

## Supplementary Material

### Strong fisheries management and governance positively impact ecosystem status

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File includes:

Table S1: Management Effectiveness and Governance Quality Survey Template, including instructions to experts and a glossary of terms.

Table S2: Weighting factors for estimation of average ecosystem compliance scores for multi-jurisdictional ecosystems .

Table S3: Additional social, economic, governing and ecological indicators used in BEST analysis.

Table S4: Spearman correlations between social and economic indicators for the 27 IndiSeas ecosystems. Acronyms are provided in Table S3. Indicators in bold were used in the BEST Analysis<sup>1</sup>.

Table S5: Average Scores for each of the 11 questions from the Management Effectiveness and Governance Quality Survey

Figure S1. Cluster analysis of the 11 Management Effectiveness and Governance Quality Survey results.

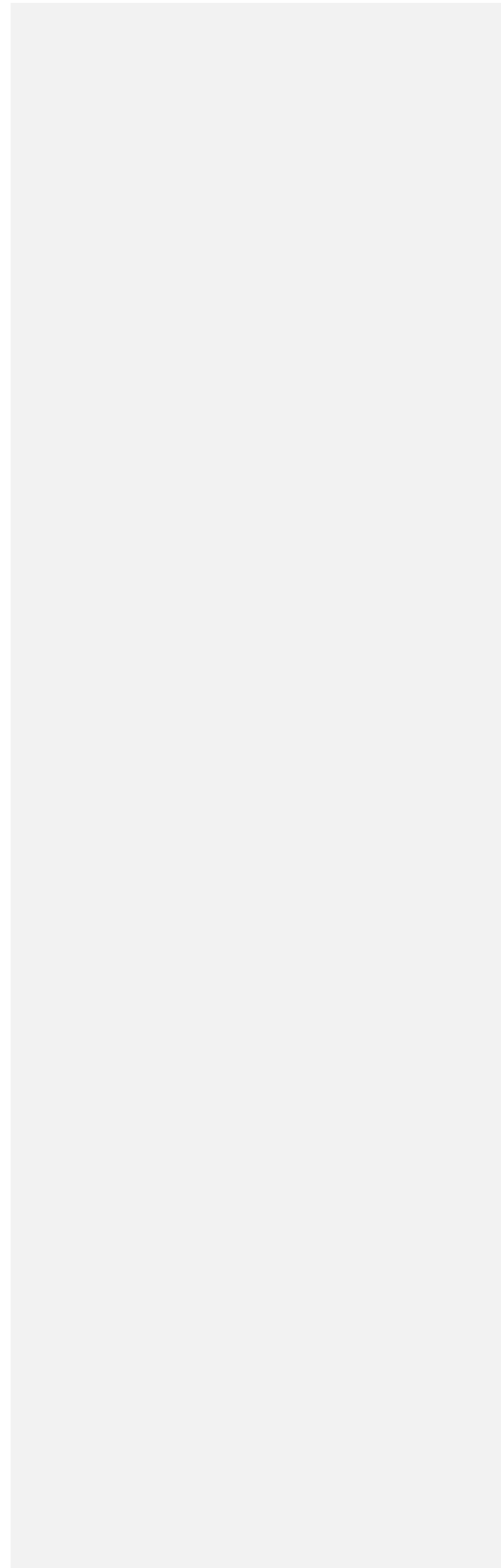


Table S2: Weighting factors for estimation of average ecosystem compliance scores for multi-jurisdictional ecosystems.

Ecosystem	Countries	Landings Source	Years	% contribution
Barents Sea	Norway	SAUP ( <a href="http://www.seaaroundus.org">http://www.seaaroundus.org</a> )	2004-2006	52
	Russia	SAUP ( <a href="http://www.seaaroundus.org">http://www.seaaroundus.org</a> )		48
Central Baltic Sea	Finland	SAUP ( <a href="http://www.seaaroundus.org">http://www.seaaroundus.org</a> )	2000-2010	13
	Germany	SAUP ( <a href="http://www.seaaroundus.org">http://www.seaaroundus.org</a> )		6
	Latvia	SAUP ( <a href="http://www.seaaroundus.org">http://www.seaaroundus.org</a> )		10
	Lithuania	SAUP ( <a href="http://www.seaaroundus.org">http://www.seaaroundus.org</a> )		2
	Russia	SAUP ( <a href="http://www.seaaroundus.org">http://www.seaaroundus.org</a> )		6
	Denmark	SAUP ( <a href="http://www.seaaroundus.org">http://www.seaaroundus.org</a> )		14
	Estonia	SAUP ( <a href="http://www.seaaroundus.org">http://www.seaaroundus.org</a> )		9
	Poland	SAUP ( <a href="http://www.seaaroundus.org">http://www.seaaroundus.org</a> )		22
	Sweden	SAUP ( <a href="http://www.seaaroundus.org">http://www.seaaroundus.org</a> )		19
	English Channel	UK		ICES ( <a href="http://www.ices.dk">http://www.ices.dk</a> )
France		ICES ( <a href="http://www.ices.dk">http://www.ices.dk</a> )	60	
Netherlands		ICES ( <a href="http://www.ices.dk">http://www.ices.dk</a> )	24	
Irish Sea	Ireland	ICES ( <a href="http://www.ices.dk">http://www.ices.dk</a> )	2000-2011	32
	UK	ICES ( <a href="http://www.ices.dk">http://www.ices.dk</a> )		68
North-central				
Adriatic Sea	Italy	GCFM ( <a href="http://www.fao.org/gfcm">http://www.fao.org/gfcm</a> )	2000-2010	68
	Croatia	GCFM ( <a href="http://www.fao.org/gfcm">http://www.fao.org/gfcm</a> )		32
North Aegean	Greece	GCFM ( <a href="http://www.fao.org/gfcm">http://www.fao.org/gfcm</a> )	2000-2010	64

Sea				
	Turkey	GCFM ( <a href="http://www.fao.org/gfcm">http://www.fao.org/gfcm</a> )		36

Table S3. Additional social, economic, governance and ecological indicators used in BEST analysis. <sup>1</sup>See descriptions below.

TYPE <sup>1</sup>	Ecosystem/National Indicators	Source	# ecosystems for which data is available
(i)	1. HDI: Human Development Index	International Human Development Indicators–UNDP <a href="http://hdr.undp.org/en">http://hdr.undp.org/en</a> accessed February 2016	27
	2. IHDI: Inequality-adjusted HDI value		
	3. HDI-Loss: Loss due to inequality in income (%)		
	4. EDUC: Mean years of schooling (adults, years)		
	5. Research and Development: R&D-(% of GDP):average 2006 - 2012		
(ii)	6. Fisheries Subsidies: % GDP (SUBS)	Khan et al. (2006)	27
	7. BAD Fisheries Subsidies: % GDP (B-SUBS)		
	8. Voice and Accountability (V&A)	The Worldwide Governance Indicators The World Bank Kaufman et al.,2011	27
	9. Political Stability and Absence of Violence/Terrorism (PS)		
10. Government Effectiveness (GE)			

Code de champ modifié

	11. Regulatory Quality (RQ)	<a href="http://www.govindicators.org">www.govindicators.org</a>	
	12. Rule of Law (RL)	accessed February	
	13. Control of Corruption (CC)	2016	
(iii)	14. Ecosystem Size	<a href="http://www.indiseas.org">www.indiseas.org</a>	27
		accessed February	
		2016	
	15. Sustainable Stocks (SS): Proportion of moderately and underexploited species as defined by FAO.  Calculated as the number of under plus moderately exploited stocks as a proportion of the total number of stocks in the ecosystem.	Shin et al. 2010;  Coll et al. 2016	25
	16. NDES: Non-Declining Exploited Species  Calculated as the proportion of exploited species in the ecosystem with a non-declining biomass over time. Biomass trends were estimated by calculating the Kendall's tau coefficient for each exploited species in an ecosystem with time series of biomass data.	Kleisner et al. 2015	18

	<p>17. IndiSeas 1 Results (-1,0,+1)</p> <p>Aggregate indicator of ecosystem status based on synthesis of indicators trends relative to an initial state. Ecosystems were classified as deteriorating (-1), stationary (0) or improving (1).</p>	Bundy et al. 2012	13
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## **Description of Additional Ecosystem Characteristics**

### **(i) Social and economic indicators**

The UNDP International Human Development Indicator (HDI) is comprised of metrics that attempt to capture the “key achievements in human development: education (mean and expected years in school), health (life expectancy at birth), and income (per capita annual gross national income (GNI)), UNDP (2013). We considered the complete HDI (all indicators) and an inequality adjusted HDI (I-HDI), whereby the health, education, and income scores for each country are discounted by the level to which those achievements are distributed among its population, and the “loss” in potential human development due to inequality. This loss is calculated as the difference between the HDI and the I-HDI (HDI-Loss). We also considered the mean years of schooling indicator from the HDI on its own since it is a less complex indicator and easier to understand than the full HDI. Similarly, we considered the research and development expenditure indicator independently, since this metric contextualises the research environment in which fisheries science may take place, and is an important metric for management success. These data were extracted from the 2013 UNDP HDI report for 2012 (UNDP 2013).

### **(ii) Governance Indicators**

The Worldwide Governance Indicators (WGI) are a composite of hundreds of different measures that assess, in very broad but comprehensive terms, the social structure and functioning of 215 countries over the period from 1996-2014, scoring them along six component composite indicators: (1) Control of Corruption, (2) Government Effectiveness, (3) Political Stability and Absence of Violence, (4) Regulatory Quality, (5) Rule of Law, (6) Voice and Accountability, (Kaufman et al. 2011). We evaluated each of the six WGI components as individual indicators. The WGI attempts to comprehensively capture the differences between the type and process of selection and monitoring of governments, the capacity for effective governance and rule setting and enforcement, and the deference of government officials and



citizens for the governing institutions. WGI data were downloaded from [www.govindicators.org](http://www.govindicators.org) and an average taken for the years 2004-2013.

Fisheries subsidies, financial help from the State or other public entities to reduce the cost of fishing, can lead, directly or indirectly, to overexploitation of fishery resources through over-capacity. Khan et al (2006) in their assessments of global fisheries subsidies identified three forms of subsidy: good, bad and ugly. We used their estimates of total subsidies (SUBS) and bad subsidies (B-SUBS), expressed as the proportion of the landed value of the catch, as a measure of governance specific to fisheries. These data were only available for the year 2000 (Khan et al. 2006).

### (iii) Ecological Indicators

The IndiSeas program has explored a suite of ecological indicators to assess the status of exploited marine ecosystems (Shin et al., 2010, 2012). To characterize the ecological status of ecosystems, we selected four indicators that capture different aspects of the ecosystem: ecosystem size ([www.indiseas.org](http://www.indiseas.org)); an indicator of stock status (Sustainable Stocks: SS), which is a measure of the proportion of stocks that are under or moderately exploited (Shin et al. 2010; Coll et al. 2016); an ecosystem level indicator, the proportion of exploited species that are not declining ('Non-Declining Exploited Species': NDES, Kleisner et al. 2015) and an IndiSeas aggregate indicator of status, "ES" (Bundy et al. 2012), which provides an overall synthesis of the IndiSeas results published in 2010 (Shin and Shannon 2010) using a suite of eight ecological indicators (which includes SS, but not Size or NDES). "ES" has 3 possible outcomes: +1, which indicates an improving ecosystem status, 0, which indicates that there was no detected change in status and -1, which indicates a degrading status.

Table S4. Spearman correlations between social and economic indicators for the 27 IndiSeas ecosystems. Acronyms are provided in Table S3.

Indicators in bold were used in the BEST Analysis<sup>1</sup>.

	<b>Size</b>	<b>HDI</b>	IHDI	HDI-Loss	EDUC	<b>R&amp;D</b>	SUBS	<b>B-SUBS</b>	V&A	<b>PS</b>	GE	RQ	RL
HDI	0.20												
IHDI	0.17	0.97											
HDI-Loss	-0.12	-0.83	-0.92										
EDUC	0.33	0.91	0.91	-0.79									
R&D	0.49	0.68	0.74	-0.72	0.76								
SUBS	-0.17	0.35	0.41	-0.47	0.17	0.38							
B-SUBS	-0.39	0.05	0.13	-0.27	-0.19	0.07	0.85						
V&A	0.21	0.82	0.86	-0.83	0.86	0.72	0.22	-0.07					
PS	0.25	0.69	0.74	-0.78	0.74	0.67	0.20	-0.04	0.84				
GE	0.31	0.87	0.90	-0.86	0.88	0.86	0.28	0.01	0.91	0.86			
RQ	0.29	0.90	0.92	-0.86	0.91	0.80	0.23	-0.08	0.95	0.84	0.97		
RL	0.24	0.86	0.91	-0.88	0.86	0.84	0.30	0.04	0.92	0.87	0.99	0.97	
CC	0.31	0.79	0.85	-0.86	0.84	0.82	0.15	-0.08	0.90	0.86	0.96	0.95	0.97

<sup>1</sup>The UNDP International Human Development Indicators HDI, IHDI, HDI-Loss and EDUC had absolute Spearman rank correlations,  $\rho$  between 0.79-0.97. Only the HDI was retained for further analysis, since it is a widely known indicator. Correlations between “Research and Development” and the other UNDP indicators ranged from 0.68 to 0.75, and so it was considered sufficiently different and retained. The Worldwide Governance Indicators were all highly correlated with each other, with an average Spearman rank correlation of 0.92, (range 0.84-0.99). Of the six indicators, ‘Voice and Accountability’ and ‘Political Stability and Absence of Violence/Terrorism’ were least correlated ( $\rho=0.84$ ). Since the WGI were also highly correlated with the UNDP International Human Development Indicators ( $\mu=0.85$ , range 0.69-0.92), the WGI that was least correlated, ‘Political Stability and Absence of Violence/Terrorism’ (average  $\rho=0.74$ ), was selected to represent the Worldwide Governance Indicators. The two fisheries subsidies indicators (Subsidies and Bad-Subsidies) were correlated with one another ( $\rho=0.85$ ), so only Bad-Subsidies was selected, since this represents the most negative aspects of fisheries subsidies (Khan et al. 2006).

Table S5. Average Scores for each of the 11 questions from the Management Effectiveness and Governance Quality Survey

		Median	Average	Stdev	MAX	MIN	Mode
1	Frq stock assessments?	4.18	4.04	0.93	5	1.5	5
2	Reference points?	3.00	3.04	1.17	5	1	5
3	Depleted stocks?	3.50	3.44	1.43	5	1	5
4	Frequent review?	3.68	3.38	1.19	5	1	2
5	Ecosystem impacts addressed?	3.00	2.59	0.64	4	1	3
6	IUU addressed?	4.00	3.37	1.27	5	1	4
7	Minimize conflict?	3.50	3.39	1.22	5	1	5
8	Long term objectives*?	3.00	2.96	1.49	5	1	2
9	Social impacts?	2.00	<b>2.21</b>	1.06	4.85	1	2
10	Economic impacts?	2.00	2.65	1.12	5	1	2
11	Harvesting sector participation?	3.00	3.13	1.39	5	1	5

Table S6. Variable scores on the first three principle components of the PCA of 11 IndiSeas Ecosystems based on additional ecosystem characteristics from BEST 4. Bold numbers indicate higher loadings on the principle components.

Additional Ecosystem Indicator	PC1	PC2	PC3

1	Size	-0.204	<b>-0.574</b>	<b>0.780</b>
2	HDI	-0.303	<b>0.649</b>	0.460
3	SS	<b>-0.574</b>	-0.160	-0.160
4	NDES	<b>-0.520</b>	0.345	-0.009
5	ES	<b>-0.516</b>	-0.323	-0.392

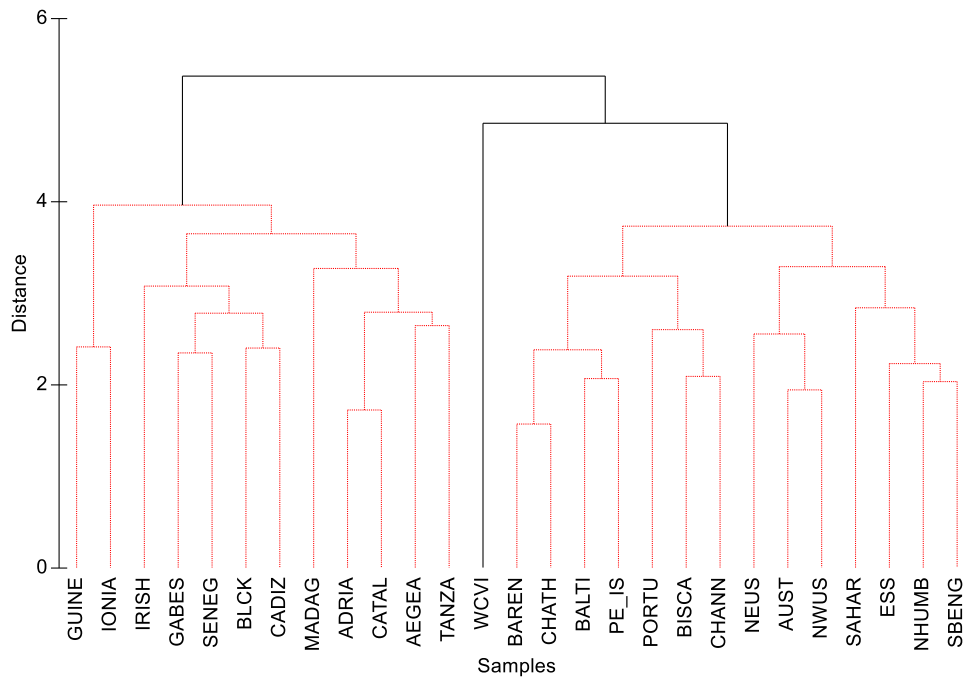


Figure S1. Cluster analysis of the 11 Management Effectiveness and Governance Quality Survey results.

Solid lines represent significant cluster, red dashed lines represent non-significant clusters (using the SIMPROF test).

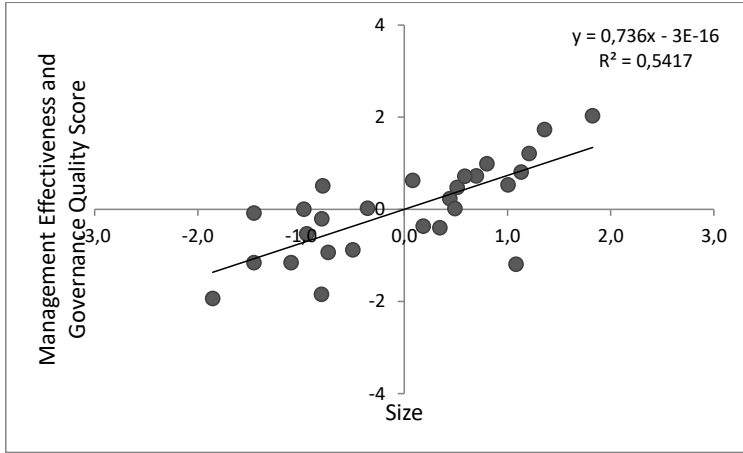


Figure S2. Standardised average Management Effectiveness and Governance Quality Survey scores plotted against ecosystem size (squareroot transformed and standardised)