A system-wide approach to supporting improvements in seafood production practices and outcomes

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Environmental certification and consumer awareness programs are designed to create market incentives for implementing fisheries and aquaculture practices that are more sustainable. Typically focused on particular species and activities, such programs have so far triggered few changes to improve seafood sustainability. Here, we present a conceptual, system-wide fisheries and aquaculture certification program designed to recognize and promote change toward more sustainable and resilient seafood production systems. In contrast to previous efforts, this program concentrates on both ecosystems and various human stakeholders, relies on an adaptive management approach (termed "continual improvement") to enhance outcomes, and considers socioeconomic factors. The goal of this program is to support the restoration and maintenance of healthy ecosystem states and thriving human communities as well as the improvement of whole social–ecological systems.

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In recent decades, there has been growing awareness of widespread and escalating overexploitation of natural resources, degradation of whole ecosystems, and loss of a multitude of associated ecosystem services (Vitousek *et al.* 1997; MA 2005; Halpern *et al.* 2008). Incentive-based solutions that take advantage of consumer demand, including environmental certifications and consumer awareness programs, differentiate products in the marketplace, rewarding producers for sustainable practices through increased prices and/or market access. These approaches hold great promise because they create incentives for managing natural resources sustainably, thereby aligning economic and conservation objectives.

In a nutshell:

- Unsustainable fishing and aquaculture practices are degrading marine ecosystems while simultaneously exacerbating human poverty and social conflict
- To improve both ecological and social outcomes, we argue that seafood production should be assessed and sustainability promoted for entire systems, including ecosystems and the people associated with them, and for all types of fisheries and aquaculture
- New seafood certification programs could support improvement in socially and ecologically responsible practices rather than setting a fixed bar of difficult-to-reach goals that primarily consider biological metrics
- Expected benefits include more sustainable and equitable use of human, economic, and natural resources, increased income stability for producers, and a more reliable seafood supply

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Examples of environmental certification programs include the Forest Stewardship Council's certification of sustainable forestry products, as well as the Fairtrade certification system, which helps producers in developing countries achieve better trading conditions (WebPanel 1). For the marine environment, product certification is conducted by several organizations, primarily the Marine Stewardship Council (MSC) for wild capture fisheries and the Aquaculture Stewardship Council (ASC) for the aquaculture industry (Figure 1; Table 1; WebPanel 1). The MSC applies a suite of criteria to identify sustainable fisheries (Ward and Phillips 2008; Gutiérrez *et al.* 2012); as of 31 March 2013, the MSC has certified 198 fisheries worldwide, with an additional 100 fisheries currently being assessed (according to the MSC's Annual Report 2012/13; www.msc.org). Likewise, the ASC certifies aquaculture operations based on global standards for responsible production practices, with more than 60 ASC-certified tilapia and *Pangasius* farms in nine countries (as of January 2014; www.asc-aqua.org). A number of large corporations (eg Walmart US, Whole Foods) have made commitments to source MSC- and ASC-certified products. Seafood recommendation lists produced by organizations such as the Monterey Bay Aquarium's Seafood Watch program and WWF are another important, complementary approach used to distinguish sustainable seafood from less responsibly sourced products (Figure 1; Table 1).

Unfortunately, in marine environments, progress toward more sustainable practices triggered by certification programs and recommendation lists has been rare

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Figure 1. *Certification labels and recommendation lists signal ecologically sustainable seafood products to consumers.*

and their effectiveness has been debated (Jacquet and Pauly 2007; Ward 2008; Jacquet *et al.* 2010; Froese and Proelss 2012; Martin *et al.* 2012), in part because existing certification programs do not comprehensively examine whole marine ecosystems and the human societies that depend on them. Fisheries or aquaculture operations can be certified despite degradation of marine ecosystems, loss of income among local people, and negative social impacts from the non-certified fisheries and aquaculture operations that overlap certified production systems. Furthermore, the high financial costs and data requirements associated with meeting certification and recommendation-listing standards often discourage or prevent small-scale seafood harvesters and producers from participating (Ward and Phillips 2008). For instance, while a substantial fraction of global fisheries catch and most fisheries jobs are generated in developing countries, developing-world fisheries account for only 8% of the total MSC-certified fisheries. Even in the developed world, smaller vessels are often unable to afford the high cost of certification assessment (Reed *et al.* 2013). For these seafood producers, alternative approaches are needed to incentivize sustainable practices.

We suggest that new recognition programs for sustainable fisheries and aquaculture should focus on restoring and maintaining healthy ecosystems and increasing the prosperity of human communities. Key features of such programs would include:

(1) Using a system-wide unit of assessment rather than focusing on single activities, including the full seafood-production process and other activities in a specified area, and their costs and benefits to both ecosystems and marine users;
(2) Overcoming common barriers to change by addressing not just ecological but also institutional, social, and economic objectives and constraints, and the suite of social–ecological outcomes associated with different management actions; and
(3) Adopting a continual improvement model rather than a static bar of sustainability to spur broader participation by small-scale and developing country fisheries.

Such programs would consider all fisheries and aquaculture activities within a system or region as well as their possible interactions with – and cumulative impacts on – ecosystems or marine users; management actions that promote ecological, social, and economic resilience; and the capacity of human communities to implement these actions and to equitably share costs and benefits.

Promoting system-wide fisheries and aquaculture sustainability

Our premise is that management of social–ecological systems, including fisheries and aquaculture, should strive to achieve both ecological and socioeconomic sustainability goals (eg Young and McCay 1995; Costanza and Folke 1997). Ecosystem health and human health are closely connected and interdependent (Fleming *et al.* 2006). Therefore assessing and promoting sustainability requires a focus on both ecosystems and people, and active participation and commitment by the latter. Stringent regulations may result in healthier ecosystems, but regulations are difficult to enforce and are unlikely to lead to sustainable outcomes if they entail high social and economic costs and lack legitimacy (defined as governance in which decisions are based on objective expertise, with clear and stable rules; include public dialogue; and are derived from an open and transparent process of decision making; Cosens 2013). Heavy reliance on enforcement may be ineffective due to negligible participation by users, high poverty levels, and limited economic alternatives that encourage people to engage in illegal activities including resource overexploitation (eg Brashares *et al.* 2004). More inclusive management strategies that incorporate community participation and create incentives for compliance (eg by allowing users to benefit directly from conservation and management efforts) can be more effective. Global assessments provide evidence of the benefits of increased participation and appropriate incentives (Costello *et al.* 2008; Gutiérrez *et al.* 2011; Cinner *et al.* 2012; Grimm *et al.* 2012) and of changes in stakeholder perceptions of fisheries management (Gelcich *et al.* 2009). For example, a highly successful program in the Kwazulu-Natal region of South Africa partnered the traditional mussel harvesters of the Sokhulu community with provincial wildlife managers to be jointly responsible for not only research and monitoring activities but also development and enforcement of regulations. This program has greatly increased regulatory compliance and improved sustainability of the mussel harvest, while simultaneously building capacity and skills in the local community in an area where the previous system of top-down management had failed to sustain the resource (Harris *et al.* 2003).

Table 1. Comparison of the primary seafood certification and sustainability assessment programs

Program	*Certification or recommendation list*	*Wild-caught or aquaculture*	*Stock status*	*Stock welfare*	*Seafood safety and quality*	*Ecosystem impacts*	*Energy considerations and pollution*	*Socioeconomic considerations*	*Management systems*	*Website*
Aquaculture Certification Council	Certification	A	X	X	X	X	X	X	X	www.aquaculturecertification.org
Blue Ocean Institute	Recommendation list	W,A	X		X	X	X		X	www.blueocean.org/programs/sustainable-seafood-program/seafood-choices
Environmental Defense Fund	Recommendation list	W,A	X		X	X	X		X	www.edf.org/page.cfm?tagID=13201
FishWise	Recommendation list[i]	W,A	X		X	X	X		X	www.fishwise.org/science/assessment-methods
Food & Water Watch	Recommendation list	W,A	X		X	X	X	X	X	www.foodandwaterwatch.org/fish/seafood
Friend of the Sea	Certification	W,A	X			X	X	X	X	www.friendofthesea.org
Greenpeace	Recommendation list	W,A	X			X	X	X	X	www.greenpeace.org/international/en/campaigns/oceans/seafood/red-list-of-species
Marine Conservation Society	Recommendation list	W,A	X	X		X	X		X	www.fishonline.org
Marine Stewardship Council	Certification	W	X			X			X	www.msc.org/about-us/standards/standards
Monterey Bay Aquarium Seafood Watch Program	Recommendation list	W,A	X			X	X		X	www.seafoodwatch.org
New England Aquarium	Recommendation list	W,A	X			X	X		X	www.neaq.org/conservation_and_research/projects/fisheries_bycatch_aquaculture/sustainable_fisheries/corporate_partners/methods_and_criteria_for_evaluation.php
Sea Choice - Canada	Recommendation list	W,A	X		X	X	X		X	www.seachoice.org/seafood-recommendations/seachoice-methodology
Sustainable Fisheries Partnership (FishSource)	Assessment of fisheries status[ii]	W	X			X			X	www.fishsource.org/faqs
World Wildlife Fund (WWF)	Recommendation list	W,A	X	X		X	X	X	X	www.panda.org/what_we_do/how_we_work/conservation/marine/sustainable_fishing/sustainable_seafood/seafood_guides

Notes: For each program we report the type of seafood extraction or production activities (wild-caught fisheries [W], aquaculture [A], or both) and the criteria used in assessments. [i]FishWise is a program for retailers wishing to market fish based on the sustainability of their farming or catch methods. [ii]FishSource is a resource about the status of fish stocks and fisheries targeted toward major seafood buyers.

A system-wide sustainability program may be perceived by users and managers as too complex and expensive, impairing progress by letting "the perfect be the enemy of the good" and setting the bar for sustainability out of reach. However, the goal is to create mechanisms and standards that will lead to progress toward more resilient and sustainable systems. Although the emphasis is both on the current ecological and socioeconomic condition of systems and on the steady improvement toward sustainability goals, many years may be required to achieve the anticipated positive outcomes. Reasons for this are twofold. First, it is unlikely that many systems have achieved sustainable management of all their seafood production activities. Thus, criteria based on fixed thresholds for performance indicators that are reasonable for single fisheries (selected for certification because they are well managed) would greatly limit the range of candidate systems when multiple activities are considered.

Second, applying fixed thresholds for performance indicators across all activities may bias selection against systems that currently have insufficient resources or information to implement sustainable management but have institutions and conditions that may enable improvements, such as well-defined access rights. Examples include fishing cooperatives that hold concessions for target species and TURFs – territorial use rights fisheries (Gelcich *et al.* 2010; McCay *et al.* 2013). Thus it is vital to recognize the potential for improvement to engage more fishery and aquaculture systems in the quest for sustainability.

An emphasis on improving the seafood production process does not imply that the social–ecological system's current status is irrelevant; without evidence of acceptable and possibly improving ecological and social conditions, development of better processes would clearly not achieve the ultimate goal of creating more sustainable seafood production for ecosystems and people. Consequently, a fishery in which resource management efforts have improved while the system continues to deteriorate – for instance due to overharvesting and/or habitat degradation – should not be awarded certification. It is therefore essential to provide objective criteria and measurable indicators of the status and performance of fisheries and aquaculture throughout the whole system.

Assessing system-wide performance of fisheries and aquaculture

Criteria and indicators

Criteria used by current programs (Table 1) incorporate guidelines developed by the UN Food and Agriculture Organization (FAO), both for capture fisheries (FAO 2005) and aquaculture (FAO 2008). All programs assess the status of the targeted stocks, ecosystem impacts (eg bycatch, habitat damage), and the existence of effective management regulating the target fishery or aquaculture (Table 1). Yet these programs do not consider the cumulative impacts of multiple activities occurring in an area; only a few assessments include socioeconomic indicators, while none evaluate institutions that might promote sustainability (Table 1).

To identify possible criteria and indicators for system-wide assessments, we compiled indicators from 13 sources, including major certification programs, regional seafood sustainability initiatives, and socioeconomic sustainability programs (eg OXFAM and Fairtrade; WebPanel 1). We propose a set of indicators assessing (1) ecosystem condition and the effects of fisheries and aquaculture on ecosystem structure and function; (2) social context and outcomes, including investment in social and human capital; and (3) governance capacity and management mechanisms for maintaining ecological and socioeconomic resilience (eg access rights and other institutional arrangements for stakeholder involvement and stewardship; Table 2). Representing a synthesis of indicators already in use by existing programs, these indicators, for the first time, are combined into a single program that evaluates ecological, social, economic, and governance attributes, as well as overall system performance.

Ecological and social indicators assess the current performance of the system and highlight areas where improvement is most urgently needed (eg rebuilding overfished stocks, addressing bycatch issues, improving working conditions) to achieve specified objectives (eg eliminating overfishing, maintaining intact food webs, providing fair wages and safer working conditions). Likewise, governance indicators assess the capacity to devise and implement actions to address these issues. In particular, metrics of effective leadership (Gutiérrez *et al.* 2011) and the presence of viable institutions for local-level and system-wide management can be used to evaluate a system's potential for improvement. A key goal of a system-wide program should be to identify such features and expand their scope to include a wider range of target species and activities.

Pre-assessment

Even seafood production systems that are extremely data-poor or face tremendous conservation challenges can participate in such programs, provided that there is the capacity for improvement. As a first step, the scale and scope of the system should be defined and the "client" (the stakeholders engaged in seafood production) identified. The next step is to pre-assess the system, using expert knowledge, to identify major issues (eg the absence of institutions with sufficient authority to implement regulations and monitor change) and to evaluate the potential for improvement. If the pre-assessment indicates that there is local capacity for improvement, then conducting a system-wide assessment of the current conditions and performance would follow.

Performance indicators and goals

Assessments entail scoring the performance indicators' information available in the peer-reviewed and gray literature as well as through interviews with resource managers and relevant stakeholders. Some indicators refer to pre-conditions for improvement and thus set the minimum acceptable standards that system-wide assessments would guarantee to businesses, governments, and consumers (eg free labor; Table 2). Clearly, systems where forced or child labor exist will require major social and political changes before other issues can be addressed. In contrast, some of the socioeconomic and all of the ecological indicators signal current performance of the system and reveal aspects that require improvement to achieve desired outcomes (eg fair wages; occupational health and safety; functioning, resilient ecosystems; Table 2).

Analyses of the effectiveness of certification programs suggest that a three-tiered risk-based assessment approach (eg high, medium, or low risk) may be most effective for incentivizing change, and such an approach could also be designed to be more inclusive of systems that have serious

Table 2. Criteria and indicators for system-wide assessments

Governance	*Socioeconomic*	*Ecological*
1. Leadership - Existence of a decision-making and management body	**11. Equity** - No discriminatory practices	**21. Water quality** - Water-quality parameters are within acceptable bounds
2. Legislation - Existence of effective legal and/or customary framework	**12. Free labor** - No forced labor	**22. Native biodiversity** - Strategies in place to minimize impacts of fisheries/farms on natural diversity
3. Enforcement of regulation - Existence/effectiveness of a regulation and sanction system	**13. Compliance with child labor laws** - No child labor	**23. Habitat integrity** - Strategies in place to minimize impacts of fisheries/farms on habitat structure and function
4. Governance structure and function - Governance has a nested structure, partial autonomy of different levels of authority	**14. Socioeconomic development** - High investment in community infrastructure and human capital	**24. Food-web integrity** - Strategies in place to minimize impacts of fisheries/farms on food-web structure and dynamics
5. Incentives - Existence/effectiveness of incentives for following the rules and promoting sustainable use	**15. Education** - High investment in younger generation, eg presence of adequate schooling	**25. Resilience** - Resilience is maintained by conserving key species, functional groups, and functional redundancy
6. Management plan - Long-term management plans in place	**16. Fair wages and benefits** - Meet or exceed minimum wage and benefit requirements	**26. Stock abundance** - Target stocks are at a level that maintains high productivity and has a low probability of recruitment overfishing
7. Harvest control - Well-defined and effective harvest control rules are in place	**17. Occupational health and safety** - Written risk assessment, policies, and procedures for safe and healthy working conditions	**27. Interaction with endangered species** - Fishery does not pose a risk of serious or irreversible harm to endangered, threatened, or protected species and does not hinder their recovery
8. User involvement mechanisms - High level of stakeholder involvement, information dissemination to the community, mechanisms in place for conflict resolution	**18. Fair conditions of employment** - Employers are up to date on labor regulations and comply with legal regulations and collective bargaining agreements	**28. Connectivity** - Connectivity maintained by avoiding extreme habitat and population reduction and fragmentation
9. Defined boundaries and access rights - Long-term tenure, use rights, and boundaries are clearly defined, documented, and legally established	**19. Traceability** - Products traceable from harvest to sale	**29. Bycatch** - Fishery does not pose a risk of serious or irreversible harm to bycatch species and does not hinder the recovery of depleted bycatch species
10. Presence of MPAs - Representative samples of existing ecosystems are protected	**20. Diversification** - Diversification of fisheries and non-extractive activities (communities do not engage in and depend on a single activity)	**30. Chemicals/drugs/pesticides** - Acceptable drug and chemical management, microbial sanitation, minimized and safe use of agrochemicals

Notes: Criteria were identified based on review and synthesis of 13 sources, including major certification programs, regional seafood sustainability initiatives, socioeconomic sustainability programs and frameworks, and Australia's Ecological Risk Assessment for the Effects of Fishing (see WebPanel 1).

conservation concerns yet have the capacity for improvement (Bush *et al.* 2012; Tlusty 2012). Risk-based frameworks that rely on literature reviews and expert judgment to identify ecosystem vulnerability to stressors (Productivity–Susceptibility Analysis; Hobday *et al.* 2007, 2011), human impacts on marine habitats (Halpern *et al.* 2007), and other data-poor fishery assessment tools (Honey *et al.* 2010) have been developed and applied to evaluate fisheries.

While thresholds for the performance indicators (Table 2) could be set to indicate minimal, moderate, and high levels of performance, regular audits could also provide information on how performance is changing over time. This information would allow wholesalers, retailers, and consumers to choose products from the assessed system, depending on the current level of sustainability, the trajectory of improvement, or both. Some businesses, for instance, may prefer to limit risk by sourcing products only from systems that currently meet a moderate or high level of sustainability, whereas others may prefer to support systems that are improving rapidly.

Promoting progress toward sustainability goals: the cycle of continual improvement

We envision the proposed process – once initiated – as a series of successive, iterative steps, similar to those of the two most widespread certified environmental management schemes (EMS): the European Union's Eco-Management and Audit Scheme (EU EMAS) and ISO 14001 (WebPanel 2). Our proposed cycle of continual improvement (Figure 2) is modeled on the Deming cycle, which consists of a logical sequence of repetitive steps. Applied to seafood production, this means that organizations managing production would continually *assess* conditions and issues, develop management *plans*, implement *actions* established through those plans, *evaluate* outcomes, and update and possibly *redirect* plans founded upon learning during the initial phase (Figure 2).

Much like the EU EMAS and ISO 14001 schemes, the cycle is designed to target both the seafood production process and outcomes (eg the ecosystem state, social conditions, aspects of governance). Analyzing and improving

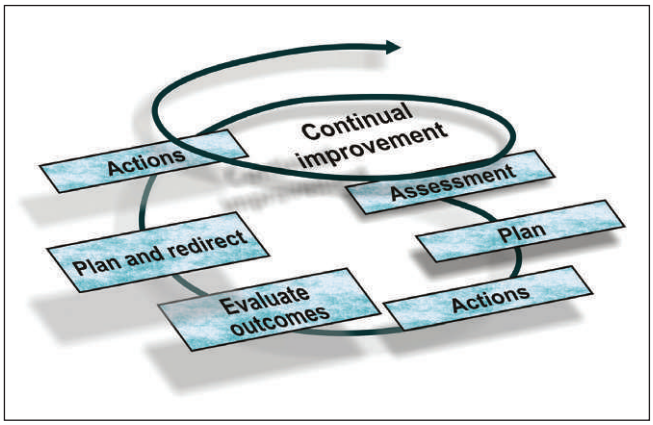

Figure 2. *The cycle of continual improvement starts with an initial system-wide assessment that provides information for the development of management plans, followed in subsequent steps by the implementation of actions, the evaluation of outcomes, and the updating and, if necessary, redirecting of plans as additional information becomes available.*

the seafood production process is critical to achieving sustainability outcomes, but focusing on process alone does not guarantee successful outcomes. While improvements in the process are attempted through the steps listed above, progress toward desirable outcomes – ultimately, achieving healthier ecosystems and human communities – is assessed, over a specified timeline, from changes in the ecological, socioeconomic, and governance performance indicators (Table 2).

Promoting system-wide sustainability in practice: a case study

Here, we illustrate why a system-wide approach is needed and how it might be implemented, using an example from the Pacific coast of Mexico. The California spiny lobster (*Panulirus interruptus*) fishery of the Vizcaino region of Baja California (Figure 3) was the first small-scale fishery to be certified by the MSC (Pérez-Ramirez *et al.* 2012). Fishers are organized in cooperatives that hold 20-year concessions granting exclusive exploitation rights for lobster, abalone (*Haliotis* spp), and other target marine invertebrates (McCay *et al.* 2013). Lobster management includes strictly enforced size limits, seasonal closures, and controlling fishing effort, as well as continued surveillance to minimize illegal fishing (Phillips *et al.* 2008).

Total lobster catches were stable from the 1970s through the 1990s, and have increased in the past decade. MSC and other independent assessments did not find serious ecological impacts of these fisheries on nontarget species and habitats (SCS 2004; Shester and Micheli 2011). Thus, the Mexican lobster fishery is an ecological and economic success. However, finfish fishers in the same areas generally rely on gillnets that generate large amounts of bycatch and considerable impacts on habitat (Shester and Micheli 2011). Although providing a critical source of local income (Shester and Micheli 2011), these finfish fisheries lack a management plan and are at risk of resource overexploitation with consequent detrimental impacts on both the ecosystem and fishers' future livelihoods. In addition, a sustained decline in valuable abalone stocks, attributed to a combination of overfishing and climate-change impacts, poses a major threat to the economy of local communities. This example illustrates how current certification programs fail to identify issues affecting the broader ecosystem and its stakeholders, and neglect to create incentives for addressing these issues.

To achieve more sustainable seafood production, we recommend that long-term ecological targets should include demonstrated recovery of both abalone stocks and the broader ecosystem, socioeconomic targets should include improved employment opportunities within coastal communities, and governance targets should include expanding access privileges (ie cooperative exploitation rights to fish) to encompass the coastal ecosystem instead of a few species (Table 2). In our proposed program, outcomes would be periodically evaluated and actions may be redirected. Progress toward these targets would be assessed by local and regional organizations, as is currently being performed by the Vizcaino cooperatives in partnership with the Mexican nongovernmental organization (NGO) Comunidad y Biodiversidad (http://cobi.org.mx/en/programas/regions/baja-california-peninsula).

Situations where certified or recommended fisheries overlap with fisheries that have high ecological impacts, inadequate management, or low performance because of external pressures (eg from pollution or climate change) are not unique to Vizcaino fisheries (eg the recently certified American lobster fishery of the US state of Maine [Steneck 1997; Steneck and Wilson 2010]; the Gulf of California sardine fishery [Sala *et al.* 2004; Sáenz-Arroyo *et al.* 2005]; and the northern shrimp fisheries of Atlantic Canada [Foley 2013]). In fact, the co-occurrence of multiple seafood production activities with variable impacts is likely the rule rather than the exception.

Challenges

System delineation and governance

In principle, system-wide assessments could be performed at local (eg a fishing community) to regional (eg a state) scales. As the geographic scope increases, however, so does the complexity of assessments and ensuing actions. Criteria for system delineation may include the geographic scope of the organization or producer responsible for managing seafood production. For instance, access privileges to particular marine regions or resources would be one reasonable criterion for delimiting the system, as in the case of the aforementioned Vizcaino example, the Management

Figure 3. *(a) Lobster and (b) finfish fishing in the Vizcaino region of Baja California, Mexico.*

and Exploitation Areas of Chile, and the coastal shellfish of Uruguay (Castilla and Defeo 2001; Castilla and Gelcich 2008; Gelcich *et al.* 2010). Where institutions are not sufficiently comprehensive and organized, lack jurisdiction over resources and ecosystems, or possess jurisdiction that is too localized or limited to specific resources, actions first must be directed toward building such capacity and tenure (eg Basurto 2005, 2008). Access privileges that extend to entire ecosystems are required to create stewardship incentives that extend to all the fisheries and aquaculture activities in a given area (Fujita *et al.* 2013). In some cases, it might be possible to form ad-hoc institutions (eg cooperatives or coalitions among governmental agencies, resource users, and other interested parties). Formalization and legal recognition of such institutions is important for durability of the program and effective stewardship.

Threats such as climate change and pollution may originate from beyond the boundaries of the focal system and if appraised as important, their potential effects and associated remediation must be taken into consideration. For example, local programs or organizations may take steps to address regional climatic impacts by reducing cumulative impacts from locally occurring stressors through the establishment of marine protected areas or by diversifying their activities (eg Micheli *et al.* 2012). It will be difficult, however, to apply system-wide assessments to pelagic fisheries because the ecosystem boundaries and associated human community may be too challenging to demarcate (Costa *et al.* 2012). Thus, system-wide assessments must at present be restricted to coastal fisheries and aquaculture with identifiable boundaries.

Costs

In existing seafood certification programs, the seafood producers absorb all or most of the costs. Nevertheless, innovative financing mechanisms and "hybrid" financing models that include contributions from foundations, governments, banks, and private investors are needed to ensure the long-term sustainability and financial viability of improvement projects (Jain and Garderet 2011). Such financial strategies are necessary to encourage the broader participation of small-scale and developing-world seafood producers who could otherwise not afford the cost of participation. Another possible financing mechanism is to establish direct payments or performance payments to offset the costs incurred by local communities to conserve and restore their environment (Ferraro and Kiss 2002; Fujita *et al.* 2013). Contracts established with governments or NGOs compensate users of marine resources for the costs of their conservation efforts. Additionally, some organizations (eg Sustainable Fisheries Partnership, WWF) have successfully engaged seafood retailers in supporting improvement projects for individual fisheries in a fashion similar to retailers' investment in the sustainability of their supply chain in terrestrial environments (eg Carrefour, the world's second largest retailer in terms of revenue, after Walmart). Given the right market conditions, exclusive contracts could possibly be established between seafood retailers or other actors and seafood producers to absorb the costs of system-wide programs. For instance, Fish2.0 (www.fish20.org) is a recently launched business competition that aims to help promote companies that are operating profitably and creating positive social or environmental impacts. Their approach is to create connections between fishing and aquaculture businesses and investors interested in adding sustainable seafood businesses to their investment portfolios. Private foundations, NGOs, academic institutions, and government agencies would likely continue to be major contributors of financial and technical support, especially in the early stages of business development.

■ Anticipated benefits of system-wide sustainability programs

A major goal of our proposed program is to increase the resilience of ecosystems and human systems in the face of environmental, political, and economic shocks, thus reduc-

ing the risk associated with a variable and unstable seafood supply. Producers and businesses could benefit through increased stability of income, more reliable seafood resources (and in some cases higher-quality products and lower production costs), and a more sustainable use and allocation of human, economic, and natural resources.

Also, by influencing commercial transactions between seafood producers and retailers, system-wide programs could inform and guide the purchasing strategies of retailers committed to "greening" their businesses and provide incentives for businesses to purchase their seafood products from regions that (1) meet the minimum standards set through system-wide assessments and (2) have committed to specific actions aimed at improving their ecological and socioeconomic performance.

Furthermore, system-wide programs could result in benefits and incentives granted by regional governments through extended licensing periods, tax cuts, or other financial incentives (eg health care support, retirement programs). There is some evidence to suggest that certification attracts additional government investment (eg Pérez-Ramirez *et al.* 2012).

Finally, system-wide programs could direct investments of NGOs and philanthropic organizations toward regions or communities in need. Thus, benefits to producers could also come from increased visibility and support for improvement projects by NGOs and foundations.

Conclusions

Multiple tools for promoting a more sustainable future for marine ecosystems and the human societies that depend on them are urgently needed. Contemporary programs and approaches have met with some success, but the dire state of coastal marine ecosystems, world fisheries, and fishing-dependent communities demands novel approaches. Our proposed system-wide program would provide new mechanisms for promoting sustainable seafood production. By building on existing methodologies and standards, system-wide programs fill a current gap in the sustainable seafood movement by fostering recognition and support for a broader suite of small-scale and developing-world seafood production systems. These programs will provide a means for small-scale and developing-world fisheries and aquaculture to engage in improvement projects, access new markets, and create new cross-sectoral partnerships with commercial, governmental, environmental, and philanthropic organizations.

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