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Research, part of a Special Feature on Cooperation, Local Communities, and Marine Social-ecological Systems: New Findings from Latin America

Estimating the Adaptive Capacity of Local Communities at Marine Protected Areas in Latin America: a Practical Approach

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ABSTRACT. The establishment of marine protected areas (MPA) has become the prevailing management strategy to stop the degradation of coastal and marine ecosystems; however, the effectiveness of MPAs is affected not only by ecological factors but also by social ones. Identifying and understanding socioeconomic conditions and the institutional context of fishing communities is essential to achieve success with MPAs. We propose a practical methodology for estimating the adaptive capacity (AC) of local communities to the establishment of MPAs. Adaptive capacity is defined as the ability of households to anticipate and respond to disturbances, natural or human induced, and to minimize, cope with, and recover from the consequences. We propose an index of adaptive capacity (IAC) of fishing communities that can be estimated at a local scale. This composite index comprises three dimensions, i.e., socioeconomic, social-ecological, and socio-political/institutional, which attempt to capture comprehensively the determinants of AC. Each dimension is constructed from three indicators, whose estimation is based on information collected from a household structured survey for which we suggested specific questions. We proposed the use of a Min function to highlight the weakest dimension of the IAC and guide decision makers with respect to elements that should be addressed to improve AC. A discussion about normalization and aggregation issues is also included.

RESUMEN. El establecimiento de áreas marinas protegidas (AMP) ha sido la principal estrategia utilizada para enfrentar la degradación de ecosistemas marinos y costeros. Sin embargo, la efectividad de las AMP depende tanto de factores ecológicos como de factores sociales. Para alcanzar el éxito esperado en el manejo de las AMP se hace esencial identificar y entender las condiciones socioeconómicas y el contexto institucional de las comunidades costeras. En este artículo se propone una metodología práctica para estimar la capacidad adaptativa (CA) de las comunidades locales al establecimiento de AMP. La capacidad adaptativa es definida como la habilidad de los hogares para anticiparse y responder a disturbios, naturales o antrópicos, y enfrentar, minimizar y recuperarse de las consecuencias de dichos disturbios. Se propone un índice de capacidad adaptativa (ICA) de las comunidades costeras de pescadores que pueda ser estimado a nivel local. Este índice compuesto incluye tres dimensiones: socioeconómica, socio-ecológica y sociopolítica / institucional, con las cuales se busca capturar de forma comprehensiva los determinantes de CA. Cada dimensión se construye a partir de tres indicadores, cuya estimación se basa en información obtenida de encuestas estructuradas a hogares (se incluye el conjunto de preguntas sugeridas para su estimación). Para agregar las dimensiones se propone el uso de una función MIN, de forma que el valor agregado del ICA dependa de la dimensión más débil; así se espera que sirva como guía para la formulación de políticas que apunten a resolver los aspectos más limitantes en la construcción de capacidad de adaptación de las comunidades. También se incluye una discusión sobre la normalización y agregación de indicadores.

Key Words: *adaptive capacity determinants; fishery resources; governance; marine ecosystems management; sustainable livelihoods; vulnerability*

Erratum 1: The Spanish abstract of this paper was rewritten on 17 February 2014.

INTRODUCTION

Despite global and national efforts to protect coastal and marine ecosystems, they continue to deteriorate (Wilkinson 2004, Millenium Ecosysem Assessment 2005). Establishment of marine protected areas (MPA) constitutes one of several management strategies to halt the degradation of these ecosystems. Some authors, however, argue that MPAs are not only globally under-represented (Spalding et al. 2008), but also that their effectiveness in achieving conservation objectives is, at best, limited (Kareiva 2006). Particularly, the effectiveness of MPAs is affected by both ecological factors involved in the reserve design, such as size and connectivity (Nyström and Folke 2001, Halpern and Warner 2003), and social factors, such as ignoring the role of local users when designing management strategies (Bailey and Jentoft 1990, McClanahan 1999, Camargo et al. 2009).

Management of marine areas and their coastal resources involves understanding both the ecological processes and the local-user conditions, as well as involving the relevant stakeholders (Berkes et al. 1991, Brunner et al. 2005, McClanahan et al. 2006, Armitage et al. 2007, Cinner et al. 2010). In particular, it should be recognized that the establishment of MPAs generates not only local, national, and global benefits, but also costs, which are mainly assumed by poor and powerless local resource users who are restricted to the access and use of the marine resources. Therefore, identifying and understanding the socioeconomic conditions and the institutional context of fishing communities is essential for the success of marine protected areas (Cinner and Pollnac 2004, Shipley 2004, Christie et al. 2005, Cinner et al. 2010).

Given the complexities associated with social, economic, and institutional contexts in which resource-dependent communities are immersed, understanding their living conditions requires holistic measurements that allow researchers and policy makers to comprehensively capture the multiple and interrelated dimensions of their livelihoods (Béné 2003). Strategies for carrying out this task have been proposed; for instance, the

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sustainable livelihoods approach offers a theoretical framework to understand the outcomes of rural communities. Under this approach, livelihoods are sustainable when households or communities can face and recover from external perturbations, whether natural or human induced, and maintain, or even improve, current and future generations' well-being without deteriorating the natural resource base (Chambers and Conway 1992, Carloni and Crowley 2005). The concept of sustainable livelihoods is closely related to the concepts of adaptive capacity and vulnerability. In social contexts, adaptive capacity refers to the ability of a household or community to recover from external disturbances, be robust, take advantage of new opportunities, and respond to changes, e.g., climate change impacts, government interventions, or other changes in the social-ecological system, without losing future opportunities (Folke et al. 2002, Walker and Salt 2006, Parry et al. 2007, Armitage and Plummer 2010). On the other hand, vulnerability refers to the potential of households or communities to suffer damages or losses when facing stresses and shocks (Folke et al. 2002, Benson and Twigg 2007).

Although the term adaptive capacity (AC) is closely related to other terms frequently used interchangeably, such as vulnerability, resilience, and robustness (Walker et al. 2004, Galllopin 2006, Smit and Wandel 2006), they are not the same, and their interpretation and conceptualization varies among disciplines and problem areas (Gallopin 2006). Within the framework of social-ecological systems, we focus on the concept of adaptive capacity and its relation with vulnerability, applied specifically to social systems. We understand adaptive capacity, also termed capacity of response, adaptability, and coping capacity, as a key component of vulnerability (Yohe and Tol 2002, Gallopin 2006, Smit and Wandel 2006). On the other hand, although AC and social resilience are concepts that overlap and for some authors are parallel (Smit and Wandel 2006), we adopt the term adaptive capacity following Gallopin (2006), who presents resilience as a subset of adaptive capacity, at least for the social component of social-ecological systems (SES). Gallopin (2006) describes AC as a long-term condition that allows not only to maintain but also to improve the system, perhaps even to transform it, when faced with structural and general changes. On the other hand, resilience is seen as a condition that preserves the behavior of a particular system and adjusts it without collapsing, when specific and nonstructural disturbances occur. For details on the discussion about conceptualization and linkages between social resilience and adaptive capacity see Gallopin (2006) and Walker et al. (2004). [Erratum 2]

The concept of adaptive capacity has been mainly developed and used to analyze the adaptability of communities, countries, and regions to external perturbations through climate change and natural disasters (Smit and Pilifosova 2001, Eakin and Lemos 2006, Smit and Wandel 2006, Lacambra et al. 2008). Its application to other more local, human-induced disturbances, such as public or private interventions, is, to the best of our knowledge, limited (Marshall and Marshall 2007, Mascia and Claus 2008, McClanahan et al. 2008). Specifically, a government intervention, such as the establishment of MPAs, can be seen as a structural intervention that limits the access to and use of resources by local communities. Therefore, we argue that the adaptive capacity concept might be useful for both understanding livelihoods of resource-dependent communities and determining their adaptability to this specific type of intervention. The operationalization of the concept constitutes an initial step to guide the design of strategies for the management of MPAs and the development of responses that would allow local users to face, overcome, take advantage of, and likely, contribute to its effective implementation and thus to the conservation of ecosystems.

Despite important developments in the understanding of fishing communities' livelihoods and the way they respond to changes (Marshall and Marshall 2007, McClanahan et al. 2008, 2009, Cinner et al. 2009*a*, *b*, 2010), the effective incorporation of the role of local communities in the design of conservation strategies for marine ecosystems still requires advancement in operationalizing conceptual frameworks, standardizing indicators, as well as their definitions and measurement approaches, and developing a composite index capable of both organizing those indicators by categories of analysis and adding multiple indicators proposed in the literature. This would allow a quantificaton of the adaptive capacity of fishing communities to the establishment of MPAs, thereby helping to determine which actions should be considered to enhance their adaptive capacity to cope with management interventions that restrict access to and use of resources.

By following and combining previous approaches (Smit and Pilifosova 2001, Eakin and Lemos 2006, Smit and Wandel 2006, McClanahan et al. 2008, 2009, Cinner et al. 2009*a*, 2010, Keskitalo et al. 2011), our objective is to contribute a conceptual and methodological approach that will allow estimation of the adaptive capacity of fishing communities to the establishment of MPAs that restrict their rights to access and use the resources they depend on. Our ultimate purpose is to offer a practical approach for estimating the adaptive capacity of fishing communities, which can be used as input for the design of MPA management strategies that recognize the role and incorporate the needs of local resource users.

We propose an index of adaptive capacity (IAC) that is formed by three comprehensive and complementary dimensions of adaptive capacity: socioeconomic, socio-political/institutional, and social-ecological. These analytical dimensions were chosen to capture different determinants of adaptive capacity proposed in the relevant literature, but adjusted and made applicable at the local level and to the specific purpose mentioned. An empirical application of this index was developed in Moreno-Sánchez and Maldonado (2013).

METHODOLOGICAL APPROACH: THE INDEX OF ADAPTIVE CAPACITY

Conceptual approach

Adaptive capacity (AC) is defined as the potential of a society to cope with perturbations and take advantage of new opportunities (McCarthy et al. 2001). Specifically, for coastal communities, McClanahan et al. (2008:57) defined it as "the ability of households to anticipate and respond to changes in coral reef ecosystems, and to minimize, cope with, and recover from the consequences." Changes and perturbations may be climate change impacts, natural disasters, or human-induced disturbances to the social-ecological system, such as tourism developments, infrastructure projects, and even conservation

[Erratum 2]: Phrasing in this paragraph has been altered from the original publication. The change took place on 18 August 2014.

interventions such as the establishment of MPAs, which restrict access to and the use of resources by local users.

Adaptive capacity depends on the interaction among different types of variables that act simultaneously in a dynamic context and reflect strategies, capacities, and assets available to households for coping with changes and disturbances (Smit and Pilifosova 2001). Most operative developments of AC include, as highlighted by Eakin and Lemos (2006:10), both "physical elements (infrastructure, material wealth, technology) and social/ institutional elements (human capital, political legitimacy, and institutional strength)." Those elements, conditions, and characteristics are called determinants of adaptive capacity (Smit and Pilifosova 2001). Following Smit and Pilifosova's (2001) framework, determinants of AC could be organized into six categories: economic resources, technology, information and skills, infrastructure, and institutions and equity. Nevertheless, in the relevant literature, those determinants and the selection of indicators for their operationalization diverge depending on scale, approach, and context.

Based on Smit and Pilifosova's (2001) framework, Table 1 summarizes the determinants and indicators of adaptive capacity proposed in the recent literature from several authors under different contexts, approaches, and scales. From Table 1, proxies for the determinant economic resources may include a variety of indicators, such as poverty measurements (Yohe and Tol 2002), GDP and per capita income (Brooks et al. 2005), income generation diversity (McClanahan et al. 2008, Cinner et al. 2009*a*, Swanson et al. 2009), wealth and assets ownership (Eakin and Lemos 2006, McClanahan et al. 2008, Cinner et al. 2009*a*), and financial capital (Eakin and Lemos 2006). The rationale behind incorporating economic resources as an AC determinant is straightforward because poverty is one of the main drivers of vulnerability (Smit and Pilifosova 2001).

Technology enhances the ability of communities to implement adaptation options by increasing the range of possible responses (Smit and Pilifosova 2001). For technology, indicators range from research and development investments and early warning systems at the national scale (Brooks et al. 2005, Eakin and Lemos 2006), to the diversity of gears used for fishing (McClanahan et al. 2008) and the access and availability of sanitation and water treatment systems (Grambsch and Menne 2003) at the local scale.

With respect to information and skills, Fankhauser and Tol (1997) stated that to achieve success with adaptation, the "recognition of the necessity to adapt knowledge about available options, the capacity to assess them, and the ability to implement the most suitable ones" is necessary. Although the AC determinant, information and skills, has also been addressed using different proxies, studies agree on incorporating formal education and levels of knowledge, either local or scientific. In the context of marine areas and local scales, McClanahan et al. (2008) and Cinner et al. (2010) used indicators to measure the capacity of individuals to learn and define causal relationships between human activity and ecosystems deterioration, or knowledge about causes of resource deterioration.

Infrastructure enables households and communities to face and overcome external disturbances by allowing them to improve human capital, to mobilize and communicate, and to obtain information that reduces vulnerabilities, among others. For infrastructure, indicators more frequently used are the presence of paved roads, sanitation and water systems, energy supply, and health and education facilities (Brooks et al. 2005, Eakin and Lemos 2006, McClanahan et al. 2008, 2009).

Institutions, understood as social arrangements, i.e., norms and rules that govern human relationships (North 1990), constitute a key component of AC because it is not only enhanced by resource endowments, but also by the social and institutional relations that provide rights and enable or restrict access to and control of them (Sen 1992, Armitage et al. 2007). Moreover, social capital constitutes a relevant strategy at the local scale for facing different types of external disturbances (Dercon 2002). A strong consensus on subdeterminants and indicators is found for this determinant of AC; all studies presented in Table 1 incorporate different measurements of social capital, including networks, informal rules and norms, and participation in community organizations and leadership. Under this determinant, indicators proposed by some authors for political capital and institutions' legitimacy could also be incorporated (Yohe and Tol 2002, Brooks et al. 2005, Eakin and Lemos 2006).

Equity is a determinant closely related to institutions. Equitable distribution of power and resources confer AC to communities when facing perturbations (Smit and Pilifosova 2001). Equity is incorporated in the studies that analyze adaptive capacity determinants at national or subnational scale, and it is measured through traditional distributional figures such as the Gini coefficient (Yohe and Tol 2002, Brooks et al. 2005, Eakin and Lemos 2006).

As shown in Table 1, there are, however, some indicators proposed in the literature that do not exactly match with those proposed by Smit and Pilifosova (2001); particularly, elements that allow the identification of risk-spreading mechanisms and the communities' ability to anticipate and develop responses to changes are explicitly included by several authors (Yohe and Tol 2002, Brooks et al. 2005, McClanahan et al. 2008, Cinner et al. 2009*a*).

The adaptive capacity index we propose for local fishing communities, follows closely those proposed by McClanahan et al. (2008, 2009) and Cinner et al. (2010), which have been adjusted, complemented, and framed by AC literature (see last column Table 1). Although we do not follow directly the structure proposed by Smit and Pilifosova (2001), our IAC incorporates most of their determinants and operationalizes them to local scale. Specifically, we incorporated three major adjustments to previous contributions:

1. To analyze comprehensively several determinants of AC at the local level and different sets of variables, we grouped and consolidated them into an operative index of adaptive capacity made up of three categories of analysis that constitute complementary dimensions: a socioeconomic dimension (SN), a socio-political and institutional dimension (SI), and a social-ecological dimension (SE).
2. As shown in the last column of Table 1, dimensions, indicators, and variables proposed are directly or indirectly related to most of the determinants proposed previously for estimating adaptive capacity in the framework of climate change, but continue being specific enough to estimate AC locally in the

Table 1. Determinants and indicators of adaptive capacity: comparison of different approaches and our proposal.

Smit and Pilisofova 2001	Yohe and Tol 2002	Brooks et al. 2005	Eiken and Lemos 2006	Swanson et al. 2009	McClanahan et al. 2008	Cinner et al. 2009*a*	Our proposal
General context of climate change	Context: multiple stressors Scale: national, regional	Context: vulnerability to climate change Scale: national	Context: climate change and the role of the state on adaptability Scale: national	Context: climate change and agriculture Scale: subnational	Context: climate change and marine resources Scale: local	Context: MPAs and coastal communities Scale: local	Context: MPAs and fishing communities Scale: local
1. Economic Resources	Availability of resources: poverty.	Economy: GDP, income/per capita.	Wealth and financial capital: accessibility and availability of financial instruments.	Economic resources: income generation, diversity of employment opportunities.	Occupational mobility. Occupational multiplicity. Wealth: material style of life (e.g., household appliances).	Flexibility: livelihood diversity, dependence on resource use. Assets: material style of life (e.g., household appliances).	Socioeconomic: POV, OCC. Social-ecological: RUD.
2. Technology	Available technological options for adaptation: flood control options.	Technical capacity: R&D investment.	Information and technology: comm. networks, technology transfer, data exchange, innovation capacity, early warning systems.	Technology: water access technology.	Technology: number of different gears used by fishing households.		Socioeconomic: POV1 (UBNI: access to sanitation and water services); POV3 (productive assets).
3. Information and Skills	Human capital: enrollment in education; life expectancy. Ability to manage information. Awareness: public's perceived attribution of the source of stress.	Education: literacy rate. Health and nutrition.	Human capital: knowledge (scientific and local), education levels; health.	Information, skills and management: management practices.	Recognition of causality and human agency on marine resources.	Capacity to learn: perceptions about humans as causal agents in marine ecosystems, education monitoring of resources.	Socioeconomic: POV1 (UBNI: children school attendance, economic dependence –education of household head). Social-ecological: AEP, AAD.
4. Infrastructure		Infrastructure: roads, access to safe water, access to sanitation.	Infrastructure: transport, water infrastructure, buildings, sanitation, energy supply.	Infrastructure: soil resources, surface water resource, ground water resource, transportation network.	Infrastructure: presence of infrastructure items in the community (e.g., health and education facilities, piped water, sewage systems, electricity and phone services, transportation infrastructure).	Assets: infrastructure.	Socioeconomic: INF (health center, hospital, elementary school, high school, roads, piped drinking water, sewerage, public electricity, solid waste collection, adequate solid waste disposal and natural gas).
5. Institutions	Social capital. Structure of critical institutions/ allocation of decision-making authority: political rights, civil liberties.	Institutions, governance, and social capital: civil liberties, political rights, voice, and accountability.	Social capital: state-civil society relations, local networks, density of institutional relationships. Political capital: leadership legitimacy, participation. Institutions and entitlements: informal and formal rules.	Institutions and networks: social capital, e-mail, and internet use.	Social capital: membership to community organizations.	Flexibility: formal and informal institutions that govern marine resources. Capacity to organize: involvement in community organizations. Participation in community decision making.	Socio-political and institutional: SSC, CSC PAP.

(con'd)

6. Equity	Distribution of resources across population: Gini coefficient.	Economy: Gini coefficient.	Wealth and financial capital: income and wealth distribution.	Equity: employment opportunities, access to health and social services, distribution of income.			Socioeconomic: POV3.
Others	Risk spreading.	Dependence on agriculture.			Occupational mobility. Occupational multiplicity. Capacity to anticipate change and develop response strategies.	Flexibility: livelihood diversity, dependence on resource use, linkages and feedbacks between marine and terrestrial resource use sectors. Capacity to organize: migration.	Socioeconomic: OCC (mobility and diversity). Social-ecological: AAD, RUD.

This table shows similarities and differences between adaptive capacity determinants proposed by Smit and Pilisofova (2001; column 1) and determinants and indicators proposed by other authors (columns 2-7). The last column shows dimension and indicators proposed by our study.
MPA = marine protected areas; POV = poverty level; OCC = occupational characteristics; RUD = resource-use dependence; UBNI = index of unsatisfied basic needs; AEP = awareness of ecological processes and functions; AAD = ability to anticipate disturbances; INF = public infrastructure; SSC = structural social capital; CSC = cognitive social capital; PAP = community perception of MPAs.

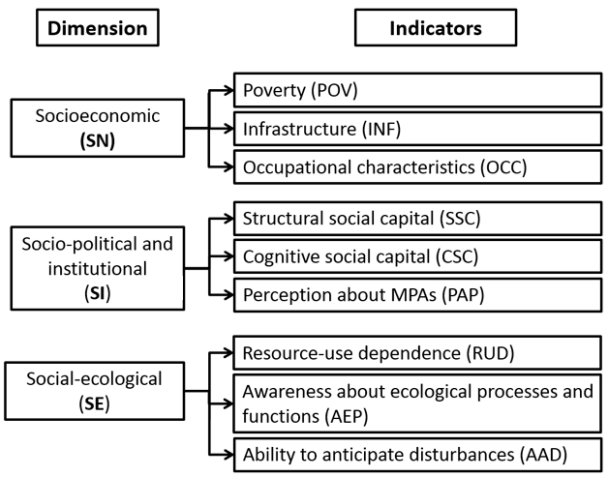
framework of the establishment of MPAs and consistent with previous work performed by McClanahan et al. (2008, 2009) and Cinner et al. (2010) for marine social-ecological systems.

3. Several indicators and variables, which we believe improved the utility of the index to approximate AC of local resource users, were added.

Adaptive capacity dimensions

Figure 1 shows the general structure of the index of adaptive capacity we propose.

Fig. 1. Proposed dimensions and indicators to measure adaptive capacity.



Socioeconomic dimension

The socioeconomic dimension (SN) incorporates social and economic characteristics of households and communities, which shape their relationship with the natural environment and confers on them the ability to face disturbances. It comprises the following indicators: poverty level (POV), public infrastructure (INF), and occupational characteristics (OCC). As shown in Table 1, these indicators are proxies of some of the determinants of adaptive capacity proposed previously.

$$SN=SN(POV,INF,OCC) \quad (1)$$

Poverty (POV) is approached through a combination of three sub indicators (Table 2): basic needs satisfaction (POV1), poverty perception (POV2), and material style of life (POV3).

Basic needs satisfaction (POV1) is based on the index of unsatisfied basic needs (UBNI), which allows the identification of critical deficiencies in a specific population using structured surveys for collecting household data. Unsatisfied basic needs (UBNI) is used to characterize poverty in several Latin American countries since the Economic Commission for Latin America (ECLAC) proposed it in the 1980s.

The basic UBNI is made up of four elements (Feres and Mancero 2001): (1) access to housing, i.e., quality and overcrowding, (2) access to sanitary services, i.e., access to potable water and a sewage system, (3) access to education for children, and (4) economic capacity, i.e., probability of insufficient economic resources. Given the comprehensive and multidimensional nature of the UBNI, it is a good proxy for several of the AC's determinants proposed in previous literature. The UBNI we propose for estimating AC follows the standardized approach applied by the National Administrative Department of Statistics (DANE) in Colombia; its value ranges from 1 to 100 and reflects the proportion of households in a community that exhibits at

Table 2. Calculation of poverty indicator and subindicators.

Poverty (POV)	$POV = 1/3(POV1 + POV2 + POV3)$	
	Household level	Community level
Basic-needs Satisfaction (*POV1*)		$POV1 = 100 - UBNI$ *UBNI*: Index of unsatisfied basic needs
Poverty Perception (*POV2*)	$POV2_i = POPE_i * 10$ $POPE_i$: self-perception about well-being for each household *i*.	$POV2 = \frac{1}{N}\sum_{i=1}^{N} POV2_i$ *N*: total number of households in sample
Material Style of Life (*POV3*)	$MSOL_i = \frac{1}{K}\sum_{k=1}^{K} MSOL_i^k$ $MSOL_i^k$: Score of material style of life for household *i* and asset component *k*.	$POV3 = \frac{100}{N}\sum_{i=1}^{N} MSOL_i$

least 1 out of 5 of the following conditions: (1) inadequate housing, (2) inadequate access to clean water and sewage, (3) economic dependence, (4) presence of children who do not attend school, and (5) households with critical overcrowding.

The second subindicator of our poverty indicator, poverty perception (POV2), allows consideration for not only the formal poverty measurement (UBNI), but also households' perceptions of their own well-being relative to others in the same community. Each household head reports, on a scale from 1 to 10, his own perception about his household's well-being relative to the others in the community ($POPE_i$). This value is multiplied tenfold to obtain a 0-100 score to further obtain the indicator at the household level. Poverty perception (POV2) is calculated as the average of individual measurement for the *N* surveyed households (Table 2).

The material style of life (POV3) is a proxy for wealth and reflects accumulated, physical, private capital as a result of livelihood strategies (Pollnac and Crawford 2000, McClanahan et al. 2008); POV3 can also be seen as an input for maintaining or improving livelihood strategies. To estimate this subindicator, we followed McClanahan et al. (2008) and Cinner et al. (2010) who used the principal component analysis method to carry out a factor analysis of selected households' assets. For our purposes, we included 18 household assets distributed between household appliances, e.g., refrigerator, TV, DVD player, blender, fan, radio, stove, stereo, power generator, and bicycle, and productive assets, e.g., sewing machine, freezer, long lines, fishing nets, fishing single lines, boats, and outboard motors. Weights from principal component analysis were used to calculate a score for each component *k* and each household *i*, $MSOL^k_i$. Scores were standardized on a 0-100 scale. Finally, estimated values from components were averaged to get a household's material style of life measurement ($MSOL_i$; Table 2). The final list of assets has to be adapted depending on the particular community context, given economic and cultural differences among communities. For example, to determine culturally appropriate items, Cinner et al. (2009*a*) asked key informants to describe the house of a rich person and the house of a poor person in the village.

Within the socioeconomic dimension, poverty is complemented with other indicators. Community infrastructure (INF) offers an idea about the presence of government institutions and the provision of public goods. To estimate this indicator we chose, following McClanahan et al. (2008) and Cinner et al. (2010), a set of 10 public infrastructure items, which were evaluated in terms of their presence in the community: health center, hospital, elementary school, high school, roads, piped drinking water, sewerage, public electricity, solid waste collection and disposal, and natural gas. We assigned 10 points to the presence of each item; the greater the number of services to which the community had access, the higher the score. For small communities characterized by sharing the same access to these services, the indicator could be obtained from a key informant. For more heterogeneous communities, the questions could be included in the survey and asked of every household. In the latter case, principal component analysis (PCA) can be performed to obtain weights and scores for each variable and for the indicator, as done by McClanahan et al. (2008).

Table 3. Calculation of occupational characteristics indicator and subindicators.

Occupational Characteristics (OCC)	$OCC = \frac{1}{2}(OCDI + OCMO)$	
	Household level	Community level
Occupational Diversity (OCDI)	$OCDI_i = \frac{EAHH_i}{THHW_i}$ *EAHH*: number of economic activities carried out by household members *THHW*: total members of the household engaged in economic activity	$OCDI = \frac{100}{N}\sum_{i=1}^{N} OCDI_i$ *N*: total number of households in sample
Occupational Mobility (OCMO)		$OCMO = \frac{VWCH}{WCH} * 100$ *VWCH*: Number of household heads that voluntarily changed their economic activity in the last five years *WCH*: Number of household heads that wanted to change their economic activity in the last five years

Several authors have highlighted the role of occupational diversity and mobility as relevant determinants of adaptive capacity conferring risk spreading and flexibility to households when facing perturbations (Table 1). We combined two subindicators, occupational diversity (OCDI) and occupational mobility (OCMO) into one that we called occupational characteristics (OCC). Occupational diversity (OCDI) reflects the variety and number of economic activities that are carried out in a community, i.e., the portfolio of economic activities; OCMO demonstrates the real ability or ease of moving from one economic activity to another. Lack of human or financial capital, for instance, may limit the ability of resource users to shift from their current economic activity, based on extraction of resources and characterized by risk and unstable income, to another economic but less resource-intensive activity. Table 3 presents details about the calculation of these subindicators.

Occupational diversity is estimated first for each household *i* ($OCDI_i$) as the ratio between the number of different main economic activities carried out by household members (EAHH), and the number of total members of the household with any economic activity (THHW). Then, the occupational diversity subindicator (OCDI) is calculated as the average of $OCDI_i$ for *N* surveyed households.

On the other hand, occupational mobility (OCMO) is calculated as the proportion of household heads who voluntarily changed their main economic activity (VWCH) given that they wanted to change this activity (WCH). Occupational mobility might be restricted by a variety of issues, such as the lack of financial resources, limited access to technical assistance and land, and even, as found by Marshall and Marshall (2007), social constraints. To capture sources that constrained households' occupational mobility, we asked household heads for reasons associated with limited occupational mobility.

Socio-political and institutional dimension

Socio-political and institutional dimension (SI) reflects formal and informal rules and norms that govern relationships among individuals, and between them and external institutions for controlling access to and use of resources and natural capital upon which they depend. Particularly, the relevant literature suggests that social capital is a key element for initiating and maintaining conservation activities and sustainable resource management at the local level (Pretty 2003, Olsson et al. 2004, Pretty and Smith 2004, Ostrom 2005). The stronger the social capital and the greater the legitimacy of rules, the easier it is to reach and to enforce agreements among resource users and between them and external institutions, thus conferring adaptive capacity (Jentoft 2000, Folke et al. 2005, Grafton 2005, Armitage et al. 2007, Berkes 2007, Sekhar 2007). Given that social capital involves several dimensions and variables, and that the ability of a community to adapt to external institutions is favored by the legitimacy of those institutions, we included three subindicators at the socio-political and institutional dimension of IAC: (1) structural social capital (SSC), (2) cognitive social capital (CSC), and for measuring external institutions' legitimacy (3) community perceptions about MPAs (PAP):

$$SI=SI(SSC,CSC,PAP) \quad (2)$$

Although structural social capital refers to "relatively objective and externally observable social structures, such as networks, associations, and institutions, and the rules and procedures they

embody" (Uphoff 2000, Grootaert and Van Bastelaer 2002:3), cognitive social capital incorporates "subjective and intangible elements such as norms of behavior, shared values, reciprocity, and trust" (Grootaert and Van Bastelaer 2002). The estimations of SSC and CSC proposed in this methodology were based on questions proposed by Grootaert and Van Bastelaer (2002:3) for measuring social capital.

To incorporate structural social capital (SSC) into IAC, we constructed five subindicators as shown in Table 4: (1) community organization (SSC1), (2) organizational density (SSC2), (3) networks and mutual support (SSC3), (4) expectations about networks and support (SSC4), and (5) collective action (SSC5). The community organizations (SSC1) subindicator is estimated at the community level. The total number of existent organizations in the community (TNOC) is determined and converted into the 0-100 scale, using a transformation that allows valuing the presence of community organizations positively, but at a decreasing rate (Table 4).

The organizational density (SSC2) subindicator is calculated first at the household level (SSC2*i*) as the share of household members, above 15 years old, which reported that they belonged to any community organization. Then, SSC2 is calculated as the average of household values.

Networks and mutual support (SSC3) measures perceptions about networks and mutual support around an event that would affect the community's main economic activity, i.e., fishing; it is also initially calculated at the household level (SSC3*i*) based on the household head's answer to the single-choice question presented in Table 4. Answers received a score ranging from 0 to 1, increasing as the support for dealing with the exposed situation came from larger and further networks (Table 4). Networks and mutual support (SSC3) was then estimated as the average of SSC3*i*.

Expectations about networks and support (SSC4) and collective action (SSC5) are estimated similarly to SSC3. The SSC4 measures the expectations of a community about networks and mutual support around an event that would affect just a proportion of the population, e.g., lack of teachers at school. The SSC5 measures the previous collective action through the frequency of household heads' participation at village meetings convened for discussing common problems. As suggested by a reviewer, grading the level of participation at meetings could enrich information provided by SSC5. Both SSC4 and SSC5 are first calculated at the household level, i.e., SSC4*i* and SSC5*i*, based on households' answers to single-choice questions, as presented in Table 4. Next, SSC4 and SSC5 are estimated as the average of SSC4*i* and SSC5*i*, respectively.

On the other hand, cognitive social capital (CSC) is estimated through the construction of three subindicators (Grootaert and Van Bastelaer 2002): (1) solidarity (CSC1), (2) cooperation (CSC2), and (3) trust (CSC3).

Similarly to the estimation of structural social capital subindicators, cognitive social capital subindicators are first calculated at the household level (CSC1*i*, CSC2*i*, and CSC3*i*) based on answers to single-choice questions (Table 5), and then subindicators at the community level are estimated as the average for *N* households. In Table 5, we present some examples of questions; most of them adjusted from Grootaert and Van Bastelaer (2002) and propose a grading scale for responses that could be used for estimating SSC. As in the case of other indicators and subindicators, questions and grading scales guide users of the methodology rather than act as a unique and exclusive way to estimate those social capital dimensions.

Finally, to approximate a measure for an external institution's legitimacy, we use a subindicator named perception about marine protected areas (PAP), which reflects households' perceptions about effects of marine protected areas (MPAs) on household and community well-being (PAP*i*). The PAP*i* is measured using questions that ask the household head to grade, using a 1-10 scale, both the existence of a MPA on their own household well-being (PAP1*i*) and the existence of a MPA on the community's well-being (PAP2*i*). In the case of a new MPA, PAP will measure perceptions about potential effects of MPAs on households and community well-being. A higher grade would imply a more positive effect of MPAs on household and community's well-being, and thus, there is greater legitimacy of that external institution and a greater ability of local resource users to adapt to its implementation. The two grades are averaged to obtain the household-level indicator (PAP*i*). The indicator estimated at the household level is multiplied tenfold and averaged at the community level to estimate perceptions about MPAs (PAP).

Social-ecological dimension

The social-ecological dimension (SE) captures both the relationships between communities and the surrounding natural environment and their ability to anticipate perturbations that affect the natural capital they depend on. The social-ecological dimension (SE) does not pretend to capture explicitly ecological factors; instead, it reflects actual and hypothetical 'interactions' between social and ecological systems as relevant elements that confer adaptive capacity. This dimension includes some of the indicators proposed previously by McClanahan, Cinner, and others (McClanahan et al. 2008, 2009, Cinner et al. 2009*a*, *b*, 2010).

The social-ecological dimension of the IAC is made up of three indicators: (1) resource use dependence (RUD), (2) awareness about ecological processes and functions (AEP), and (3) ability to anticipate disturbances (AAD):

$$SE=SE(RUD,AEP,AAD) \quad (3)$$

The dependence on the use of resources (RUD) shows the extent to which local communities' livelihoods are dependent on the surrounding natural environment. It reflects the flexibility of households' livelihoods to adapt when perturbations affect natural capital (Cinner et al. 2009*a*) and can also be seen as a measure of risk spreading (Table 1).

The RUD is estimated at the community level as the complement of the ratio between the number of members in the community whose main economic activity is related to the use or extraction of natural resources (NRRW) and the total number of members of the community engaged in any economic activity (TW; Table 6). The ratio between NNRW and TW shows the dependence on natural resources to generate income. A community exhibits more

Table 4. Calculation of structural social capital indicator and subindicators.

Structural Social Capital (*SSC*)	$SSC = \frac{1}{5}\sum_{m=1}^{5} SSC_m$	
	Household level	Community level
Community Organization (*SSC1*)		$SSC1 = 30 * \ln(TNOC)$ *TNOC* = number of community organizations in the community. If the community has none or one organization, the score would be zero; if the community has more than 28 organizations, the score would be 100.
Organizational Density (*SSC2*)	$SSC2_i = \frac{HORT_i}{MAH_i}$ $HORT_i$ is the number of members (above 15 years) from household *i* who belong to any community organization; MAH_i is the number of members above 15 years in household i.	$SSC2 = \frac{100}{N}\sum_{i=1}^{N} SSC2_i$ *N*: total number of households at sample
Networks and Mutual Support (*SSC3*)	$SSC3_i$ takes different values depending on answers to the following question: "If there were a problem affecting the entire village, for instance a reduction in the amount of fish in the sea, who do you think would work together to deal with this situation?" Grading: (a) None: 0 points. (b) Fishing organizations: 1/3 points. (c) All fishermen, local government: 2/3 points. (d) Community Council, Communal Board, all people from the community, religious organizations, or external agents: 1 point.	$SSC3 = \frac{100}{N}\sum_{i}^{N} SCC3_i$
Expectations about Networks and Support (*SSC4*)	$SSC4_i$ takes different values depending on answers to the following question: "If the school in this village went without a teacher for, say, six months or more, who do you think would meet to solve this problem?" Grading: (a) None: 0 points. (b) All parents: 1/3 points. (c) Association of parents, religious organizations, other local community organizations, or local government: 2/3 points. (d) Community Council, Communal Board, all people from the community, or others outside the community: 1 point.	$SSC4 = \frac{100}{N}\sum_{i}^{N} SSC4_i$
Collective Action (*SSC5*)	$SSC5_i$ takes different values depending on HH's answers to the following question: "Last year, how often have you met with other members of this village to discuss resolving common problems?" Grading: (a) Never: 0 points. (b) Once: 1/3 points. (c) Twice: 2/3 points. (d) More often: 1 point.	$SSC5 = \frac{100}{N}\sum_{i}^{N} SSC5_i$

Table 5. Calculation of cognitive social capital indicator and subindicators.

Cognitive Social Capital (*CSC*)	$CSC = \frac{1}{3}\sum_{m=1}^{3} CSC_m$	
	Household level	Community level
Solidarity (*CSC1*)	$CSC1_i$ takes different values depending on answers to the following question: "Suppose a family in the village were impacted by an extreme event, such as the household-head's death or illness. Who do you think they could turn to for help?" Grading: (a) Family: 1/4 points. (b) Neighbors or close friends: 1/2 points. (c) Religious leader, community leader, political leader, the police, a middleman, or a community organization to which the family belongs: 3/4 points. (d) Other community organization, local government, Community Council, Communal Board, or all people from the community: 1 point.	$CSC1 = \frac{100}{N}\sum_{i}^{N} CSC1_i$ N: total number of households in sample
Cooperation (*CSC2*)	$CSC2_i$ takes different values depending on answers to the following question: "Suppose your friend faces these alternatives: a) own a 10-hectare farm single-handedly or b) own a 25-hectare farm jointly. Which would he prefer?" Grading: (a) Alternative a: 0.5 points. (b) Alternative b: 1 point.	$CSC2 = \frac{100}{N}\sum_{i}^{N} CSC2_i$
Trust (*CSC3*)	$CSC3_i$ takes different values depending on answers to the following question: "If you and your spouse leave the village for two days, who would care for your children?" Grading: (a) Extended family: 1/3 points. (b) A neighbor or a friend: 2/3 points. (c) Any person from the community or other: 1 point. (d) None or do not have any children: 0 points.	$CSC3 = \frac{100}{N}\sum_{i}^{N} CSC3_i$

adaptive capacity when the members depend less on natural resources; therefore, the indicator is calculated as the fraction of nonresource dependent workers (Table 6).

Literature suggests that the capacity to both learn from previous experiences, observations, social interactions, or by doing, and to use acquired knowledge, either scientific or traditional, for responding to disturbances, is a key component of any adaptive process (Armitage et al. 2007, Berkes 2007, Cinner et al. 2009*a*). We propose to incorporate the subindicator awareness of ecological processes and functions (AEP) to approach, at least partially, local ecological knowledge, which provides the capacity to interact with the ecological system and thus constitutes an enhancer of the adaptive capacity of communities to the establishment of MPAs: AEP favors the management of ecosystems and the services they provide. When resource users know, recognize, and understand the ecological processes and the effects that their own, and others, activities generate on the ecosystems and species, management interventions for modifying declining systems might be more effective and legitimate (Ostrom 1990, 2005, Olsson and Folke 2001, Becker and Ghimire 2003, Aswani and Hamilton 2004).

To estimate and analyze different issues associated with the awareness of ecological processes and functions (AEP), we propose to adjust Cinner et al. (2010) by incorporating four questions into the survey:

- "Have sea fish increased, reduced, or stabilized in the last 10 years?" Captures perception about the condition of fisheries (*k=1*)
- "What is the main cause of sea fish reduction?" Captures knowledge about what is affecting the fish stock in the sea (*k=2*)
- "Who is responsible for this reduction?" Captures knowledge about responsibilities (*k=3*)
- "How do we increase sea fish stocks?" Captures knowledge about solutions (*k=4*)

The AEP is estimated, first at the household level (AEP*i*) for those households thinking that the amount of fish at sea, during the last 10 years, has been reduced, by applying principal component analysis (PCA) of the answers to the three subsequent open-ended questions (*k=2,3,4*). To do this, open answers for each question should be grouped into thematic categories. Categories for each question are scored and weighted using the component analysis, and then they are standardized on a 0-1 scale ($HAEP^k_i$). Standardized scores from the answers are averaged to provide a final value for each household *i*, AEP*i*. Finally, AEP at the

Table 6. Calculation of social-ecological dimension and its indicators.

Indicators	Household level	Community level
Dependence on the Use of Resources (RUD)		$RUD = \left(1 - \frac{NRRW}{TW}\right) * 100$ *NRRW*: Number of members in the sample whose main economic activity is natural-resource related. *TW*: Total number of members in the sample engaged in economic activities.
Awareness about Ecological Processes and Functions (AEP)	$AEP_i = \frac{1}{K}\sum_{k=1}^{K} HAEP_i^k$ $HAEP_i^k$: Score from the principal component analysis for the three (*K*) questions about awareness on ecological processes from household *i*.	$AEP = \frac{100}{N}\sum_{i=1}^{N} AEP_i$
Ability to Anticipate Disturbances (AAD)	*AADi*, takes different values depending on household head's answers to a hypothetical scenario in which a 75% decline in catches occurs. Alternative activities are proposed as possible shift in income source and household head should think what to do to satisfy food as well as other needs of the household. Differentiation is made for household heads whose main activity is fishing and those who depend on other activities for income generation. Possible scores are: (a) Continue fishing, do nothing, or migrate out the community: 0 points. (b) Move to an activity based on natural resources extraction: 1/3 points. (c) Move to agricultural activities: 2/3 points. (d) Move to commercial, manufacturing, or service-related activities, including activities related with nonconsumptive and sustainable use of natural resources: 1 point.	$AAD = \frac{100}{N}\sum_{i}^{N} AAD_i$

community level is calculated as the average of AEP_i for *N* surveyed households (Table 6).

The RUD and the AEP are complemented by an indicator that measures the ability a community has to confront an unexpected perturbation that would affect their livelihoods: the ability to anticipate disturbances (AAD). The AAD is estimated initially at the household level (AAD*i*). To estimate the AAD*i*, we followed Cinner et al. (2010) and McClanahan et al. (2008) and confronted the household head with a hypothetical scenario in which, because of increases in the sea temperature, a 75% decline in fish catches occurred. This hypothetical scenario aimed to avoid confronting fishers with a total restriction on access to and use of marine resources as a result of the establishment of MPAs. Individuals should choose among a variety of alternative activities they think they are able to shift to, to satisfy both food and other basic needs of the household. Activities should be chosen to include the whole range of feasible activities in the region and fit into social and ecological contexts of the fishing community.

Household answers are sorted into the following suggested categories, which are associated with a score ranging from 0 to 1 (AAD*i*) depending on the ability of the household to move away from the shock and continue to generate income and well-being:

- Continue fishing, do nothing, or emigrate: 0 points.
- Move to an activity based on natural resources extraction: 1/3 point.
- Move toward agriculture: 2/3 point.
- Move to commercial, manufacturing, or services, including nonconsumptive and sustainable use of natural resources: 1 point.

Then, AAD is estimated by averaging the ability to anticipate disturbances at the household level (Table 6).

Data and aggregation issues

Using indicators is always a challenge because ample debate is found in the literature about their use and aggregation. As defined by the Organisation for Economic Co-operation and Development (OECD), a composite indicator is formed when individual indicators are compiled into a single index, which usually measures multidimensional concepts that cannot be captured by a single indicator (Nardo et al. 2008). Using composite indicators requires an understanding of the associated pros and cons; the main advantages are that they can summarize complex dimensions of a reality to support decision makers, are easy to interpret, facilitate communication with general audiences, and enable users to compare complex dimensions effectively. On the other hand, they may send misleading messages if poorly constructed or misinterpreted, may invite simplistic conclusions and lead to inappropriate policies if some dimensions are ignored, and mainly, the selection of indicators and weights could be subject to political dispute (Nardo et al. 2008). We considered these issues in our selection of indicators and weights.

In practice, there are challenges related with how to obtain the information for calculating the indicators, and once estimated, how to standardize, weigh, and aggregate them. First, to obtain the information needed to calculate the indicators for the IAC, we propose a central instrument: a household survey. This survey might be complemented with direct observation, interviews with key informants, and where available, secondary information. Direct observation and interviews are useful for contextualizing the index, adjusting the survey if needed, and capturing information at the community level that need not be asked at the household level. Secondary information is useful when previous estimations of indices, such as the index of unsatisfied basic needs (IUBN) or any other measurement of structural poverty, have been calculated for the community of interest.

Notwithstanding, the survey is proposed as the main instrument to obtain information for indicators. We designed a question set for inclusion in a household survey that provides the information needed to calculate all the indicators and the index. Table A-1 in Appendix 1 shows some specific examples of questions for each indicator and subindicator, which can be adapted to different contexts or even complemented by others.

To guarantee adequate comparison and aggregation between indicators requires normalization. From available normalization approaches (Freudenberg 2003, Jacobs et al. 2004, Nardo et al. 2008), we used a Min-Max approach, which transformed the values of all indicators and subindicators, even if they were qualitative, to a 0-100 scale. In this case, values closer to 100 reflected a greater adaptive capacity. Interindicator comparison was facilitated.

The next decision related to indicator weighting and aggregation. With respect to weighting, several techniques are available, such as principal component analysis or factor analysis, data envelopment analysis, unobserved component models, budget allocation process, analytical hierarchy processes, and conjoint analysis; all of them with pros and cons (Nardo et al. 2008).

We used the same weighting for each indicator within each dimension. The equal weighting technique implies that all variables have the same relevance in the composite. An advantage of using an equal weights technique is that it allows different forms of aggregation. There is however a risk that, if two indicators are highly correlated, a double counting might be introduced into the dimension (Nardo et al. 2008). Another risk is that if the number of indicators in each dimension is different, the weights are also different. To avoid unequal distribution of weights, we have organized the index so that each dimension has three indicators.

Another possibility is to give different weightings to indicators based, for example, on results from the analytic hierarchy process methodology as McClanahan et al. (2008) did to estimate adaptive capacity.

With respect to aggregation, the most used techniques are linear, geometric, and multicriteria aggregation (Nardo et al. 2008). Within the linear aggregation, the simplest method, additive aggregation, implies the summation of the weighted and normalized indicators. Being simple and direct, it is preferred in many instances. An important drawback is that although the marginal contributions of each indicator can be added together, the technique assumes that aggregation does not generate any synergy or conflict. This is a property known as preference independence (Funtowicz et al. 1990, Nardo et al. 2008), and it might not be suitable for ecological processes. Another characteristic of additive methods is that they imply full compensability, in the sense that poor performance of some indicators might be compensated for by high values in other indicators (Nardo et al. 2008). This disadvantage can be overcome with the use of geometric methods. The final choice of the method of aggregation is a practical issue, which also involves value judgments.

For the methodology presented here, we used the additive aggregation with the equal weighting technique for the indicators in each dimension:

$$\begin{aligned} SN &= a_1*POV + a_2*INF + a_3*OCC \\ SI &= a_4*SSC + a_5*CSC + a_6*PAP \\ SE &= a_7*RUD + a_8*AEP + a_9*AAD \end{aligned} \quad (4)$$

With a_i=1/3, (i=1... 9). This aggregation and weighting has been used for measuring adaptive capacity in other contexts (Swanson et al. 2009).

Although policy makers and stakeholders gain information from estimates of individual dimensions, the composite index provides policy makers with a clear signal on where to concentrate efforts to improve the adaptive capacity of communities. We focused on the weakest dimension, using a Min function for aggregating the dimensions:

$$IAC = min(SN, SI, SE) \quad (5)$$

No matter how well other dimensions perform, the status of the adaptive capacity of a community is constrained by the dimension with the lowest value. In this sense, increasing adaptive capacity involves primarily addressing the dimension, or its indicators, that exhibits the worst conditions.

It is important to recall that any applied technique for either weighting or aggregation should be tested by sensitivity analysis for robustness under different scenarios. For instance, weightings can be modified either by using bootstrapping and analyzing

sensitiveness to changes in the weights or using participatory methods, which legitimize the procedure. Aggregation methods can also be tested for robustness; additive or geometric aggregation, for instance, can be useful to test for preference independence and compensability.

After making the decision about the weighting and aggregation, each dimension, indicator, and subindicator is standardized to a 0-100 range. For analytical and comparative purposes, we suggest a colored scale, in which green is associated with indicators within the range 66 to 100, yellow with indicators exhibiting values between 33 and 65, and red is used for indicators displaying values below 32; those colors reflect, respectively, high, moderate, and low ability of indicators to confer adaptive capacity to communities.

DISCUSSION

Based on previous conceptual and empirical developments, we have proposed a practical methodology for estimating the adaptive capacity of fishing communities to the establishment of marine protected areas. Specifically, our contribution consists of adjusting an existing conceptual framework designed for climate change adaptation and combining it with practical approaches for constructing an index of adaptive capacity (IAC) of fishing communities, which could be estimated at a local scale, to understand the extent to which local marine-resource dependent communities are able to face, overcome, and take advantage of structural government interventions of the MPA type, which restrict access to and use of resources upon which they depend.

We developed a composite measure, an index of adaptive capacity, which makes the concept of AC operative. The IAC comprises three dimensions: socioeconomic, socio-political/institutional and social-ecological, which attempt to capture comprehensively the determinants of adaptive capacity. The IAC is practical because practitioners in the field could develop it by applying well-designed, structured surveys and because the estimation of indicators and subindicators does not require sophisticated knowledge of statistics or econometrics as do other previously proposed methodologies.

Through the estimation of three analytical and complementary dimensions, the index of adaptive capacity allows the understanding of not only the socioeconomic and institutional features of fishing communities, but also the interactions between the social and ecological systems they are immersed in. As observed in Table 1, the IAC we propose covers directly or transversally several determinants of adaptive capacity suggested previously in the conceptual and empirical literature on adaptation to climate change; we have incorporated comprehensive indicators and subindicators and scaled down some of them to make it possible to estimate AC at the local, marine resource-use community scale.

Particularly, our poverty indicator, within the socioeconomic dimension, contributes two ideas to the previous literature: (1) it includes a multidimensional subindicator of poverty (POV1), which helped us to understand the poverty of marine-resource dependent communities using a measure more comprehensive than income (UBNI). It has been well discussed that fishing communities' income is extremely unstable because it depends on both noncontrollable natural conditions and highly volatile market prices, e.g., fish prices on a local scale. Therefore, approaches to the economic resources dimension proposed by Smit and Pilifosova (2001) based, for example, on income per capita (Brooks et al. 2005, Swanson et al. 2009) might not be adequate for communities dependent on marine resources. As presented above, the UBNI is a standard multidimensional poverty measure used in Latin America, and it could be obtained either from secondary information, i.e., from national departments of statistics, or estimated using the standard methodology proposed by ECLAC. In Appendix 1 we present the questions needed to estimate this index. Moreover, as presented in Table 1, UBNI allows the capture of other AC dimensions, i.e., technology, information and skills, because it is based on variables related to access to water and sanitations services (technology) and children's school attendance and years of education of the household head (information and skills). The index of unsatisfied basic needs (UBNI) is complemented with two additional subindicators: (1) material style of life (POV3), previously proposed and applied by McClanahan et al. (2008) and Cinner et al. (2010), which is included to capture the ability of households to transform cash into physical capital, specifically household and productive assets, and (2) poverty perception (POV2), our proposal, which allows weighting the standardized UBNI with household's perceptions about their own well-being relative to others in the same community. Although we believe that POV2 could reflect equity issues within a community, this determinant of adaptive capacity could also be addressed or complemented by estimating, for example, the variance for the sample of productive-assets values.

In addition to poverty, the socioeconomic dimension of IAC includes indicators that capture both the actual and potential ability of households and communities to diversify occupational activities and allows them to spread risk, i.e., occupational characteristics, and the public context that enables resource-dependent communities to increase their capacity to adapt to external disturbances by endowing them with basic public goods, i.e., infrastructure. Both indicators have also been proposed by most of the previous approaches reviewed for this study (see Table 1). With respect to occupational characteristics, a reviewer highlighted the role of factors such as human capital, i.e., type and quality of skill sets, economic dependency and demographics, i.e., adults, seniors, and infants, that might affect the ability of local resource users to meet labor markets. To understand these underlying factors and other constraints, we complemented this indicator with context-specific information that allows precise interpretations of its estimated value, e.g., open questions about why people are not able, or even wanting, to change their current economic activity.

The socio-political and institutional dimension of our proposed IAC deserves special attention because, given the recognized relevance of social capital not only as a determinant of adaptive capacity (Table 1), but also as key element for the success of conservation strategies, we propose to go beyond a single measure of social capital to include, through two complementary indicators, two elements to determine that concept (Uphoff 2000, Grootaert and Van Bastelaer 2002): structural social capital and cognitive social capital. To that end, several subindicators, which measure membership to community organizations to trust, cooperation, and solidarity, were incorporated into this dimension. Questions, noted in the appendix as examples for estimating the social capital indicator, are based on some of those suggested by Grootaert and

Van Bastelaer (2002); however, other questions suggested by the same authors, or others tested and proposed by the relevant literature for approaching the different components of social capital, might be used. Social capital indicators are complemented with a subindicator intended to reflect the legitimacy of external institutions, particularly natural park authorities, among fishing households, i.e., perception about MPAs. In Table 1, it can be observed that 'institutions,' as determinants of adaptive capacity, have been approached in different ways and, specifically, that, in addition to social capital, other indicators related to political and civil rights, property rights, and entitlements have been proposed. Although other subindicators could be included in the socio-political and institutional dimension to specifically reflect those elements, we think that a simple indicator, such as the households' perceptions about how MPAs affect their well-being, allows us to capture, indirectly, community participation, approval, and the legitimacy of rules that modify entitlements and rights regarding resources.

We group three indicators, which had been previously proposed, although dispersedly, to estimate the adaptive capacity of fishing communities, i.e., dependence on resource use, awareness on ecological processes, and ability to anticipate changes (see Table 1), within the social-ecological dimension. The social-ecological dimension, however, does not attempt to explicitly incorporate elements for determining the state of the ecological system; instead, its purpose is to reflect the outcomes of interactions between social and ecological systems. As observed in Table 1, two of the social-ecological indicators (RUD and AEP), which we suggest, are related to two dimensions of AC proposed by Smit and Pilifosova (2001), economic resources and information and skills, and the ability to anticipate a hypothetical perturbation (AAD) complements them by reflecting the potential of households and communities to face unexpected events that affect their fishing.

To make the IAC simple and general enough to be applied by field practitioners in any context, we have proposed the linear addition of indicators and subindicators within each dimension, and we have suggested using the same weights for their aggregation.

We recognize that the selection of functional forms and weights could greatly affect the results and might generate different policy implications; therefore, we further suggest performing sensibility analysis to determine the robustness of AC dimensions to changes on weights and functional forms and to offer policy implications coherent with the identified sensitiveness.

Our proposal for estimating IAC is practical, simple, and based on structured surveys. Nevertheless, the quality of results depends on the quality of data; therefore, standard recommendations on survey design and application should be followed to guarantee reliability and representativeness, i.e., sample issues, previous test of the survey, enumerators' training, and adequate data handling and processing, among others. Questions suggested could be adjusted for particular conditions and contexts; however, those are the basis for estimating the dimensions, indicators, and subindicators that make up the IAC.

Perhaps the most relevant application of this IAC is that it allows decision makers to identify needs and to prioritize actions when the budget is limited and there are several conflicting goals. Any policy aimed at enhancing conservation within the MPA should consider strategies to improve conditions of local communities. As noticed by the reviewers, the methodology proposed has a wider potential because it could be adapted to other contexts and management strategies; for instance, it could be applied to zones in which community-based management or comanagement is the main conservation strategy, to fishing communities not subjected to any type of management, and to nonfishing communities affected by the presence of MPAs.

Despite being a static approach, this is a first step that shows general factors that should be understood and addressed when looking for effective conservation management strategies around marine protected areas in developing countries. To approximate dynamic measures of adaptive capacity, governments and conservation agencies should be engaged in continuous monitoring of not only yearly, but also seasonal data collection for some sensitive variables.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/issues/responses.php/5962

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Appendix

Table A-1. Necessary survey questions to calculate proposed indicators

Indicator / sub-indicator	**Question(s)**
Socioeconomic dimension	
Poverty (*POV*) / Basic-needs satisfaction (*POV1*)	Inadequate housing: - Main wall fabric - Main floor fabric Inadequate sanitary services: - Main source of household drinking-water - How is sewage disposed of in this house? Economic dependence - Number of working members in the household - Household size - Maximum education-level of household head Children's school attendance - Number of children, 6-12 years - Number of children 6-12 years attending school Critical housing overcrowding - Number of bedrooms - Household size
Poverty (*POV*) / Perception about poverty (*POV2*)	Question: *Imagine a staircase with 10 steps in which all the families from this community are placed. The families with the best well-being are placed on the 10th step and the families with the worst well-being are placed on the first step. On which step do you think your family would be?*
Poverty (*POV*) / Material style of life (*POV3*)	Question: *Does your household have any of the following items?* Options: power-generator, fridge, stove, stereo, radio, TV set, DVD player, blender, fan, sewing machine, bicycle, freezer, fishing nets, long line, fishing single lines, boat, outboard-motor.
Infrastructure (*INF*)	For small communities: From a key informant, question: *Does your community have any of the following?* Options: health center, hospital, elementary school, high school, roads, piped drinking water, sewage, electricity, solid waste collection, adequate solid waste disposal, natural gas. For larger or heterogeneous communities: From the survey: *Does your household have access to any of the following services?* Options: piped drinking water, sewage, electricity, solid waste collection, adequate solid waste disposal, natural gas. *Can your household reach (within a range of 30 min using the most usual transportation means) any of the following services?* Options: health center, hospital, elementary school, high school, roads.
Occupational characteristics (*OCC*) / Mobility (*OCMO*)	Number of household heads that voluntarily changed their main economic activity during the last five years (*VWCH*). Number of household heads that wanted to change their main economic activity (*WCH*).
Occupational characteristics (*OCC*) / diversity (*OCDI*)	Number of different economic activities performed within the household (*EAHH*) Number of members of the household engaged in economic activity

	(*THHW*)
Socio-political and institutional dimension	
Structural social capital (*SSC*) / Community organization (*SSC1*)	Number of existing organizations in the community
Structural social capital (*SSC*) / Organizational density (*SSC2*)	Number of household members (above 15 years old) who belong to any community organization (*HORT*) Number of household members (above 15 years old) (*MAH*).
Structural social capital (*SSC*) / Networks and mutual support (*SSC3*)	- Question: *If there were a problem affecting the entire village, for instance a reduction in the amount of fish in the sea, who do you think would work together to deal with this situation?* - Possible answers: a) none, b) fishing organizations, c) all fishermen, d) local government, e) community council, f) Communal Board, g) all people from the community, h) religious organizations, i) others.
Structural social capital (*SSC*) / Expectations about networks and support (*SSC4*)	- Question: *If the school in this village went without a teacher for, say, six months or more, who do you think would meet to solve this problem?* - Possible answers: a) none, b) all parents, c) association of parents, d) religious organizations, e) other local community organizations, f) local government, g) community Council, h) Communal Board, i) all people from the community, j) others outside the community.
Structural social capital (*SSC*) / Collective action (*SSC5*)	- Question: *Last year, how often have you met with other members of this village to discuss resolving common problems?* - Possible answers: a) never, b) once, c) twice, d) more often.
Cognitive social capital (*CSC*) / Solidarity (*CSC1*)	- Question: *Suppose a family in the village were impacted by an extreme event, such as the household-head's death or illness. Who do you think they could turn to for help?* - Possible answers: a) family and relatives, b) neighbors, c) close friends, d) religious leader, e) community leader, f) political leader, g) the police, h) middlemen, i) a community organization to which the family belongs, j) other community organization, k) local government, l) Community Council, m) Communal Board, n) all people from the community.
Cognitive social capital (*CSC*) / Cooperation (*CSC2*)	- Question: *Suppose your friend faces these alternatives: a) Own a 10-hectare farm single-handedly* or b) *Own a 25-hectare farm jointly. Which would he prefer?* - Possible answers: a) To own and farm 10 hectares of land on his own, b) To own and farm 25 hectares of land jointly with another person.
Cognitive social capital (*CSC*) / Trust (*CSC3*)	- Question: *If you and your spouse leave the village for2 days. Who would care for your children?* - Possible answers: a) extended family, b) a neighbor, c) a friend, d) any person from the community, e) other, f) none, g) do not have children.
Perception about MPA (*PAP*)	Question: *On a scale from 0 to 10, where 10 means the most positive, please grade*: - The relevance of the close MPA for your household wellbeing (*PAP1*)

	- The relevance of the close MPA for your community wellbeing (*PAP2*)
Socio-ecological dimension	
Dependence on the use of natural resources (*RUD*)	Number of members in the community whose main economic activity is related to the use or extraction of natural resources (*NRRW*) Total number of members of the community engaged in any economic activity (*TW*)
Awareness about ecological processes and functions (*AEP*)	- Do you think that the availability of fish in the sea has diminished in the last ten years? - What do you think is the main reason behind that reduction? - Who do you think is responsible for this reduction? - What do you think could be done to recover the amount of fish in the sea?
Ability to anticipate disturbances (*AAD*)	Question: *Suppose climate-change raises sea-surface temperature, with impact on regional fishing for one year and, as a consequence, three out of four fishermen have no harvest. Under such situation:* - *Which main activity would you engage in to ensure family food?* - *Which main activity would you engage in to satisfy other family needs?* Answers are classified in categories and generate a score: - Continue fishing, do nothing or migrate out the community - Move to an activity based on natural resources extraction - Move to agricultural activities - Move to commercial, manufacturing or service-related activities (including activities related with non-consumptive and sustainable use of natural resources).