs does not presuppose whether, how or how much these inputs support the creation of sustainable incomes and health ecosystems.

The 54 input metrics, divided in 15 dimensions, capture management descriptors and exogenous enabling conditions that may affect output indicator scores. This list mirrors the empirical framework used for resource self-governance (Anderson et al. 2015) by positing a link between a set of exogenous enabling conditions and management success. Selecting a tractable and credible set of enabling factors to include is challenging since the fisheries management literature discusses many approaches, each supported by case studies of non-randomized (and nearly always successful by some measure) implementations. Some focus exclusively on technical measures (MPAs, gear innovations, TACs), others on the social institutions surrounding the resource (self-governance, property rights systems); all are influenced by macroeconomic, infrastructure and resource conditions. Dimensions and corresponding metrics are anchored in competing theories of fishery management, with the intent of testing their causal or conditional effects; it is not implied that higher input scores lead to higher output performance, or that effects are monotonic within metrics or linear across metrics (Anderson et al. 2015).

Table 1. Schematic of the Output Indicators and the Associated Dimensions and Metrics.

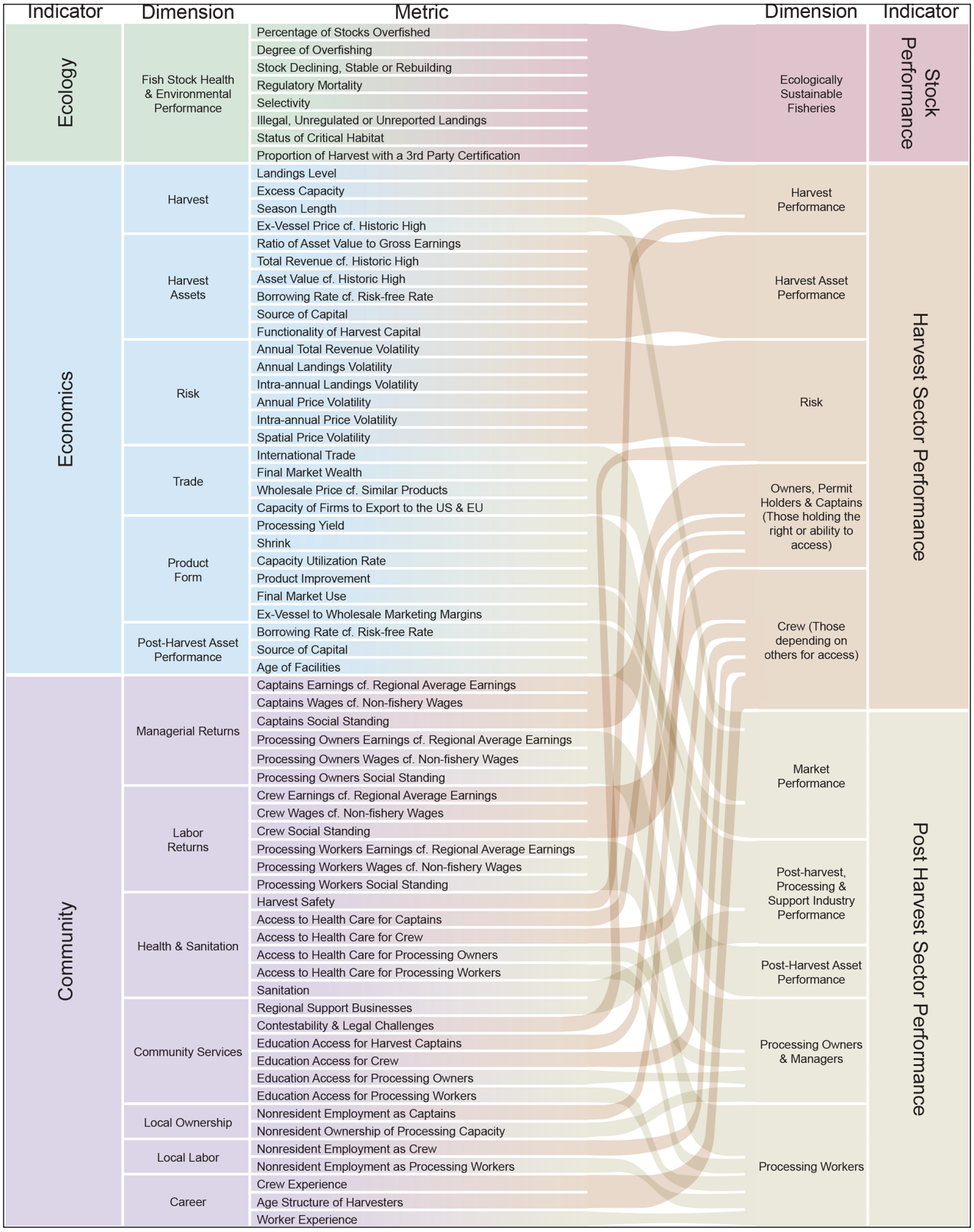

Table 2. Schematic of the input components and the associated dimensions and metrics.

Component	Dimension	Measure
Macro Factors	General Environmental Performance	Environmental Performance Index (EPI)
	Exogenous Environmental Factors	Disease and Pathogens
		Natural Disasters and Catastrophes
		Pollution Shocks and Accidents
		Level of Chronic Pollution (Stock effects)
		Level of Chronic Pollution (Consumption effects)
	Governance	Governance Quality
		Governance Responsiveness
	Economic Conditions	Index of Economic Freedom
		Gross Domestic Product (GDP) Per Capita
Property Rights & Responsibility	Fishing Access Rights	Proportion of Harvest Managed Under Limited Access
		Transferability
		Security
		Durability
		Flexibility
		Exclusivity
	Harvest Rights	Proportion of Harvest Managed with Rights-based Management
		Transferability
		Security
		Durability
		Flexibility
		Exclusivity
Co-Management	Collective Action	Proportion of Harvesters in Industry Organizations
		Harvester Organization Influence on Fishery Management & Access
		Harvester Organization Influence on Business & Marketing
	Participation	Days in Stakeholder Meetings
		Industry Financial Support for Management
	Community	Leadership
		Social Cohesion
	Gender	Business Management Influence
		Resource Management Influence
		Labor Participation in Harvest Sector
		Labor Participation in Post-Harvest Sector
Management	Management Inputs	Management Expenditure to Value of Harvest
		Enforcement Capability
		Management Jurisdiction
		Level of Subsidies
	Data	Data Availability
		Data Analysis
	Management Methods	MPAs and Sanctuaries
		Spatial Management
		Fishing Mortality Limits
Post-Harvest	Markets & Market Institutions	Landings Pricing System
		Availability of Ex-vessel Price & Quantity Information
		Number of Buyers
		Degree of Vertical Integration
		Level of Tariffs
		Level of Non-tariff Barriers
	Infrastructure	International Shipping Service
		Road Quality
		Technology Adoption
		Extension Service
		Reliability of Utilities/Electricity
		Access to Ice & Refrigeration

PRELIMINARY RESULTS

In the following, we show a brief profile of the fishery's core characteristics followed by two figures of the FPI outputs and inputs analysis. The study case was chosen to demonstrate the potential value and versatility of the FPIs. The study case provides valuable illustration of the effectiveness of the indicators in characterizing the performance of the fishery and the management system.

Outputs: Measuring Performance in the Artisanal Queen Conch in the Colombian Caribbean

Figure 1 below illustrates the average output indicator scores for the Artisanal Colombian Queen Conch fishery management system. The artisanal Colombian queen conch fishery receives moderate scores for owners of the processing capital and captains/boat owners. The fishery also receives marginal scores for risks and crew. Other indicators such as ecological sustainability, processing workers and the performance of the market, harvest and post-harvest sector suggest that there is room for substantial improvement.

Inputs: Measuring Wealth Enable Inputs in the Artisanal Queen Conch in the Colombian Caribbean

Formal analysis of the relative magnitude and functional relationship between the wealth enabling inputs and the outputs which attempt to measure economic, ecological and community sustainability will be subject of additional study once more data are collected. However, from Figure 2 below, it is clear that Artisanal Colombian Queen Conch receives higher mid-range scores for Macro Factors (such as Environmental Risk and National Economics). National Environmental Performance, markets institutions, management methods, participation, and collective action receive lower mid-range scores. The

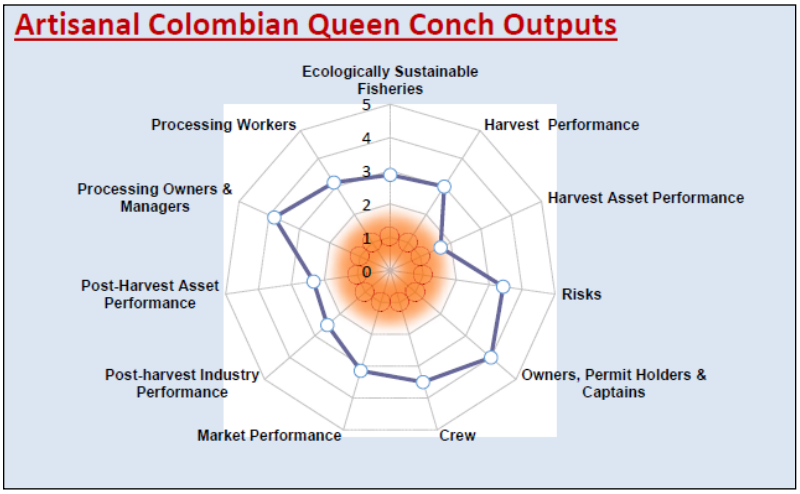

Figure 1. Fishery Performance Indicators (Outputs, Measuring Wealth). Note: Scores below 3.5 indicate that there is room for substantial improvement.

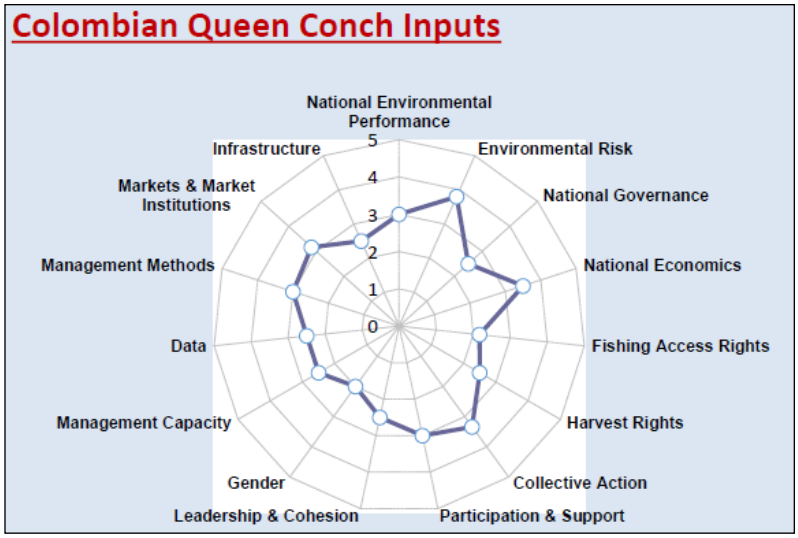

Figure 2. Fishery Performance Indicators (Wealth Enable Inputs). Note: Scores below 3.5 indicate that there is room for substantial improvement.

artisanal Colombian queen conch scores low in infrastructure, data, management capacity, gender, leadership and harvest and fishing access rights.

Results from the FPI evaluation revealed a lack of data in the post-harvest sector and some other important dimensions such as co-management capacity and collective action. To correctly determine the potential (total) economic value of the fishery, we need to collect new and precise data about market performance (i.e., value of conch products in both national and international markets, the total capacity of the fishery to export conch products, etc.) and capacity for conch products improvement (whether or not the fishery is able to add value to products derived from queen conch).

DISCUSSION

The artisanal queen conch fishery in the Colombian Caribbean is characterized by overexploitation and IUU fishing. Since 2015, industrial fishing has been banned and all catch is being devoted to local consumption (local markets). Nowadays, the artisanal fishing activity is highly restricted. Regulatory mechanisms for the fishery include closed areas, closed seasons, and strong restrictions on gear used and handling practices. Additionally, given that past quotas were set too high, Colombia has informally adopted a control (conservation) rule based on harvesting 8% of the estimated exploitable biomass (exploitation at constant rates). Although the fishery performs poorly (below 3.5) in the environmental and economic metrics of the FPI evaluation, conch fishing is highly prized by the local community; in addition, conch products have strong economic potential in international markets. Moreover, we detected during the FPI evaluation that stakeholders and fishery managers base their decisions almost exclusively on ecological information. At this moment, policies and fishery management are focused on stock recovery and ecosystem health. No major studies on regional economic sustainability have been published. For all these reasons, we suggest that fishery managers and stakeholders, in the short term, should focus on optimal management strategies for the queen conch resource and the introduction of the Triple Bottom Line perspective into fisheries management. Current regulation of fish stocks should be enhanced by the introduction of long-term socio-economic objectives with clear deadlines that can be monitored. Colombia needs to improve monitoring and enforcement of regulations, however, a corollary challenge in Colombia is to introduce the Triple Bottom Line perspective (economic, community and ecological sustainability) into fisheries management. Another important challenge for the fishery is how to export conch products. In the past, artisanal fishery (local community) and industrial fishery (non-local community) were competing for the same (scarce) resource. How to determine rent- maximizing exploitation rates while simultaneously ensuring the environmental sustainability of the resource will be key for the next years. In the long term, the definition of new economic strategies designed to add value to products derived from queen conch would be a prerequisite for economic sustainability. And, as said above, formal analysis of the relative magnitude and functional relationship between the wealth enabling inputs and the outputs which attempt to measure economic, ecological and community sustainability should be subject of additional study once more data are collected.

LITERATURE CITED

Agrawal, A. 2002. Common resources and institutional sustainability. In National Research Council (ed.). *The Drama of the Commons*. The National Academies Press, Washington, D.C. USA.

Anderson, J.L., C.M. Anderson, J. Chu, J, Meredith, F. Asche, G. Sylvia, et al. 2015. The Fishery Performance Indicators: A Management Tool for Triple Bottom Line Outcomes. *PLoS ONE* **10**(5): e0122809. doi:10.1371/journal.pone.0122809

Anderson, J.L., C . M . Anderson, J . Chu, and J, Meredith. 2016. *Fishery Performance Indicators Manual (Version 1.3).* DOI: 10.13140/RG.2.2.32536.39681

Cinner, J.E., T.R. McClanahan, M.A. MacNeil, N.A. Graham, T.M. Daw, A. Mukminin, D.A. Feary, A.L. Rabearisoa, A. Wamukota, and N. Jiddawi. 2012. Co-management of coral reef social-ecological systems. *Proceedings of the National Academy of Sciences* **109**:5219 - 5222.

Mora, O. 1994. Análisis de pesquería de caracol pala (*Strombus gigas* L.) en Colombia. Pages 137-144 in: RS Appeldoorn, and B Rodriguez (Eds.) *Queen Conch Biology, Fisheries, and Mariculture*. Fundación Cientifica Los Roques, Caracas, Venezuela.

Ostrom, E. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action.* Cambridge University Press, Cambridge, England.

Ostrom, E. 2009. A general framework for analyzing sustainability of social-ecological systems. *Science* **325**:419 - 422.

Prada, M., E. Castro, E. Taylor, V. Puentes, R. Appeldoorn, and N. Daves. 2008. Non-detrimental findings for the Queen Conch (*Strombus gigas*) in Colombia. *NDF Workshop Case Studies WG 9 – Aquatic Invertebrates Case Study 3.*