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Essay

Incentivizing biodiversity conservation in artisanal fishing communities through territorial user rights and business model innovation

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Abstract: *Territorial user rights for fisheries are being promoted to enhance the sustainability of small-scale fisheries. Using Chile as a case study, we designed a market-based program aimed at improving fishers' livelihoods while incentivizing the establishment and enforcement of no-take areas within areas managed with territorial user right regimes. Building on explicit enabling conditions (i.e., high levels of governance, participation, and empowerment), we used a place-based, human-centered approach to design a program that will have the necessary support and buy-in from local fishers to result in landscape-scale biodiversity benefits. Transactional infrastructure must be complex enough to capture the biodiversity benefits being created, but simple enough so that the program can be scaled up and is attractive to potential financiers. Biodiversity benefits created must be commoditized, and desired behavioral changes must be verified within a transactional context. Demand must be generated for fisher-created biodiversity benefits in order to attract financing and to scale the market model. Important design decisions around these 3 components—supply, transactional infrastructure, and demand—must be made based on local social-ecological conditions. Our market model, which is being piloted in Chile, is a flexible foundation on which to base scalable opportunities to operationalize a scheme that incentivizes local, verifiable biodiversity benefits via conservation behaviors by fishers that could likely result in significant marine conservation gains and novel cross-sector alliances.*

Keywords: Chile, human-centered design, marine conservation, marine protected areas, market solutions, offsets, small-scale fishers

Incentivar la Conservación de la Biodiversidad con Comunidades de Pesca Artesanal por medio de Derechos de Uso Territorial y la Innovación de Modelos de Negocio

Resumen: *Los derechos de uso territorial en las pesquerías están siendo promovidos para mejorar la sustentabilidad de las pesquerías a pequeña escala. Utilizando a Chile como estudio de caso, diseñamos un programa con base en el mercado para mejorar el sustento de los pescadores a la vez que se incentiva el establecimiento y la aplicación de áreas de reserva sin pesca dentro de áreas manejadas por regímenes de derechos de uso territorial. Usamos una estrategia de diseño antropocéntrico basada en condiciones explícitas del lugar (es decir, altos niveles de gobernanza, participación y empoderamiento) para diseñar un programa que tenga el apoyo y la aceptación necesarios por parte de los pescadores locales y que resulte en beneficios para la biodiversidad a escala de paisaje. La infraestructura transaccional debe ser lo suficientemente compleja para capturar estos beneficios durante su creación, pero lo suficientemente simple para que el programa pueda subir de escala y sea atractivo para los financiadores potenciales. Los beneficios creados deben ser un bien transable, y los cambios conductuales deseados deben verificarse dentro de un contexto transaccional. La demanda debe generarse para los beneficios de biodiversidad creados para*

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así poder atraer financiamiento y mantener a escala el modelo de mercado. Se deben tomar decisiones importantes de diseño alrededor de tres componentes – suministro, infraestructura transaccional y demanda- con base en las condiciones socio-ecológicas locales. Nuestro modelo de mercado, que está en etapa de prueba piloto en Chile, es un cimiento flexible sobre el cual se pueden basar oportunidades expandibles para volver operacional un esquema que incentiva los beneficios locales y verificables para la biodiversidad por medio de comportamientos de conservación de los pescadores. El modelo podría resultar en ganancias significativas de conservación marina y alianzas novedosas a través de differentes sectores.

Palabras Clave: áreas marinas protegidas, Chile, compensaciones, conservación marina, diseño antropocéntrico, pesquerias de pequeña escala, soluciones de mercado

Introduction

As concerns about anthropogenically driven declines of marine resources and biodiversity continue to increase, territorial user rights for fisheries (TURFs) are becoming a policy prescription that is being promoted to enhance the sustainability of small-scale fisheries. The potential use of TURFs as a tool to also conserve marine biodiversity is increasingly garnering attention (Costello & Kaffine 2009; Gaines et al. 2010; Gelcich et al. 2012). In 1991 Chile established a national TURF policy which gave the government the authority to assign exclusive access rights to artisanal fisher organizations for the sustainable harvesting of benthic resources (Castilla et al. 1998). As of 2010, there were over 700 TURFs ($>$1100 km^2) decreed to fisher organizations throughout coastal Chile (Gelcich et al. 2012). This large TURF network places Chile at the forefront of establishing a rights-based approach to marine resource management.

Chile's TURF network presents an opportunity to design conservation programs focused on incentivizing biodiversity outcomes from small-scale fisheries. TURFs hold the potential to provide the necessary conditions for business model innovations that can improve fishers' livelihoods while incentivizing environmental stewardship. Market-based approaches to conservation are gaining popularity in both developing and developed countries (Wunder et al. 2008; Milne & Niestan 2009; Fujita et al. 2013). Such approaches are attractive because of their low transaction costs, outcome-based focus, and potential to combine livelihood improvement with biodiversity conservation. Further, most potential stakeholders for the provision of biodiversity and ecosystem services already operate in, and often prefer, markets: the buying and selling of products or services (Donlan 2015). We present a market model aimed at improving livelihoods and incentivizing the establishment and enforcement of no-take areas within TURFs. We are applying the framework to our on-going work in Chile with artisanal fishers. Our framework focuses on co-designing a program with artisanal fishers that compensates them for the opportunity costs forgone by setting aside a portion of their TURF as a no-take zone (Fig. 1). We devised a scalable program that provides a supplementary revenue stream to fishers in exchange for management actions that produce enforced and verified biodiversity benefits and promote sustainable fisheries. While the market model may appear straightforward, we highlight important design choices necessary for implementation and scale. Our framework has 3 broad components: enabling conditions, program design, and financing (Fig. 2). Although we used Chile as a working example, our market model provides an overriding framework that can aid those seeking to leverage market-based approaches to incentivize biodiversity conservation outcomes within small-scale fisheries that have established rights-based management schemes.

Social Enabling Conditions

The increasing need for improved marine management has resulted in a global trend toward the allocation of rights and privileges, commonly referred to as rights-based management (Costello & Kaffine 2009). TURFs are place based and allocate some or all resources within a designated coastal zone to a collective agent (Castilla et al. 1998). They generally assign spatial user rights to groups of fishers for the sustainable management of a species or group of species. The rationale for establishing user rights is based on common property theory, which assumes that securing access and sharing control over resources can create incentives for sustainable institutional arrangements among fishers, who will then be incentivized to manage and harvest collectively and sustainably (Ostrom & Schlager 1996). TURFs are also expected to contribute to sustainability by increasing fishers' likelihood of compliance (Gelcich et al. 2013).

Despites the advantageous conditions of TURFs, simply specifying spatial access rights will not necessarily provide the conditions for innovations that promote improved livelihoods and biodiversity benefits. Rather, a number of other key features that build upon a TURF designation are necessary. First, TURFs must facilitate the creation of necessary institutional arrangements that enable a strong governance setting (Cinner et al. 2012). Second, the level of coordination among TURF members influences fisheries performance and the

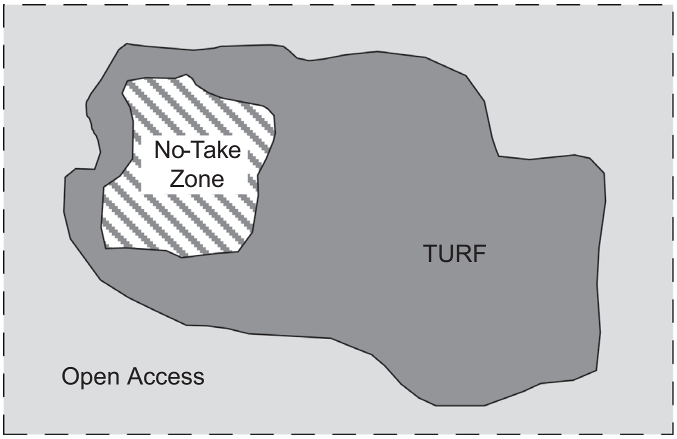

Figure 1. Conceptualization of a fishing cooperative agreement to set aside part of its territorial user rights for fisheries (TURF) as a no-take zone. Baseline conditions are established and biodiversity is monitored at 3 sites: the no take-zone, inside the TURF where harvesting is occurring by the cooperative, and outside the TURF in the open access area. The cooperative agrees to conduct anti-poaching surveillance for the TURF and newly created no-take area.

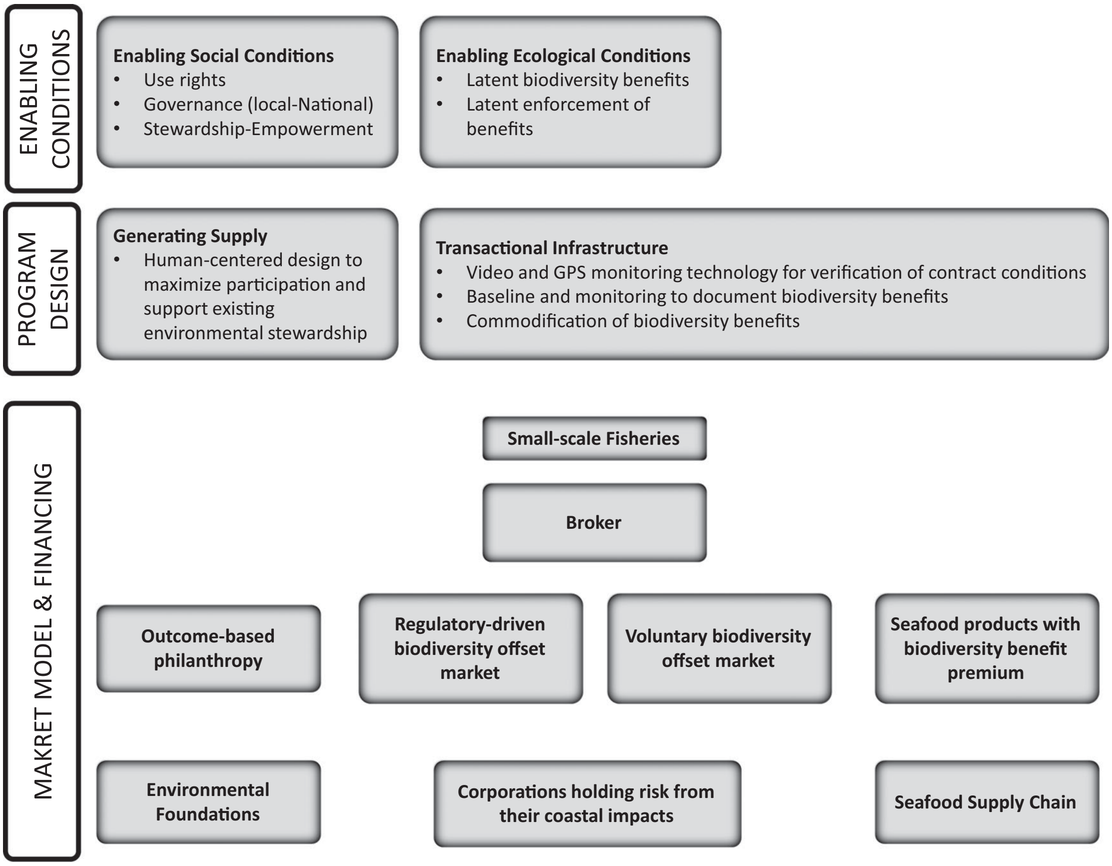

Figure 2. Conceptual model for establishing a biodiversity payment scheme associated with territorial user rights for fisheries (TURFs).

acceptance of new models, such as integrating no-take zones into TURF management frameworks (Costello & Kaffine 2009). Third, active participation and empowerment within small-scale fishers are also enabling conditions (San Martin et al. 2009). In sum, TURFs provide a foundation on which governance, coordination, participation, and empowerment can create the necessary conditions to design, test, and mainstream new business models that include explicit incentives for environmental stewardship. We refer to these conditions collectively as enabling conditions. Some TURFs have high levels of governance, participation, and empowerment; others do not (Gelcich et al. 2009).

In Chile these enabling conditions are present at some sites within the established national TURF framework (Gelcich et al. 2009). In well designed and implemented TURFs, increased coordination between TURF members and other institutions are generating vertical social capital. These vertical linkages have been associated to more sustainable management outcomes (Marin et al. 2012). Chilean fishers have been empowered through the process of engaging and developing TURFs (Gelcich et al. 2009). In many TURFs, the capacity for sustainable benthic resource management is already in place. That capacity is apparent in the documented positive shift in fishers' environmental attitudes after their participation in a TURF program (Gelcich et al. 2008).

Ecological Enabling Conditions

The Convention on Biological Diversity set ambitious conservation targets which were most recently highlighted as the Aichi Targets, which include the protection of at least 10% of all marine ecological regions (CBD 2013). Such targets seem overly ambitious for many nations, including Chile, especially given that many marine protected areas (MPAs) lack sufficient management and enforcement. Less than 1% of Chile's coast is formally protected, and there is resistance from fisher communities to the implementation of government-sanctioned no-take MPAs (Gelcich et al. 2009). Thus, at least in Chile, there is a pressing need to develop new conservation instruments to achieve biodiversity benefits that have the support of local communities in order to have a chance at meeting the Aichi Targets.

If biodiversity benefits are an explicit objective of any market model, then latent biodiversity outcomes must exist that can be realized through behavioral changes. Well-managed and enforced TURFs, alone, can provide biodiversity benefits for target and non-target species (Gelcich et al. 2012). Those benefits can be protected against external pressures. In well-managed TURFs, members regularly conduct surveillance and enforcement activities to prevent poaching. Thus, the potential biodiversity and fisheries benefits of integrating enforced, no-take areas within TURFs are likely to be substantial. Enforced MPAs often achieve conservation goals, and, in some cases, may also increase the resilience of surrounding fisheries and enhance local catches (Lester et al. 2009). Numerical modeling suggests that networks of MPAs and TURFs under the right conditions could result in both biodiversity and economic benefits (Costello & Kaffine 2009). Thus, latent biodiversity benefits are likely in many TURF systems, which can be realized through programs that incentivize behavioral changes by participating fishers.

In central Chile TURFs support higher levels of biodiversity than open-access areas (higher species richness, biomass, and density of reef fish and macroinvertebrates) (Gelcich et al. 2012). The levels of biodiversity that TURFs support is directly related to the level of enforcement—antipoaching activities by fishers (Gelcich et al 2012). Yet, even within well-enforced TURFs, latent biodiversity benefits are present that could be realized by the establishment of no-take zones inside TURFs. A 20-ha enforced no-take MPA in Chile supports higher densities (approximately 40%), biomass (approximately 50%), and species richness (approximately 15%) of reef fishes and macroinvertebrates than well-managed TURFs (Gelcich et al. 2012).

In Chile, TURFs facilitate conditions for the development of enforcement capacity and social norm internalization. It is common in Chile for fishers to design and implement surveillance programs and rules for resources management, both of which are sustained by active stakeholder participation. The resulting benefits are both perceived and valued by TURF members (Gelcich et al. 2009). Game theory experiments reveal that fishers associated with well-managed TURFs are better able to internalize common pool resource sustainable management norms than fishers associated with poorly managed TURFs (Gelcich et al. 2013).

Generating Supply through Human-Centered Program Design

We believe that a human-centered approach to program design that strives to understand place-based perceptions and needs of target stakeholders is critical to a successful program (Brown 2008; Donlan 2015). Achieving levels of program participation in voluntary market models that deliver biodiversity benefits requires careful attention not only to how the program structure influences potential biodiversity outcomes, but also to how it influences fishers and their willingness to participate. Program structure and delivery are important, but often overlooked, elements that can heavily influence participation (Sorice et al. 2013). A participatory human-centered design approach provides a proven method for designers to understand stakeholders' needs and requirements during all phases of program design—from initial stages, to testing prototypes, to implementation (Liedtka 2011; Ogilvie & Liedtka 2011).

In Chile we took a human-centered approach with small-scale fishers to co-design a program that aligns with fishers' needs and delivers biodiversity outcomes. For example, we used stated-preference choice experiments and focus groups to understand fishers' preferences for different program components, such as contract length, perceived benefits, and enforcement requirements. By placing fishers' needs, desires, and constraints at the forefront, we were able to design a program that has the support and participation needed to deliver landscape-level biodiversity benefits (e.g., 87% of fishers we surveyed in central Chile stated they would participate in the program we co-created with them [authors' unpublished data]).

Transactional Infrastructure Design

Transactional infrastructure refers to the mechanisms and stakeholder roles that allow a market-based program to function. For our model, key components included a science-based method to quantify biodiversity benefits and translate them into a currency that can be bought and sold; a system for third-party verification of desired behavioral changes that are dictated in a contract with fishers; and a broker to administer the program, streamline supply, and liaise between suppliers and buyers (Donlan et al. 2013).

We used well-tested monitoring methods to establish baselines and document subsequent changes in biodiversity (i.e., annual subtidal transect monitoring and multivariate analysis of benthic invertebrates and reef fish [Gelcich et al. 2012]). We established biodiversity baselines in established no-take zones within TURFs and in 2 nearby control sites: one within the TURF where the no-take zone is located and harvesting is present and one adjacent in an open access area (Fig. 1). We also used the well-enforced formal no-take MPA at Estación Costera de Investigaciones Marinas as a regional reference site (Navarrete et al. 2010). While desirable, a well-enforced MPA as a reference site is not a requirement for a crediting scheme; rather, the biodiversity monitoring system can rely upon repeated monitoring of open access and TURF control sites to document relative changes in biodiversity within the established no-take zone.

Commoditizing biodiversity benefits into a currency must be done in a way that is complex enough to capture the biodiversity created yet simple enough to allow for scalable transactions and to be tractable to potential buyers (Donlan 2015). Many market-based environmental programs are not outcome based (e.g., credits are sold before biodiversity benefits are realized and verified) (Bekessy et al. 2010). In contrast, our market model allows for the sale of credits only after the biodiversity benefits are created and verified. Credits are area based (i.e., 1 credit = 1 ha) and are conservatively estimated using dynamic thresholds established from baselines and on-going monitoring (Fig. 3). A dynamic threshold approach offers several advantages. First, it allows for variation in biodiversity responses due to environmental conditions beyond the control of fishers. Second, it simplifies transactions both on the supply and demand side of the market, while still allowing for a performance-based framework (e.g., every certified credit is treated equally). Last, the dynamic threshold can be set so that the currency is conservative: credits and thresholds can be structured so that there is a very high probability that a credit sold is delivering the claimed biodiversity benefits.

Independent of defined user rights, explicit incentives will often be needed to promote fishing behaviors that produce biodiversity benefits. This is especially the case if fishers are present biased (i.e., high discount rate), regardless of any potential future benefit (e.g., increased recruitment from an established no-take zone) (Johnson & Saunders 2014). Such incentives are delivered by some value transfer mechanism, which can take a variety of

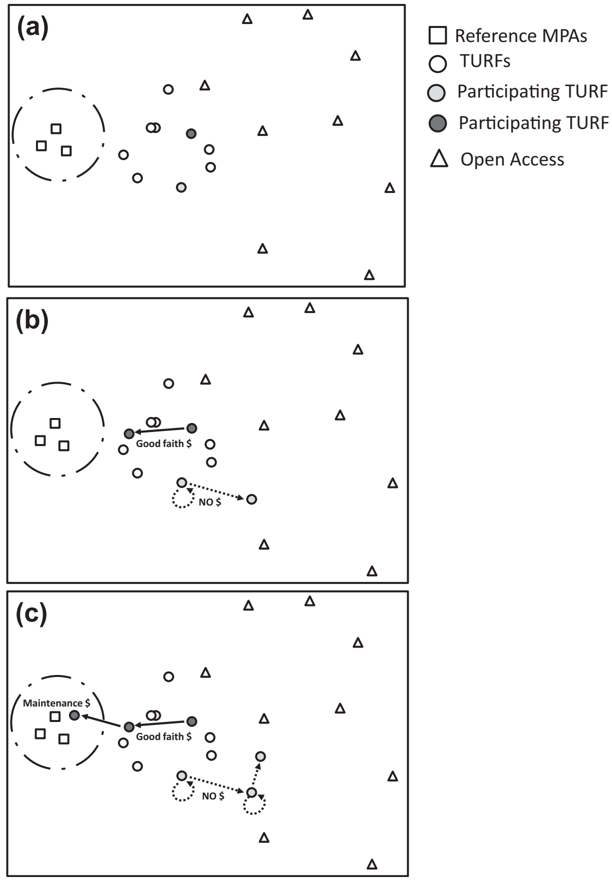

Figure 3. Multidimensional scaling plot that represents subtidal community assemblages associated with no-take marine protected areas (MPAs), territorial user rights for fisheries (TURFs), and de facto open access areas under (a) current conditions and under 2 hypothetical periods after implementation of a crediting scheme: (b) after the first monitoring period and (c) after a series of monitoring periods. The current condition is for 38 reef fish and invertebrate species associated with 100-m transects reported in Gelcich et al. (2012). On all graphs, the dotted circle is the multivariate space used to define credits and black and gray dots are 2 TURFs in the crediting program. In (a) and (b) black dots show the TURF that comes close to the community structure of reference MPAs (solid line) and receives a good faith payment and gray dots show the TURF with no improvement in its trajectory (dotted line) that receives no payment (NO $). In (c) black dots show the TURF that becomes part of the multivariate space for receiving credits associated with an MPA and gray dots show the TURF that remains associated with the community structure of TURFs and does not improve, in which case they receive no payment.

forms, such as cash payments, productive assets, services, or access to credit (ACS and SEA 2013). Because Chilean artisanal fishers actively participate in mature markets, the value transfer mechanism in our model takes the form of annual monetary payments. To account for present bias, we devised 2 types of payments: good faith payments and biodiversity maintenance payments (Fig. 3). Lasting a maximum of 5 years, good faith payments are annual payments for an established no-take zone that remains on a trajectory toward reaching the established biodiversity threshold. Payments are based on the similarity in community assemblages between the established no-take zone and control and reference sites (Fig. 3). Once the threshold is reached, TURF members receive an annual payment for maintaining the no-take zone within the threshold through the continuation of excluding harvesting and conducting antipoaching surveillance.

While biodiversity benefits are created, quantified, and commoditized, the program's centerpiece is a contractual relationship with participating fishing cooperatives that dictate explicit behaviors: exclusion of harvesting activity by TURF members and regular anti-poaching surveillance to prevent harvesting from non-members. These conditions must be defined and verified, and a process must be developed to address underperformance. We are working with the technology company Shellcatch to develop cost-effective means of verifying contracts with participating fishing cooperatives. Land-based video monitoring documents day and night intrusions into the established no-take zone either by TURF members or outside poachers (Fig. 4). Video monitoring data are made available to the participating fishing cooperatives. This component highlights the value of a human-centered approach to program design. Fishing cooperatives in Chile are interested in improving their ability to conduct surveillance of fishing grounds irrespective of our program. Thus, the co-designed surveillance system aligns the interest of fishing cooperatives (i.e., reducing poaching events) and the program (i.e., verifying behavioral changes that produce biodiversity benefits).

Brokers can be important to achieving transactions at scale, particularly in new or emerging markets (Donlan et al. 2015). A broker's role is critical in consolidating and streamlining the supply side of the market, thereby reducing transaction costs and helping the market scale. The broker recruits and negotiates agreements with fishing cooperatives, lowers the risk of market entry for fishers, and absorbs some of the financial risk associated with generating and selling credits. These actions are important early on in the program. The broker will buy, and hold temporarily if necessary, credits produced by fishers irrespective of demand (Donlan et al. 2013). A broker will also validate plans to generate credits and provide accreditation to third parties that conduct monitoring and verification of credits. On the demand side, the broker's role is as important. The broker provides critical market access by developing relationships with potential buyers and ensures alignment between the benefits the suppliers are creating and the buyers' needs. In Chile we created a nonprofit organization (Capital Azul) to serve as a broker, and it is now developing potential demand opportunities (Fig. 2). Based on a similar broker model (Donlan et al. 2015), our preliminary financial models suggest that our program is a cost-effective way to incentivize long-term biodiversity outcomes in coastal Chile. How cost-effective depends on the number of fishing communities and hectares enrolled in the program; greater participation lowers transaction costs. A similar

Figure 4. (a) A designated pilot no-take zone within a territorial user right for fisheries (TURF) area in central Chile and its onshore coastal monitoring system. (b) The video apparatus that allows for coastal monitoring of designated no-take zones and provides contract verification and increased antipoaching surveillance capabilities.

broker model suggests that credit prices are relatively robust to changes or uncertainty in start-up and on-going programmatic expenses, as well as transaction-specific costs (20%–80%) (Donlan et al. 2015). We are currently piloting the program with 3 fishing communities, which will allow us to refine our financial model and stress test the overall transactional infrastructure.

Market Model and Financing

To achieve financial sustainability, short- and long-term demand for the biodiversity benefits that a program creates and maintains must be secured. Demand for credits could potentially come from different sources, while the broker manages and consolidates different demand. In Chile we are scoping and developing 3 main financing strategies for our market model: outcome-based philanthropic funding, biodiversity offsets, and sustainable seafood markets.

Outcome-based Philanthropy

Investing in well-enforced no-take zones managed by fishing communities is a low-risk, high-impact investment opportunity for foundation and corporate philanthropy. There are at least 4 reasons for this. First, with adherence to a human-centered design approach, fisher-managed no-take zones will have strong community support. Second, because of the combination of an established TURF and a contract-based agreement, the no-take zone will be protected from poaching events through the required surveillance activities. This is in contrast to many of MPAs today that lack effective enforcement (Mora et al. 2006). Third, the investment would be outcome-based and flexible. Both environmental performance (e.g., antipoaching surveillance) and biodiversity outcomes are monitored and quantified on a regularly basis. Thus, any fund established for purchasing credits on a regular basis could negotiate long-term contracts with well-performing fishing communities and not renew contracts with underperforming fishing communities. This flexibility would help maximize environmental returns. Last, investment in our market model incentivizes local environmental stewardship by placing a real value on the creation and management of a no-take zone, while covering the associated opportunity costs. Biodiversity payments would provide income diversification to participating fishing communities, which would help reduce the high financial risk and volatility of income that is common in the sector (Kasperski & Holland 2013).

Some philanthropic organizations may be reluctant to support programs with explicit financial transactions. However, we argue that a market model will be more efficient, effective, equitable, and transparent in the appropriate scenarios and geographies than other models. A transactional model that relies on local users directly (e.g., fishing communities) for the creation of biodiversity benefits allows for more value to be transferred to the end users as opposed to relying on multiple intermediaries to drive biodiversity outcomes. While a broker is necessary for our model to function, it relies on a contractual relationship with fishers to produce the biodiversity benefits. Properly designed and executed, a market model can be driven by outcomes (i.e., enforced no-take zones and biodiversity credits) as opposed to many philanthropic models that are driven by inputs (e.g., salaries and equipment). Philanthropic foundations have been supporting the due diligence, design, and piloting of our program. A next step is the establishment of a fund designed to establish contracts and purchase credits once they are created.

Biodiversity Offsets

Over the past decade, interest in biodiversity offsets has increased within the public, private, and NGO sectors (McKenney & Kiesecker 2010). Although marine-based offsets are less common than terrestrial-based offsets, the former have distinct advantages due to the potential swift responses to conservation or restoration actions because of rapid recruitment and short lifecycles of some marine species (e.g., benthic invertebrates [Cudney-Bueno et al. 2009]). These responses have been demonstrated in coastal Chile (reviewed by Navarrete et al. 2010). Implementing a biodiversity offset program, however, has challenges, including time lags, uncertainty, and the measurability of the biodiversity being offset. A transparent and outcome-based model that is based on a well-established baseline allows for those challenges to be addressed (Bull et al. 2014). Our market model overcomes challenges by establishing biodiversity baselines and control sites a priori, along with the establishment of a broker that facilitates third-party verification of biodiversity benefits prior to them being sold as offsets.

In Chile the government recently modified important aspects of environmental impact assessment policy to allow offsetting and is in the process of revising the offset framework within a new biodiversity and protected area policy. Because there are on-going marine and coastal impacts from the private and public sector throughout Chile (Jara 2005), we anticipate opportunities for marine biodiversity offset programs under a voluntary and regulatory scenario (Bovarnick et al. 2010). For instance, outfall pipes from pulp mills are common on the coast, and the Chilean pulp industry is pursuing environmental certification standards (S.G., unpublished data). Similarly, thermoelectric plants are being developed along the Chilean coast to meet growing electricity demand (Carcamo et al. 2011). Our recent interviews with executives suggest that companies are interested in no net biodiversity loss programs and are willing to consider participating in biodiversity offset programs (S.G., unpublished data). Fisher-managed no-take zones within TURFS, located in the region where pulp mill or thermoelectric marine impacts are occurring, could provide a source of like-for-like biodiversity offsets, whether those impacts are temporary or permanent.

Sustainable Seafood Markets

Given growing demand of sustainable products, some argue there is an opportunity for seafood certification programs to drive fishery sustainability (Lester et al. 2013). Although there is increasing evidence that eco-labeled seafood products can capture economic premiums (Roheim et al. 2011), major seafood certifiers have yet to integrate MPAs into their programs (Lester et al. 2013). There may be potential for integrating the biodiversity benefits generated in our model into the seafood products the participating fishers are harvesting. If a premium could be captured, where along the supply chain and if it would be sufficient to fund the program remain unanswered questions—ones we are currently exploring. Relatedly, higher seafood prices could potentially be captured by existing demand as a result of biological benefits from the establishment of no-take zones. While the potential benefits within our system are unknown, larger shellfish have captured higher prices elsewhere as a direct result of buffer areas around no-take zones (Castilla et al. 1998).

Market differentiation with certification schemes is often unsuccessful with cookie-cutter approaches (Loureiro & Umberger 2003). Rather, understanding the perceptions, preferences, and needs of consumers is critical to designing a program with sufficient demand. This important aspect is all too often ignored in the design of market-based conservation programs. In essence, customer-driven research is needed to create a program that will have sufficient demand to finance and scale a market model that includes seafood products with integrated benefits in the form of no-take areas.

Conclusions

Our proposed model is based on a contractual agreement that provides financial compensation for explicit changes in human behavior (i.e., agreement to not harvest resources in a designated area and conduct surveillance to minimize others from doing so). Yet, the outcomes of interests are the biodiversity benefits created from those behavioral changes. This creates a challenge with respect to the goal of an outcome-based program. At one extreme, fishing cooperatives would be paid solely based on contract performance (e.g., number of intrusions into the no-take zone). At the other extreme, payments would be based solely on the biodiversity benefits created and verified as a result of the behavior changes (Fig. 3). The best strategy will be influenced by the demand side of the market—who is buying the credits. For example, if the no-take zone is participating in a biodiversity offset scheme, the actual biodiversity benefits are critical in order for an offset program to be valid. In contrast, if a no-take zone is being financed by philanthropy, incentivizing long-term environmental stewardship may be the primary factor of interest. This challenge highlights an advantage of a broker managing the program because a broker can receive multiple revenue streams for the overall program and manage individual contracts (and the biodiversity benefits created) in order to balance the need for environmental stewardship behaviors and verified biodiversity outcomes in a dynamic setting.

As with any market model, our program has anticipated benefits and costs. Anticipated benefits are straightforward: fisher-enforced no-take zones within TURFs that will result in increased densities, biomass, and diversity of reef fish and macroinvertebrates (Gelcich et al. 2012). Our surveys with fishers suggest they will spend a portion of the payments on surveillance of the entire TURF, including areas that are harvested. If true, the program will further contribute to improved livelihoods. Bio-economic modeling suggests that investing in effective enforcement of Chilean TURFs can increase fishers' revenue up to 50% (Davis et al. 2015). While the biodiversity and economic benefits of any spillover effect from a no-take zone is unknown, fishers themselves believe the no-take zone will produce such effects (S.G., unpublished data). Known costs are the transaction and management costs of the program. Cash payments and a broker model reduce those respective costs to some degree. Our current model was designed to be run by a non-profit organization with the eventual goal of financial viability: credits sold to buyers to finance all aspects of the program, including recruitment of new fishing communities along the Chilean coast.

In some circumstances, perverse outcomes in stakeholders' stewardship behaviors might result from conservation programs with financial incentives (Frey & Jegen 2001). Financial payments can run the risk of reducing internal motivation: fishers could potentially not expend more effort on conservation behaviors than is minimally required by a contract (M.G. Sorice & C.J.D., unpublished). Relatedly, payments could create the perception that it is the duty of someone else to contribute to the provision of biodiversity benefits. Our human-centered approach to program design helps mitigate these hidden costs by aligning external motives (i.e., payments) with internal motives (i.e., existing environmental stewardship), which should help facilitate a self-sustaining motivation for stewardship (M.G. Sorice & C.J.D., unpublished).

In principle, our overall framework could apply to any small-scale TURF fishery across the globe. Yet, TURFs are highly variable in their effectiveness, and most have been created for fisheries management not biodiversity conservation. Thus, exactly how a program can incentivize human behavioral changes to produce biodiversity benefits and how those benefits can be financed depends on local social-ecological conditions. In addition to the existence of latent biodiversity benefits and access to control or reference sites, fishers' capacity to enforce TURF areas is critical for program success. Local enforcement by fishers not only requires financing and local governance, but also cross-scale linkages with regional and national institutions that can develop and support effective enforcement (Cudney-Bueno et al. 2009).

Creating market incentives to establish enforced, no-take zones within TURFs presents a unique opportunity to integrate livelihood improvement and marine biodiversity protection. We approached this opportunity by developing the 3 factors that are, in our view, key to success: enabling conditions, program design, and a market model and financing. We advocate for a human-centered design approach that can result in increased participation by fishing communities and robust demand for the biodiversity benefits produced by the program. By co-designing the program with fishers, we created a program that aligns with fishers' values and needs (e.g., improved antipoaching surveillance) that is resulting in high rates of participation and interest—a prerequisite for landscape-level outcomes. By paying fishers for biodiversity benefits with a performance-based contract, a program can be created that improves the lives of many small-scale fishers. Our general framework presents a scalable opportunity, one with challenges, to operationalize a scheme that incentivizes local, verifiable biodiversity benefits that could likely result in substantial marine conservation gains and novel cross-sector alliances.

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