Fisheries management impacts on target species status

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Fisheries management systems around the world are highly diverse in their design, operation, and effectiveness at meeting objectives. A variety of management institutions, strategies, and tactics are used across disparate regions, fishing fleets, and taxonomic groups. At a global level, it is unclear which particular management attributes have greatest influence on the status of fished populations, and also unclear which external factors affect the overall success of fisheries management systems. We used expert surveys to characterize the management systems by species of 28 major fishing nations and examined influences of economic, geographic, and fishery-related factors. A Fisheries Management Index, which integrated research, management, enforcement, and socioeconomic attributes, showed wide variation among countries and was strongly affected by per capita gross domestic product (positively) and capacity-enhancing subsidies (negatively). Among 13 management attributes considered, three were particularly influential in whether stock size and fishing mortality are currently in or trending toward desirable states: extensiveness of stock assessments, strength of fishing pressure limits, and comprehensiveness of enforcement programs. These results support arguments that the key to successful fisheries management is the implementation and enforcement of science-based catch or effort limits, and that monetary investment into fisheries can help achieve management objectives if used to limit fishing pressure rather than enhance fishing capacity. Countries with currently less-effective management systems have the greatest potential for improving long-term stock status outcomes and should be the focus of efforts to improve fisheries management globally.

resource management | stock assessment | fisheries enforcement | fishery subsidies | marine conservation

Studies in recent years have yielded divergent views of the status of marine populations and recommendations for how the world's fisheries should best be managed (1–6). Although scientists are generally unanimous in calling for stronger management, some proposed solutions involve widespread establishment of marine reserves (4), whereas others involve greater investment in management structures, such as stock assessments and enforcement of catch or effort limits (6–8), or in reforms of fishing fleets toward rights-based management (1). Fisheries management systems involve a wide array of policies and regulations to meet conservation and socioeconomic objectives (5, 9, 10). These aspects vary within and among countries, target species, and fishing fleets. Given the great diversity in fisheries management systems, it has not been clear which specific management characteristics lead to success across systems, but it seems increasingly clear that successful attributes involve the capacity to limit fishing pressure (1, 2, 6–8, 11).

We used expert surveys to characterize attributes of research, management, enforcement, and socioeconomics of fisheries management systems in 28 major fishing countries that collectively account for >80% of global total catch. We specified survey criteria as to whether these attributes play an effective role in limiting fishing pressure for target species. We quantified geographic, economic, and fishery-related influences on the management system, and in turn quantified how management attributes individually affect recent status and trends of stock size and fishing mortality.

Survey responses from fishery experts showed high variability among 28 countries in research, management, enforcement, and socioeconomics dimensions of management systems, as well as in stock status (Fig. 1). Values for each dimension are weighted means of several criteria, with answers of 0, 0.5, or 1 reflecting the degree to which a criterion was met for each of 10 species in the country. Survey responses were correlated among research, management, enforcement, and socioeconomics dimensions ($r = 0.66$–0.82) (Fig. S1*A*) and were averaged with equal weighting to obtain a Fisheries Management Index (FMI) for each returned survey ($n = 191$) (Fig. S2*A*), which were subsequently aggregated by country. FMI is an indicator of the effectiveness of management systems at meeting objectives. Survey responses were weighted by confidence scores in answers provided for individual questions and self-assigned level of expertise; sensitivity analyses considered alternative weighting schemes. Countries with high FMI values included the United States, Iceland, Norway, Russia, New Zealand, South Africa, and Canada; Myanmar, Thailand, Brazil, China, and Bangladesh had the lowest FMI values among countries (Fig. 1).

To explain variation in country FMI values, we considered the background and self-assigned expertise of respondents (Fig. S3), as well as geographic, economic, and fishery-related factors (*SI Materials and Methods*, Fig. S4, and Table S1). Of 12 numerical covariates considered in a mixed-effects model, three of the most influential factors involved monetary investment into management systems. Per capita gross domestic product (GDP) had the strongest effect on FMI (Fig. S5*A*), with mean FMI values ranging from 0.42 to 0.83 at the lowest and highest values of per capita GDP, respectively (Fig. 2 and Fig. S6). This finding suggests that countries with greater wealth generally have greater capacity for investment in management, although many other factors will also contribute to the extent of potential investments. Second, countries with greater reported catches in exclusive economic zones (EEZs) had greater FMI, suggesting that with greater landed value derived from fisheries resources, countries invest more to

Significance

There is broad public interest in the health of our oceans and marine life at local, national, and international levels. In recent years there has been increasing concern about whether our fisheries can sustainably provide seafood without overfishing fish stocks. Several papers have described the global status of fish populations (i.e., their abundance and exploitation rates) and have hypothesized influences of fisheries management, but this report is unique in being a comprehensive analysis of how specific management attributes (which are numerous and operate simultaneously) affect population status across oceans, countries, and taxonomic groups. Our report integrates management policies and population ecology to assess sustainable harvesting outcomes of target species in marine fisheries; results have important global food security implications.

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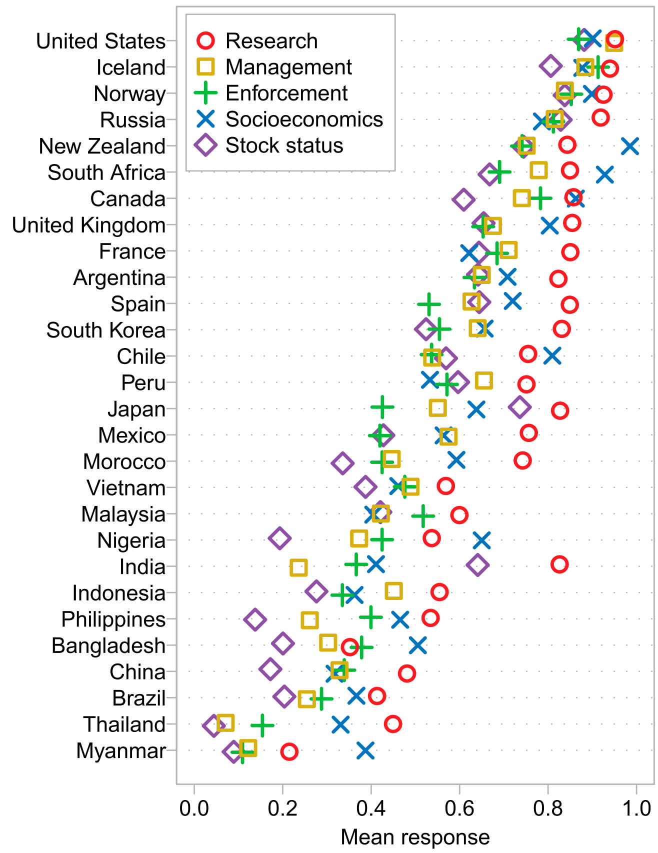

Fig. 1. Summarized survey answers by dimension and country. Responses are weighted by both respondent expertise and confidence in individual answers provided, and are adjusted for observed differences among respondent background categories. Countries (n = 28) are sorted by FMI values, a composite of research, management, enforcement, and socioeconomics dimensions.

better manage those resources. Third, the ratio of beneficial ["good" (12)] subsidies (i.e., investment in research, management, and enforcement) to landed value positively influenced the FMI, as expected. In contrast, the ratio of capacity-enhancing ["bad" (12)] subsidies to landed value negatively influenced FMI (Fig. 2); this association was the strongest of all predictors, with the exception of per capita GDP. The strong association of capacity-enhancing subsidies with poor management outcomes is consistent with concerns raised previously (3, 12–14).

The proportion of landings recorded as miscellaneous "not elsewhere included" species groups in the United Nations Food and Agriculture Organization (FAO) landings database was a negative indicator of FMI (Fig. 2 and Figs. S5*A* and S6). Countries with more developed management systems are often better prepared to collect landings data at a higher taxonomic resolution, but this also highlights the correlative nature of these data. Respondent background categories were treated as random intercepts; government managers and scientists tended to give higher FMI (conditional modes, 0.70–0.72), whereas individuals from environmental nongovernmental organizations (NGOs) and external organizations, such as the FAO, tended to give a lower FMI (0.63–0.64) than respondents from the fishing industry and from universities (0.65–0.68), which were intermediate (Fig. 2 and Fig. S5*B*). All respondents providing answers for countries >35° absolute latitude had an FMI > 0.5, whereas values for countries 0–35° were more variable (Fig. 2). Tropical fisheries are more often mixed-species fisheries compared with temperate fisheries, presenting additional challenges for research and management (5, 15). The full model with 12 fixed-effect covariates and random intercepts for respondent background explained 61% of the variability in logit-transformed FMI values. Alternative weighting and adjustment schemes were considered (Fig. S7) and observed results were robust to alternatives (Figs. S1*B* and S2*B* and Table S2).

We quantified effects of 13 fisheries management attributes on four stock status criteria: current biomass status, trend in biomass, current fishing mortality, and trend in fishing mortality (*SI Materials and Methods*). These four criteria involved management targets, consisting of whether biomass or fishing mortality were currently in or trending toward desirable states (Dataset S1). Random forest analyses suggested that 3 of the 13 management attributes considered were particularly important, with strong positive influence: the extensiveness of stock assessments influenced all four stock status variables; the strength of fishing pressure limits influenced the current status and trend in fishing mortality; and the comprehensiveness of enforcement programs influenced the trends in biomass and fishing mortality (Fig. 3). This analysis supports arguments that a crucial key to successful fisheries management is the implementation of science-based limits on catch or fishing effort coupled with adequate enforcement of those limits (6–8, 11, 16). Management attributes with weaker influence on stock status criteria for target species included body size or age data, landings data, and protection of sensitive habitats; influence of other management attributes was intermediate (Fig. 3).

Of the four stock status measures considered, trend in fishing mortality may be the best indicator of future stock status. Trends in fishing pressure were positively associated with the level of transparency and stakeholder involvement in the management process and with the absence of capacity-enhancing subsidies (Fig. 3). This finding suggests that greater stakeholder engagement within governance frameworks can improve sustainable harvesting outcomes for targeted species, consistent with arguments from previous studies (15, 17, 18).

Characterizing fisheries management systems across countries is challenging considering the wide variety of management approaches used. Relative FMI values among countries were similar to those of some related studies but contrast sharply with others. Pitcher et al. (19) evaluated many of the same countries in their adherence to principles, indicators, and steps toward implementation of ecosystem-based fisheries management (EBFM). Strong correspondence between EBFM performance and FMI values was observed (r = 0.63–0.70; see Fig. 4*A* for the aggregate measure), except for Russia, which had high FMI but low EBFM performance. The expertise required to complete FMI surveys meant that respondents typically completed a survey for only the country in which they work; we cannot rule out self-scoring biases that may differ among countries. Our estimates for Russia were in line with those of Mora et al. (20), who also used surveys to characterize several aspects of fisheries management across countries. Overall correspondence with FMI values was lower (r = 0.44), partly because of China having a low FMI but having the highest value of management effectiveness in Mora et al. (20) among the countries that overlapped between studies. There was little correlation (r = 0.15) between country FMI and the Food Provision Index from Wild Capture Fisheries (a component of the Ocean Health Index, OHI), which assesses the amount of wild-caught seafood that can be sustainably harvested (21) (Fig. 4*A*).

Observed differences among studies partly reflect the variety of criteria included in each overall index. Our survey criteria focused primarily on target species, whereas EBFM criteria (19) placed greater emphasis on ecosystem-level values, structure, function, and change (Table 1 and Fig. S8). Criteria strongly overlapped between studies in some attributes (fishery management plan, protection of sensitive habitats, community involvement), but other attributes were only considered in one or the other study depending on overall focus. Some of our criteria in other attributes (limits on fishing pressure, capacity to adjust fishing pressure, fisheries

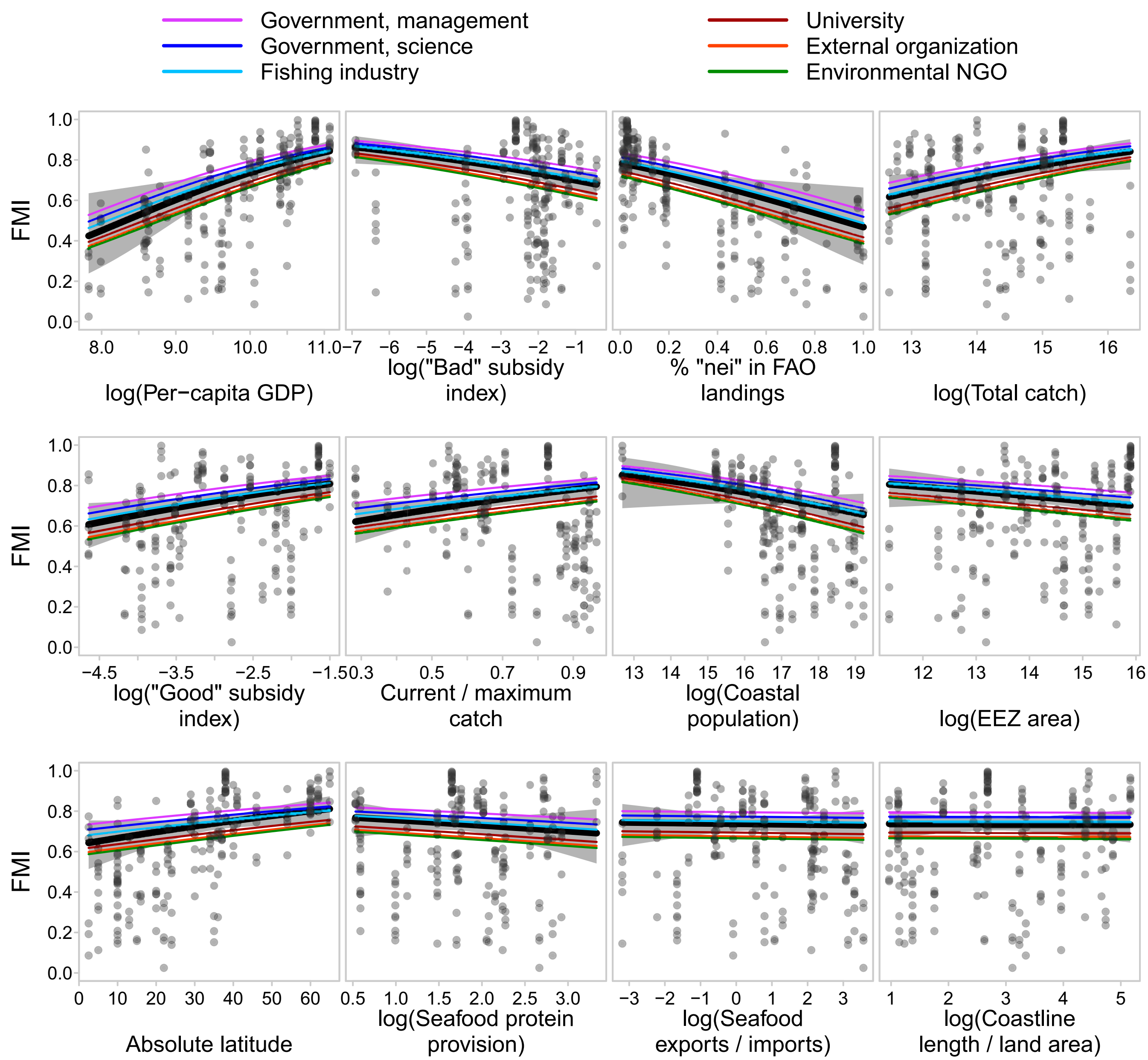

Fig. 2. Influences of country-level factors on FMI values. Data points show FMI values for each respondent and country (n = 191 surveys), weighted by confidence in individual answers provided. Black lines show overall best fits with 95% confidence bands in gray, weighted by respondent expertise. Best-fit lines for respondent background categories are overlaid. Panels are sorted left to right by absolute values of t-statistics for predictor variables.

enforcement) strongly overlapped with survey questions for management effectiveness (20) (Table 1 and Fig. S8). Although our study and that of Mora et al. (20) both focused on the effectiveness of fisheries management systems and covered similar topics, the correspondence between index values for overlapping countries was less than expected. The wording of survey criteria may partly explain differences: our criteria specified not only whether various management instruments were in place, but whether they were effective at limiting fishing pressure. Differences may also arise from the sampling unit at which questions were posed: answers to our survey criteria were given for specific target species, whereas answers to questions in Mora et al. (20) were given for the entire country; the stock-specific approach may simplify responses. Overall aims and attributes covered differed substantially between our country FMI and the Food Provision Index from Wild Capture Fisheries (21) (Table 1). The latter index consists primarily of the OHI "Fisheries Status" component; this component more closely resembles our stock status attribute, which is not included in the calculation of FMI values to better distinguish management characteristics from their effects on target species. A significant advantage of the FMI survey over previous studies is that data were collected for individual fisheries. In this paper we aggregate results to the country level, but more detailed analyses will consider differences among taxa.

There was little correlation between the present study's stock status values and either the OHI Fisheries Status (21) or the Environmental Performance Index (EPI) "Fish Stocks" measure [from Sea Around Us Project (22)] of the fraction of stocks overexploited or collapsed (inverted in Fig. 4B, such that increasing values represent increasingly desirable states). These other measures rely on catch-based methods, which have received recent criticism for poorly representing stock status (23, 24). Answers provided in FMI expert surveys about current status and trends of stock size and

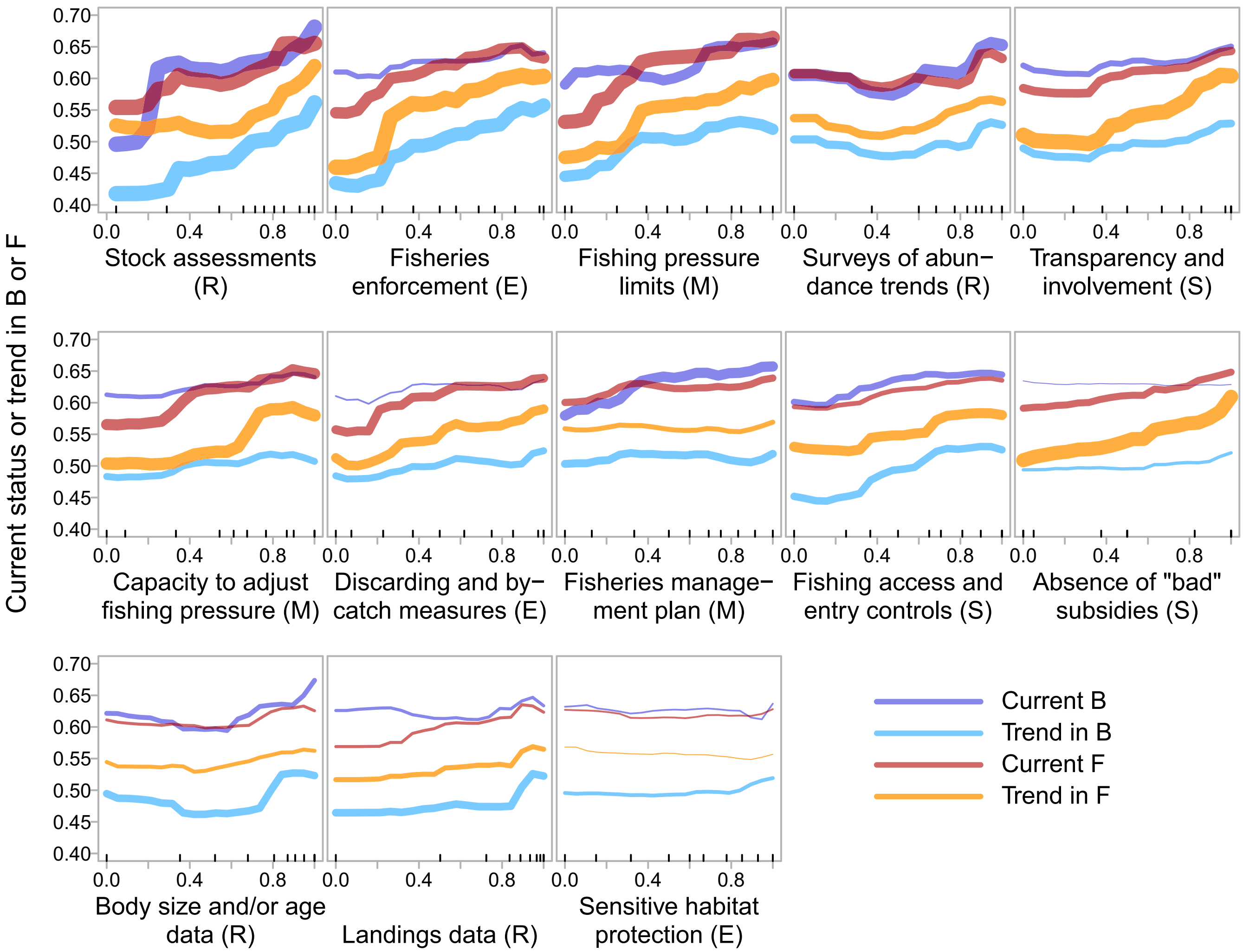

Fig. 3. Effects of fisheries management attributes in research (R), management (M), enforcement (E), and socioeconomics (S) dimensions on the current status and trends of biomass (B) and fishing mortality (F). Higher values of response variables indicate increasingly desirable states or trends toward desirable states with respect to management targets (i.e., high values of F do not indicate $F > F_{MSY}$, but rather $F \leq F_{MSY}$). Line thicknesses are proportional to predictor variable importance scores from random forest analyses for each response variable. Panels are sorted left to right by the sum of standardized variable importance scores across all four response variables. Response and predictor variables are weighted by confidence in individual answers. All variables range from 0 to 1, but vertical axes are truncated. Rug marks at bottom show deciles of predictor variable values.

fishing mortality reflect the opinions of individuals most familiar with national fisheries management systems and their managed fish stocks.

The high diversity of fisheries management systems mirrors the diversity across regions, target species, and fishing fleets. There is no single management strategy or tactic that will yield success in

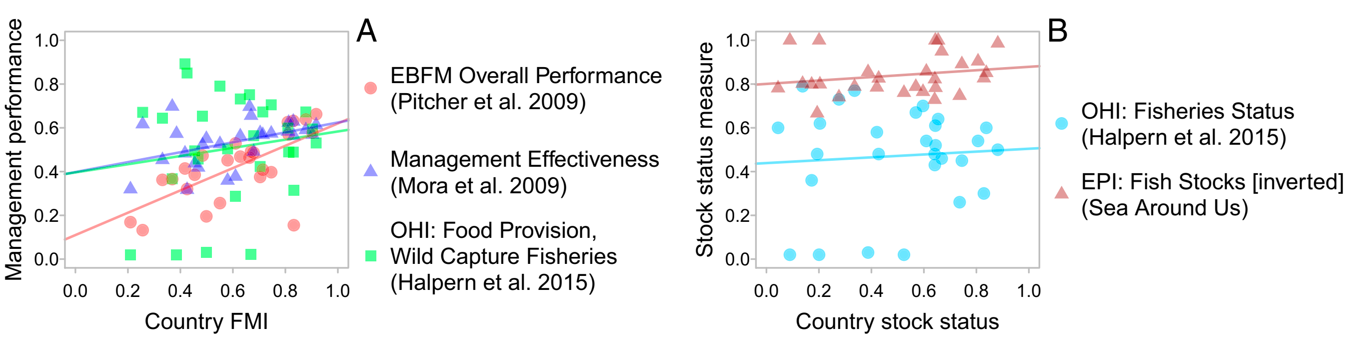

Fig. 4. Comparison of country FMI or stock status values with published indices of fisheries management or status. (*A*) EBFM overall performance [Pitcher et al. (19)] ($r = 0.68$), overall management effectiveness in EEZs [Mora et al. (20)] ($r = 0.44$), and OHI–Food Provision from Wild Capture Fisheries [Halpern et al. (21)] ($r = 0.15$) compared with FMI, by country. (*B*) OHI–Fishery Status (21) ($r = 0.07$), and EPI–Fish Stocks, using Sea Around Us Project estimates (22) ($r = 0.21$, inverted such that greater values suggest lower percent overfished stocks) compared with stock status values ($n = 28$). Best-fit lines are shown for each comparison.

Table 1. Overlap of fisheries management and related attributes considered in the present study and three previous studies

Dimension	Attribute	Fisheries Management Index	Ecosystem-based management [Pitcher et al. (19)]*	Management effectiveness in EEZs [Mora et al. (20)]†	Wild capture fisheries food provision (Halpern et al. (21))‡
Research	Landings data	3		1	
	Body size or age data	3		1	
	Surveys to monitor trends in abundance	3	2 **(1)**		
	Stock assessments	5	1	3 **(1)**	
	Skills and training in fishery science			1	
Management	Fishery management plan	3	5 **(2)**		
	Effective limits on fishing pressure	3	2 **(1)**	2 **(2)**	
	Capacity to adjust fishing pressure	3	2 **(1)**	3 **(3)**	
	Number or proportion of species regulated			1	
	Recreational fishing extent and regulations			6	
	Artisanal fishing extent and regulations			5	
Enforcement	Fisheries enforcement	4		4 **(2)**	
	Protection of sensitive habitats	3	3 **(3)**		4
	Discarding and by-catch measures	3	1 **(1)**	2 **(1)**	
	Frequency of corruption and bribery			1	
Socioeconomics	Controls on access and entry into fishery	3		1	
	Transparency and community involvement	3	9 **(3)**	1 **(1)**	
	Subsidies	2	1	1 **(1)**	
	Pressures to increase catch			1	
	Other overcapacity			2	
Stock status	stock status	5	1 **(1)**	1	1 **(1)**‡
Other	Ecosystem structure, function, and change		3	1	
	Ecosystem values		3		
	Ecological risk assessment		1		
	Research and information priorities		1		
	Fisher education and training		1		
	Fishing methods			8	4
	Foreign fleet agreements			1	
	Pollution and environmental variables			1	2
	Alien species and mariculture escape				2
	Worldwide Governance Indicator				2
	IUCN assessments				1

The number of criteria, survey questions or component variables associated with each attribute is listed for each study. Boldfaced numbers in parentheses for previous studies indicate the number of criteria, questions, or variables that strongly overlap with FMI survey criteria. Individual criteria or survey questions from previous studies may be associated with more than one attribute category of the present (FMI) study. See Fig. S8 for further details of overlap.

*Criteria include 5 EBFM principles, 6 EBFM indicators, and 12 EBFM implementation steps (Fig. S8), which together contribute to an overall performance score (19).

†Most of 22 survey questions (mainly with the exception of fishing methods, recreational fishing, and artisanal fishing) contribute to an overall management-effectiveness score (20).

‡Component variables of status (1 component), pressures (12 components), and resilience (5 components) contribute to this OHI goal (21). Wild-capture fisheries food provision scores are weighted heavily toward the Fisheries Status component, which is associated with the stock status attribute of the present study.

all cases, but the findings presented here suggest broad support for the importance of establishing and enforcing science-based catch or effort limits to the sustainable harvesting of marine populations. Countries in which management systems are currently less effective at meeting conservation and socioeconomic objectives have the greatest potential for improving long-term stock status outcomes and should be the focus of efforts to improve fisheries management globally.

Materials and Methods

Fishery experts from diverse backgrounds were invited to complete a survey characterizing the management systems for 10 species in their country of familiarity. Institutional review board approval was not required for these surveys and Respondents were given the option of being acknowledged for their contribution or remaining anonymous; see *SI Extended Acknowledgments* for a list of expert survey participants. A total of 191 surveys were completed by 182 individual respondents; the number of returned surveys per country ranged from 2 to 17 (mean = 6.8). This range represented an overall 41% response rate from 467 invitations originally extended. Survey responses for research, management, enforcement, and socioeconomics dimensions were aggregated into a Fisheries Management Index. Variation among countries in the FMI was attributed to geographic, economic, and fishery-related influences using mixed-effects models. In turn, the influence of management-related attributes on the current status and trends in stock abundance and fishing pressure were evaluated using random forests. See *SI Materials and Methods* for details and Dataset S1 for the survey file listing specific attributes and criteria within each dimension.

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Supporting Information

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SI Materials and Methods

Expert Surveys. Fishery experts familiar with the management systems of one or more countries were invited to participate in a survey characterizing the management system. The 28 countries included in this study include the top 20 countries in terms of global marine catch; the remaining 8 countries were selected from 5 continents, including Oceania to ensure global representation. We ensured that a variety of backgrounds were represented by respondents; 191 completed surveys across 28 countries were provided by 182 individuals (or groups): government scientists (n = 60), government managers (n = 28), and members of industry associations (n = 16), universities (n = 35), environmental NGOs (n = 27), and external organizations (n = 25). Respondents were instructed to complete a spreadsheet survey for 10 major fished species in the country of question using one of two formats: in survey A, answers were provided for each of 46 criteria for each of the 10 species separately, whereas in survey B a single answer was provided for each criterion across all 10 species together. Midway through the survey mailing period, only survey A was sent to respondents because this was the preferred format for most respondents and also provided higher-resolution data. Respondents were instructed to provide answers in a global context, recognizing that similar surveys were being conducted across countries differing in the development of their fisheries governance systems. Full instructions provided to respondents are contained in the original survey file (Dataset S1). Respondents were given the option of being acknowledged for their contribution or remaining anonymous; see *SI Extended Acknowledgments* for a list of expert survey participants.

Management attributes surveyed included aspects of research (programs for collection of landings data and body size/age data, surveys, stock assessments), management (management plans, limits on fishing pressure, capacity to adjust fishing pressure), enforcement (monitoring and observing programs, penalties, protection of sensitive habitats, discarding or by-catch measures), and socioeconomics (access into the fishery, transparency, community involvement, absence of subsidies), as well as stock status. The survey hierarchy was such that individual criteria were nested within attributes, which were nested within dimensions (Table 1 and Dataset S1).

The list of 10 species for each survey file was semirandomized and biased toward species with greater volumes and values of landings by the country in question. The FAO capture-production database (25) was used along with global ex-vessel price estimates (26) to compile time series of landings and landed values for each species (or other taxonomic group) in the FAO landings database caught by the country in question in the FAO areas adjacent to the main EEZ of the country (i.e., excluding distant-water catches and from overseas territories). Arithmetic means of landings and landed values in 5 recent years (2007–2011) were calculated for each species. The four species with greatest landings and four species with greatest landed values (which often overlapped) were included in all survey files for the country. The remaining two to six species were randomly sampled in proportion to their joint probability of standardized landings and standardized landed values. This resulted in species lists reflecting the major species caught by the country, but occasionally including minor species also.

Respondents provided answers to the survey criteria, a confidence score for each criterion to reflect the uncertainty in the answers provided, additional comments, and a self-assigned level of familiarity with the country's fisheries. Answers of 0, 0.5, 1, or "not applicable" indicated the degree to which each of 46 criteria were met for each of 10 species. Confidence scores for individual criteria (A, B, C, or D) were later used as weighting terms for aggregating survey criteria within attributes and within dimensions. Self-assigned familiarity ("level of expertise"; also A, B, C, or D) was later used as a weighting term for individual respondents in analyses. Level of expertise varied across respondent background categories as expected (Fig. S3), with government managers and scientists indicating greater familiarity with national fisheries management systems. All comments provided by respondents were reviewed in detail to ensure that survey questions were interpreted as intended and to occasionally adjust answers to ensure consistency across respondents in the interpretation of questions. Clarifications were made before finalizing a set of responses. After a completed survey was returned, the respondent was asked to self-identify into a primary background category: government science, government manager, fishing industry, university, environmental NGOs, or organization external to the country, such as the FAO. Data analyses accounted for possible influences of background category on the answers provided by respondents.

Filtering of Survey Responses. Following the review of surveys and quality-assurance procedures, additional filters were applied to the compiled dataset before analyses. Refer to Dataset S1 for the full wording of the criteria. The following filters were applied:

Under the research attribute "Body size or age data," the first two criteria were collapsed into a single criterion to avoid penalizing against research programs that collect only one of these data types. The maximum value provided for criteria "Body size data collected using consistent protocols…" and "Age data collected using consistent protocols…" was used.

Under the research attribute "Surveys to monitor trends in abundance," if stock assessments using population models were in place that do not rely on "catch per unit effort" (CPUE) estimates, we did not penalize research programs that do not additionally collect or use CPUE data. If the answer for the criterion "Fishery-dependent relative abundance estimates (e.g. CPUE, kg/tow) are collected..." was less than the answer for the criterion "In assessments, population models are fit to catch data…" under the attribute "Stock assessments," the answer was overridden with the higher value.

Under the research attribute "Stock assessments," numerical answers for the criterion "For stocks with assessments, assessment results are used…" were overridden with "NA" (not applicable) if previous answers to the criterion "Some form of assessment of abundance and/or fishing mortality rate exists…" were "0," suggesting that stock assessments were not actually in place for the species.

Under the stock status attribute "stock status," numerical answers for the criterion "Stock size and/or fishing mortality rate are reliably estimated" were overridden with "NA" if previous answers to the criterion "Some form of assessment of abundance and/or fishing mortality rate exists…" were "0," suggesting that stock assessments were not actually in place for the species.

Under the stock status attribute "stock status," the two criteria "For stocks with reliable estimates, stock size is thought to be…" and "For stocks with reliable estimates, fishing mortality rate is thought to be…" are conditional on the first criterion "Stock size and/or fishing mortality rate are reliably estimated." If the answer to this first criterion was "0," then answers to the two criteria are not applicable, so any numerical answers given for these two criteria were overridden with "NA."

Under the enforcement attribute "Protection of sensitive habitats," all three criteria are only relevant for species that have at least some association with the seafloor. For pelagic or diadromous species with little or no association with the benthos, any numerical answers provided for these three criteria were overridden with "NA." This was not possible with the few survey B responses because for these, answers were provided for the list of 10 species together instead of for each species separately.

Under the enforcement attribute "Discarding and by-catch measures," the third criterion "Discard mortality and/or by-catch limits exist, with consequences for exceeding those limits (e.g. penalties; individual quota reductions; fishery shutdown)" was eventually considered to be redundant given the existence of the other two criteria under this attribute, "Management measures are in place and effective at reducing the catch (or subsequent discard mortality) of juveniles of the target species" and "Management measures are in place and effective at reducing by-catch of non-target species." This third criterion was omitted from analyses.

Country-Level Covariates. Twelve country-level numerical variables (Table S1) were considered in the mixed-model analysis to explain variability in FMI values. The original list of possible country-level explanatory variables was longer, including other indicators related to population, economics, governance, development, transparency, food security, environmental performance, as well as current and historical levels of fishery catch, landed values, and international trade. Many of these variables showed high correlation, so the list of possible variables to include in analyses was shortened. First, groups of related variables were plotted together in paired scatterplots and correlation coefficients were calculated between pairs of variables. When high correlations (>0.7) were observed, one of the two variables was eliminated from consideration. Second, all variables carried forward from the initial groups were pooled and again visually inspected to remove highly-correlated variables. Third, after remaining variables showed low-to-moderate levels of correlation (<0.7), variance inflation factors (VIF) were calculated to further assess possible confounding. Variables with high levels of covariation with other predictor variables were removed from the list until all variables had VIF < 6, leaving 12 variables for consideration in analyses. Most variables were log-transformed to avoid overly skewed distributions, and all variables were standardized to mean = 0 and SD = 1 for analyses. Values of covariates for each country are shown in Fig. S4.

Data Analyses.

Aggregation of survey responses. For analysis at the country level, survey responses were aggregated across the 10 species in each completed survey. Answers to individual criteria were further aggregated into either dimensions or attributes (see hierarchy in Dataset S1) using weighted means. Aggregation by dimension was used for mixed-effect model analyses that quantified influences of country-level covariates on FMI values. Aggregation by attribute was used for random forest analyses that quantified influences of management attributes on stock status variables. These aggregations were performed for each of the 191 completed surveys. Thus, for each survey we obtained aggregate estimates of 13 management attributes (not including stock status) as well as aggregate estimates of the four dimensions (five dimensions including stock status).

In both types of aggregations, the confidence scores associated with the answers to each criterion were used as weighting factors. These confidence scores provided by respondents were qualitative, ranging from A (low uncertainty in answers provided) to D (high uncertainty), reflecting the number of answers across the 10 species that were possibly too high or too low (Dataset S1). We assigned the following weighting terms to the qualitative confidence categories: A = 1.0, B = 0.8, C = 0.6, D = 0.4. Thus, answers with less uncertainty were given more weight when calculating weighted means of answers for individual criteria into attributes or into dimensions.

The four dimensions—research, management, enforcement, and socioeconomics—were combined into the the FMI using an arithmetic mean with equal weighting. The weightings of the FMI referred to in the main text simply reflect that earlier weightings were carried forward. Thus, "FMI weighted by confidence score in the answers provided to individual criteria" indicates that weighted means were used for aggregations within each of the four dimensions, but weights across the four dimensions are equal. Similarly, "unweighted FMI" indicates that unweighted means of answers to individual criteria were calculated within each dimension, and subsequently an unweighted mean of the four dimensions was calculated. The main results presented use weighted means, but sensitivity analyses (Figs. S1*B* and S2*B* and Table S2) instead used unweighted means. There was little difference between main analyses and sensitivity analyses because weighted-mean FMI values and unweighted-mean FMI values were very similar after aggregation (Fig. S7*A*), despite the relatively strong penalties applied to answers with associated confidences scores of C or D.

Influences of country-level factors on FMI. Average survey response values by dimension (Fig. 1) and FMI values (Fig. S2*A*) varied considerably by country. To explain variability in the FMI without resorting to categorical country effects, 12 country-level numerical covariates of geographic, economic, and fishery-related factors (Fig. S4 and Table S1) were used as predictor variables. The FMI also varied among respondents for a given country (Fig. S2*A*), partly because of their background and possibly because the semirandomized lists of species differed among respndents. The six respondent background categories (Fig. S3) were treated as random intercepts in a linear mixed-effects model with logit-transformed FMI values as response variables. The "lmer()" function in the R package "lme4" v1.1-8 (27) was used, optimizing the restricted maximum likelihood.

The respondents' self-assigned level of familiarity with the country's fisheries (Fig. S3) was used as a weighting factor in the mixed-effect regression model. These levels of expertise were qualitative: A = expert, B = strong familiarity, C = moderate familiarity, D = limited familiarity. We assigned the following weighting terms: A = 1.0, B = 0.8, C = 0.6, D = 0.4, giving respondents with greater familiarity more weight in the regression model. The main results presented use level of expertise for regression weights, but sensitivity analyses (Figs. S1*B* and S2*B* and Table S2) instead used equal weight across respondents. There was little difference among expertise-weighted and unweighted FMI values (Fig. S7*B*), and thus little difference between main analyses and sensitivity analyses despite the relatively strong penalty applied to respondents with familiarity of "C" (there were no respondents with familiarity of "D").

It was necessary to adjust country-level aggregated FMI values by respondent background because there was uneven representation of respondents in each of the six background categories in each country. The conditional modes of respondent background categories (Fig. S5*B*) are modifiers of the overall fixed-effect intercept, such that government managers and scientists tended to give answers resulting in relatively high FMI values, whereas respondents from environmental NGOs and external organizations tended to give answers resulting in relatively low FMI values. The magnitude of the effect is shown as overlaid best fit lines for background categories in Fig. 2. These conditional modes were used to adjust FMI values (in logit space) based on respondent background. Adjusted FMI values were back-transformed to linear space and appear in Fig. 1 and Fig. S2*A*, whereas unadjusted FMI values are shown in Fig. S2*B*. The adjustment procedure had more effect on FMI values than either of the two weighting procedures, but the magnitude of adjustments (Fig. S7*C*) was still small compared with the range of the FMI values observed.

Model fits were evaluated using diagnostic plots of residuals and by calculating conditional R^2 values. Typical R^2 values for linear models are not estimable in mixed-effect models, so we extracted variance components (fixed-effect variance, random-effect variance, and residual variance) and estimated conditional R^2 as the proportion of total variance explained by fixed and random effects together. The "VarCorr()" function in the "lme4" R package (27) was used to extract variance components. The marginal R^2 for fixed effects and the conditional R^2 for fixed and random effects together are reported in Table S2. Model fits to FMI values on the linear scale are shown in Fig. 2, and fits to standardized FMI values on the logit scale are shown in Fig. S6.

Influences of management attributes on stock status. Answers to many of the survey criteria were correlated within respondent datasets. This was especially apparent when aggregated into dimensions (Fig. 1 and Fig. S1), but also when aggregated into attributes. Random forests (28), a recursive data-splitting method involving an ensemble of regression trees, are often better able to handle covariation in predictor variables compared with linear models. This nonparametric method also allows for quantifying nonlinear relationships between predictor and response variables and uses a cross-validation method for quantifying the relative importance of predictor variables in their effect on a response variable. Random forests were used to quantify the influence of individual attributes within research, management, enforcement, and socioeconomics dimensions on four criteria in the stock status dimension: current stock size, current fishing mortality rate, and trends toward desirable states in stock size or fishing mortality (Dataset S1). Analyses were conducted separately for each of these four stock status response variables. Like other survey criteria, answers for these stock status criteria were 0, 0.5, 1, or NA, reflecting the degree to which species were currently in or trending toward a desirable state. Only species with reliable estimates of stock size or fishing mortality rate were included in this analysis.

Random forest analyses involve two forms of randomness: (*i*) each regression tree of the forest is based on a bootstrapped dataset from the original data, and (*ii*) at any given node of a component tree, only a random subset of predictors is available to be selected for explaining variability in the response variable (i.e., splitting the dataset into two at the node). Whichever predictor yields the greatest reduction in the sum of squares of the response variable is the one selected, and the process is repeated for additional nodes downstream. The number of predictor variables available for selection at any given node is determined by m_{try}, a tuning parameter. Visual diagnostics of the mean-square error of model fit suggested that the best value to use was $m_{try} = 3$, which was used for all four analyses. Forests of 10,000 trees were sufficient on the basis of other visual diagnostics. The R package "randomForest" v4.6-10 (29) was used for analyses.

Partial dependence plots were used to show the marginal influence of each of the 13 management attributes on each of the four stock status response variables. At a given value of predictor variable x, a value of the response variable is predicted from all of the combinations of observed values of the other predictor variables in the random forest dataset, and the average response is determined. This process is repeated for many values of x (in our case, 20) to construct a dependence plot for each predictor variable. Self-assigned levels of respondent expertise were used as weighting terms for partial dependence plots, and input data for management attributes were weighted by the confidence scores associated with answers to individual survey criteria. Sensitivity analyses showed little effect of either weighting procedure. Variable importance scores of management attribute predictors were calculated for each of the four stock status response variables. These variable importance scores were standardized to the maximum importance value for each response variable, and were then incorporated into the partial dependence plots as the line thickness for each predictor variable.

SI Extended Acknowledgments

These 120 individuals (or groups) completed surveys for up to 10 species in the country(ies) indicated and were willing to be acknowledged. In addition, 62 individuals (or groups) completed surveys but preferred to remain anonymous. We extend our sincere gratitude to all survey respondents. The primary respondent background category and survey type completed (A or B) are listed in parentheses.

Argentina: Ernesto Julio Godelman (Environmental NGO; survey A)

Argentina: Guillermo Cañete (Environmental NGO; survey A)

Argentina: Nadine Parry (Fishing industry; survey A)

Argentina: María Eva Góngora (Government, science; survey A)

Argentina: María Isabel Bertolotti (Government, science; survey A)

Argentina: Mario Luis Lasta (Government, science; survey A)

Bangladesh: Md. Golam Mustafa (External organization; survey A)

Bangladesh: Rishi Sharma (External organization; survey A)

Bangladesh: Rudolf Hermes (External organization; survey B)

Bangladesh: Nasiruddin Md. Humayun (Government, management; survey A)

Bangladesh: A. K. Yousuf Haroon (Government, science; survey A)

Bangladesh: Shahroz Mahean Haque (University; survey A)

Brazil: Monica Brick Peres (Environmental NGO; survey A)

Brazil: Fernando Pinto das Neves (Fishing industry; survey A)

Brazil: José Augusto Negreiros Aragão (Government, science; survey A)

Brazil: Jose Heriberto Meneses de Lima (Government, science; survey A)

Brazil: Jorge P. Castello (University; survey A)

Brazil: Manuel Haimovici (University; survey A)

Brazil: Maria Gasalla (University; survey A)

Brazil: Victoria Judith Isaac (University; survey A)

Canada: Stefan Leslie (Government, management; survey A)

Canada: Ghislain Chouinard (Government, science; survey A)

Canada: Stephen J. Smith (Government, science; survey A)

Canada: George Rose (University; survey A)

Chile: Ernesto Julio Godelman (Environmental NGO; survey A)

Chile: Héctor Bacigalupo (Fishing industry; survey A)

Chile: Marcel Moenne (Fishing industry; survey A)

Chile: José Zenteno (University; survey A)

Chile: Renato Molina (University; survey A)

China: Songlin Wang (Environmental NGO; survey A)

China: Yimin Ye (External organization; survey A)

China: Xianshi Jin and Xiujuan Shan (Government, science; survey A)

France: André Forest (Government, science; survey A)

France: Paul Marchal (Government, science; survey A)

France: Tristan Rouyer (Government, science; survey A)

France: Sylvain Bonhommeau (Government, science; survey A)

France: Olivier Le Pape (University; survey A)

Iceland: Birgir Runolfsson (University; survey A)

Iceland: Gunnar Stefansson (University; survey A)

Iceland: Ragnar Arnason (University; survey A)

India: Derek Staples (External organization; survey A)

India: Yugraj Singh Yadava, and Rajdeep Mukherjee (External organization; survey A)

India: K. Sunil Mohamed (Government, science; survey A)

India: Muktha Menon (Government, science; survey A)

India: P. U. Zacharia (Government, science; survey A)

Indonesia: Purwito Martosubroto (External organization; survey A)

Indonesia: Rishi Sharma (External organization; survey A)

Indonesia: Rudolf Hermes (External organization; survey A)

Indonesia: Gellwynn Jusuf (Government, management; survey A)

Indonesia: Duto Nugroho (Government, science; survey A)

Indonesia: Tonny Wagey (Government, science; survey A)

Indonesia: Abdul Ghofar (University; survey A)

Indonesia: Michael De Alessi (University; survey A)

Japan: Makoto Suzuki (Environmental NGO; survey A)

Malaysia: Rishi Sharma (External organization; survey A)

Malaysia: Dato Ahamad Sabki Bin Mahmood (Government, management; survey A)

Mexico: Juan Manuel Garcia Caudillo (Environmental NGO; survey A)

Mexico: J. Fernando Marquez Farias (Government, science; survey A)

Mexico: Miguel A. Cisneros (Government, science; survey A)

Mexico: Pablo Arenas Fuentes (Government, science; survey A)

Mexico: Alvaro Hernández Flores (University; survey A)

Morocco: Mohamed Naji (University; survey B)

Myanmar: Rishi Sharma (External organization; survey A)

Myanmar: Rudolf Hermes (External organization; survey B)

Myanmar: U Han Tun, U Kyaw Min, and U. Kyaw Kyaw Tun (Government, management; survey A)

Myanmar: Khin Maung Soe (Government, science; survey A)

New Zealand: Katherine Short and Tony Craig (Environmental NGO; survey A)

New Zealand: Pamela Mace (Government, science; survey A)

New Zealand: Paul Starr (Government, science; survey A)

New Zealand: Rosemary Hurst (Government, science; survey A)

Nigeria: Abba Y. Abdullah (External organization; survey A)

Nigeria: Adedayo Olubunmi Adesanya (Fishing industry; survey A)

Nigeria: Akinbobola Adedayo Paul (Government, management; survey A)

Nigeria: Foluke Omotayo Areola (Government, management; survey A)

Nigeria: Parcy Ochuko Obatola (Government, science; survey A)

Nigeria: Anetekhai Martins Agenuma (University; survey A)

Nigeria: Tosan Fregene (University; survey A)

Norway: Fredrik Myhre (Environmental NGO; survey A)

Norway: Per Sandberg (Government, management; survey A)

Norway: Peter Gullestad (Government, management; survey A)

Norway: Åsmund Bjordal (Government, science; survey A)

Norway: Harald Gjøsæter (Government, science; survey A)

Norway: Kjell Nedreaas (Government, science; survey A)

Peru: Ernesto Julio Godelman (Environmental NGO; survey A)

Peru: Jose Antonio Zavala Huambachano (Environmental NGO; survey A)

Peru: Ulises Munaylla-Alarcón (Fishing industry; survey A)

Peru: Juan Carlos Sueiro (University; survey A)

Philippines: Stuart Green (Environmental NGO; survey A)

Philippines: Maripaz L. Perez (External organization; survey B)

Russia: Randy Ericksen (Environmental NGO; survey A)

Russia: Zgurovskiy Konstantin (Environmental NGO; survey A)

Russia: Andrey V. Dolgov (Government, science; survey A)

Russia: Konstantine Drevetnjak (Government, science; survey A)

Russia: Vladimir Radchenko (Government, science; survey A)

Russia: Dmitry Lajus (University; survey A)

South Africa: Jessica Greenstone (Environmental NGO; survey A)

South Africa: John Duncan (Environmental NGO; survey A)

South Africa: Kevern Cochrane (External organization; survey A)

South Africa: Johann Augustyn (Fishing industry; survey A)

South Africa: Kim Prochazka (Government, science; survey A)

South Africa: Carryn de Moor (University; survey A)

South Africa: Serge Raemaekers (University; survey A)

South Korea: Dong Woo Lee and Young Il Seo (Government, science; survey A)

South Korea: Chang-Ik Zhang (University; survey A)

South Korea: Sukgeun Jung (University; survey A)

Spain: Marina Santurtún (Government, science; survey A)

Spain: Raquel Goñi and Federico Alvarez (Government, science; survey A)

Spain: Raúl Prellezo (University; survey A)

Thailand: Derek Staples (External organization; survey A)

Thailand: Rudolf Hermes (External organization; survey A)

United Kingdom: E. John Simmonds (External organization; survey A)

United Kingdom: Michael Park (Fishing industry; survey A)

United Kingdom: Aisling Lannin (Government, management; survey A)

United Kingdom: Carl Michael O'Brien (Government, management; survey A)

United Kingdom: Joe Horwood (Government, science; survey A)

United States: Jake Kritzer (Environmental NGO; survey A)

United States: Steve Eayrs (External organization; survey A)

United States: Wally Pereyra (Fishing industry; survey A)

United States: Andrew J. Applegate (Government, management; survey A)

United States: David Witherell (Government, management; survey A)

United States: Diana Stram (Government, management; survey A)

United States: John DeVore (Government, management; survey A)

United States: Thomas A. Nies (Government, management; survey A)

United States: Bill Karp and Paul Rago (Government, science; survey A)

United States: Steven X. Cadrin (University; survey A)

Vietnam: Nguyen Thi Dieu Thuy (Environmental NGO; survey A)

Vietnam: Thong Ba Nguyen (Environmental NGO; survey A)

Vietnam: Stephen Reiss Fisher (Fishing industry; survey A)

Vietnam: Pham Anh Tuan (Government, management; survey B)

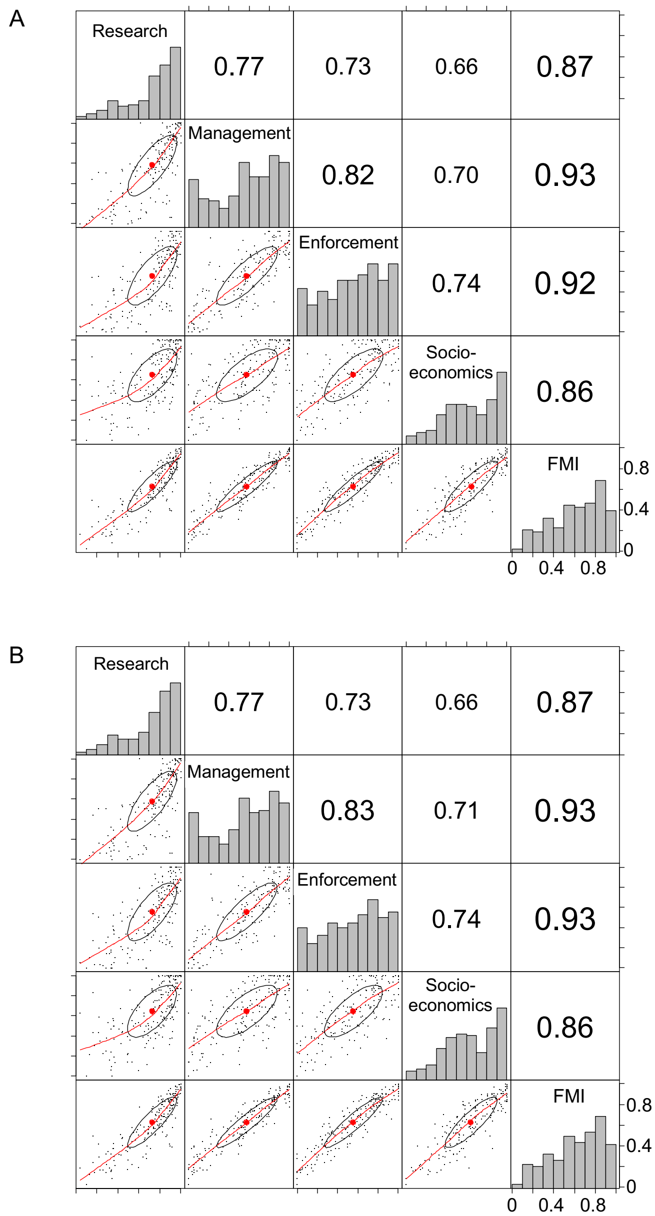

Fig. S1. Summary statistics of survey answers by dimension. Responses for individual questions within dimensions have: (*A*) weighting by confidence score in the answers provided for individual questions; or (*B*) equal weighting. The FMI is a composite of research, management, enforcement, and socioeconomics dimensions with equal weighting. Diagonals show histograms of survey responses (n = 191) across all countries and respondents. Lower panels show scatterplots between pairs of dimensions, with correlation ellipses (black lines), loess smoothers (red lines), and bivariate medians (red circles) overlaid. *Upper* panels show Pearson correlation coefficients between pairs of dimensions with font size scaled to r.

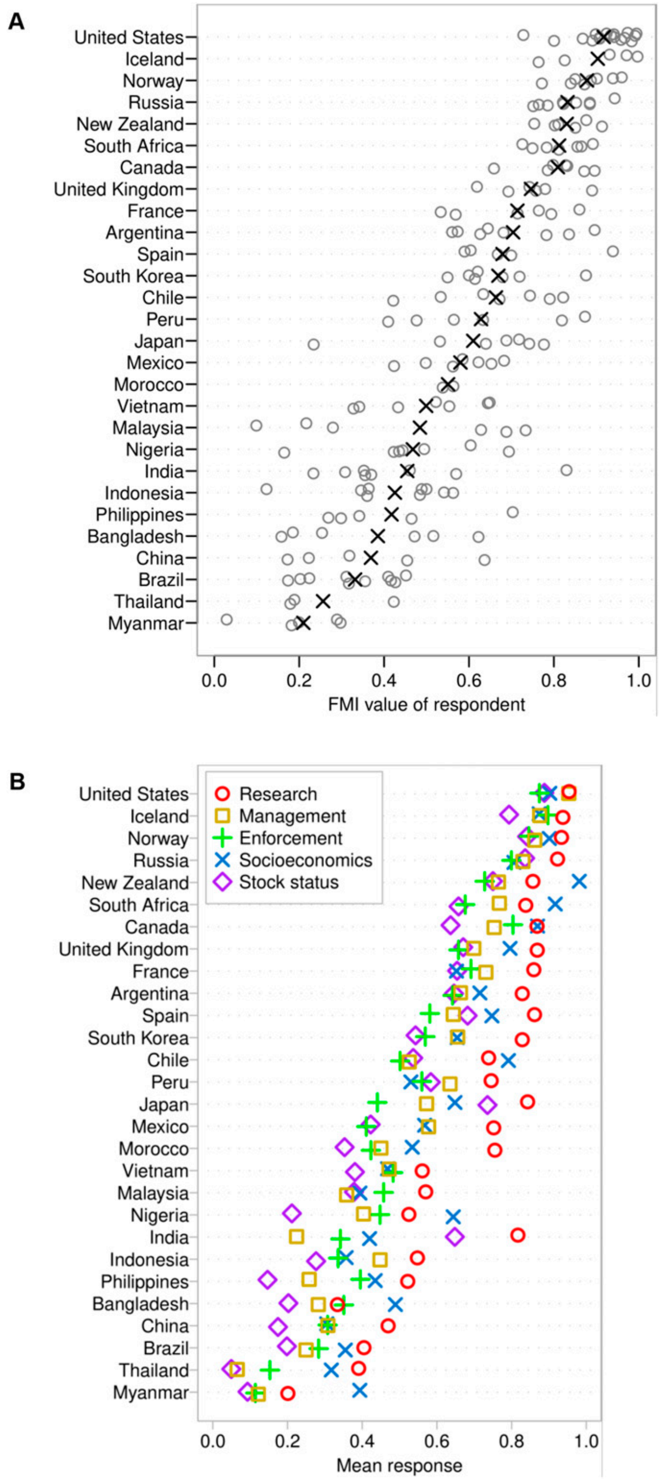

Fig. S2. Summarized survey answers and FMI values by country. FMI is a composite of research, management, enforcement, and socioeconomics dimensions with equal weighting. (*A*) Circles show mean FMI values of individual respondents' answers, weighted by the confidence score provided for individual questions, and adjusted for respondent background category using the random effect conditional mode estimates shown in Fig. S5*B*. The grand mean across respondents for each country is shown by "x" symbols, weighed by the level of expertise of respondents. (*B*) Unweighted and unadjusted summarized survey answers by dimension and country. Similar summaries that were weighted by both level of expertise of respondents and confidence in the answers provided for individual questions and that were adjusted for the background category of respondents were shown in Fig. 1.

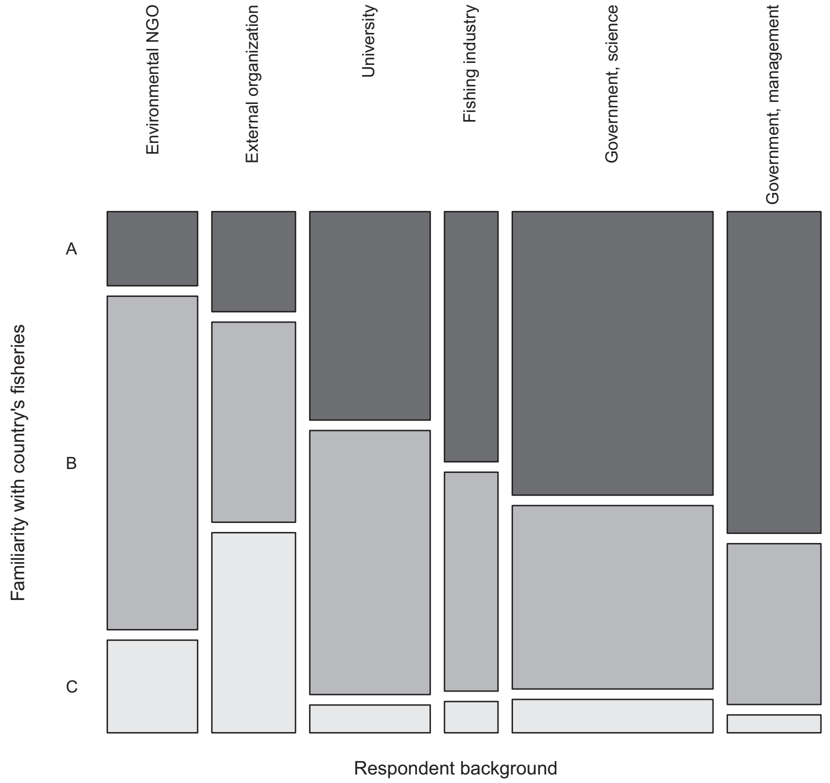

Fig. S3. Mosaic plot of respondent background category and self-identified level of familiarity with the country's fisheries. Bar widths are proportional to the number of respondents in each background category, ranging from 16 to 60 surveys (total n = 191 surveys completed by 182 individuals). Shading denotes levels of familiarity (A = expert, B = strong familiarity, C = moderate familiarity, D = limited familiarity).

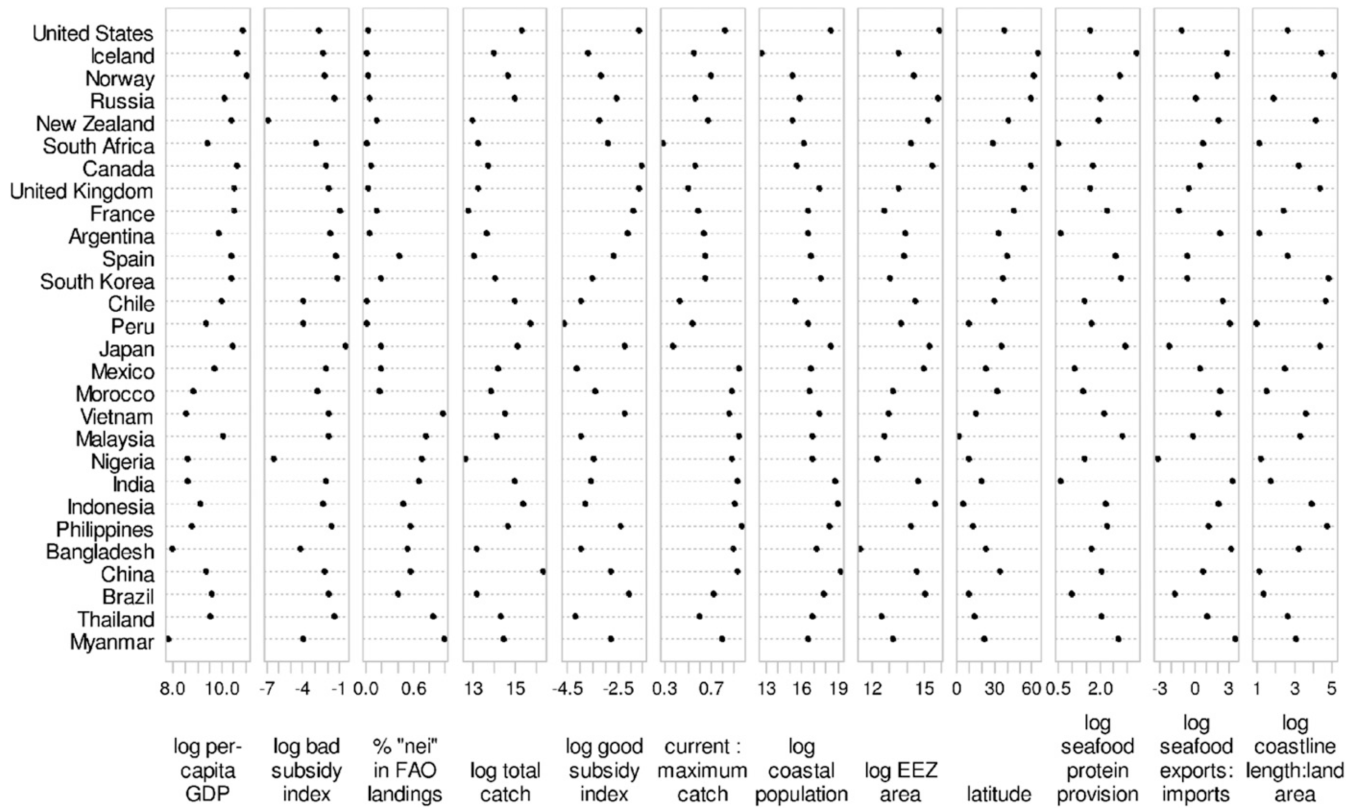

Fig. S4. Values by country of 12 numerical covariates considered in analysis. See Table S1 for a description of each variable including units. nei, not elsewhere included.

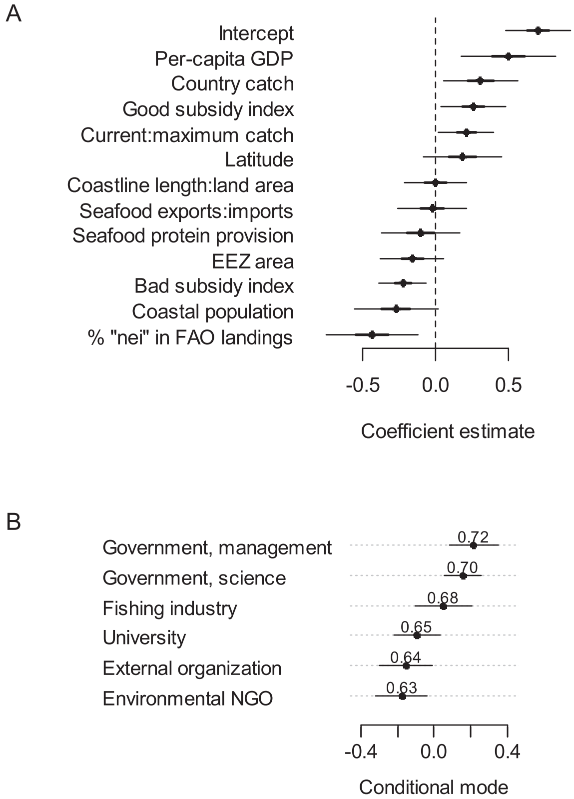

Fig. S5. Effect sizes of predictor variables on logit-transformed FMI values. Responses are weighted by both level of expertise of respondents and confidence in the answers provided for individual questions. (*A*) Estimated coefficients of standardized numerical fixed-effect covariates are shown with SDs (thicker bars) and 95% confidence limits (thinner bars). (*B*) Conditional modes of respondent background categories, treated as random intercepts, are shown with estimated SEs. Values above data points in *B* show back-transformed FMI values on the linear scale calculated at mean values of fixed-effect covariates. Descriptions of covariates in *A* are given in Table S1. nei, not elsewhere included.

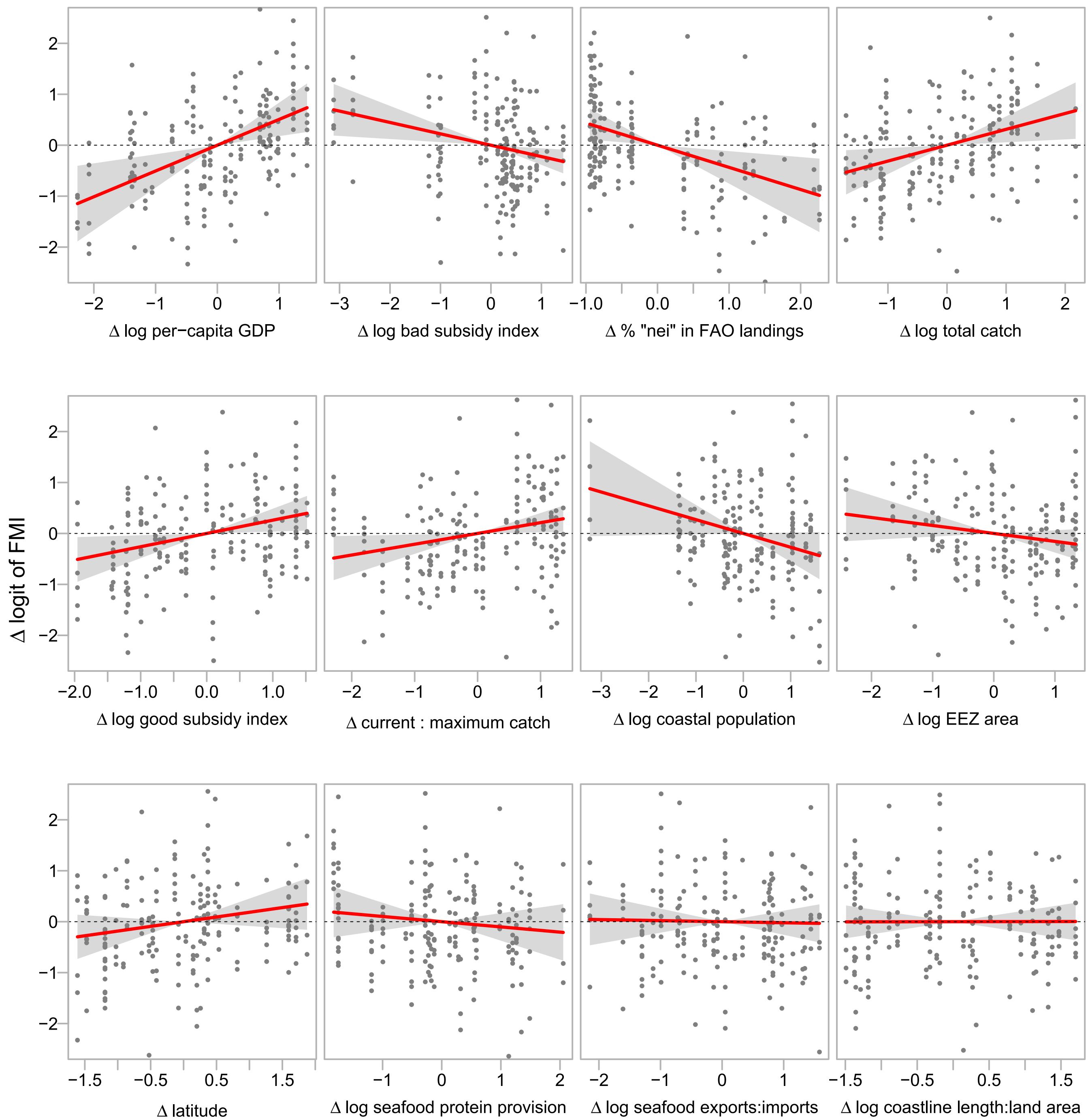

Fig. S6. Standardized effects of country-level numerical covariates on logit-transformed FMI values. FMI responses are weighted by both level of expertise of respondents and confidence in the answers provided for individual questions. All predictions (red lines) intersect [0,0] and show the change in logit(FMI) associated with a change in a standardized numerical covariate after accounting for effects of other predictors including random intercepts for respondent background category. Partial residuals and 95% confidence bands around predictions are shown. Overlap of confidence bands with dashed lines at 0 suggests no significant effect (α = 0.05) of the covariate on the FMI. Panels are sorted left to right by absolute values of *t*-statistics for predictor variables. nei, not elsewhere included.

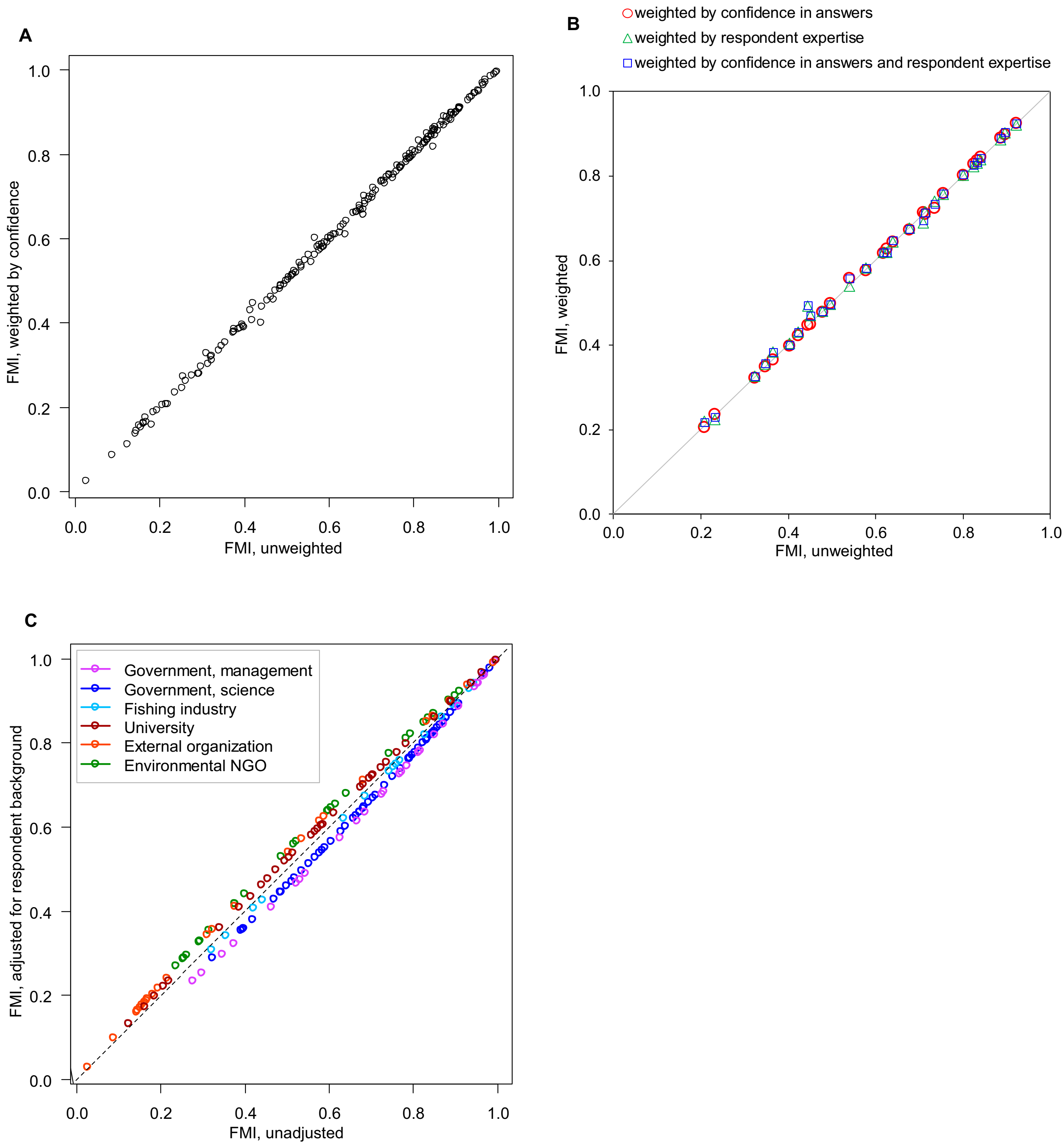

Fig. S7. FMI values calculated under different weighting schemes and adjustments. FMI is a composite of research, management, enforcement, and socio-economics dimensions with equal weighting. In all panels, values along horizontal axis are unweighted and not adjusted for respondent background category. (*A*) Values along vertical axis are weighted means of answers to individual questions within each dimension, weighted by the confidence scores provided for each answer (n = 191 surveys, r = 0.999). (*B*) Values along vertical axis are weighted by confidence scores in the answers provided for individual questions, by the self-identified level of familiarity of respondents with the country's fisheries ("expertise"), or by both (n = 28 countries, all r > 0.998). Confidence scores and respondent expertise were collected as qualitative categories (A, B, C, D) and assigned values of: A = 1.0, B = 0.8, C = 0.6, D = 0.4. (*C*) Values along vertical axis are adjusted for respondent background category using the random effect conditional mode estimates shown in Fig. S5*B*.

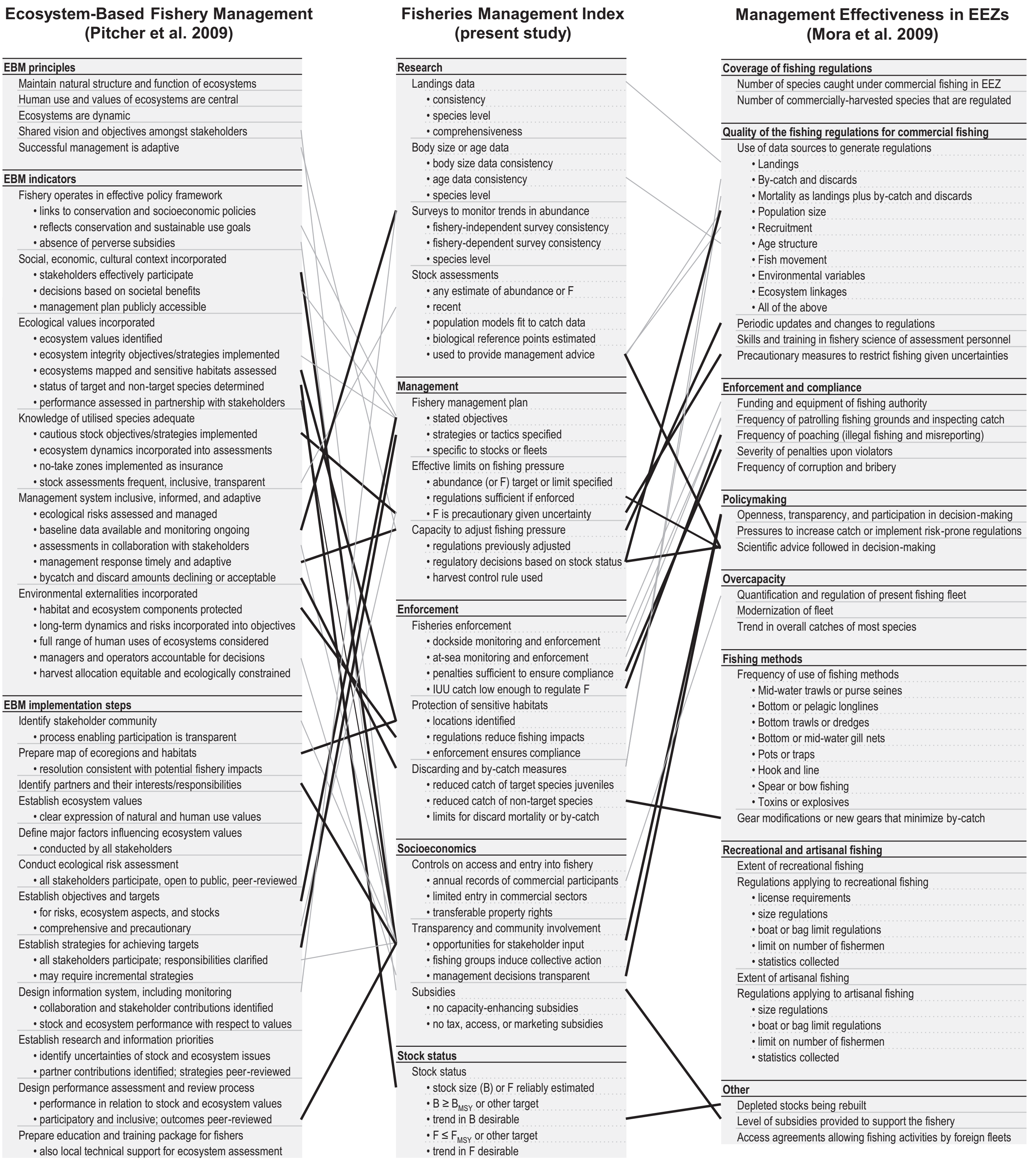

Fig. S8. Detailed comparison and overlap of individual criteria from the present study with criteria or survey questions from previous studies (19, 20). Lines join related criteria/questions between the present study (in the center) and previous studies (on both sides); thick black lines show strong overlap and thin gray lines show weaker overlap between paired criteria. Phrasing of criteria is abbreviated in all studies. EBM, ecosystem-based management.

Table S1. Descriptions of country-level numerical covariates considered as fixed effects in mixed-effect models for describing variation in FMI values

Variable	Description
Absolute latitude	Absolute value of average latitude of country (°).
Log EEZ area	Total area of country's main EEZ, excluding territories (km^2).
Log coastline length/land area	Ratio of coastline length to land area of country ($m \cdot km^{-2}$).
Log seafood protein provision	Fish and seafood protein supply ($g \cdot capita^{-1} \cdot d^{-1}$), reported by the FAO of the United Nations (30), values for 2011.
Log coastal population	Population within 25 km of coastline, reported by the OHI (21) and referencing the Gridded Population of the World (GPW) Population Density Grid Future Estimates reported by the Center for International Earth Science Information Network (Columbia University) and the Centro Internacional de Agricultura Tropical (31), values for 2014.
Log per-capita GDP	Purchasing power parity per-capita gross domestic product ($ current international), reported by World Bank (32), values for 2013.
Log total catch	Total landings (t) in FAO areas adjacent to the country's main EEZ (i.e., excluding distant-water catches), reported by FAO (25), average of 2007–2011.
Current/maximum catch	Ratio of current landings (average 2007–2011) in FAO areas adjacent to the country's main EEZ to the maximum historical total landings since 1950, reported by the FAO (25).
Percent "nei" groups in FAO landings	Proportion of total landings in FAO areas adjacent to the country's main EEZ comprised of "nei" (not elsewhere included) miscellaneous species groups, reported by the FAO (25), average of 2007–2011.
Log seafood exports/imports	Ratio of seafood exported value to seafood imported value, reported by the FAO (33), values for 2011.
Log "good" subsidy index	Beneficial subsidy index, calculated as beneficial subsidies (US$) per landed value (US$), subsidy values for 2003 (12), and landed values estimated from FAO landings (25) and price (26) data.
Log "bad" subsidy index	Capacity-enhancing subsidy index, calculated as capacity-enhancing subsidies (US$) per landed value (US$), subsidy values for 2003 (12), and landed values estimated from FAO landings (25) and price (26) data.

Table S2. FMI values and average values of research (R), management (M), enforcement (E), socioeconomics (S) and stock status (B) dimensions by country under different weighting and adjustment schemes

	Weighted and adjusted*						Unweighted and not adjusted†					
Country	FMI	R	M	E	S	B	FMI	R	M	E	S	B
Argentina	0.70	0.82	0.65	0.63	0.71	0.64	0.71	0.83	0.66	0.64	0.72	0.65
Bangladesh	0.39	0.35	0.30	0.38	0.51	0.20	0.36	0.33	0.28	0.35	0.49	0.20
Brazil	0.33	0.41	0.26	0.29	0.37	0.20	0.32	0.40	0.25	0.28	0.36	0.20
Canada	0.81	0.86	0.74	0.78	0.86	0.61	0.82	0.87	0.75	0.80	0.87	0.64
Chile	0.66	0.76	0.54	0.54	0.81	0.57	0.64	0.74	0.53	0.50	0.79	0.54
China	0.37	0.48	0.33	0.34	0.32	0.17	0.35	0.47	0.31	0.31	0.31	0.17
France	0.71	0.85	0.71	0.69	0.62	0.64	0.73	0.86	0.73	0.69	0.65	0.65
Iceland	0.90	0.94	0.88	0.91	0.88	0.81	0.90	0.94	0.88	0.90	0.87	0.79
India	0.46	0.83	0.24	0.37	0.41	0.64	0.45	0.82	0.22	0.34	0.42	0.65
Indonesia	0.43	0.56	0.45	0.34	0.36	0.28	0.42	0.55	0.45	0.34	0.36	0.28
Japan	0.61	0.83	0.55	0.43	0.64	0.74	0.63	0.84	0.57	0.44	0.65	0.74
Malaysia	0.48	0.60	0.42	0.52	0.41	0.42	0.45	0.57	0.36	0.46	0.39	0.38
Mexico	0.58	0.76	0.58	0.42	0.56	0.43	0.58	0.75	0.58	0.41	0.57	0.42
Morocco	0.55	0.74	0.45	0.43	0.59	0.34	0.54	0.76	0.45	0.42	0.53	0.35
Myanmar	0.21	0.22	0.12	0.11	0.39	0.09	0.21	0.20	0.12	0.11	0.39	0.09
New Zealand	0.83	0.84	0.75	0.74	0.99	0.75	0.83	0.86	0.77	0.73	0.98	0.75
Nigeria	0.47	0.54	0.37	0.43	0.65	0.19	0.48	0.53	0.40	0.45	0.64	0.21
Norway	0.88	0.93	0.84	0.85	0.90	0.84	0.89	0.93	0.86	0.85	0.90	0.84
Peru	0.63	0.75	0.66	0.57	0.53	0.60	0.62	0.75	0.64	0.56	0.53	0.58
Philippines	0.42	0.53	0.26	0.40	0.47	0.14	0.40	0.52	0.26	0.40	0.44	0.15
Russia	0.83	0.92	0.82	0.81	0.79	0.83	0.84	0.92	0.83	0.80	0.81	0.84
South Africa	0.81	0.85	0.78	0.69	0.93	0.67	0.80	0.84	0.77	0.68	0.92	0.66
South Korea	0.67	0.83	0.64	0.55	0.66	0.52	0.68	0.83	0.66	0.57	0.65	0.54
Spain	0.68	0.85	0.63	0.53	0.72	0.65	0.71	0.86	0.64	0.58	0.75	0.68
Thailand	0.26	0.45	0.07	0.15	0.33	0.04	0.23	0.39	0.07	0.15	0.32	0.05
U.K.	0.75	0.86	0.68	0.65	0.80	0.65	0.76	0.87	0.70	0.66	0.80	0.67
United States	0.92	0.95	0.95	0.87	0.90	0.88	0.92	0.95	0.95	0.87	0.90	0.89
Vietnam	0.50	0.57	0.49	0.48	0.46	0.39	0.50	0.56	0.47	0.48	0.47	0.38
Fixed-effect $R^{2‡}$	0.59	0.54	0.47	0.36	0.49		0.59	0.54	0.46	0.36	0.49	
Total model $R^{2‡}$	0.61	0.55	0.48	0.41	0.50		0.61	0.55	0.48	0.41	0.49	

*"Weighted and adjusted" consists of survey responses weighted by both confidence in answers to individual questions and respondent expertise, and adjusted to correct for difference among respondent background categories.

†"Unweighted and not adjusted" does not weight by either confidence or respondent expertise and does not adjust survey responses based on respondent background.

‡Conditional R^2 values of model fits are given for fixed effects and for total model fits including a random effect of respondent background category.

Dataset S1. Fishery management survey questionnaire

Dataset S1

Versions sent to respondents additionally contained a semirandomized list of 10 species caught by the country. Respondents provided answers to each criterion for each of the 10 species and a confidence level for the answers provided for each criterion. Detailed instructions are contained in the survey file.