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Fishery Socioeconomic Outcomes Tool: A rapid assessment tool for evaluating socioeconomic performance of fisheries management

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ABSTRACT

As linked social-ecological systems, evaluating the socioeconomic outcomes of fisheries management is essential to understanding fishery performance. While a number of tools have been developed in recent years to evaluate social and economic outcomes of fisheries, many require extensive data collection, making them difficult to implement on a large scale, while others rely on existing data, limiting their applicability to data-limited fisheries. Additionally, socioeconomic objectives of fisheries are likely to differ substantially between fisheries of different scales operating in different geographic and socio-cultural contexts, making the development of universal indicators and comparing results between fisheries challenging. This paper describes a novel tool for evaluating and tracking fishery management socioeconomic outcomes by linking outcomes directly to management objectives. Indicators of these outcomes are scored by key informants and weighted according to the importance of particular fishery management objectives, resulting in standardized scores of fishery management outcomes. The resulting scores can be compared between fisheries and tracked over time. This tool was tested in two disparate fisheries on the U.S. West Coast and in Sinaloa, Mexico. Results of testing demonstrate that the outcomes generated similar scores, although the primary objectives of each were very different, permitting comparison of the performance of the two fisheries. The results for the West Coast groundfish fishery were groundtruthed using existing data to assess reliability of survey scores. This tool furthers the landscape of fishery evaluation by enabling comparison of performance among dissimilar fisheries and by facilitating the rapid assessment of social outcomes of fisheries management.

1. Introduction/background

1.1. Importance of evaluating social and economic performance of fisheries

Fisheries are social-ecological systems, where human behavior explicitly or implicitly affects the availability and distribution of fishery resources, and vice versa [1]. As such, it is important to evaluate the biological, social, and economic status of fisheries in order to assess their performance. Evaluating the performance of fisheries across a variety of metrics under existing management (or lack thereof) can demonstrate which aspects of fisheries management are successful and which need to be improved [2]. Using this information, managers can make adaptations to arrive at a system that achieves biological, social, and economic goals.

Evaluations of biological indicators, such as how a stock is performing against a reference point, have long been a staple of fisheries management assessment tools. For decades, stock assessments have been used to evaluate the health of stocks and provide important biological reference points for making management decisions [3]. Evaluation of social and economic outcomes – the consequences of fisheries management on the socioeconomic components of the system - has sometimes been neglected. More recently, fisheries have been increasingly evaluated against triple bottom line outcomes, with a recognition that effects on the social and economic components of the fishery system are likewise important [4], and should be incorporated into management objectives, design, and performance evaluations [5–7].

Fisheries management determines who fishes, what they fish, when they fish it, how much of it they can fish, and where they can fish. The

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outcomes of management are therefore dictated by these constraints (or lack thereof) along with other external drivers such as market forces, governance, and baseline social and economic conditions, as well as biological and ecological drivers acting on the fishery. Indicators of socioeconomic outcomes measure how the human component of the fishery, including fishers, fishworkers, other stakeholders, and fishing communities, is faring as a result of fishery management institutions. Implementing or improving fishery management affects the economic and social dimensions of fisheries in myriad ways, and while improving the biological sustainability of a fishery can also result in improvements across economic and social dimensions [8–13], tradeoffs are frequently required between or among certain economic and social objectives (e.g., Refs. [14,15]).

Sometimes these tradeoffs are explicit in the fishery management design, such as reducing the capacity of the fishing fleet, which may reduce total employment in the fishery but increase revenues and wages and provide more stable jobs for those fishers remaining in the fishery [16]; Ye et al., 2013; [17]. In other cases, outcomes of management may be unexpected or unplanned for, as when a change of management results in large shifts of effort into or out of a fishery, leading to cascading effects on wages, revenues, capacity, and resource sustainability.

A fishery management system with an inclusive, equitable, transparent, and effective public participation process, where affected stakeholders have the opportunity to express their desired outcomes of the management system, should in theory lead to more desirable and equitable outcomes for all stakeholders [6], as constrained by the capacity of the supporting ecosystem to enable those outcomes. In such a system, tradeoffs among outcomes can be made explicit, and stakeholders with sufficient information can weigh these tradeoffs and provide input into the design of fisheries management interventions that reflect their desired objectives. A well-designed fishery management system can address concerns about certain consequences of management on social and economic outcomes through, for example, implementing caps on ownership, or through setting aside quota for new entrants to a fishery [18–21]. However, socioeconomic outcomes of fisheries management are typically not sufficiently evaluated, making it difficult for managers and stakeholders to have sufficient knowledge of these tradeoffs in order to design a management system to achieve desired outcomes.

1.2. Existing fishery performance evaluation tools

The field of fishery evaluation has grown substantially in recent years. The first tools to evaluate and assess fisheries performance were focused primarily on the sustainability of target stocks as the fishery responded to sustainable harvest needs [5,22]. Evaluations targeting biological sustainability can overlook the role of fisheries and fisheries management on the production and distribution of economic benefits, the capacity of a community to meet livelihood and food security needs, and other social and economic outcomes of fisheries management.

More recently, a number of evaluation tools have focused on assessing social and economic outcomes of natural resource management. However, none of these truly meet the criteria of being simple, affordable to deploy, applicable to data-poor contexts, and able to track outcomes over time and across multiple fisheries in a way that facilitates comparison, all of which are important criteria for a tool that can be used broadly across a wide variety of fisheries in order to further illuminate the linkages between outcomes and management interventions.

Reviews of existing tools and frameworks that measure social and economic conditions and outcomes of fisheries management (see Table 1 for a sample of tools reviewed) find that each has limitations, including their limited applicability to a single type of fishery or region, the extensive amount of data required and the resources necessary to collect the data, their reliance on existing data, or some combination thereof. Indeed, many efforts at understanding the social outcomes or effects of fisheries management rely on household or stakeholder surveys in one or more communities (e.g., Refs. [23,29–32]). While individual surveys can provide rich data and are a reliable means of measuring stakeholder perceptions, they can be very costly to conduct, are difficult to replicate at regular intervals, and can generally only be applied to a limited geographic area, possibly excluding fisheries spread across a broad area from analysis [33,34].

Many other tools rely on existing data, yet fisheries-level economic and social data are frequently either out of date or are non-existent, particularly for data-poor fisheries. Available datasets often used in fisheries performance evaluation such as national and regional statistics from agencies including the United Nations or the World Health Organization on indicators related to poverty, wages, and food security (e.g. Ref. [23]), are often unavailable at the right scale, which may be either a single fishing community or a larger region. Other efforts have relied on census data (e.g. Refs. [26,35]), from which it can be difficult to parse data directly related to fishers and their communities. Additionally, tracking changes in performance outcomes over time can be challenging when relying on available data, which may not be collected at the ideal intervals for evaluation.

While measuring social outcomes of fisheries is difficult, more challenging still is comparing fisheries performance across social metrics among a variety of fisheries types. There is often a need to compare the performance of fisheries against one another for a variety of reasons including [5]:

1. Understanding how fisheries outcomes may be improving or declining vis-à-vis other fisheries.
2. Understand regional or global trends in fisheries outcomes.
3. Determining which governance characteristics are correlated to positive social and economic outcomes in fisheries.
4. Measuring whether investment in a fishery has impacted social and economic outcomes relative to other fisheries.
5. For fisheries management agencies, non-governmental organizations, and international organizations involved in the fisheries management space to evaluate the outcomes of their interventions.

The Fishery Performance Indicators (or FPIs [5]); were an important step toward a tool for comparison of fisheries performance on a global scale. However, as explained below, there are a number of social outcomes of interest not covered in the FPIs or other tools.

1.3. Linking objectives and outcomes

One of the foremost challenges of evaluating social and economic outcomes of fisheries, and in designing fisheries management that achieves desired outcomes, is that the relationship between fisheries management and fisheries performance is not always well understood, particularly when it comes to social outcomes, making it difficult to develop management interventions to match these objectives [36–40]. Additionally, fisheries operate in a diversity of social and cultural contexts, adding to the complexity of evaluating fisheries management. Just as these contexts are likely to be diverse across geographies, across the scale of a fishery (small-scale vs. large-scale, community vs. regional scale), and across underlying social, economic, and demographic factors, so too are the desired outcomes and fishery objectives for achieving these outcomes likely to differ.

Social objectives, and thus desired social outcomes, may thus differ significantly within and between fisheries stakeholders – for example, some fisheries management objectives may include maximizing employment in a community, while others may include minimizing conflict among users, and these objectives could at times be at odds. Further, economic objectives can at times contradict social objectives, such as a desire to maximize efficiency in a fishery, which typically results in a reduction in capacity and thus employment or access to the resource [6,18,41]. This complexity is why stated social objectives of

Table 1
A sample of previous fisheries evaluation tools reviewed.

Tool/Paper	Authors	Focus (what it measures)	Evaluation Methods
A Social Wellbeing in Fisheries Tool (SWIFT)	[23]	Social Wellbeing: security, flexibility, and viability	Relies on publicly available data and desk-based research (reports and online).
Fisheries Performance Indicators	[5]	68 economic and community related metrics of fishery management	Dimensions scored based on expert assessment of multiple metrics to compensate for lack of data.
Fair Trade (Certification)	[24]	Core Standards: Empowerment, Economic Development, Social Responsibility, Environmental Stewardship	Audit Process - Independent auditor assesses fishery. Fishery gets audited again every several years.
Fishery Assessment Methodology and Guidance to Certification Bodies (Certification)	[22]	Environmental standards	Audit Process - Independent auditor assesses fishery. Fishery gets audited again every several years.
IndiSeas	[25]	Effects of fishing on health of ecosystems	Combination of expert knowledge, questionnaires (scoring based on 1–5), and available data.
Development of Social Indicators of Fishing Community Vulnerability and Resilience in the U.S. Southeast and Northeast Regions	[26]	Wellbeing, vulnerability, and resilience based on gentrification and income diversification	Data collected from the Census Bureau's American Community Survey, American Factfinder, NOAA, and more. Uses factor analysis to reduce the outcome of one index based on multiple variables.
Measuring the Effects of Catch Share Indicators	[27]	Objective social and economic outcomes of catch shares	Uses available data to report on status and trends of catch share fisheries in the US
Seafish Responsible Fishing Scheme (complementary certification)	[28]	Welfare of crew and the vessel, quality of the catch, sustainability	Audit Process - Independent auditor assesses fishery. Fishery gets audited again every several years.

fisheries management are often very broad or vaguely worded [36]. Indeed, social outcomes are sometimes linked to indicators that are vague and difficult to measure [5,23], or that are more specific and measurable but may not necessarily represent the full suite of objectives in a fishery [5]. As Anderson et al. [5] point out, social objectives of fisheries are often either not explicit or are not agreed upon within a fishery, and thus when social outcomes are measured for a fishery, they are not always those that would be considered the highest objectives by stakeholders [36]. Recognizing the likelihood of tradeoffs, it is important to evaluate a fishery's performance against its objectives, both stated and implied, which may differ substantially across fisheries.

The Fishery Socioeconomic Outcomes Tool (Appendix A) was developed to address gaps identified in existing fisheries performance evaluation tools by evaluating fisheries based on these management objectives. What is described herein is a rapid assessment tool for evaluating socioeconomic outcomes of fisheries management that pairs outcomes with fisheries objectives, and that is relatively easy to use and can be applied across a broad range of fishery types, encompassing both large-scale industrial fisheries and small-scale fisheries. This tool allows for fisheries to be compared according to their performance against the stated or implied objectives of the fisheries, weighting indicators based on the importance of their corresponding objectives. Evaluating socioeconomic outcomes is critical not only to understanding the success of fisheries management at achieving its objectives, but also to evaluating the effects of fisheries management on the well-being of fishers and other stakeholders.

2. Methodology

2.1. Selecting indicators to measure outcomes

To inform the tool development process, a literature review was conducted of existing tools designed to measure the performance of fisheries or to measure the outcomes of fisheries or other natural resource management (see Table 1). Within the twenty tools evaluated, a great diversity of approaches, guiding theories, resource intensiveness, and scope or focus were identified. Fisheries management outcomes cited in the literature were also reviewed, with a focus on evaluating outcomes after a transition to rights-based management (RBM) because of its potential for producing positive fisheries management outcomes [9]. Biological and economic outcomes discussed in the literature resulting from a transition to RBM are generally positive (e.g. Refs. [9,17]), while the social outcomes of RBM discussed in the literature tend to be more mixed (e.g., Ref. [42]). From this review, a number of commonly cited outcomes of fisheries management were selected for inclusion in the Fishery Socioeconomic Outcomes Tool, and indicators were developed to measure aspects of these outcomes (Table 2).

Rather than being comprehensive of all possible outcomes, the Fishery Socioeconomic Outcome Tool is designed to capture some of the most commonly cited social and economic outcomes of fisheries reform, and does so by identifying indicators of each outcome that are identifiable and measurable by either quantitative or qualitative means. Further, it was necessary that each indicator be measurable in a way that is straightforward, and can be tied directly to fisheries management objectives. Many of the tools and frameworks reviewed emphasized individual and community well-being [7,29,44,47,48] et al., [31]. Such frameworks evaluate indicators including health outcomes, access to education, or educational attainment, and while undoubtedly important, typically a relationship between these outcomes and fisheries management is not so straightforward. The indicators selected were those for which one could plausibly hypothesize a change in indicator status resulting from a fisheries management intervention rather than external factors.

2.2. Tool design and methodology

The tool methodology is largely adopted from the FPIs tool [5], expanding on their work to include more indicators of social outcomes, and to simplify some of their indicators of economic outcomes to make them less data intensive. Fisheries performance is evaluated based on a number of indicators for economic and social outcomes. These are scored by key informants, who rate the performance of each indicator, choosing the category of performance from a pre-defined set of increasingly positive outcomes on a Likert scale from 1 through 5 (with 5 being the highest performance), based on the best judgment of the key informant. The tool is ideally deployed in person to ensure maximum clarity, including making sure the respondents all understand the questions and scale in the same way, and allowing the user to follow up with additional questions to provide context, but surveys conducted over the phone can also provide reliable data.

Key informants are those with a substantive knowledge of the fishery, and may include scientists, academics, fishery managers, or others who are likely to have a deep understanding of fisheries outcomes, and are able to speak broadly about outcomes across the fishery beyond their own experiences. Multiple key informants (a minimum of 4–6) should be surveyed to identify consistent patterns in scores as well as to identify and possibly eliminate outliers.

Like any tool that uses experts to assess the conditions in a fishery or

Table 2
Objectives and Indicators for measuring Economic Outcomes and Social Outcomes included in tool.

Fisheries Management Objective	Indicator Type	Indicator
Economic Outcomes		
Increasing/Maintaining Employment	Contextual	o Part-time vs. full-time fishing opportunities
	Performance	o Employment trends – Vessel Operators/Captains [27]
		o Employment trends – Crew [27]
		o Employment trends - post harvest seafood supply workers [27]
		o Employment trends - shoreside support workers [27]
		o Employment turnover- Captains/Vessel owners [43]
		0Employment turnover - Crew
		o Employment turnover - Post-harvest workers
		o Average years experience – Crew [5]
Increasing Value of Fishery Landings	Performance	o Industry-wide total gross revenue – trend [44]
		o Industry-wide total gross revenue - volatility
		o Per Vessel Gross Revenue – Trend
		o Per Vessel Gross Revenue –Volatility
		o Ex-vessel price –Trend
		o Ex-vessel price –Volatility
Increasing Fishery Earnings	Contextual	o Average percentage of fishing income derived from this fishery [43]
		o Average percentage of income derived from fishing vs. non-fishing sources [26,43]
	Performance	o Vessel operator/captain earnings compared to regional average [5]
		o Crew earnings compared to regional average [5]
		o Vessel operator/captain earnings - trend
		o Crew earnings – trend [27]
Financial Investment in Infrastructure	Performance	o Change in number of fishing vessels [27]
		o Condition of/investment in fishing vessels [24]
		o Change in amount of fishery infrastructure in region
		o Condition of fishery related infrastructure in region [44]
Economic Outcomes - Community	Contextual	o Importance of fisheries related employment in community [25,45]
		o Condition of fishery-related infrastructure in community [44]
		o Location of seafood processing/post-harvest facilities [43]
	Performance	o Vessel operator/captain wages compared to community average [5]
		o Crew wages compared to community average [5]
		o Change in amount of fishery infrastructure in community
Social Outcomes		
Equitable Distribution of Fisheries Benefits	Performance	o Equitable distribution of fisheries benefits [23,25]
		o Concentration of ownership [43]
Maintaining Fishing Opportunities for Small-Scale Operators	Contextual	o Importance of small-scale fishing [43]
	Performance	o Change in small-scale fishing operations
		o New entrants to the fishery – trend [24,43]
Reducing Conflict in the Fishery	Performance	o Conflict on the water within this fishery [25,27,44]
		o Conflict on the water with other fisheries [25,27,44]
		o Relationship between harvesters and supply chain [46]
		o IUU fishing activity in the fishery
Improving Safety at Sea	Performance	o Fisheries-related injuries, hospitalizations – trend ([23,24,27,43,44,46]; Sea Fish)
		o Fisheries-related fatalities – trend [23,24,27,28,43,44,46]
		o Number of lost/sunk vessels – trend [24,27,28]
Providing Employment Opportunities for Women in the Fishery	Contextual	o Importance of fishery as source of livelihood or employment for women [45]
		o Women's roles in harvesting [45]
		o Women's roles in post-harvest processing, selling [45]
	Performance	o Women's roles in harvesting - trend
		o Women's roles in post-harvest processing, selling – trend
Promoting Food Security in Community	Contextual	o Community-level food security and general vulnerability [45]
		o Frequency of seafood consumption in community [44]
	Performance	o Availability and access to seafood [25,44,45]
		o Nutritional quality of available food products in community
		o Sources of seafood in community
		o Trend in catch [27]
		o Seafood caught that is consumed within community [45]
Maintaining Cultural Importance of Fishing to the Community	Contextual	o Presence of cultural, traditional, and historic practices [43,44]
		o Identity as fishing community – importance [44]
		o Prevalence of subsistence fishing activity [43]
	Performance	o Cultural, traditional, and historic practices - trend
		o Subsistence fishing activity - trend
		o Seafood harvesters are members of local community [5]
		o Vessel owners are members of local community [5]
		o Post-harvest workers are members of local community [5]

Contextual indicators provide context to an objective but are not evaluated for performance over time; Performance indicators should be tracked annually or at regular intervals. Also included are references to other tools or papers which have employed similar indicators.

other natural resource context, some caution should be applied in relying on the informed opinions of so-called 'experts' or key informants [49]. While this tool is designed to be applied with individuals who have broad and substantive knowledge of the fishery, sometimes key informants or others representing the majority opinion of stakeholders or those stakeholders who are the most vocal can under-represent the experiences and perspectives of other stakeholders, particularly those of marginalized groups. Thus it is important to identify any potential conflict of interest upfront and use this as criteria for screening key informants for inclusion. Fishers and leaders of fishers' organizations, as

well as perhaps fisheries managers and members of NGOs or other civil society organizations, may consciously or unconsciously have a conflict of interest, including an incentive to portray the fishery as performing better or worse than it actually is. At the same time, these are often the stakeholders with the greatest knowledge of fishery performance. Where a bias may exist, tool users can attempt to balance the key informants included by selecting them from different sectors. Additionally, while the survey questions ask key informants to generalize responses across the fishery, it is important to remember that the survey still relies on the perceptions of the key informants to evaluate the performance of the fishery, emphasizing the need for multiple perspectives in gathering survey responses for an accurate picture of the fishery. While it may not be possible to completely eliminate bias while relying on the perceptions of individuals, to the extent possible the tool user should try to identify any biases and either eliminate those responses thought to be biased or counter them with additional perspectives in selecting key informants.

The indicators are sometimes scored using a binned quantitative scale (e.g., percent change in revenue) to enable scoring when data are not available, and sometimes by qualitative categories (e.g., a change in the existence of cultural, traditional, or historic practices in the community), particularly those measuring social outcomes. This consistent evaluation methodology will more easily facilitate comparison among fisheries. The tool user will end up with several key informant scores for each indicator, and should take the mode of the scores rather than the mean to prevent any outliers from influencing the score. Each score is also given a level of certainty (1 through 3), also in line with the methodology used in Anderson et al. [5], based on the key informant's level of confidence in each response. The level of certainty can be used to weight the scores or to discard outliers. Where there is not general consensus among key informants about the performance of an indicator, the user may need to conduct additional surveys or conduct further investigation to better understand the performance of the fishery.

A significant difference in how this approach departs from the methodology used in the FPIs is in the addition of a criterion to score the importance of a particular management objective to a fishery. As noted above, one of the challenges in evaluating the performance of fisheries against social indicators in particular is the variability in social objectives of fisheries management, including scoring indicators based on the 'best' outcome where the best outcome may be subjective. What may be an important objective for managing one fishery (e.g., maintaining food security in a community highly dependent on fisheries as a source of food) may not be a concern for another fishery. Thus the tool includes a scoring mechanism asking the key informant to rate the importance of a particular management objective (2 for a primary or explicit objective of the fishery; 1 for a secondary or implicit objective of the fishery; 0 for an outcome that is not relevant or not an objective of the fishery). In some cases these objectives will be clearly defined in management documents; in others the tool may rely on key informants' understanding of what managers' or other stakeholders' objectives are in managing the fishery.

The scores comprising of a set of indicators evaluating the outcome of a fishery under a particular objective are then weighted by the Importance of Objective score, giving more weight to outcomes that correspond to those objectives that are of most importance to the fishery, less weight to those outcomes that correspond to secondary objectives, and eliminating those indicators corresponding to objectives that are not relevant to the fishery, as demonstrated below. The objective scores are then summed, and divided by the highest possible score for the fishery, creating the Economic and Social Performance Index scores. Weighting the summed scores under each objective allows the user to align a hierarchical scoring system with scoring the importance of the objectives to the fishery. The resulting standardized index scores can then be compared across various fisheries, either across a particular objective (e.g., Increasing the Total Value of Fishing Activity), or between fisheries using the aggregated index scores, even where the fisheries have very different objectives.

2.2.1. Demonstration of weighting for performance index scores

Performance Index Score = Objective 1 Score * Importance of Objective Score + Objective 2 Score * Importance of Objective Score + Objective 3 Score * Importance of Objective Score / Sum of Importance of Objective Scores

While the tool can be applied to create a snapshot of performance at a particular point in time, it is ideally suited for tracking outcomes over time, and in particular, before and after a management intervention. The tool should ideally be applied at regular intervals (e.g., annually, every three years, etc.) to develop a time series of data. These scores can be used to track changes in performance before and after a management intervention, to track changes longitudinally after a management intervention is in place, or to evaluate the performance of fisheries being considered for a management intervention.

The time period evaluated by the indicator changes depending on the indicator and its purpose. Some of the indicators ask the user to rank the performance of a particular indicator at present, while others ask for the evaluation of a trend in performance over time (typically five years), or in the case where a fishery is being evaluated after a management intervention, since the management intervention. These indicators can establish trends in the absence of a time series of quantitative data collected to analyze such trends. For some objectives, the tool also asks the user to answer questions aimed at establishing a baseline or contextual information for a fishery, such as the importance of the fishery as a source of employment for women, or the breakdown of full-time versus part-time fishers in the fleet. These are indicators that are not included in the scoring, because they are not likely to change on an annual basis, but may experience change on a longer time scale (e.g., decadal-scale change). These indicators are nonetheless important for understanding the performance of a fishery and for adding context to the performance of other indicators. They should still be tracked over time because changes in these contextual indicators may demonstrate larger systems-level changes to the fishery if, for example, the fishery shifts from one predominated by small-scale fishers engaged in multiple fisheries to one predominated by industrial fisheries operations.

2.3. Testing the tool

The tool was designed and refined through an iterative process with the help of expert reviewers. After reviewing the literature and designing the tool, a beta version of the tool was tested in two fisheries to test for usability, clarity of the questions, and the scoring mechanisms. Two very different fisheries were selected – the U.S. West Coast Groundfish Trawl IFQ (Individual Fishing Quota) fishery (an industrial fishery) and a small-scale, multispecies fishery based in the Altata Lagoon, in Sinaloa, Mexico. The tool was applied surveying key informants in each fishery, including six experts in West Coast Groundfish trawl fishery drawn from fisheries managers (including NOAA regional and Pacific Fishery Management Council staff), social scientists (including NOAA economists), and stakeholder groups, and four experts in the Altata Lagoon fishery, including members of civil society organizations and fisheries managers who have been involved in developing a fishery management plan for the region. Their scores were used to develop a performance index for both economic and social outcomes for each fishery. The results of these two case studies are below. Additionally, the scores for the West Coast Groundfish Trawl IFQ fishery were compared against existing quantitative and qualitative data for the fishery drawn from the West Coast Groundfish Trawl Catch

Table 3
Example scores from the west coast groundfish trawl fishery for two objectives.

Indicator	Key Informant 1	Key Informant 2	Key Informant 3	Key Informant 4	Key Informant 5	Key Informant 6	Indicator Score (Mode)
Objective: Increasing Fishery Earnings							
A - Vessel Operator/Captain wages compared with regional average	4	N/A	4	4	4	4	4
B - Crew wages compared with regional average	4	N/A	4	2	2	5	**4**
C - Trend in vessel operator/captain wages	5	5	4	4	4	4	**4**
D - Trend in crew wages	5	5	N/A	4	4	4	**4**
Mean Objective Score							**4.0**
Objective: Reducing Conflict in the Fishery							
A - Conflict on the water	3	2	N/A	3	4	5	**3**
B - Relationship between harvesters and supply chain	2	4	N/A	3	3	3	**3**
C - IUU fishing activity	5	5	N/A	5	5	5	**5**
Mean Objective Score							**3.7**

Scores range from 1 through 5, with 5 being the highest score. Each score corresponds to either a range in values or to a qualitative description. Each indicator is scored by the user taking the mean of the key informants' scores, and taking the level of certainty into consideration to drop or downweight those with low certainty. A score for each objective is calculated by taking the mean of the indicator scores. Scores are provided below for two objectives (Increasing Fishery Earnings and Reducing Conflict in the Fishery). N/A indicates the respondent did not respond or did not know. Scores are shaded by level of certainty (white = high certainty[3]; light gray = medium certainty[2]; darker gray = low certainty[1]). For all indicators in this table the difference in scores among the key informants were within one quintile in either direction.

Table 4
Economic and Social Outcome Scores from testing the tool in two fisheries.

	U.S. West Coast Groundfish Trawl Fishery	Altata-Ensenada del Pabellón Lagoon Multispecies Fishery
Economic Objectives		
Increasing/Maintaining Employment	3.0	3.6*
Increasing Value of Fishing Activity	3.7*	3.0
Increasing Fishery Earnings	4.0	3.2
Financial Investment in Infrastructure	2.5	3.0
Community Economic Outcomes	3.9	3.1
Economic Performance Index	**3.5**	**3.2**
Social Objectives		
Equitable Distribution of Benefits	3.4	2.5*
Maintaining Fishing Opportunities	2.0*	3.8*
Reducing Conflict	3.7	3.0*
Improving Safety at Sea	3.2*	N/A
Employment Opportunities for Women	N/A	3.8
Promoting Food Security	N/A	3.4*
Maintaining Cultural Importance of Fishery	3.5	3.9
Social Performance Index	**3.0**	**3.3**

Scores for each objective are calculated by taking the sum of scores for each indicator, divided by the highest possible score. The Economic and Social Performance Index scores are the average scores for the set of economic or social objectives, weighted by the objective importance score as scored by the respondents (with scores for those indicators scored as primary objectives doubled). N/A are those objectives which were not considered important for the fishery. Those scores with an asterisk (*) are considered primary management objectives.

Share Program – Five-Year Review document [50] to test for accuracy of survey responses. A comparison of the tool against the existing data is found in Table 5.

3. Results

Testing the beta version of the tool allowed us to understand how the tool performed, and to make some important revisions based on results and feedback. The test results demonstrated how the tool can be used to evaluate and compare a variety of different fishery types with different objectives, and demonstrated the relative efficacy of the tool at obtaining accurate survey responses.

The U.S. West Coast Groundfish trawl IFQ fishery (non-whiting component) is an industrialized fishery operating on a large geographic scale. It has been managed using individual fishing quotas since 2011, and thus the tool included questions about changes since this particular management intervention. In 2000, this fishery was declared a disaster as many stocks within this multispecies fishery were considered overfished. The poor state of the fishery also led to poor economic outcomes. Since the implementation of the IFQ, a number of stocks have been rebuilt (Warlick et al., 2018). Testing the tool asked about the performance of social and economic factors in the fishery at present, as well as how social and economic outcomes have changed since the transition to an RBM system.

The Altata-Ensenada del Pabellón Lagoon multispecies fishery in Sinaloa, Mexico, the other fishery on which the tool was tested, differs greatly from the West Coast Groundfish trawl fishery. While both are multispecies fisheries, the Altata Lagoon fishery is a small-scale fishery based in a handful of communities and targeting shrimp, crabs, finfish, and bivalves. Although fishers are required to have a permit to sell their fish, much of the fishing takes place by fishers without a permit. There has been little direct management of this fishery but stakeholders have been working together to develop a fishery management plan - this fishery is considered to be in a pre-intervention (i.e., baseline) state.

Table 5
Comparison of Key Informant Survey Scores with Available Data for West Coast Groundfish Trawl Fishery. Relevant data from the 5-Year IFQ Review for the West Coast Groundfish Trawl Fishery [50] are provided for each indicator where available, and the corresponding score from the tool is provided for comparison with the performance score for each indicator generated from the key informant surveys. Those indicators for which no data were found are marked with an N/A and no score was generated.

Objectives	Indicators	Data from IFQ Review [50]	Corresponding Tool Score	Survey Score
Economic Outcomes				
Increasing/Maintaining Employment	Employment trends - Captains/Vessel owners	Decrease in full-time employment/increase in part-time employment	2	2
	Employment trends - Crew	22.8% decrease	2	2.5
	Employment trends - Post-harvest workers	23.1% Decrease	2	2
	Employment trends - Shoreside support workers	N/A		2.5
	Employment turnover- Captains/Vessel owners	58% of survey respondents have been fishing since before the age of 20	5	4
	Employment turnover - Crew	Low	4	3
	Employment turnover - Post-harvest workers	High	2	3
	Average years of experience – Crew	20 years	5	4
Increasing Value of Fishery Landings	Industry-wide total gross revenue – trend	22.9% Increase	4	4
	Industry-wide total gross revenue – volatility	Increases/decreases by < 10%	5	4
	Per Vessel Gross Revenue – Trend	42.7% increase	5	5
	Per Vessel Gross Revenue –Volatility	Steady increase by < 10% annually	5	4
	Ex-vessel price –Trend	5.3% increase	3	3
	Ex-vessel price –Volatility	Increases/decreases by < 10%	5	4
Increasing Fishery Earnings	Vessel operator/captain earnings compared to regional average	N/A		4
	Crew earnings compared to regional average	N/A		4
	Vessel operator/captain earnings - trend	26.9% increase	5	4
	Crew earnings – trend	Slight decrease	3	4
Financial Investment in Infrastructure	Change in number of fishing vessels	23.7% decrease	2	1.5
	Condition of/investment in fishing vessels	N/A		4
	Change in amount of fishery infrastructure in region	Declined somewhat	2	2
	Condition of fishery related infrastructure in region	N/A		3
Economic Outcomes – Community	Vessel operator/captain wages compared to community average	N/A		4
Newport, OR				
	Crew wages compared to community average	N/A		4
	Change in amount of fishery infrastructure in community	No change	3	4
Social Outcomes				
Equitable Distribution of Fisheries Benefits	Equitable distribution of fisheries benefits	Gini coefficient 0.45 (2015)	3	3
	Concentration of ownership	Some consolidation of fleet size, but strong accumulation limits	4	3
Maintaining Fishing Opportunities for Small-Scale Operators	Change in small-scale fishing operations	47.1% decrease	1	1
	New entrants to the fishery – trend	N/A	2?	3
Reducing Conflict in the Fishery	Conflict on the water within this fishery	Some new conflicts	3	3
	Conflict on the water with other fisheries	Few conflicts within the fishery mentioned	4	3
	Relationship between harvesters and supply chain	0.9% of survey respondents reported conflicts	4	3
	IUU fishing activity in the fishery	Very few enforcement infractions	5	5
Improving Safety at Sea	Fisheries-related injuries, hospitalizations – trend	No change	3	3
	Fisheries-related fatalities – trend	No change	3	3
	Number of lost/sunk vessels – trend	No change	3	3
Providing Employment Opportunities for Women in the Fishery	N/A			
Promoting Food Security in Community	N/A			
Maintaining Cultural Importance of Fishing to the Community –	Cultural, traditional, and historic practices – trend	N/A		3
Newport, OR	Subsistence fishing activity - trend	974% increase in fish for personal consumption*	5	3
	Seafood harvesters are members of local community	N/A		5
	Vessel owners are members of local community	High number of vessels owners	5	4
	Post-harvest workers are members of local community	N/A		3.5

Fishing is mostly done by a single captain-owner from small boats, or by women from shore, particularly for bivalves. As there are very few crew and little processing is done of the catch, questions about crew wages and longevity and post-harvest processing were mostly irrelevant and not answered.

The key informants scored each indicator and provided a weighting for each objective depending on the importance of the objective to the fishery (see Table 3 for an example of two objectives from West Coast Groundfish Trawl fishery). The key informants also provided a level of certainty for each score - in cases where there were significant discrepancies between scores (scores differed by more than 1), any scores with a low level of certainty were dropped from the final scoring. Indicator scores were totaled for each objective, weighted according to the importance of the objective, and averaged across key informants to give a performance index for each objective. The weighted objective scores were then averaged to create an Economic Performance Index and a Social Performance Index.

3.1. Comparing two dissimilar fisheries

The scores that resulted from testing the tool in two fisheries (Table 4) show that two dissimilar fisheries can have similar scores across various social and economic objectives based on their performance. Both fisheries had somewhat similar scores for the Economic Performance Index, which is the averaged score across all economic objectives, while the index scores for the individual economic outcomes differed. Both fisheries scored highest on Increasing or Maintaining Fishery Earnings, indicating that fishery earnings have been increasing in both fisheries and that earnings perform relatively well compared with regional averages. However, the two fisheries differed across other objectives; the West Coast Groundfish trawl fishery performed well against the Increasing Value of Fishing Activity and Promoting Community Economic Outcomes objectives, while the Altata Lagoon fishery performed highest against the Increasing or Maintaining Employment objective.

The social objectives for the two fisheries differ markedly. Improving Safety at Sea is a primary objective for the West Coast Groundfish trawl fishery, but not an objective at all for the Altata Lagoon fishery (which is a nearshore fishery, including harvesting bivalves from shore), while Maintaining Employment Opportunities for Women and Promoting Food Security are objectives for the Altata Lagoon fishery but not the West Coast Groundfish trawl fishery. Across social outcomes, the West Coast Groundfish trawl fishery performed best against the Reducing Conflicts in the Fishery objective, while the Altata Lagoon fishery performed somewhat poorly, and the Altata Lagoon fishery performed well at Maintaining Fishing Opportunities while the West Coast Groundfish trawl fishery performed less well. Overall, the Altata Lagoon fishery had a higher Social Performance Index score (3.3) (the averaged score across the social objectives) than the West Coast Groundfish fishery (3.0).

3.2. Groundtruthing survey scores against available data

In order to further test our tool and assess the validity of the scores obtained by the key informant surveys, we compared the survey scores for the West Coast Groundfish trawl fishery with data available in a 5-Year Review report of the IFQ program [50]. This document included quantitative data on trends since the implementation of the IFQ program that could be used to score some of the questions and qualitative data that could inform others. A comparison of scores is found in Table 5.

Generally the survey responses and the available data were well aligned. For only one indicator (Trend in Subsistence Fishing) did the score developed using the surveys differ from the corresponding score developed using the IFQ Review document by more than one quintile. Most of the key informants believed there had been no change in the practice of subsistence fishing while the data demonstrate it had increased substantially since the implementation of the IFQ program. However, as noted in the report, this may be due to a change in reporting rather than practice [50]. For about half of the indicators for which data could be found in the document (13 out of 27), the score matched the score from the surveys or differed by a half a quintile. For the other half (14 out of 27), the score differed by one quintile. In some cases this difference may be due to a difference in interpretation of available information, particularly for the more subjective questions. This groundtruthing exercise demonstrates that overall the key informants provided responses that were fairly aligned with available data, although not entirely in agreement. This finding provides support for the utility of this tool in the absence of data on a given fishery, but it should be supplemented with data when available.

4. Discussion

This paper presents a new tool - the Fishery Socioeconomic Outcomes Tool - for rapidly evaluating and tracking social and economic outcomes for comparison across divergent fisheries. Designing a tool to measure the social outcomes of fisheries in particular has proved challenging, in part because there are so many possible outcomes, and because these outcomes are not always universal, in some cases conflicting with one another. This tool addresses this problem through explicitly linking outcomes to fisheries management objectives. Doing so resolves some of the challenges that have made developing a tool to measure social outcomes of fisheries so difficult - namely, that objectives differ among fisheries, and thus determining what constitutes good performance across social dimensions is often subjective. Using a standardized index can allow comparison of multiple fisheries of various sizes and in a variety of different geographic contexts, comparing across objectives they share in common as well as across objectives that are not applicable in all contexts. At the same time, the tool is designed to be applied for rapid assessment with minimal resources, and to be used at the scale of the fishery, rather than much finer or coarser scale approaches.

Testing this tool on two different fishery types with divergent goals - the U.S. West Coast Groundfish trawl fishery and the Altata Lagoon fishery in Sinaloa, Mexico - resulted in fairly similar scores based on the evaluation of the indicators aligned with their objectives, demonstrating that while outcomes may differ, they are performing equally well (or poorly) against their management objectives. These two fisheries differ substantially in the size and scale of the fisheries, in the species targeted, and in the importance of the fisheries to local communities, and yet their total scores across economic and social outcomes were similar, reflecting mixed success in achieving their objectives for both fisheries. Their performance across common objectives, such as increasing fishery earnings, where both fisheries performed well, can be compared directly, and summed scores were developed into an index of performance to compare across overall social and economic performance.

Further testing the tool by comparing the results of the key informant surveys for the West Coast Groundfish trawl fishery, as a relatively data-rich fishery, with readily available data for some of the indicators included in the tool found that the survey yielded fairly (although not entirely) accurate results. If one were solely concerned with the economic outcomes of this fishery, existing data on metrics including employment, fisheries revenue, and ex-vessel prices could be used to evaluate the fishery rather than employing key informant surveys. However, using this tool enables a fuller understanding of social outcomes of the fishery that cannot be discerned from available data, and allows these data to be converted to qualitative scores on a 1 through 5 scale for comparison with the Altata Lagoon fishery data or other fishery data. The Altata Lagoon fishery, on the other hand, is a data-limited fishery, and most of the data collected by this tool are not otherwise available.

The Fishery Socioeconomic Outcomes Tool does not account for biological performance of the fishery, largely because there are numerous other tools available to assess biological performance (including traditional stock assessment methods, MSC tools [[22]], FISHE [[51]], and others). However, while the focus of this tool is on social and economic outcomes, an evaluation of these outcomes should still be done simultaneously with biological performance. As linked social-ecological systems [1], the biological and ecological performance of a fishery will influence its social and economic outcomes and vice versa. A fishery that is performing well economically and socially but is experiencing declining fish stocks or significant overfishing will most likely experience an eventual decline in its socioeconomic performance as well.

Fisheries management interventions, most often directed at improving biological outcomes through reducing overfishing and rebuilding fish stocks, may result in positive, negative, or neutral social and economic outcomes, and often result in a mix. Of course, the drivers of economic and social outcomes in fisheries are complex, and there may be many intervening factors that have little to do with management objectives or interventions. Global demand or other market factors can affect the ex-vessel price of seafood, determining revenue and wages. Likewise, the costs of fuel, ice, or other necessities also determine vessel profits. Numerous underlying social and economic factors will influence many of the social outcomes of management, such as how equitably the benefits of fisheries are distributed, and whether there are conflicts among fisheries stakeholders. An evaluation of a fishery also requires some understanding of the context in which these social and economic outcomes are occurring. This tool is not intended to replace engaging with stakeholders in the fishery, which can allow managers or others interested in evaluating a fishery to better understand the context in which the fishery operates. Still, evaluating these outcomes is the first step in identifying successful management interventions, as well as for identifying problems where they exist. The next steps may include employing diagnostic tools to understand why outcomes are occurring, and designing experiments or using large data sets to better link social outcomes to particular types of management interventions, to be able to more effectively design fisheries management measures that reliably result in those desired outcomes.

One of the objectives addressed in this tool and deserving of further explanation is community food security. Evaluating food security in a community is incredibly complex, as it requires an understanding not only of the availability of seafood in a community heavily reliant on seafood as a form of protein, but also on the presence of other alternative protein sources, on access to food, and on the income required to purchase it. Previous tools have relied on country-level measures of food security (e.g. Refs. [52,53]), or employing household surveys to understand individual- and household-level seafood and other protein consumption patterns [54–56]. The former is much too coarse to understand food security within fishing communities, particularly given that fishing communities may often be poorer and/or more reliant on seafood than the average household in a country [57–59]. The latter is likely to be impractical for many fisheries because of the time and resources required. This tool provides a series of questions designed to ascertain a basic understanding of food security and seafood reliance in fishing communities, and should be combined with other economic data to assess the extent to which a community is likely to be food secure, and to which this level of (in)security may be affected by changes to the fishery, whether through changes to catch, exports, or income levels. As with other indicators in this tool, the metrics here are helpful for providing a picture of food security and how it may change over time, but in fisheries or communities where food security is identified as a significant concern, more detailed surveys may be needed to more precisely characterize and track this issue and its relationship with the fishery.

Finally, it is important to remember that what are presented here are indicators of performance, and they do not provide a complete picture of fisheries performance, or allow the user to understand the drivers of fishery performance. A thorough assessment of some of the indicators included here, such as those evaluating food security or the equitable distribution of benefits, may ultimately require household surveys or other methods to understand in more detail how they may vary between stakeholder groups and how vulnerable populations may be affected. As noted above, these methods can be costly and/or time-consuming, and may not always be practical given available resources. Using a rapid assessment tool such as the one presented here can allow a user to determine where and when to expend the resources for more detailed information should it be necessary or feasible.

The next step in this work is to use the Fishery Social and Economic Outcomes Tool to explore hypotheses about why certain social and economic outcomes occur, and then to provide guidance on the design of appropriate fisheries management interventions to facilitate desirable outcomes based on these outcomes and detailed contextual information. Applying this tool broadly and developing a large data set of various fisheries around the world can enable this analysis and others. This tool could also be combined with the FPIs or other existing indicators for an even more robust set of data. Tracking the performance of numerous fisheries over time before and after a management intervention can help to identify trends in what types of outcomes can be anticipated from certain elements of fisheries management and design. The tool described here adds a standardized, rapid assessment approach to the landscape of fisheries evaluation tools to answer the question of how successful various fisheries are at meeting a broad selection of important social and economic objectives, furthering the ability of fisheries managers and others to evaluate social outcomes on equal footing with economic outcomes.

Conflicts of interest

Declarations of interest: none.

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Appendix A. Supplementary data

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