Unmasking the Threat to Property Rights: Unauthorized Fishing Activity during the COVID-19 Pandemic

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The SDG^nexus Network, supported by the DAAD with funds of the German Federal Ministry for Economic Cooperation (BMZ).

Overview

- **Question:** How does the level of compliance with property rights by commercial vessels **change in the face of economic shocks**?
- **Approach:** A Two-Way Fixed Effect (TWFE) Model, using the lockdowns during the COVID-19 pandemic as a quasi-experiment. I exploit the heterogeneity in the implementation of lockdowns across countries, disaggregating fishing activity into authorized and unauthorized segments.
- **Goal:** To study the fishing behavior and the change in the level of compliance of commercial vessels in response to economic or social shocks.

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Agenda

1. Motivation
2. Data and empirical model
3. Results
4. Final Remarks

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Motivation

Why Should We Care About the Marine Resources and Fishing Sector?

1. **According to FAO (2020), more than three billion people depend on marine resources.**
   - 38.98 million people worldwide depend on fishing for their livelihood.
   - Fish consumption equivalent to 20.3 kg/year per person.
     - The fish trade is estimated at 168 trillion dollars (2018).
     - 11% of total agricultural trade.
2. **Additionally, oceans absorb 40% of emitted carbon dioxide in the atmosphere** (DeVries et al., 2017)**.**
3. **However, overfishing jeopardizes ecosystem sustainability and economic stability** (FAO, 2020)**.**
   - 34.6% of fishing occurs outside sustainability standards.
   - The cost of overfishing is estimated at 32 trillion dollars.
   - The total value of current Illegal, Unreported and Unregulated (IUU) fishing losses worldwide are between $10 bn and $23.5 bn annually (Agnew et al., 2009)

Motivation

Exclusive Economics Zones as Property Rights and Fishing Access

The Exclusive Economic Zones (EEZ) are property rights instruments that each country has over maritime resources, and their coverage is up to 200 nautical miles from the coast (United Nations Conference on the Law of the Sea, 1973–82)**.**

- EEZ cover approximately 39% of the ocean surface, and where more or less 95% of the global fish catch (Englander, 2019).
- EEZs grant all the exploitation rights to the country.
- Each country has the autonomy to prohibit or negotiate the access of foreign vessels within its borders, in addition to defining the terms within which fishing activity is allowed.
- In accordance with international agreements, unauthorized vessels that are apprehended are required to adhere to fines and economic sanctions.

There is evidence of the existence of a deterrent effect in the reduction of unauthorized fishing efforts.

▸ (Englander, 2019)

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Motivation

COVID-19 pandemic, lockdowns measures and commercial fishing activity

In some regions, the implementation of lockdowns led to the disruption of supply chains and the constrained progression of routine economic activities, exerting potential influence on the dynamics of fishing activities (Gaspar et al., 2020).

- Lockdowns were effective in containing the contagion indicators, however, they generated adverse economic shocks (Chen et al., 2021)
- The closure of markets and restrictions on transportation generated a negative impact on the commercial fishing industry; in addition to the decrease in demand for seafood (Macusi et al., 2022).
- In some regions, COVID-19 pandemic reduced monitoring and control capabilities (Quimbayo et al., 2022)
- Despite the implications of the COVID-19 pandemic, most fisheries did not present considerable changes in effort levels; Furthermore, there was no evidence that commercial fishing had been prohibited (Lindley-Smith et al., 2020).

▸ Trends

Research questions

How does the level of compliance with property rights by commercial vessels change in the face of economic shocks?

- **Q1:** What was the effect of COVID-19-related mobility measures on commercial fishing activity?
- **Q2:** What factors can explain changes in the level of compliance by commercial fishing vessels?

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Contribution

What do I find?

- There is no evidence that the fishing activity of national (authorized) vessels was altered by the pandemic.
- Evidence of an increase in unauthorized fishing is found, **especially in low and middle-income countries**. Results reveal heterogeneous effects depending on the **health of the ecosystems**.
- **The evidence suggests that commercial fishing vessels are responsive to economic incentives**.

I contribute to the literature on property rights and IUU fishing activity by studying the effects of the COVID-19 pandemic on economic activity in fishery sector (Russo et al., 2021; March et al., 2021; Gold et al., 2023)**.**

- I provide empirical evidence of the behavior of commercial vessels globally during COVID-19 pandemic with data at a weekly level.
- This article is the first to address the question of the effects that the heterogeneities associated with lockdowns during the pandemic had on compliance with maritime regulations through a **global** causal estimation **disaggregating by authorization**.

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Data and empirical model

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Data

Global Fishing Watch ▸ Detection

Information on fishing efforts and the characteristics of commercial vessels on a weekly basis for 2019 and 2020.

Exclusive Economic Zones ▸ Map

Information from the Marine Regions Repository, which provides data on the geographic boundaries of EEZs for 146 coastal countries.

Oxford COVID-19 Government Response Tracker ▸ Stringency Index

Information on the restrictions related to the COVID-19 per day for each country: Stringency Index, internal mobility restrictions, workplace closures and stay-at-home measures.

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Data

Sea Around Us - Internal Fishing Access Agreements

Using this data, I create a variable indicating whether the fishing conducted by a vessel from one country in another country in a given year is authorized or unauthorized, taking into account the year of agreement termination.

Additional Data

USAF Climatology Center obtained from the National Oceanic and Atmospheric Administration (NOAA): Temperature, wind speed and precipitation.

▸ Descriptive Statistics

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Empirical model

Two Way Fixed Effect Model

$$Y_{ijzt} = \beta SI_{zt} + \gamma X_{it} + \alpha_z + \tau_t + \epsilon_{ijzt} \tag{1}$$

Where Y_{ijzt} is the outcome variable, which represents the total number of fishing hours or the number of vessels conducting fishing from country i, of type j, in EEZ z (or its influence area) in week t. SI_{zt} is the treatment variable representing the stringency index, X_{it} is a vector of observable time-varying covariates such as temperature, wind speed, and precipitation. α_z and τ_t are fixed effects for EEZ/country and week, respectively. ϵ_{ijzt} represents the error term with robust standard errors.

$$Y_{ijzt} = \tau D_{zt} + \gamma_z + \gamma_t + \gamma_{ijt} + \epsilon_{ijzt} \tag{2}$$

Y_{ijzt} indicates the fishing activity variable for authorized and unauthorized vessels. D_{zt} is an indicative variable that takes the value of 1 when the stringency index becomes positive and 0 otherwise.

Considering timing heterogeneity, I present the estimations from Callaway & Sant'Anna (2021).

Results

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Main findings

Lockdown Measures Effects on Commercial Fishing

Table 1: TWFE Model: Stringency index and industrial fishing activity

	All		Quintiles							
			1st		2nd		3rd		4th	
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
Panel A. Total Fishing Efforts										
Stringency index	-5.55**	-6.56**	-0.10	0.30	-0.29	-0.44	0.16	-0.18	-22.44***	-22.7***
	(2.22)	(2.65)	(0.29)	(0.28)	(0.76)	(0.80)	(1.10)	(1.21)	(7.45)	(8.43)
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
EEZ and week FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	103,258	95,566	25,989	22,479	27,103	25,549	25,366	22,999	24,800	24,539
Panel B. Total MMSI										
Stringency index	-7.5**	-9.15**	-0.04	0.32	0.22	-0.09	-0.14	-0.88	-30.1**	-31.01**
	(3.81)	(4.54)	(0.36)	(0.41)	(0.90)	(0.94)	(1.61)	(1.78)	(13.8)	(14.2)
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
EEZ and week FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	103,258	95,566	25,989	22,479	27,103	25,549	25,366	22,999	24,800	24,539

Note: * p<.10, * p<.05, ** p<.01. Results of the Two-Way Fixed Effects Model were estimated using the 'reghdfe' command in Stata. Robust standard errors are reported in parentheses. Control variables include temperature, wind speed, and precipitation.

Main findings

Lockdown Measures Effects on Commercial Fishing

Table 2: TWFE model: First change of stringency index and commercial fishing activity

	Authorized			Unauthorized		
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Panel A. Total Fishing Efforts						
1. Stringency index	22.17	-1.608	-1.690	-18.58*	74.8	77.92*
	(152)	(2.873)	(2.897)	(9.95)	(45.6)	(45.7)
Controls	No	No	Yes	No	No	Yes
FE	*z*	*z, t, ijt*	*z, t, ijt*	*z*	*z, t, ijt*	*z, t, ijt*
Observations	26.156	9.928	9.928	14.437	9.164	9.164
Panel B. Total MMSI						
1. Stringency index	63.16	-3.275	-3.400	-12.64	25.9	27.7
	(247)	(4.862)	(4.907)	(10.3)	(46.7)	(46.6)
Controls	No	No	Yes	No	No	Yes
FE	*z*	*z, t, ijt*	*z, t, ijt*	*z*	*z, t, ijt*	*z, t, ijt*
Observations	26.156	9.928	9.928	14.437	9.164	9.164

Note: * p<.10, * p<.05, ** p<.01. The dependent variable is fishing activity in Panel A, and total MMSI vessels in Panel B. Each column presents the results of an TWFE estimate. Controls and fixed effects by date, eez, flag and gear type are included. Robust standard errors in parentheses. Control variables include temperature, wind speed, and precipitation.

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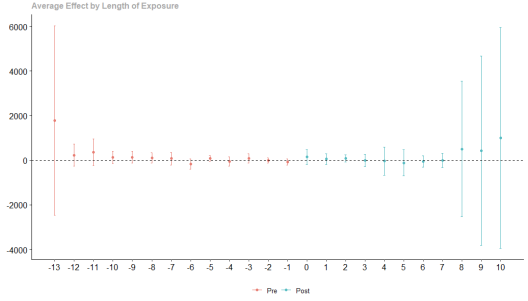
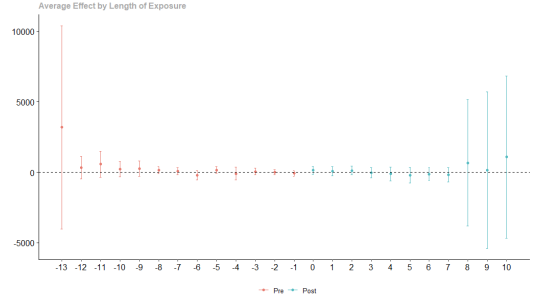
Robustness check

Lockdown Measures Effects on Authorized Commercial Fishing



(a) Total Fishing Efforts



(b) Total MMSI

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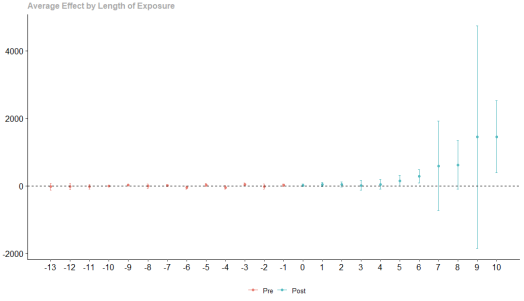
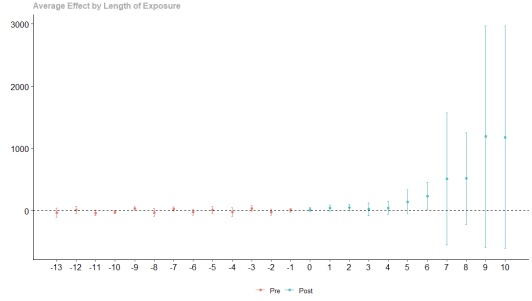
Robustness check

Lockdown Measures Effects on Unauthorized Commercial Fishing



(a) Total Fishing Efforts



(b) Total MMSI

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Heterogeneity Analysis

Lockdown Measures Effects on Commercial Fishing by Income levels

Table 3: TWFE model: First change of stringency index and commercial fishing activity by income levels

	Authorized		Unauthorized	
	(1)	*(2)*	*(3)*	*(4)*
Panel A. Total Fishing Efforts				
1. Stringency index	-1.829	-1.872	16.1	17.5
	(1.766)	(1.797)	(59.9)	(60.3)
1.Stringency index * Low and Middle Income	1.511	1.920	123.7**	131.1**
	(2.987)	(2.994)	(59.9)	(62.1)
Controls	No	Yes	No	Yes
FE	*z, t, ijt*	*z, t, ijt*	*z, t, ijt*	*z, t, ijt*
Observations	9.174	9.174	7.048	7.048
Panel B. Total MMSI				
1. Stringency index	-2.845	-2.972	-10.6	-8.33
	(3.071)	(3.138)	(74.1)	(74.5)
1.Stringency index * Low and Middle Income	759	1.670	94.2	94.1
	(4.978)	(4.958)	(63.5)	(64.9)
Controls	No	Yes	No	Yes
FE	*z, t, ijt*	*z, t, ijt*	*z, t, ijt*	*z, t, ijt*
Observations	9.174	9.174	7.048	7.048

Note: * p<.10, * p<.05, ** p<.01. The dependent variable is fishing activity in Panel A, and total MMSI vessels in Panel B. Each column presents the results of an TWFE estimate. Controls and fixed effects by date, eez, flag and gear type are included. Robust standard errors in parentheses. Control variables include temperature, wind speed, and precipitation.

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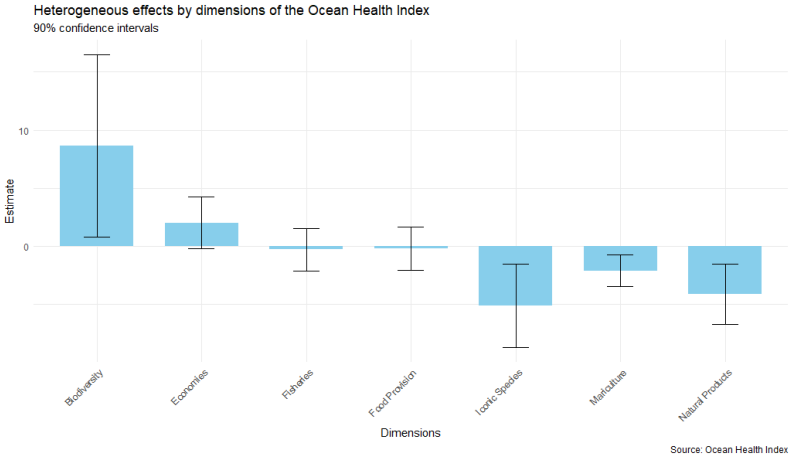
Heterogeneity Analysis

Lockdown Measures Effects on Commercial Fishing by Ocean Health Index



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Heterogeneity Analysis

Economic Support Effects on Commercial Fishing

Table 4: TWFE model: First change of economic support index and commercial fishing activity

	Authorized			Unauthorized		
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Panel A. Total Fishing Efforts						
1.Economic support index	286.9**	-8.871	-8.976	-2.65	-81.15**	-87.36**
	(139.4)	(5.527)	(5.536)	(6.68)	(40.23)	(40.45)
Controls	No	No	Yes	No	No	Yes
FE	*z*	*z, t, ijt*	*z, t, ijt*	*z*	*z, t, ijt*	*z, t, ijt*
Observations	32.268	11.580	11.580	18.799	11.358	11.358
Panel B. Total MMSI						
1.Economic support index	305.7	-11.089	-11.320	6.69	-57.29*	-60.28*
	(212.9)	(8.732)	(8.751)	(7.09)	(31.93)	(32.04)
Controls	No	No	Yes	No	No	Yes
FE	*z*	*z, t, ijt*	*z, t, ijt*	*z*	*z, t, ijt*	*z, t, ijt*
Observations	32.268	11.580	11.580	18.799	11.358	11.358

Note: * p<.10, * p<.05, ** p<.01. The dependent variable is fishing activity in Panel A, and total MMSI vessels in Panel B. Each column presents the results of an TWFE estimate. Controls and fixed effects by date, eez, flag and gear type are included. Robust standard errors in parentheses. Control variables include temperature, wind speed, and precipitation.

Key points...

1. **There is no evidence that the fishing activity of national vessels was altered by the pandemic.** On the margin, a higher stringency index is associated with lower total fishing activity, however, the onset of the lockdown measures had no effect on authorized fishing efforts.

2. **Economic supports contributed to the reduction of unauthorized fishing efforts.** Commercial fishing vessels are responsive to economic incentives.

3. The analysis of heterogeneity reveals that **a greater increase in unauthorized fishing efforts is observed in low- and middle-income countries**. Furthermore, **the healthier the ecosystem, the greater the increase in unauthorized fishing efforts.**

4. The existence and proper management of iconic species are associated with a lower level of unauthorized fishing, as is the proper management of natural products. It is found that **regions with a higher level of mariculture development experienced reductions in unauthorized fishing.**

5. **To deepen our understanding of these findings, further research is needed to explore the underlying mechanisms driving the observed patterns.**

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Thank you

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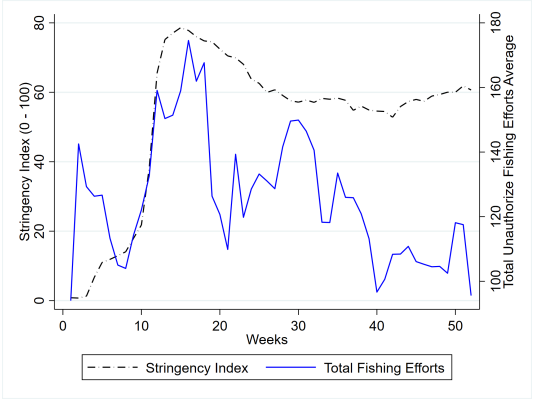
Motivation

Evolution of unauthorized commercial fishing activity



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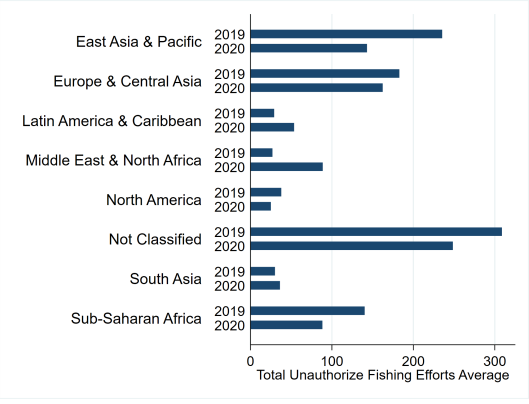
Motivation

Evolution of unauthorized commercial fishing activity



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Property rights and the protection of global marine resources

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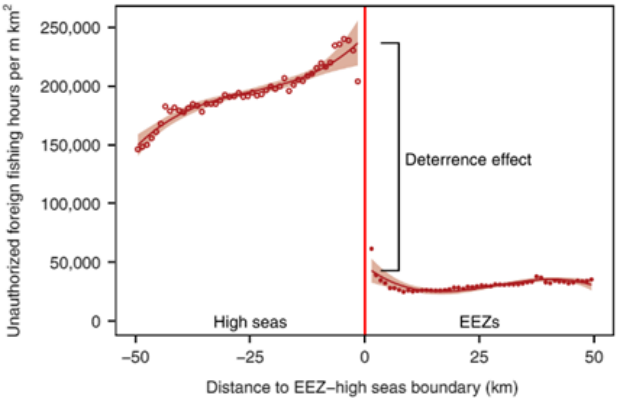

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Global Fishing Watch: Monitoring system

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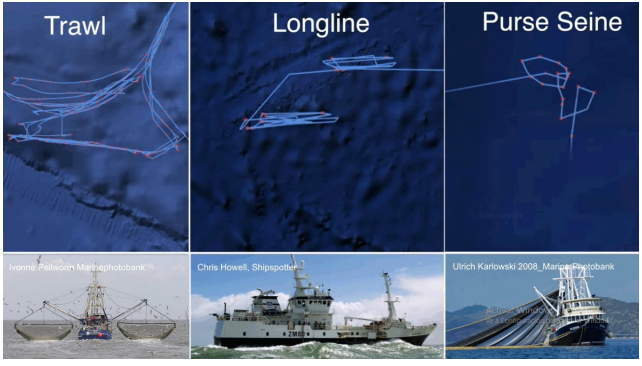
Global Fishing Watch: Monitoring system



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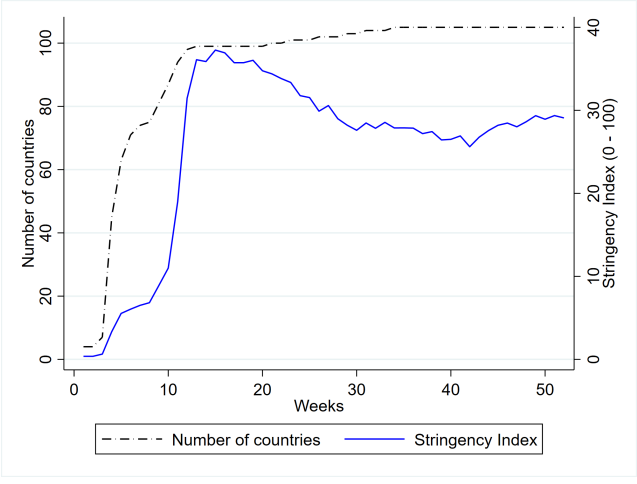
Stringency Index

Table 5: Stringency index components

Number	Components	Description
1	School closing	Record closing of schools and universities
2	Workplace closing	Record closing of workplaces
3	Cancel public events	Record canceling public events
4	Restrictions on gathering	Record the cut-off size for bans on private gatherings
5	Close public transport	Record closing of public transport
6	Stay at home requirement	Record orders to "shelter-in-place" and otherwise confine to home
7	Restrictions on internal movement	Record restrictions on internal movements
8	International travel controls	Record restrictions on international travel
9	Public info campaigns	Record presence of public info campaigns

Source: Dang & Trinh (2021). Note: Each component is measured on an ordinal scale (e.g., 0-no measure, 1-recommended closing, 2-require partial closing, 3-require closing all levels). It is then rescaled by the maximum value to create a score between 0 and 100. These scores are then averaged to obtain the stringency index. The stringency index is measured by the OxCGRT team as a simple average of individual component indicators.

Stringency Index



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Map of Exclusive Economic Zones

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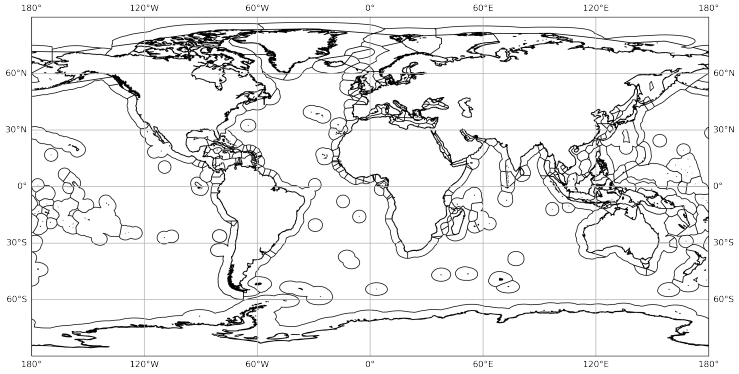

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Descriptive statistics

Table B2: *Data sources and summary statistics*

Sources/Variable	Description	2020				2019			
		Mean	Standard deviation	Min	Max	Mean	Standard deviation	Min	Max
Global Fishing Watch									
Total Fishing Efforts	Sum of fishing efforts by EEZ	465.4	5,156.8	0.5	323,988	503.4	5,976.2	0.5	436,402
Fishing Average	Average fishing efforts per vessel/EEZ	2.7	4.6	0.5	143.1	2.6	4.2	0.5	215.5
Total MMSI	Sum of vessels by EEZ	567.3	8,906.7	1	617,320	612.7	11,030	1	911,097
Oxford covid-19 government response tracker (OxCGRT)									
Stringency index	Total government responses to COVID-19 (Score between 0-100)	53.07	26.7	0	100	-	-	-	-
Government response index	Government responses to COVID-19 (Score between 0-100)	49.99	22.69	0	89.84	-	-	-	-
Containment and health index	Containment and health measures related to COVID-19 (Score between 0-100)	50.7	34.25	0	100	-	-	-	-
Economic support index	Economic support related to COVID-19 (Score between 0-100)	49.91	22.53	0	91.96	-	-	-	-
Sea Around Us									
Internal Fishing Access Agreements	Categorization of the validity of access agreements	0.54	0.5	0	1	0.61	0.49	0	1
Ocean Health Index (OHI)									
Index	Total Ocean Health Index	68.45	5.44	48.44	82.97	69.25	5.49	47.29	83.21
Biodiversity	Ocean Health Index related to biodiversity	71.38	5.59	51.01	91.16	71.94	6.19	51.58	91.32
Economies	Ocean Health Index related to economies	91.39	14.92	0.05	100	89.71	17.55	18.57	100
Fisheries	Ocean Health Index related to fisheries	49.6	16.28	10.89	83.93	51.39	17.18	10.91	85.39
Food Provision	Ocean Health Index related to food provision	51.4	16.84	14.82	83.9	53.21	17.31	14.89	85.38
Iconic Species	Ocean Health Index related to iconic species	62.58	7.86	48.07	92.52	63.71	7.63	53.04	92.57
Livelihoods	Ocean Health Index related to livelihoods	76.39	18.01	35.15	100	76.22	18.74	3.34	100
Livelihoods and Economies	Ocean Health Index related to livelihoods and economies	83.89	11.76	27.48	100	82.96	13.48	12.8	100
Mariculture	Ocean Health Index related to mariculture	30.82	35.86	0	88.47	28.84	35.33	0	88.38
Natural Products	Ocean Health Index related to natural products	79.13	17.2	0	100	77.36	18.65	0	100
Mobility Rates									
Retail & recreation	Changes in people's mobility (percent) in retail and recreation	31.36	65.66	-84	545	-	-	-	-
Grocery & pharmacy	Changes in people's mobility (percent) in grocery and pharmacy	46.53	60.86	-58	615	-	-	-	-
Parks	Changes in people's mobility (percent) in parks	163.7	195.9	-69	1206	-	-	-	-
Transit stations	Changes in people's mobility (percent) in transit stations	49.19	80.85	-75	524	-	-	-	-
Workplaces	Changes in people's mobility (percent) in workplaces	12.64	29.51	-74	260	-	-	-	-
Residential	Changes in people's mobility (percent) in residential	19.66	11.69	-4	63	-	-	-	-
NOAA									
Temperature (Celsius)	Mean temperature for the day in degrees Celsius to tenths	19.89	9.44	-26.9	37.92	20.21	9.62	-24.6	37.19
Wind speed	Mean wind speed for the day in knots to tenths	54.52	120.2	0.44	632.6	54.85	116.5	0.49	566.3
Precipitation (inches)	Total precipitation (rain and/or melted snow) reported during the day in inches and hundredths	9.81	15.48	0	95.23	9.31	14.3	0	95.23