SubsidyExplorer - Methods

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Acronyms and Abbreviations

AIS	automatic identification system
ASFIS	Aquatic Sciences and Fisheries Information System
CNN	convolutional neural network
CSV	comma-separated values
EEZ	Exclusive Economic Zone
emLab	Environmental Market Solutions Lab
EU	European Union
FAO	Food and Agriculture Organization [of the United Nations]
F/F_{MSY}	fishing mortality relative to that yielding maximum sustainable yield
FMI	Fishery Management Index
FSE	fisheries support estimate
FTE	full-time equivalent
GFW	Global Fishing Watch
IMO	International Maritime Organization
INTERPOL	International Criminal Police Organisation
ISSCAAP	International Standard Statistical Classification of Aquatic Animals and Plants
IUU	Illegal, unreported, and unregulated
LDC	Least-developed country
MMSI	Maritime Mobile Service Identity
MSY	maximum sustainable yield
OECD	Organisation for Economic Co-operation and Development
PDF	Portable Document Format
RAMLDB	RAM Legacy Stock Assessment Database
RFMO	Regional fisheries management organization
S&DT	special and differential treatment
UCSB	University of California, Santa Barbara
WDI	World Development Indicators
WTO	World Trade Organization

1. Introduction

This document contains a detailed account of the materials and methods underlying the "SubsidyExplorer" toolkit created by the Environmental Market Solutions Lab (emLab) at the University of California, Santa Barbara (UCSB). This interactive web-based application was created to evaluate possible outcomes resulting from fisheries subsidies reforms being negotiated by the World Trade Organization (WTO) between 2017 - 2020.

All data and code for the SubsidyExplorer toolkit is available at https://github.com/kmillage/SubsidyExplorer (hereafter referred to as the "project repository"). All analysis was done using R version 3.6.2 (1), and the SubsidyExplorer toolkit was built using the *shiny* (2) package.

2. Data Sources

Data for this analysis came from numerous publicly available datasets, as well as some datasets obtained directly from their creator(s) and used with permission. For ease of description, we sort these datasets into three categories based on the subjects to which they primarily pertain and/or are used for in this analysis: 1) demographics, 2) fisheries (subsidies), and 3) fisheries (other).

Demographic datasets (discussed in section 2.1):
- The World Bank World Development Indicators (WDI) database (3);
- The 2017 Food and Agriculture Organization (FAO) of the United Nations Yearbook of Fishery and Aquaculture Statistics (4);
- Estimates of the number of full-time equivalent (FTE) jobs in marine capture fisheries from Teh and Sumaila (5).

Fisheries subsidy datasets (discussed in section 2.2):
- Estimates of global fisheries subsidies from Sumaila et al. (6);
- The Organisation for Economic Co-operation and Development (OECD) fisheries support estimate (FSE) database (7);
- Estimates of global small-scale fisheries subsidies (unpublished updates of those from Schuhbauer et al. (8)).

Other fisheries datasets (discussed in section 2.3):
- The FAO Global Capture Production Database (9);
- Reconstructed global ex-vessel prices of fished species from Melnychuk et al. (10);
- The RAM Legacy Stock Assessment Database (RAMLDB) (11, 12);
- Estimates of global stock status from Costello et al. (13);
- Fisheries management indicators from Melnychuk et al. (14);
- The Combined IUU Vessel List (15).

All code used to process the data listed above, as well as the raw data itself (whenever possible), are included in the "data" folder of the project repository.

This analysis also leverages satellite-derived estimates of global fishing effort from Global Fishing Watch (GFW) (16, 17). An aggregated version of the GFW data is freely available to download at

https://globalfishingwatch.org/, but this analysis draws on higher-resolution data that was available to the authors as part of a research collaboration between emLab and GFW. All code used to process the raw data is included in the project repository, but the raw data is hosted on Google's BigQuery cloud data system and is not publicly accessible.

2.1. Demographic datasets

2.1.1. World Bank WDI database

The World Bank WDI database (3) is a collection of global data, containing time series of 1,600 different indicators related to many different facets of development aggregated to the country, regional, and global level. The WDI data used in this analysis were last downloaded through the WDI package for R (18) on August 6, 2020. Three indicators were extracted for all countries for all available years between 2000-2018: total GDP in current $USD (NY.GDP.MKTP.CD), the contribution to GDP from fisheries, forestry, and agriculture in current $USD (NV.AGR.TOTL.CD), and total population (SP.POP.TOTL).

2.1.2. FAO Yearbook of Fishery and Aquaculture Statistics 2017

The FAO Yearbook of Fishery and Aquaculture Statistics is an annual publication that compiles statistical data on capture fisheries, aquaculture production, employment, commodities production and trade, apparent fish consumption and fishing fleets. Released in 2019, the 2017 issue (4) is the most recent release. The data on the total number of fishers by country from the Employment section of the Yearbook was used in this analysis. This data is either reported directly by each country's fishery agency to the FAO, or is estimated directly by the FAO. For most major fishing countries, data is available for 1995, 2000, 2005, 2010, and 2012-2017. We manually transcribed these data from PDF to CSV format.

2.1.3. Contribution of marine fisheries to worldwide employment (Teh and Sumaila 2011)

Teh and Sumaila (5) compiled available information on marine fisheries employment for 144 countries from the FAO, as well as a number of other peer-reviewed and grey literature sources. Where information was missing, out of date, or considered to be unreliable, they used a proportional transfer approach to estimate the number of persons in each country employed in the marine fisheries sector. They then converted the number of marine fisheries jobs in each country into FTE units to better allow for comparison across countries. Estimates of FTE marine fisheries employment is from 2003. These data were provided to us directly by the creators.

2.2. Fisheries subsidy datasets

2.2.1. Updated estimates and analysis of global fisheries subsidies (Sumaila et al. 2019)

Sumaila et al. (6) identified and compiled published information on financial transfers provided to the fishing sector by governments and estimated the likely magnitudes of fisheries subsidies (in 2018 $USD) in countries for which this information was not available. They assign subsidies to one of 13 categories (Table 1) based on many factors including the policy objective of the subsidy, the description of the subsidy program, scope, coverage, and duration, sources of funding, the administering authority, annual magnitude, recipients, and mechanisms of transfer (19). Each category is associated with one of the three subsidy types first described by Sumaila et al. (20): beneficial ("good") subsidies, capacity-enhancing ("bad") subsidies, and ambiguous ("neutral") subsidies. This work builds upon the estimates previously presented in 2009 $USD by Sumaila et al. (19). These data were provided to us directly by their creators.

By definition, beneficial subsidies are those that lead to investment in natural capital assets (maximize economic rents). In the context of fisheries, these types of subsidies often aim to increase the growth of fish stocks via conservation, allow for improved monitoring of catch rates, or enhance fisheries management to achieve biologically or economically optimal use of the resource. Subsidies included in the following three categories are considered to be "good" subsidies: 1) fisheries management programs and services, 2) fishery research and development (R&D), and 3) Marine Protected Areas (MPAs).

Capacity-enhancing subsidies are those that lead to disinvestments in natural capital assets. In the fisheries context, "bad" subsidies allow for fishing capacity to develop beyond the point that would be sustainable in the long term by artificially increasing profits. This overcapacity can then compound overexploitation problems such as overfishing. Subsidies included in the following seven categories are considered to be "bad" subsidies: 1) fuel subsidies and tax exemptions, 2) boat construction, renewal, and modernization, 3) fishing port construction and renovation, 4) price and marketing support (processing and storage infrastructure), 5) fishery development projects and support services, 6) foreign access agreements, and 7) non-fuel tax exemptions.

Ambiguous subsidies are those that may lead to either investment or disinvestment in the fishery resource, often depending on the specific mechanisms of the subsidy program. Subsidies included in the following three categories are considered to be "neutral" subsidies: 1) fisher assistance programs, 2) vessel buyback programs, 3) rural fishers' community development programs.

2.2.2. OECD FSE database

The OECD FSE database (7) measures and describes fisheries support policies across all OECD member countries and selected non-members. The FSE database analyzes fisheries policies and expresses the amount of support they provide to the fishing industry using support indicators, which are comparable across time and between countries. In order to be included in this database, a policy must generate a transfer to fishers, regardless of the nature, objectives or impacts of the policy. 'Transfers' can include budgetary payments such as direct payments to fishers and general support for the fishing sector in terms of management, harbors, and other infrastructure, as well as non-budgetary payments such as tax measures. In order to qualify as a 'transfer', there also must be a clear source (i.e. the group bearing the cost) and recipient (i.e. the group receiving the benefit) of the value. The FSE Manual (21) specifies a very clear set of criterion for identifying the scope of fisheries policies that can be included in the FSE database.

The classification system used by the OECD to identify different types of policies first makes the distinction between non-budgetary transfers to individuals, budgetary transfers to individuals, transfers to the sector generally, and cost recovery charges. Within each of these four categories, policy measures are then classified according to implementation criteria, defined as the conditions under which transfers are provided to fishers (or the conditions of eligibility for the payment). The categories and sub-categories used in the FSE database, as well as brief descriptions of the types of programs included in each are listed in Table 2.

These data can be accessed and downloaded directly from the OECD iLibrary portal in several formats (https://stats.oecd.org/Index.aspx?DataSetCode=FISH_FSE). The data used in this analysis were last downloaded as a CSV file on March 10, 2019.

2.2.3. How subsidies affect the economic viability of small-scale fisheries (Schuhbauer et al. 2017)

Schuhbauer et al. (8) identified and compiled published information on financial transfers provided to small-scale fisheries by governments and estimated the likely magnitudes of small-scale fisheries

subsidies (in 2009 $USD) in countries for which this information was not available. They use the same subsidy types described by Sumaila et al. (20).

The data used in this analysis are unpublished updates of those from (8) in 2018 $USD. These updated estimates were provided to us directly by their creators and are based upon the global subsidy estimates published in (6).

2.3. Other fisheries datasets

2.3.1. FAO global capture production database

Released on May 21, 2020, version 2020.1.0 of the FAO global capture production database (9) contains an annual time series of capture production statistics from 1950 - 2018. This dataset can be accessed and downloaded directly in several formats from http://www.fao.org/fishery/statistics/global-capture-production/en. The data used in this analysis were last downloaded as a CSV file on July 25, 2019.

The FAO global capture production database includes catches of fish, crustaceans and molluscs, and other aquatic animals, plants, and mammals taken for commercial, industrial, recreational, and subsistence purposes. This dataset does not include production from aquaculture, or discarded catches. All aquatic organisms included in this database are classified according to ~2,400 commercial species items. These species items may comprise a single species, genus, family, or higher taxonomic level. These species items are then matched to the Aquatic Sciences and Fisheries Information System (ASFIS) list of species (~13,000 items). Each species item is also classified into one of 50 different FAO International Standard Statistical Classifications of Aquatic Animals and Plants (ISSCAAP) groups on the basis of taxonomic, ecological, and economic characteristics. These 50 groups constitute nine higher ISSCAAP divisions.

All capture production entries are also classified by fishing area. There are eight major inland fishing areas and 19 major marine fishing areas established for fishery statistical purposes (Figure 1, hereafter referred to as "FAO regions"). Production statistics included in the FAO capture production database are reported to the FAO by national offices.

2.3.2. Reconstruction of global ex-vessel prices of fished species (Melnychuk et al. 2017)

Melnychuk et al. (10) created a streamlined approach to estimate nominal ex-vessel fish prices for all species items reported in the FAO global capture production database. They used three datasets from FAO to reconstruct ex-vessel prices between 1976-2012: 1) global commodities production and trade (1976-2013), 2) world fishery production - estimated value by groups of species (1994-2012), and 3) global capture production (1950-2014). These data were provided directly to us by their creators.

Their method uses three linkage tables to equate export values of fishery commodities, generally reported as the intersection of species (or groups of species) with product types (e.g. fresh; frozen; dried), with landing records of species. First, they first pooled commodities across product types, removing commodities associated with ISSCAAP groups for which a mean ex-vessel price estimate was not available from the FAO. Second, they further aggregated the pooled commodities into ISSCAAP groups in order to compare estimated mean ex-vessel prices by group with those reported by the FAO. Lastly, they linked ASFIS species reported in the FAO global production database to one of the pooled commodities, providing an estimate of average ex-vessel price by year for 1861 of the 2033 ASFIS species associated with landings records. The 172 species for which ex-vessel price estimates were not

available came from 14 out of the 50 possible ISSCAAP groups (4 groups of aquatic mammals; 4 groups of aquatic plants; frogs and other amphibians; crocodiles and alligators; turtles; corals; pearls and other shells; sponges).

2.3.3. RAM Legacy Stock Assessment Database

The RAMLDB compiles and makes available the results of fisheries stock assessments undertaken by national agencies and RFMOs around the world (11). These assessments predominantly come from Australia, New Zealand, Canada, the United States, Peru, South Africa, Russia, Argentina, Japan, the European Union (EU), and RFMOs covering multinational tuna and billfish stocks. The proportion of commercially exploited stocks included in the RAMLDB varies significantly by region. The version of the database used in this assessment is 4.491, released on February 20, 2020 (12). The RAMLDB can be downloaded directly from https://www.ramlegacy.org/. The data used in this analysis were last downloaded on July 25, 2020.

2.3.4. Global fishery prospects under contrasting management regimes (Costello et al. 2016)

The majority of global fish stocks are not assessed with formal stock assessments, and are instead managed using a variety of data-limited methods or are unassessed (22). No global database exists with the results of these data-limited methods of estimating the status of fisheries for which formal stocks assessments have not been conducted. Costello et al. (13) used data from the FAO Global Capture Production Database to provide estimates of the status of 4,316 fisheries (defined by species-country-FAO region triples) not included in the RAMLDB. These data were provided to us directly by their creators.

2.3.5. Fisheries management impacts on target species status (Melnychuk et al. 2017)

Melnychuk et al. (14) used expert surveys to characterize the fisheries management systems of 28 countries. They evaluated five different attributes of each fisheries management system for each of 10 species in each country: research, management, enforcement, socioeconomics, and stock status. The scores from different attributes were averaged and aggregated by country to calculate a total Fisheries Management Index (FMI) score. We manually transcribed these data to CSV format from Table S2 in the supplementary materials of (14).

2.3.6. Combined IUU Vessel List

Most regional fisheries management organizations (RFMOs) maintain their own lists of vessels that have been found to carry out or support illegal, unreported, and unregulated (IUU) fishing. The Combined IUU Fishing Vessel List was created by Trygg Mat Tracking, a Norwegian non-profit, to consolidate all of the different RFMO IUU lists into one (15). This dataset can be downloaded directly as an Excel file (https://iuu-vessels.org/Home/Download). The data used in this analysis were last downloaded on November 30, 2019.

2.4. Global Fishing Watch

Very few estimates of total fishing effort exist on a global scale, but GFW is a novel way of tracking fishing behavior in near real time on an individual vessel level (16, 17). GFW has processed more than 22 billion automatic identification system (AIS) positions broadcast by fishing vessels across the world. Designed to help vessels avoid collisions, AIS broadcasts a vessel's identity, position, speed, and turning angle to nearby vessels, and these transmissions are also picked up by satellite- or land-based receivers allowing companies to store and distribute this information. GFW has identified more than 80,000 unique fishing

vessels ranging in length from 6 - 146 m. GFW used data on 45,441 marine vessels listed on official fleet registries to train a convolutional neural network (CNN) to identify vessel characteristics. This model can use the behavior of vessels (as broadcast by AIS) to identify six classes of fishing vessels and six classes of non-fishing vessels with 95% accuracy and can predict vessel length, engine power, and gross tonnage.

As it only includes fishing vessels with AIS systems onboard, GFW does not represent the total global fishing effort. The International Maritime Organization (IMO) requires all vessels greater than 300 tons traveling in international waters to have AIS, though certain countries also require smaller vessels to use the device (17). There is great uncertainty regarding the total number of active fishing vessels in the world, but Kroodsma et al. (16) estimated that the number of vessels with AIS comprised approximately 56% of all vessels larger than 24 m, 9% of vessels 12-24 m, and only 0.2% of vessels under 12 m. They also estimated that vessels with AIS likely contributed between 26% - 34% of the global fishing effort (kW hours expended) of all vessels in the world, with that value increasing to 50% - 70% for all vessels fishing more than 100 nautical miles from shore (halfway to the Exclusive Economic Zone (EEZ) boundary).

The number of vessels with AIS has been increasing greatly since the period covered by this study (2012 - 2016) (17), so it is likely that the 2018 data used in this analysis represents more than 34% of global fishing effort of all vessels in the world, and more than 70% of fishing effort for vessels fishing more than 100 nautical miles from shore (both high-end estimates for the period between 2012 - 2016). For more information on the coverage of the GFW dataset, refer to the supplementary information in (16).

3. Data Processing

The objectives of the SubsidyExplorer toolkit are twofold: 1) allow users to explore the potential bio-economic effects of different fishery subsidies reforms, and 2) synthesize and present existing data on fisheries and fishery subsidies that is relevant to the WTO negotiations. Most of the information presented in the latter section is raw data that have been minimally processed, and these data account for many of the inputs into the analysis presented in the former section. Here we briefly describe the processing of the raw data sources discussed above and note which of these processed data feed into the bio-economic model discussed in section 4, and which are solely included for data visualization and exploration purposes.

3.1. Country naming, political entities, and dependencies

Our use of the word "countries" refers to countries, territories and areas without distinction. The naming of countries varies widely across the data sources used in our analysis, and we recognize that this is often intentional and political. Nonetheless, for this analysis we use the country names recognized by the WTO for display purposes whenever possible. For WTO Non-Members, we use the names recognized by the FAO for display purposes. Our use of a particular name is not meant to convey any opinions regarding the sovereignty or status of any country, territory, or area.

It is important to note that the EU as a political entity is a Member of the WTO, in addition to many of the individual countries that make up the EU. EU countries are often represented at the WTO by the EU delegation -- rather than by their respective delegations -- which is the case for the fishery subsidies negotiations (23). For the purposes of this analysis the EU is comprised of the following 28 countries (all data used in this analysis is from 2018 or before): Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia,

Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, and the United Kingdom.

There are a number of places in the SubsidyExplorer toolkit where information is presented for the EU as a whole, rather than for the individual countries that make up the EU. Conversely, there are some places where it makes more sense to display information pertaining to EU countries independently. Whenever possible, we aim to show both. In the subsequent sections, where relevant, we will make note of how information pertaining to EU countries was aggregated and/or disaggregated.

There are also parts of our analysis where it is important to associate the activities and/or information related to overseas dependencies with their sovereign states. We rely on the positions taken by the WTO regarding the sovereignty or status of different countries when doing this, and these groupings are not meant to represent any options on behalf of the authors on this subject. We will make note where relevant in the subsequent sections of whether information pertaining to dependencies was considered separately from or aggregated into totals for their sovereign states.

3.2. Data processing

The general processing of all datasets discussed in sections 2.1. - 2.3. is performed and detailed in *../scripts/01_data_wrangling.Rmd* in the project repository. All datasets were imported into R where country names were standardized using ISO-3 character codes, and data was converted to a "tidy" format (one row for each data entry) using the *tidyverse* (24), *janitor* (25), *countrycode* (26), and *readxl* (27) packages.

Aggregated entries were created for the EU for all demographic and fisheries subsidies datasets, as well as for the FAO global capture production dataset by summing the values for all EU countries. Data for the overseas dependencies of EU countries were included in these totals whenever available. An aggregate FMI score was calculated for the EU by averaging the FMI scores of EU countries.

We also created aggregate entries for the United States (including data from its overseas dependencies) for the World Bank WDI and the FAO global capture production data.

3.2.1. Extrapolating ex-vessel prices and estimating the landed value of FAO capture production

The database of ex-vessel prices reconstructed by Melnychuk et al. (10) only contains estimates through 2012, and so it was necessary to extrapolate this database to 2018 in order to estimate the landed value of capture production from the FAO in the same year. We used the Consumer Price Index (CPI) from the U.S. Bureau of Labor Statistics (28)to extrapolate ex-vessel prices in 2012 $USD into $USD equivalents for each year between 2013-2018. The CPI rates we used are given in Table 3. This method of extrapolating ex-vessel prices assumes that the relative values of different fish products remain constant. As ex-vessel prices are dependent on supply and demand, this assumption may not be completely true. However, in the absence of better (and equally comprehensive) ex-vessel data we believe this to provide a reasonable approximation on a global scale.

To estimate the landed value of all species reported in the FAO capture production database, we then match our extrapolated ex-vessel prices in 2018 $USD to 2018 landings. We first matched ex-vessel prices and landings by species (using both the scientific name and ASFIS species name). For species in the FAO capture production data without matching ex-vessel price estimates, we instead assigned the average ex-vessel price for the ISSCAAP group to which the species belongs. Species from the 14

ISSCAAP groups for which ex-vessel price estimates were not available (4 groups of aquatic mammals; 4 groups of aquatic plants; frogs and other amphibians; crocodiles and alligators; turtles; corals; pearls and other shells; sponges) are assumed to have a price of $0 and therefore do not contribute to the total estimates of landed value for each country. Landings of these species do however contribute to the total reported capture production for each country.

<u>3.2.2. Calculating relative metrics of fishery subsidization</u>

Using relative rates of fishery subsidization (as opposed to absolute magnitudes) to compare countries has been championed by many WTO delegations, and has been used in previous peer-reviewed studies ((29) is one such example). We therefore calculate a number of relative metrics of fishery subsidization using the subsidy estimates from Sumaila et al. (6) for data visualization purposes. For each of the fishery subsidy types defined by Sumaila et al., we calculate the following:
- Ratio of subsidies to total GDP
- Subsidies per capita ($USD/person)
- Subsidies per fisher ($USD/fisher)
- Subsidies per FTE marine capture employment ($USD/FTE job)
- Subsidies per tonne of capture production ($/tonne)
- Ratio of subsidies to total landed value of capture production

Relative metrics are only available if data was available from both sources for a given country. All subsidy estimates used in the calculation of these metrics are in 2018 $USD. Additionally, all capture production data are from 2018, and estimates of landed value are in 2018 $USD. The most recent year for which data was available for a given country was used for all other metrics.

3.3. Vessel list

Creation of the global vessel list from GFW is performed and detailed in *.../scripts/02_vessel_list.Rmd* in the project repository. As previously mentioned, an aggregated version of the GFW data is freely available to download at https://globalfishingwatch.org/, but this analysis draws on higher-resolution data that was available to the authors as part of a research collaboration between emLab and GFW. All code used to process the raw data is included in the project repository, but the raw data is hosted on Google's BigQuery cloud data system and is not publicly available. The *bigrquery* (30) package was used to access the BigQuery data.

The effort, catch, and subsidy data incorporated into the vessel list described in this section is used in the bio-economic model described in section 4.

<u>3.3.1. Identifying "good" fishing vessels</u>

The raw data used to create the GFW dataset may include transmissions from anything in the ocean with an AIS transponder. Therefore, we take a number of steps to identify and extract data only originating from sources that are truly fishing vessels. We first remove all transmissions from objects that are likely fishing gear (buoys, nets, etc.), rather than vessels. Then, we apply a number of filters to remove transmissions associated with non-fishing and inactive vessels, as well as vessels that may be spoofing their positions. We use the following criteria (suggested to us directly by GFW staff in a research partners training) to identify our list of Maritime Mobile Service Identity (MMSI) numbers corresponding to "good" fishing vessels:

- MMSI number must be on the best fishing vessel list created and maintained by GFW;
- MMSI number cannot be used by 2+ vessels with different names simultaneously;
- MMSI number cannot be used by multiple vessels simultaneously for more than 3 days;
- MMSI number has not been found to be offsetting its position;
- vessel class can be inferred by the neural net (i.e. it is an active vessel);
- MMSI number was active for at least 1 day and fished for at least 1 hour in a year;
- MMSI number is associated with fewer than five ship names.

Finally, we cross reference our list of good MMSI numbers with a list of manually identified vessel IDs that are not fishing vessels created by GFW and exclude any vessel identifiers on that list.

3.3.2. Extracting fishing effort and vessel characteristics

Once we create our list of "good" fishing vessels, we then extract the number of hours spent fishing by each vessel in every EEZ and on the high seas in a given year. To isolate only valid fishing activity, we apply a number of filters:

- The fishing activity must have occurred during a valid segment as identified by GFW;
- The fishing activity must have occurred during a segment with more than 10 positions that was not concurrently overlapping with another, longer, segment for the same MMSI;
- The vessel performing the fishing activity must appear on the list of "good" fishing vessels created previously.

We then sum the total number of hours each vessel on our list of "good" fishing vessels spent fishing in each EEZ, or in each FAO region (if the fishing activity occurred on the high seas). Hereafter, the areas in which vessels fish are referred to as "EEZ/FAO region", with the understanding that FAO regions are only used to fishing areas on the high seas. For fishing activity that occurred within an EEZ, we also determine whether this activity occurred within the territorial waters of the coastal state, defined as being within 12 nautical miles of land.

Eight characteristics are extracted for each vessel: flag state, vessel class, total length (m), gross tonnage (gt), engine power (kW), ship name, call sign, and IMO number. We then calculate fishing effort in units of fishing kilowatt-hours (kWh), by multiplying the hours spent fishing by the engine power of the vessel. Expressing fishing effort in kWh (as opposed to just hours) allows for a more comparable metric of fishing effort across vessels with different gear types and/or sizes.

GFW relies upon three different methods to assign vessel class, total length, gross tonnage, and engine power (16). First, self-reported characteristics ("likely") are those reported by fishing vessels with AIS. However, the identity characteristics broadcast by a vessel's AIS must be manually entered, so vessels engaging in illegal, unreported and unregulated (IUU) fishing may choose to alter their identity to avoid detection, or there is potential for human error. Second, "known" characteristics are those that appear on vessel registries (such as the EU's vessel registry or the Consolidated List of Authorized Vessels). Third, GFW used data on 45,441 marine vessels listed on official fleet registries to train a CNN model) to identify vessel characteristics. This model can use the behavior of vessels (as broadcast by AIS) to identify six classes of fishing vessels and six classes of non-fishing vessels with 95% accuracy and can predict vessel length, engine power, and gross tonnage. "Inferred" fishing vessels are those identified using the CNN. Whenever possible, known designations are considered first, followed by likely

designations, and then inferred, to assign the best characteristics to each vessel. The flag state, ship name, call sign, and IMO number we use are those most frequently broadcast by the vessel.

In some cases, there is no flag state broadcast by a vessel. For these vessels, we assume the flag state to be the same as the coastal state in whose waters the vessel spent the most time fishing. This method was used to assign flag states to 474 vessels. There were also 75 vessels with an unknown flag state in our database that only fished on the high seas which were removed.

In total, the GFW-derived database of fishing effort (2018) and vessel characteristics that is used in the SubsidyExplorer toolkit includes information from 70,586 unique vessels. Breakdown of these vessels by gear type is shown in Figure 2, and breakdown by flag state and gear type is shown in Figure 3.

3.3.3. Allocating catches, landed value, and subsidies

In order to estimate the catches, revenue, and subsidies associated with each of the vessels in our fishing effort database, we first calculate catch, revenue, and subsidy rates by flag state and FAO region. These rates-- expressed in terms of tonnes/kWh, $USD/kWh, and $USD/kWh respectively -- are then used to proportionally allocate catches, estimated landed value, and subsidies based on the total fishing effort expended (in fishing kWh) by each vessel (see methods for allocating subsidies from (31)).

For catches and landed value, we calculate rates and perform allocations by flag state and FAO region. In cases where we do not have matching catch and effort data for a given flag state-FAO region pairing, we instead calculate rates and perform allocations only by flag state. For subsidies, we calculate rates and perform allocations only by flag state. Additionally, we only use the proportion of total subsidies reported by Sumaila et al. (6) associated with industrial fisheries in the calculation of subsidy rates to be applied to vessels in the GFW dataset. The proportions of subsidies associated with industrial fisheries for each country were obtained by subtracting out subsidies for small-scale fisheries as determined by the unpublished updated estimates from Schuhbauer et al. (8).

3.3.4. Converting subsidies to "effective" subsidies

The OECD has undertaken research into the relative effects of different types of fisheries subsidies on fishing effort, harvests, fleet capacity, fishers' income, and stock size (32, 33). The idea being that one dollar of one type of subsidy may not have the same effect on fishing effort as one dollar of another type of subsidy. Overall, these studies have found that payments made to the fishing industry based on variable input use (e.g., fuel, bait), have the greatest effect on fishing effort and stock size (32, 33). Our model of the relationship between fisheries subsidies and fishing effort does not incorporate different relationships for different types of subsidies. Thus, we leverage these findings to convert the values of subsidies estimated for each of our vessels to "effective" subsidies.

We convert the absolute values of different types of fisheries subsidies being provided to industrial fisheries (5, 6) into "effective" subsidy values for each vessel in the GFW dataset. The OECD's work on the relative effects of fishery supports considers six types of payments: inputs, outputs, fuel, income, capital, and vessels. Based upon the definitions provided for each category of programs (21), we first identified the most closely related subsidy types as defined by Sumaila et al. (20) to each category (Table 8).

We then applied the relative effects of the six categories of programs identified by the OECD to the estimates of subsidies provided to industrial fisheries applied to our vessel list (5, 6). The OECD

measured the normalized effect of each policy type, such that the policy type with the largest impact is given a value of "1", and all others are expressed as a proportion of that effect. We use these proportions to calculate the effective monetary values of different subsidy types. For example, if a vessel receives $100 in subsidies of a type that has an effect on fishing effort that is 40% of the maximum, then we consider that vessel to receive $40 in effective subsidies. The relative impacts of the six policy categories assessed by the OECD used to calculate effective subsidies are given in Table 9. Only the relative effects of different policy types on fishing effort in an open-access scenario were used to calculate effective subsidies. When a subsidy type (as defined in ((22)) could be considered to match multiple OECD policy types, the median relative effect on fishing effort for that subsidy type was used.

3.4. Fisheries management

The causal relationship between certain types of fishery subsidies and overfishing (or overcapacity) likely depends on the effectiveness of the management system in place in the fishery. For example, subsidies that reduce fishing costs are less likely to have an effect in fisheries managed with quotas as compared to those managed with input restrictions (34). We therefore assign management scores to each of our vessels, such that they can later be classified into different management tiers that might respond differently to subsidy reforms. Classifying or scoring fisheries management systems is undoubtedly challenging and contentious considering the wide variety of approaches used to manage fisheries. Additionally, data on the effectiveness of fisheries management is limited. We therefore consider two different methods of assigning management scores to each of the vessels in our effort database.

Assignment of management indicators is performed and detailed in *.../scripts/03_management.Rmd* in the project repository.

3.4.1. FMI scores

Melnychuk et al. (14) have already created a comparable metric of fisheries management systems, and we use this as one potential indicator of management effectiveness. Given that the FMI scores calculated in this study relate to the behavior of the management system, we assume these to be applicable to the administering countries of each fishing area (as opposed to the flag state of each vessel). We assign the weighted FMI indicators from Melnychuk et al. (14) to each of the vessel-EEZ/FAO region pairings in our effort database based upon the location in which the fishing effort occured. Where an FMI score is not available for the administering state of an area, we instead assign a FMI score using the following hierarchy:

- FMI score for the sovereign state of the administering state
- Mean FMI score for all EU countries [EU countries and territories only]
- Mean regional FMI score
- Mean regional FMI score associated with the sovereign state
- Mean continental FMI score
- Minimum FMI score from Melnychuk et al. (14) [high seas only]

FMI scores applied to each fishing area range from 0.21 to 0.92 (Figure 4).

3.4.2. Fishing mortality by FAO region

Given that the method described in the previous section assumes that the strength of management is more closely related to the actions of the administering country than to the behavior of the vessels fishing there, we next consider fishing mortality as an indicator of the strength of fisheries management. Fishing

mortality measures the exploitation rate on fish stocks as a component of stock status and are often used to make comparisons across different stocks or areas. We calculate the median, mean, and weighted mean fishing mortality rates (F/Fmsy) by FAO region (Figure 5) for all stocks in the database constructed by Costello et al. (13). The weighted mean calculation uses the maximum sustainable yield (MSY) of each stock as the weight. These values are then applied to each of the vessel-EEZ/FAO region pairings in our effort database based upon the FAO region in which the fishing effort occurred.

4. Bio-economic Model

The key results presented in the SubsidyExplorer toolkit are projections of how a global aggregate fishery would change under different subsidy reform policies. A simple biological model forecasts how global fish biomass will change based on how the selected subsidy reform policy affects the fishing mortality rate. For each scenario, an economic model then estimates profits based on the fish price resulting from total harvest each year.

In its simplest form, the primary variables in the model are harvest (h), fishing effort (e), landing price (p), costs (c), profits (π), and biomass (b).

Harvest is calculated as a function of biomass and fishing effort:

[1.1] $h = Y(b, e)$

Landing price is a function of harvest:

[1.2] $p = D(h)$

Fishing costs are calculated as a function of fishing effort:

[1.3] $c = C(e)$

Fishery profits are calculated as a function of fish price, harvest, and costs:

[1.4] $\pi = Z(p, h, c)$

Global biomass is calculated based on a growth function (that depends on past biomass) and harvest:

[1.5] $b = G(b) - h$

Within this model, there are five main functions: the harvest function (Y), the demand function (D), the cost function (C), the profit function (Z), and the growth function (G). These functions are discussed in more detail in the following section.

4.1. Fleet characterization

If subsidy reform is not universal, it is possible that vessels or fisheries unaffected by the reforms may actually end up increasing fishing effort as a result of increased biomass and/or prices. These potential rebound effects could reduce the effectiveness of a subsidy reform policy (Figure 6) and are important to consider. Such a rebound effect could occur in response to 1) increased biomass over time resulting from decreased effort (and therefore catches) by the reform-affected fleet, or 2) increased fish price resulting from decreased supply from the reform-affected fleet, or 3) some combination of both.

In order to capture these effects, we track four fishing fleets in our model: two reform-affected fleets (managed and open-access) and two reform-unaffected fleets (managed and open-access). The distinction between managed and open-access is made using one of the two indicators of fishery management effectiveness defined above. The threshold separated managed from open-access is made based on quantile, and can be changed within the SubsidyExplorer toolkit.

The sizes and compositions of each fleet depend on the subsidy reform proposal(s) or definition(s) selected by the user within the SubsidyExplorer toolkit.

4.2. Detailed model description

The bioeconomic model used in the SubsidyExplorer toolkit to project the outcomes of different subsidy reform policies is similar to those used in the "Sunken Billions" reports (35, 36) to estimate rent losses for the global marine fishery. Our model assumes that global fisheries can be modeled as a single fish stock, represented by an aggregate growth function. Additionally, we assume that the global fishing industry can be represented by the four discrete fishing fleets mentioned in the previous section-- two affected by the subsidy reform policies ("reform-affected"), and the other two not ("reform-unaffected"). The relative sizes of the four fleets vary depending on the selected policy

4.2.1. Biomass growth

For our biomass growth function, $G(b)$, we use a form of the basic logistic surplus production model commonly referred to as the Pella-Tomlinson Model. With discrete units of time (denoted with the subscript t and hereafter years for the purposes of our model), biomass in the next year (b_{t+1}), is described by:

[2.1] $b_{t+1} = b_t + \frac{\phi+1}{\phi} g b_t (1 - (\frac{b_t}{K})^\phi) - h_t$

where ϕ is a scalar parameter that allows for asymmetry in the production curve, g is the population growth rate for the global stock, K is the carrying capacity for the global stock (maximum population size for growth to be positive), and h_t is the total harvest across all fleets.

The intrinsic growth rate of the stock (r) is given by:

[2.2] $r = \frac{\phi+1}{\phi} g$

And can be estimated directly from maximum sustainable yield (MSY) and carrying capacity:

[2.3] $r = \frac{\phi}{\phi+1} \frac{MSY}{K} (\phi+1)^{\frac{1}{\phi}}$

4.2.2. Harvest

Our harvest function, $Y(b,e)$, is really the sum of the individual harvest functions for our four fleets. Harvest for fleet j in time t is represented by:

[3] $h_{j,t} = q_j b_t e_{j,t}$

where q_j is a fleet-specific catchability parameter, and $e_{j,t}$ is the fishing effort of fleet j in time t. We estimate catchability directly using base year values for all fleets by calculating q_j as follows:

[4] $q_j = \frac{h_{j,0}}{b_0 * e_{j,0}}$

Total harvest is the sum of the harvests from all fleets:

[5] $h_t = \sum\limits_{i=1}^{j} h_{j,t}$

4.2.3. Global fish demand

In order to allow the price of fish to change as a function of harvest, we introduce a demand function, $D(h)$, for fish, and we assume it is downward-sloping. Total harvest in a given year gives rise to fish price through the constant elasticity of demand function:

[6] $p_t = (\frac{1}{\delta})^{\frac{1}{\varepsilon}} h_t^{\frac{1}{\varepsilon}}$

where ε is the constant elasticity of demand, and δ is a constant. We calculate δ as follows:

[7] $\delta = \frac{h_0}{p_0^{\varepsilon}}$

4.2.4. Fishing costs

Our cost function, $C(e)$, assumes that the fishing costs of fleet j in time t are a function of that fleet's fishing effort ($e_{j,t}$) and a fleet-specific cost coefficient (α_j):

[8] $c_{j,t} = \alpha_j e_{j,t}^{\beta}$

Where β is a scalar cost parameter that determines the shape of the cost curve (i.e. how non-linear costs are). The cost coefficient for each fleet is a function of how much each unit of effort is being subsidized for fleet j in time t ($s_{j,t}$). Assuming that global fishery profits are equal to 0, we estimate the costs for each fleet directly by calculating the α_j as follows:

[9] $\alpha_j = \frac{(p_0 * h_{j,0}) + (s_{j,0} * e_{j,0})}{e_{j,0}^{\beta}}$

4.2.5. Profits

Fisheries profits are calculated as revenue less costs plus subsidies for each fleet based on our profit function, $Z(p, h, c)$. Revenue for fleet j in time t is the fish price (p_t) times harvest ($h_{j,t}$) and costs are calculated with the function above. Profits for each fleet in each year ($\pi_{j,t}$) are therefore equal to:

[10] $\pi_{j,t} = p_t h_{j,t} - c_{j,t} + s_{j,t} e_{j,t}$

where $s_{j,t}$ is the rate of subsidization (i.e. how much each unit of effort is being subsidized) for fleet j in time t.

Effort in the next year ($e_{j,t+1}$) adjusts in response to profits and the assumed management regime of the fleet. For fleets in open-access this is given by:

[11] $e_{j,t+1} = \eta \pi_{j,t} + e_{j,t}$

where η is a parameter that regulates the speed at which effort enters and exits the fishery. For managed fleets this is given by:

[12] $e_{j,t+1} = \omega\pi_{j,t} + e_{j,t}$

where ω is again a parameter that regulates the speed at which effort enters and exits the fishery.

4.3. Parameterization

4.3.1. Global analysis

As with the models used in the original and revisited "Sunken Billions" reports (35, 36), the base form of our analysis considers all global marine fisheries as one large fishery. It is a typical aggregate fisheries model based in fisheries economics theory and empirical knowledge. This type of model is a simplified characterization of the global fishery and is not designed to analyze the performance of individual fisheries.

Many parameters used in this model are similar to those utilized in the models from the Sunken Billions reports (35, 36). The values of fixed parameters used in the global analysis, as well as brief descriptions of their source(s), are provided in Table 4. There are also certain parameters used in the model that depend on the relative sizes and compositions of each fleet. These are therefore calculated at the start of each model run based on the subsidy reform policies selected in the SubsidyExplorer toolkit. A description of the variable parameters used in the global analysis are provided in Table 5.

4.3.2. Regional analysis

Modeling the world's fisheries as a global stock allows for the easy assessment of different subsidy reform policies in a robust and transparent way due to its simplicity. However, most countries are obviously interested in assessing the effects of different reform policies on a more localized scale. We therefore also include a regional analysis. We divide all global marine fisheries into three regional fisheries in this analysis: Atlantic Ocean, Indian Ocean, and Pacific Ocean (Table 6). As with the regional analysis undertaken in the most recent Sunken Billions report (36), we note that the regional results are likely to be less reliable than the global results. Fisheries data by region tend to be less dependable than global data, and fish stocks very rarely tend to remain fixed solely within any one region.

Unlike the regional analysis in the Sunken Billions report, we classify regions based on where the fishing takes place, rather than the physical locations of the countries doing the fishing.

We use the same bioeconomic model described above for the regional analysis, with each of the three regions modeled independently. The values of fixed parameters used in the regional analysis are provided in Table 7. These parameters were estimated in the same way as those for the global analysis (see Table 4).

5. Modeling Subsidy Reform Proposals

The subsidy reform proposals submitted by Members to the WTO advocate for placing prohibitions on certain fisheries subsidies. These potential prohibitions are often grouped into three categories: 1) subsidies supporting IUU fishing, 2) subsidies to fishing on overfished or unassessed stocks, and 3) subsidies contributing to overcapacity or overfishing. Special and differential treatment (S&DT) for all

potential prohibitions is sometimes treated as a fourth category (instead of being considered within each category). For each category of prohibitions, different proposals have put forth different methods or approaches to identifying those subsidies that should be prohibited.

To speed up identification of vessels or subsidies that would be likely to trigger different proposed prohibitions within the SubsidyExplorer toolkit, we create a number of additional characteristics to apply to our vessel list. These "definitions" are based on our interpretation(s) of how existing data could be leveraged to identify prohibited subsidies as proposed to the WTO. For some proposed methods or approaches, there may be more than one possible interpretation, or multiple data sources exist that could be used. We therefore allow for different "definitions" for each category of prohibitions and apply these to our vessel list to create additional vessel characteristics. Some of these characteristics are binary (i.e. does a certain definition apply or not - yes/no?), others have a discrete number of possible options (e.g. development status), and some have a range of possible values (e.g. the proportion of time spent fishing on the high seas). This allows for alternative thresholds related to some proposed prohibitions to be explored within the SubsidyExplorer toolkit.

The process of creating and assigning additional vessel characteristics based on our reform policy definitions is performed and detailed in *.../scripts/05_subsidy_reform_definitions.Rmd* in the project repository.

The SubsidyExplorer toolkit allows users to select a subsidy reform scenario to model in one of two ways: 1) by selecting one of the pre-made proposals submitted to the WTO, or 2) by creating their own proposal. Both options ultimately utilize the "definitions" discussed in this section to identify vessels that would be likely to be affected by a certain reform policy. The only difference being that for the first case, we have already identified the relevant "definitions" for each proposal, allowing the user to see the impact of that proposal with one click. In the second case, the user is free to change as many of the settings as they would like.

5.1. Subsidy reform policy "definitions"

5.1.1. Country development status

Most subsidy reform proposals suggest S&DT for Developing and Least-developed country (LDC) Members, so we assign the development status of the flag state to each vessel in our effort database. The WTO recognizes the LDCs designated by the UN but does not have definitions of "developed" or "developing countries. Members are allowed to self-declare as "developing", though other Members may challenge this designation. For the purposes of modeling, we use make the following assumptions about development status, though we note that these could not be the same designations taken by Members:

- **LDCs:** WTO Members and Observers designated as LDCs by the UN are assumed to be LDCs for the purposes of the WTO fishery subsidy negotiations.
- **Developed:** OECD Members except Chile, Mexico, Korea and Turkey are assumed to be developed countries. The following Members with economies in transition as designated by the UN are also considered to be developed countries: Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, Serbia, Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, the Kyrgyz Republic, the Republic of Moldova, the Russian Federation, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.

-   **Developing:** All other WTO Members and Observers are considered to be developing countries for the purposes of the WTO fishery subsidy negotiations.

Some proposals have also advocated for S&DT for small vulnerable economies (SVE) Members and Observers. We assume the following countries to be SVE Members and Observers: Antigua and Barbuda, Bahamas, Barbados, Belize, Bolivia, Plurinational State of, Cuba, Dominica, Dominican Republic, El Salvador, Ecuador, Fiji, Grenada, Guatemala, Honduras, Jamaica, Mauritania, Nicaragua, Panama, Papua New Guinea, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Samoa, Seychelles, Sri Lanka, Tonga, Trinidad and Tobago.

<u>5.1.2. High seas and distant water fishing</u>

Some proposals have introduced the idea of limiting subsidy prohibitions such that they would only apply to vessels fishing on the high seas or in the EEZs of other Members ("distant-water" fishing). This isn't a straightforward classification, as most industrial fishing vessels fish across multiple jurisdictions (i.e., within the EEZ of their flag state, on the high seas, or in the EEZ(s) of other coastal states). We therefore determine the fraction of each vessel's total annual fishing effort spent fishing in each area, allowing the user to explore different thresholds relating to these proposed prohibitions for high seas or distant water fishing. For example, one could imagine a proposed prohibition that would only apply to vessels that spend more than 5% of their time fishing on the high seas; alternatively such as prohibition could only apply to vessels that spend more than 5% of their time fishing on the high seas or in the EEZs of other coastal states.

The calculation to obtain the fraction of high seas fishing effort for each vessel is straightforward. Defining what counts as distant-water fishing is somewhat more complicated as many countries have fishing agreements with one another. We apply a similar definition of distant-water fishing to that used by Cabral et al. (37).

When any of the following conditions are met, that fishing activity is NOT considered to be distant water fishing:

-   The fishing activity is occurring outside of the jurisdiction of any country (i.e., on the high seas);
-   The flag state of the vessel is the same as the administering state of the EEZ in which it is fishing (or one of the administering states in the case of joint regime and disputed areas);
-   The flag state of the vessel is a member state of the EU, Norway, Svalbard and Jan Mayen, or Iceland, and the EEZ in which it is fishing is administered by a member state of the EU, Norway, Svalbard and Jan Mayen, or Iceland (e.g., a French flagged vessel fishing in Spain's EEZ);
-   The sovereign of the vessel's flag state is a member state of the EU, Norway, Svalbard and Jan Mayen, or Iceland and the EEZ in which it is fishing is administered by a member state of the EU, Norway, Svalbard and Jan Mayen, or Iceland (e.g., a vessel flagged to the Azores fishing in Spain's EEZ).

Our definition of distant water fishing does include "sovereign fishing". Even if the vessel and EEZ in which it is fishing share a sovereign state, we still consider this activity to be distant water fishing (though this does not mean that it is foreign distant water fishing). Therefore when either of the following conditions are met, we DO consider the activity to be distant water fishing:

-   The flag state of the vessel is also the sovereign of the administering entity of the EEZ in which it is fishing (e.g. a US flagged vessel fishing in the EEZ of Palmyra Atoll).

- The sovereign country of the vessel's flag state is also the sovereign of the administering entity of the EEZ in which it is fishing (e.g. a Puerto-Rican flagged vessel fishing in the EEZ of Palmyra Atoll).

<u>5.1.3 Fishing in domestic and territorial waters</u>

Similar to the proposals advocating for limiting subsidy prohibitions to high seas or distant water fishing, other proposals have introduced the idea of offering exceptions for fishing that only occurs only within a country's domestic waters (or only within their territorial waters).

For the purposes of making these distinctions, we consider a country's domestic waters to include the entirety of their EEZ, and their territorial waters to include all waters within 12 nautical miles of land.

<u>5.1.4 Fishing in disputed waters</u>

One of the subsidy reform proposals makes reference to fishing in disputed waters. We use the Maritime Boundaries dataset (v10) from https://Marineregions.org to identify disputed areas to provide one possible interpretation of this proposed prohibition. We consider disputed waters to be any of those classified as disputed in this dataset. Nonetheless, we recognize that disputed regions are a sensitive matter, and it is not our intention to convey any opinions on the sovereignty of any region.

<u>5.1.5. IUU fishing</u>

Nearly all of the proposed prohibitions for subsidies supporting IUU fishing would require a vessel, operator, or owner to have been identified as having been engaged in IUU fishing. Currently, the most comprehensive lists of such violators come from RFMOs or international organizations such as the International Criminal Police Organisation (INTERPOL). Very few countries maintain lists of vessels having been caught engaging in IUU activities within their waters, and those that do often do not make such determinations publicly available.

Given that there is a great deal of overlap between the IUU lists maintained by RFMOs, we use the Combined IUU Vessel List (15) as one possible method of identifying vessels in our effort database that might trigger an IUU prohibition:

IUU #1: Subsidies for fishing shall be prohibited to any vessel currently listed as having engaged in IUU fishing activities by a RFMO or other international agreement.

We recognize that this method largely underestimates the actual amount of IUU fishing happening worldwide. However, any prohibition agreed upon by the WTO would require a country or international organization or agreement to make an official determination of IUU activity and this is the best source of such information currently available.

Based on the proposals submitted to the WTO, we also offer five other possible definitions of a potential IUU subsidy discipline:

IUU #2: Subsidies for fishing shall be prohibited to any vessel currently listed as having engaged in IUU fishing activities by a coastal Member state.

IUU #3: Subsidies for fishing shall be prohibited to any vessel currently listed as having engaged in IUU fishing activities by the flag Member state.

IUU #4: Subsidies for fishing shall be prohibited to any vessel currently listed as having engaged in IUU fishing activities by the subsidizing Member state.

IUU #5: Subsidies for fishing shall be prohibited to any vessel currently listed as having engaged in IUU fishing activities by a port Member state.

IUU #6: Subsidies for fishing shall be prohibited to any vessel currently listed as having engaged in IUU fishing activities by a market Member state.

For these definitions, no data currently exists on a global scale to identify vessels listed as having engaged in IUU fishing activities by coastal, flag, subsidizing Member, port, or market states. Very few states maintain their own IUU lists (e.g., the EU, United States, and Norway), and the very small number of vessels on these lists generally also appear on RFMO lists. Therefore, at present, selecting one of these five options will not return any matching vessels in our effort database.

Even though state IUU lists are extremely limited today, there is reason to believe that adoption of IUU disciplines by the WTO could incentivize more states to maintain and enforce such lists in the future. As a way of thinking about the effects that an IUU discipline could have if more states started maintaining and enforcing their own IUU lists, we offer users the option of making their own assumption about the amount of IUU fishing currently occurring worldwide. This assumption is meant to simulate the % of fishing that might someday be identified and disciplined by state-maintained IUU lists.

If the user chooses to make an assumption about the percentage of total fishing effort that is IUU worldwide in the SubsidyExplorer toolkit, we assume that the selected percentage is applied equally across all flag states.

5.1.6. Fishing on overfished or unassessed stocks

Most proposed prohibitions in this category would require two findings: a determination to be made that a particular stock is overfished, and a determination to be made that a particular subsidized vessel/owner/operator is fishing on (or targeting) that stock. In practice, both of these determinations are complicated, and the practice of doing so will depend heavily on the capabilities of the administering state of an area. Nonetheless, we offer the following as a possible interpretation.

The RAMLDB includes status information on approximately 400 fisheries (representing approximately 30-40% of global catches) (12). Though this database is not globally comprehensive, we consider it to be one method of identifying overfished stocks. We consider two possible definitions of overfished:

OA #1: Subsidies for fishing shall be prohibited if the weighted mean status of all stocks in an area is overfished (B/Bmsy < 1) as determined by the most recent stock assessments in the RAM Legacy Stock Assessment database.

OA #2: Subsidies for fishing shall be prohibited if the weighted mean status of all stocks in an area is overfished (B/Bmsy < 0.8) as determined by the most recent stock assessments in the RAM Legacy Stock Assessment database.

When applying these definitions, we aggregate stocks by FAO region. We also consider two additional possible definitions of overfished stocks based on the stock status database created by Costello et al. (13):

OA #3: Subsidies for fishing shall be prohibited if the weighted mean status of all stocks in an area is overfished (B/Bmsy < 1) as determined by the data-limited assessment done by Costello et al. (2016).

OA #4: Subsidies for fishing shall be prohibited if the weighted mean status of all stocks in an area is overfished (B/Bmsy < 0.8) as determined by the data-limited assessment done by Costello et al. (2016).

5.1.7. Subsidies contributing to overcapacity and overfishing

For the final category of subsidy disciplines, we rely on the definitions of capacity-enhancing subsidies from Sumaila et al. (6). Using the method described previously to approximate subsidy allocation, we identified vessels flagged to states that provided capacity-enhancing or ambiguous subsidies (based on Rashid Sumaila's fisheries subsidies estimates) as those likely to trigger these disciplines.

5.2. Cap and tier considerations

Most of the "definitions" discussed in the previous section are most relevant to subsidy reform proposals that advocate for a complete prohibition of subsidies according to some criteria. More recently, some proposals have put forth an alternative cap-based approach to limiting subsidies. Under such a system, Members would be divided into tiers based on some country-level criteria, and then the total amount of permissible subsidies would be capped based on some other criteria or rule.

For the purposes of modeling such proposals, we must define some additional country-level characteristics and the methods used to assign them.

5.2.1. Subsidy types for capping

Some of the cap-based proposals include a list of "green box" subsidies of which types provision should be allowed. Such subsidy types should thus not be included in the calculation of a Member's base amount of subsidies that will be used to determine that Member's cap and/or tier. A key assumption underlying this analysis is that the direct relationship between fisheries subsidies and fishing effort is only present for subsidy types that lower the cost of fishing (34). Therefore, we only include the subsidy types classified as "capacity-enhancing" or "ambiguous" by Sumaila et al. (6) when calculating the rate of subsidization for each vessel (and once aggregated, for each fleet). We therefore have implicitly created a "green box" of subsidy types for which we assume that provisioning will continue in the future, but they aren't considered in our analysis because we do not assume them to have a direct effect on fishing effort.

However, we do allow users to decide if all types of capacity-enhancing and ambiguous subsidies should be included in a Member's base for capping under the cap-based approach to limiting subsidies contributing to overcapacity and overfishing. Users are free to include some or all of the seven types of capacity-enhancing subsidies defined by Sumaila et al. (6).

5.2.2. Grouping Members into tiers

One aspect of some cap-based proposals is the separation of Members into different tiers, thus allowing for the different tiers to receive different caps that might better reflect the circumstances of the Members in that tier. Some proposals do not utilize a tiered approach (Members are therefore all included in one tier), but other proposals have put forth various approaches to sort Members into two or three different tiers. We include the following methods of dividing Members into two or three tiers:
   - % of global marine capture production;
   - % of global capacity-enhancing subsidies;
   - Development status.

5.2.3. Methods of setting caps

Once Members have been sorted into tiers (if applicable), most cap-based proposals have advocated for applying some sort of formula to determine each Member's total subsidy cap. We include the following methods of determining Member-specific subsidy caps:
- An absolute amount ($USD);
- % of existing capacity-enhancing subsidies;
- % of landed value (from marine capture production);
- % of global average subsidies per fisher multiplied by the total number of fishers;
- The highest of some or all of the previous options;
- No cap.

Different rules can be applied to each of the different tiers (if applicable).

5.3. WTO subsidy reform proposal assumptions

As previously mentioned, users of the SubsidyExplorer toolkit are able to select from pre-filled subsidy reform proposals submitted to the WTO. This section briefly describes each of the proposals, and our assumptions for modeling them. Documents are listed in the order they were submitted.

5.3.1. Philippines - De minimis [RD/TN/RL/81]

Title: Draft text: Philippines non-paper
Date: This unofficial room document was circulated at the request of the Delegation of the Philippines on March 21, 2019.
Public: No

Summary:
This communication advocates for Member-specific de minimis limits, below which Members may maintain, grant, or provide subsidies. Four criteria are provided to determine de minimis limits. 1) The de minimis limit for developed country Members and developing country Members belonging to the top [10] global marine capture fisheries producers shall be [X]% of the average total landed value of the Member's marine capture fisheries in the period [2015-2017]. 2) For developing country Members not included in 1), the de minimis limit shall be [Y]% plus [10/15]% of the average total landed value in the most recent three year period for which data are available. 3) Developing country Members included in 1) whose large-scale commercial fisheries are responsible for less than [5/10]% of the average total landed value may instead take the de minimis limit determined under 2). 4) The de minimis level for LDC Members shall be [Z]% plus [20/30]% of the average total landed value in the most recent three year period for which data are available.

Modeling Assumptions:
Prohibitions:
- We assume that each Member's base subsidy level is represented by the total amount of capacity-enhancing subsidies estimated for that Member by Sumaila et al. 2019, and we estimate the landed value of marine capture fisheries from the FAO Global Capture Production Database.
- We assume the de minimis limit for developed and developing country members belonging to the top 10 marine capture fisheries producers to be 50% of the average total landed value of the

Member's marine capture fisheries between 2016-2018. For all other developing country Members, we assume the de minimis limit to be 70% of the average total landed value between 2016-2018. For LDC Members, we assume the de minimis limit to be 90% of the average total landed value between 2016-2018.

S&DT:
- Subsidies in excess of a Member's de minimis limit in the first year of the implementation shall be reduced or phased down to the de minimis level in equal annual installments over [X] years for developed country Members, [X+3] years for developing country Members, and [X+5] years for LDC Members. Subsidies to fishing and fishing-related activities solely within the Member's territorial waters shall not be included in the de minimis for developing and LDC Members.

5.3.2. New Zealand & Iceland - Overfishing and overcapacity [RD/TN/RL/79/Rev.1]

Title: New Zealand and Iceland draft text on overfishing and overcapacity
Date: This unofficial room document was circulated at the request of the Delegations of New Zealand and Iceland on April 18, 2019.
Public: No

Summary:
This communication advocates for prohibiting subsidies that reduce the operational or capital costs of fishing when one or more of the stocks in the relevant fishery or fisheries being targeted are either 1) being fished with a measure of fishing capacity that is greater than would be required to maintain the stock(s) at a level that would maintain [MSY]; 2) being fished at a rate that is contributing to a decline in the stock(s) below a level that would maintain [MSY]. If the subsidizing Member can demonstrate that it has other policies in place that effectively ensure the stocks(s) are maintained at or above a level required to maintain [MSY], a subsidy that would otherwise be prohibited by either of the above conditions shall be allowed.

Modeling Assumptions:
Prohibitions:
- There is uncertainty regarding the status of many fish stocks.
- For the purposes of modeling this proposal, we assume that subsidies to fishing on stocks identified as overfished (B/Bmsy < 1) in the RAM Legacy Stock Assessment Database are prohibited.
- The proportion of stocks identified as overfished in the RAM Legacy Stock Assessment Database likely underestimates the actual proportion of stocks that are overfished globally, but it is unclear whether enough evidence would exist to trigger this prohibition for stocks not included in this database.
- The proposal is ambiguous about which reference points might be used to make an overfished determination, and we therefore note that this is only one very narrow possible interpretation of this text.
- It is not possible to simulate whether Members could demonstrate that they have policies in place that would negate this prohibition.

S&DT:
- No special and differential treatment is considered.

5.3.3. China - Cap [TN/RL/GEN/199]

Title: A cap-based approach to address certain fisheries subsidies that contribute to overcapacity and overfishing

Date: This communication was circulated at the request of the Delegation of China on June 4, 2019.

Public: Yes

Summary:

This communication advocates for Member-specific subsidy caps (expressed in monetary terms). Subsidies in excess of a Member's cap would be prohibited. Members may choose from one of three approaches to calculate their subsidy cap: 1) [X]% of the average base for capping during the base period; 2) [Y]% of the average landed value of a Member's total wild marine capture during the base period; 3) [Z]% of the global average base for capping per fisherman multiplied by the number of fishermen of that Member during the base period. This proposal also advocates that the following four categories of "green-box" subsidies shall not be subject to Member's capping commitments: 1) government service and management programs; 2) programs to protect fisheries resources or rebuild stocks; 3) programs to reduce fishing efforts or fishing capacity; 4) programs that rebuttably presumed not to contribute to overcapacity or overfishing.

Modeling Assumptions:

Prohibitions:

- We assume that each Member's base for capping is represented by the total amount of capacity-enhancing subsidies estimated by Sumaila et al. 2019.
- Each Member's cap is equal to whichever of the three proposed approaches for calculating a cap yields the largest amount.
- By default, caps based on the first approach are calculated as 90% of each Member's base for capping; caps based on the second approach are calculated as 90% of each Member's estimated landed value (calculated from the FAO Global Marine Capture Production Database in 2018); caps based on the third approach are calculated assuming a value of $600 per fisherman, and each Member's most recently reported total number of fishers (from the FAO Yearbook of Fishery and Aquaculture Statistics 2017). Users are free to explore different values by changing the respective sliders on the advanced policy selection tab.
- We assume that provision of the following types of capacity-enhancing subsidies (as defined by Sumaila et al. 2019) are allowed to continue irrespective of a Member's total cap: subsidies for fishing access agreements, fisheries development projects.

S&DT:

- No special and differential treatment is considered.

5.3.4. Australia - Overfished [RD/TN/RL/77/Rev.2]

Title: Australian draft text on overfished stocks

Date: This unofficial room document was circulated at the request of the Delegation of Australia on June 5, 2019.

Public: No

Summary:

This communication presents a draft text for a prohibition on subsidies for fishing on overfished stocks. It is very similar to some of the draft text provided in RD/TN/RL/119, and advocates for a prohibition on subsidies for fishing on stocks recognized as overfished by the Member under whose jurisdiction the fishing is taking place or by the relevant RFMO/A. Such subsidies shall be prohibited if they are found to be having a negative effect on the stock, defined as any of the following: 1) a lack of recovery of the fishery; 2) continuation of depletion of fish stock levels; 3) continuation of excess levels of fishing.

Modeling Assumptions:
Prohibitions:
- There is uncertainty regarding the status of many fish stocks.
- For the purposes of modeling this proposal, we assume that subsidies to fishing on stocks identified as overfished (B/Bmsy < 0.8) in the RAM Legacy Stock Assessment Database are prohibited.
- The proportion of stocks identified as overfished in the RAM Legacy Stock Assessment Database likely underestimates the actual proportion of stocks that are overfished globally, but it is unclear whether enough evidence would exist to trigger this prohibition for stocks not included in this database.
- The proposal is ambiguous about which reference points might be used to make an overfished determination, and we therefore note that this is only one very narrow possible interpretation of this text.
- Additionally, as written, this text requires that there be a causal negative effect to the stock as a result of the subsidy. This is difficult to establish given existing data on subsidy provisioning and stock status, and is not possible to model.

S&DT:
- No special and differential treatment is considered.

5.3.5. Latin 6 and others - IUU [RD/TN/RL/87]

Title: Draft text on IUU fisheries subsidies
Date: This unofficial room document was circulated at the request of the Delegations of Argentina, Colombia, Costa Rica, Panama, Peru, Uruguay, Canada, Iceland, New Zealand, and the United States on June 12, 2019.
Public: No

Summary:
This document advocates for a prohibition on subsidies to vessels or operators engaged in IUU fishing. It specifies that IUU determinations could be made by the flag or subsidizing Member states, by RFMO/As in accordance with their rules and procedures and in conformity with international law, or by coastal Member states for activities in waters under their jurisdictions provided that such a determination is made fairly.

Modeling Assumptions:
Prohibitions:
- IUU determinations are made by existing RFMO/A vessel lists, and by flag, subsidizing, and coastal Member states.
- No publicly available data exist for most flag and subsidizing Member states, nor for coastal, port, or market Member states. Therefore modeling this proposal provides a very conservative

interpretation of this text. Users are free to explore a more ambitious interpretation by making their own assumptions about the expected IUU-findings.
- No proportionality or the duration of prohibition is considered.

S&DT:
- No special and differential treatment is considered.

5.3.6. USA and others - ABNJ [RD/TN/RL/91]

Title: Proposed text on fisheries subsidies for fishing in areas beyond national jurisdictions
Date: This unofficial room document was circulated at the request of the Delegations of Argentina, Australia, Chile, New Zealand, the United States, and Uruguay on June 27, 2019.
Public: No

Summary:
This communication advocates for placing prohibitions on a Member's subsidies contingent upon, or tied to actual or anticipated, fishing activities in areas beyond that Member's national jurisdiction.

Modeling Assumptions:
Prohibitions:
- We assume that all capacity-enhancing subsidies as defined by Sumaila et al. 2019 are prohibited to vessels fishing in areas beyond that Member's national jurisdiction.
- We note that this is an ambitious interpretation of this proposal, as the text makes it clear that the fact that a subsidy is granted is not reason enough for that subsidy to be prohibited. However, data does not exist at present to make this determination for subsidy programs globally.
- By default, we consider all capacity-enhancing subsidies provided to vessels spending at least 5% of their total annual effort fishing on the high seas to be prohibited. Users can set a different threshold on the advanced policy selection tab if they wish.

S&DT:
- No special and differential treatment is considered.

5.3.7. ACP - Overfishing and overcapacity [RD/TN/RL/96]

Title: Overcapacity and overfishing
Date: This unofficial room document was circulated at the request of the Delegation of Jamaica on behalf of the African, Caribbean and Pacific Countries (ACP) Group on July 2, 2019.
Public: No

Summary:
This communication builds on TN/RL/GEN/192, as reflected in TN/RL/W/274/Rev.6, and advocates for a prohibition on subsidies for capital and operating costs, provided to large-scale industrial fishing. Capital cost subsidies include those for construction, acquisition, modernization, renovation or upgrading of vessels, direct transfers for vessel construction and modernization, purchase of machines and equipment for fishing vessels. Operating cost subsidies include those for fuel, ice, bait, personnel, income support of vessels or operators or the workers they employ, social chargers, insurance, payments based on the price of fish caught, gear, and at-sea support, or operating losses of such vessels or activities.

Modeling Assumptions:
Prohibitions:

- We assume that the following types of subsidies as defined by Sumaila et al. 2019 are prohibited: i) boat construction and renovation, ii) fuel.
- This prohibition is assumed to only apply to developed and developing country Members.

S&DT:
- Subsidies provided by developing country Members for fishing within their own EEZs shall be allowed and this prohibition shall not apply to LDC Members.

5.3.8. ACP - Overfished [RD/TN/RL/95]

Title: Overfished discipline
Date: This unofficial room document was circulated at the request of the Delegation of Jamaica on behalf of the African, Caribbean and Pacific Countries (ACP) Group on July 2, 2019.
Public: No

Summary:
This communication presents a draft text for a prohibition on subsidies for fishing on overfished stocks. It builds on TN/RL/GEN/192, as reflected in TN/RL/W/274/Rev.6, and advocates for a prohibition on subsidies to vessels fishing outside of a Member's territorial sea on overfished stocks. It defines overfished stocks as those recognized as such by the Member in whose jurisdiction the fishing is taking place, or by the relevant RFMO/A. It also provides a list of allowed subsidies.

Modeling Assumptions:
Prohibitions:
- There is uncertainty regarding the status of many fish stocks.
- For the purposes of modeling this proposal, we assume that subsidies to fishing on stocks identified as overfished (B/Bmsy < 1) in the RAM Legacy Stock Assessment Database are prohibited.
- The proportion of stocks identified as overfished in the RAM Legacy Stock Assessment Database likely underestimates the actual proportion of stocks that are overfished globally, but it is unclear whether enough evidence would exist to trigger this prohibition for stocks not included in this database.
- The proposal is ambiguous about which reference points might be used to make an overfished determination, and we therefore note that this is only one very narrow possible interpretation of this text.
- Subsidies for fishing within a Member's territorial sea shall be allowed.

S&DT:
- No special and differential treatment is considered.

5.3.9. US and others - Cap/Tier [TN/RL/GEN/197/Rev.2]

Title: A cap-based approach to addressing certain fisheries subsidies
Date: This communication was circulated at the request of the Delegations of Australia and the United States on July 11, 2019.
Public: Yes

Summary:
This communication advocates for negotiating Member-specific subsidy caps (expressed in monetary terms). Subsidies in excess of a Member's cap would be prohibited. This cap is intended to be

supplementary to any prohibitions on subsidies that support IUU, fishing beyond national jurisdiction, and subsidies for fishing that negatively affect overfished stocks. Members would also commit to maintain fisheries management and conservation measures.

Modeling Assumptions:
Prohibitions:
- We assume that each Member's base for capping is represented by the total amount of capacity-enhancing subsidies estimated by Sumaila et al. 2019.
- Members are sorted into three tiers based on a three-year average of FAO marine capture production (2015-2017). Members accounting for 0.7% or more of global marine capture production are in "Tier 1"; Members accounting for 0.05% or more, but less than 0.7%, of global marine capture production are in "Tier 2"; Members accounting for less than 0.05% of global marine capture production are in "Tier 3".
- This proposal advocates for allowing both Tier 1 and Tier 2 Members to negotiate their own subsidy caps or to accept a default cap of $50 million annually. For the purposes of modeling, we assume that Tier 1 Members receive a subsidy cap equal to 90% of their base for capping, and Tier 2 Members receive the default cap of $50 million. Tier 3 Members do not receive a cap.

S&DT:
- No special and differential treatment is considered.

5.3.10. Morocco - Industrial fishing [RD/TN/RL/103]

Title: Fishing vessels to be exclusively or mainly targeted in the context of overcapacity and overfishing disciplines
Date: This unofficial room document was circulated at the request of the Delegation of Morocco on August 7, 2019.
Public: No

Summary:
This communication defines the characteristics of vessels that shall be targeted in regards to overcapacity and overfishing disciplines. It advocates that any vessel having at least three of the six characteristics shall be affected: vessels 1) greater than 24 meters in length; 2) with gross tonnage of more than 100 GT; 3) with fishing gear towed or hauled by motor driven equipment; 4) propelled by an engine with more than 130 kW; 5) with onboard freezing equipment for storage; 6) owned or operated by a multinational enterprise, a public limited company, or a joint venture.

Modeling Assumptions:
Prohibitions:
- We assume that all capacity-enhancing subsidies as defined by Sumaila et al. 2019 are prohibited to vessels satisfying the three following characteristics: 1) total length of more than 24 meters; 2) gross tonnage of more than 100 GT; 3) engine power of more than 130 kW. In general, the tool does not include many vessels with fishing gears that are not hauled by a motor driven equipment, thus this characteristic is assumed to be satisfied. The other 2 conditions are not modeled as it is difficult to determine which vessels have onboard freezing equipment, or the characteristics of a vessel's owning or operating company.

S&DT:
- No special and differential treatment is considered.

5.3.11. European Union - IUU [RD/TN/RL/104]

Title: Possible consolidated vertical negotiating text

Date: This unofficial room document was circulated at the request of the Delegation of the European Union on September 10, 2019.

Public: No

Summary:

This communication aims to consolidate all existing texts that have been put forth or discussed with regards to a prohibition on subsidies that contribute to IUU fishing. It contains alternative approaches to crafting such a discipline, as well as alternative versions of relevant definitions.

Modeling Assumptions:

Prohibitions:
-   IUU determinations are made by existing RFMO/A vessel lists, and by flag, subsidizing, coastal, port, and market Member states.
-   No publicly available data exist for most flag and subsidizing Member states, nor for coastal, port, or market Member states. Therefore modeling this proposal provides a very conservative interpretation of this text. Users are free to explore a more ambitious interpretation by making their own assumptions about the expected IUU-findings.
-   No proportionality or the duration of prohibition is considered.

S&DT:
-   No special and differential treatment is considered.

5.3.12. Philippines - Disputed waters [TN/RL/GEN/202]

Title: Proposed solution to concerns on disputed waters

Date: This communication was circulated at the request of the Delegation of the Philippines on October 21, 2019.

Public: Yes

Summary:

This communication advocates for prohibiting subsidies in disputed waters, unless all parties have jointly notified the WTO of any agreement to subsidize. Members should attempt to reach an agreement through bilateral consultations before going to Dispute Settlement.

Modeling Assumptions:

Prohibitions:
-   We assume that all capacity-enhancing subsidies as defined by Sumaila et al. 2019 are prohibited in areas classified as "disputed" in the Marine Regions' Maritime Boundaries World EEZ dataset (v10).
-   We note that this is a very ambitious interpretation of the possible effects of this proposal.
-   It is materially impossible to model non-existing agreements to subsidize in disputed areas.

S&DT:
-   No special and differential treatment is considered.

5.3.13. European Union and others - Overfishing and overcapacity [RD/TN/RL/112/Rev.1]

Title: Proposed draft text on a prohibition of subsidies contributing to overcapacity and overfishing

Date: This unofficial room document was circulated at the request of the Delegations of the European Union, Japan, the Republic of Korea, and the Separate Customs Territory of Taiwan, Penghu, Kinmen and Matsu on February 5, 2020.

Public: Yes

Summary:

This communication advocates for a general prohibition of subsidies that contribute to overcapacity and overfishing. However, it allows for subsidies if the subsidizing Member can demonstrate that the stock(s) targeted by the subsidy recipient are managed on the based on the best publicly available scientific evidence taking into account the following elements: 1) scientific stock assessments; 2) legal institutions for resource management (i.e. vessel registration and fishery permits); 3) specific conservation and management measures for fish stocks (i.e. input, output, and technical controls taking account of fishery status); 4) monitoring, control and surveillance measures. It also provides a list of subsidies that shall be deemed not to be prohibited. Includes a reference to the precautionary principle to be included in a preamble. Prohibition should not apply to subsistence fishing.

Modeling Assumptions:

Prohibitions:
- There is uncertainty regarding the status of many fish stocks.
- For the purposes of modeling this proposal, we assume that subsidies to fishing on stocks identified as overfished (B/Bmsy < 1) in the RAM Legacy Stock Assessment Database are prohibited.
- The proportion of stocks identified as overfished in the RAM Legacy Stock Assessment Database likely underestimates the actual proportion of stocks that are overfished globally, but it is unclear whether enough evidence would exist to trigger this prohibition for stocks not included in this database.
- The proposal is ambiguous about which reference points might be used to make an overfished determination, and we therefore note that this is only one very narrow possible interpretation of this text.
- It is difficult to identify subsidies for subsistence fishing, so we approximate this condition by assuming that subsidies for fishing within a Member's territorial waters are allowed.

S&DT:
- A transition period shall be allowed for developing country Members and LDCs. We assume these transition periods to be 4 and 6 years respectively.

5.3.14. Facilitator's text - IUU [RD/TN/RL/113]

Title: Elimination of subsidies that contribute to illegal, unreported and unregulated (IUU) fishing - Facilitator's working paper

Date: This unofficial room document was circulated to the Negotiating Group on Rules by the facilitator on December 2, 2019. This document builds on the first facilitator report, RD/TN/RL/97/Rev.3 of July 12, 2019.

Public: No

Summary:

This document summarizes the Facilitator's recommendations regarding the elimination of subsidies that contribute to IUU fishing. Key takeaways:
- Making IUU determinations is a right Members have based on agreements outside the WTO.

- A subsidies prohibition should not imply an obligation related to making IUU determinations.
- All procedures need to have been followed in making the determination, including appeal and review.
- There is general agreement among Members that determinations made by a coastal state, RFMO/A, flag state, or subsidizing Member state should all trigger IUU prohibitions of subsidies.

Modeling Assumptions:
- IUU determinations are made by existing RFMO/A vessel lists, and by flag, subsidizing, and coastal Member states.
- No publicly available data exist for most flag and subsidizing Member states, nor for coastal Member states. Therefore modeling this proposal provides a very conservative interpretation of this text. Users are free to explore a more ambitious interpretation by making their own assumptions about the expected IUU-findings.
- No proportionality or the duration of prohibition is considered.

S&DT:
- No special and differential treatment is considered.

5.3.15. Facilitator's text - Overfished [RD/TN/RL/119]

Title: Overfished stocks: Facilitator's working paper
Date: This unofficial room document was circulated to the Negotiating Group on Rules by the facilitator on December 4, 2019.
Public: No

Summary:
This communication presents a draft text on subsidies for fishing overfished stocks. It aims to eliminate text no longer under consideration and consolidate the remaining possible alternative approaches that have been put forth or discussed. It is noted that this is in no way agreed text, but rather an attempt to try to focus future discussions. It advocates for prohibiting subsidies for fishing on an overfished stock. It provides two alternative approaches for crafting such a prohibition: subsidies shall be prohibited i) if there is a lack of recovery of the stock or if there is a continuous reduction in the level of the stock; ii) if they are not implemented in a manner that ensures rebuilding of the stock. It also provides two possible ways of characterizing and determining what constitutes an overfished stock: i) those recognized as such by the Member under whose jurisdiction the fishing is taking place or by the relevant RFMO/A; ii) those for which the mortality from fishing needs to be restricted to allow the stock to rebuild to some reference point.

Modeling Assumptions:
- There is uncertainty regarding the status of many fish stocks.
- For the purposes of modeling this proposal, we assume that subsidies to fishing on stocks identified as overfished (B/Bmsy < 1) in the RAM Legacy Stock Assessment Database are prohibited.
- The proportion of stocks identified as overfished in the RAM Legacy Stock Assessment Database likely underestimates the actual proportion of stocks that are overfished globally, but it is unclear whether enough evidence would exist to trigger this prohibition for stocks not included in this database.
- The proposal is ambiguous about which reference points might be used to make an overfished determination, and we therefore note that this is only one very narrow possible interpretation of this text.

S&DT:
- No special and differential treatment is considered.

5.3.16. Canada - Overfishing and overcapacity [RD/TN/RL/121]

Title: Proposed prohibition on subsidies contributing to overcapacity and overfishing
Date: This unofficial room document was circulated at the request of the Delegation of Canada on January 13, 2020.
Public: No

Summary:
This communication advocates for placing prohibitions on any subsidies contributing to overfishing or overcapacity and any subsidies for fishing outside of the jurisdictions of coastal Members or relevant RFMO/As. Subsidies shall be considered to contribute to overfishing or overcapacity if they benefit an entity engaged in fishing on a stock that is being fished at a rate that is greater than that which would allow it to be maintained at a sustainable level.

Modeling Assumptions:
Prohibitions:
- There is uncertainty regarding the status of many fish stocks.
- For the purposes of modeling this proposal, we assume that subsidies to fishing on stocks identified as overfished (B/Bmsy < 1) in the RAM Legacy Stock Assessment Database are prohibited.
- The proportion of stocks identified as overfished in the RAM Legacy Stock Assessment Database likely underestimates the actual proportion of stocks that are overfished globally, but it is unclear whether enough evidence would exist to trigger this prohibition for stocks not included in this database.
- The proposal is ambiguous about which reference points might be used to make an overfished determination, and we therefore note that this is only one very narrow possible interpretation of this text.
- We assume that all capacity-enhancing subsidies as defined by Sumaila et al. 2019 are prohibited to vessels fishing on the high seas. By default, we consider all capacity-enhancing subsidies provided to vessels spending at least 5% of their total annual effort fishing on the high seas to be prohibited. Users can set a different threshold on the advanced policy selection tab if they wish.

S&DT:
- No special and differential treatment is considered.

5.3.17. ACP - IUU [RD/TN/RL/89/Rev.2]

Title: IUU fishing
Date: This unofficial room document was circulated at the request of the Delegation of Jamaica on behalf of the African, Caribbean and Pacific Countries (ACP) Group on February 4, 2020.
Public: No

Summary:
This document builds on ACP text proposal TN/RL/GEN/192, as reflected in TN/RL/W/274/Rev.6. It specifies that IUU determinations could be made by coastal Member states for activities in waters under

their jurisdictions with respect to a foreign vessel or operator, or by RFMO/As in areas (and for species) under their jurisdictions. Members are encouraged to refrain from invoking the discipline based on minor infringements.

Modeling Assumptions:
Prohibitions:
- IUU determinations are made by existing RFMO/A vessel lists, and by flag, subsidizing, and coastal Member states.
- No publicly available data exist for most flag and subsidizing Member states, nor for coastal, port, or market Member states. Therefore modeling this proposal provides a very conservative interpretation of this text. Users are free to explore a more ambitious interpretation by making their own assumptions about the expected IUU-findings.
- No proportionality or the duration of prohibition is considered.

S&DT:
- Developing countries not engaged in large-scale industrial distant water fishing are entitled to an additional transition period. LDCs and SVEs are entitled to a different transition period.

5.3.18. ACP - Overfishing and overcapacity (revised) [RD/TN/RL/96/Rev.2]

Title: Overcapacity and overfishing
Date: This unofficial room document was circulated at the request of the Delegation of Jamaica on behalf of the African, Caribbean and Pacific Countries (ACP) Group on February 4, 2020.
Public: No

Summary:
This communication builds on TN/RL/GEN/192, as reflected in TN/RL/W/274/Rev.6, and advocates for a prohibition on subsidies for capital and operating costs provided to large-scale industrial fishing. Capital cost subsidies include those for construction, acquisition, modernization, renovation or upgrading of vessels, direct transfers for vessel construction and modernization, purchase of machines and equipment for fishing vessels. Operating cost subsidies include those for fuel, ice, bait, personnel, income support of vessels or operators or the workers they employ, social chargers, insurance, payments based on the price of fish caught, gear, and at-sea support, or operating losses of such vessels or activities. This text includes a list of subsidies that shall not be prohibited (Green Box): fisheries management, permanent cessation of fishing; implementation of international agreements, disaster relief, health and safety conditions, promotion of human capital.

Modeling Assumptions:
Prohibitions:
- We assume that the following types of subsidies as defined by Sumaila et al. 2019 are prohibited: i) boat construction and renovation, ii) fuel.
- This prohibition is assumed to only apply to developed and developing country Members.

S&DT:
- Developing country Members that individually account for less than [2%] of global marine capture production shall be exempt, and this prohibition shall not apply to LDC Members.

5.3.19. LDC - full text [RD/TN/RL/125]

Title: LDC Group Fisheries Subsidies Text Proposal

Date: This unofficial room document was circulated at the request of the Delegation of Chad on behalf of the Least Developed Countries (LDC) Group on March 6, 2020.

Public: No

Summary:

This communication advocates for fisheries subsidies prohibitions across all three categories of proposed disciplines.

Modeling Assumptions:

Prohibitions:

For IUU:

- Final determinations are made by existing RFMO/A vessel lists, by flag, subsidizing, and coastal Member states.
- No publicly available data exist for most flag and subsidizing Member, nor for coastal Member. The possible effects is a conservative interpretation of this text.
- Users are free to explore a more ambitious interpretation by making their own assumptions about the expected IUU-findings.
- No proportionality or the duration of prohibition is considered.

For Overfished:

- There is uncertainty regarding the status of many fish stocks.
- For the purposes of modeling this proposal, we assume that subsidies to fishing on stocks identified as overfished (B/Bmsy < 1) in the RAM Legacy Stock Assessment Database are prohibited.
- The proportion of stocks identified as overfished in the RAM Legacy Stock Assessment Database likely underestimates the actual proportion of stocks that are overfished globally, but it is unclear whether enough evidence would exist to trigger this prohibition for stocks not included in this database.
- The proposal is ambiguous about which reference points might be used to make an overfished determination, and we therefore note that this is only one very narrow possible interpretation of this text.

For Overcapacity and Overfishing:

- We assume that all capacity-enhancing subsidies as defined by Sumaila et al. 2019 are prohibited to vessels fishing on the high seas, and to vessels greater than 24 m in length or with a tonnage greater than 100 GT.

S&DT:

- Subsidies for fishing in a Member's territorial waters are excluded. Prohibition of subsidies to OFOC shall not apply to LDCs. A transition period of 5 years shall be allowed for Overfished and OFOC disciplines for developing country and LDC Members.

5.3.20. India - S&DT [TN/RL/GEN/200/Rev.1]

Title: Article [X]: Special and differential treatment

Date: This communication was circulated at the request of the Delegation of India on March 6, 2020.

Public: Yes

Summary:

This communication advocates for special and differential treatment for all three classes of proposed disciplines. As written, this proposal does not specify potential disciplines within each of the three categories, but rather the S&DT that should be allowed for them. To model the possible effects of such a proposal, we therefore use the disciplines proposed in LDC - Full text (excluding any S&DT).

Modeling Assumptions:
Prohibitions:
For IUU:
- Final determinations are made by existing RFMO/A vessel lists, by flag, subsidizing, and coastal Member states.
- No publicly available data exist for most flag and subsidizing Member, nor for coastal Member. The possible effects is a conservative interpretation of this text.
- Users are free to explore a more ambitious interpretation by making their own assumptions about the expected IUU-findings.
- No proportionality or the duration of prohibition is considered.

For Overfished:
- There is uncertainty regarding the status of many fish stocks.
- For the purposes of modeling this proposal, we assume that subsidies to fishing on stocks identified as overfished (B/Bmsy < 1) in the RAM Legacy Stock Assessment Database are prohibited.
- The proportion of stocks identified as overfished in the RAM Legacy Stock Assessment Database likely underestimates the actual proportion of stocks that are overfished globally, but it is unclear whether enough evidence would exist to trigger this prohibition for stocks not included in this database.
- The proposal is ambiguous about which reference points might be used to make an overfished determination, and we therefore note that this is only one very narrow possible interpretation of this text.

For Overcapacity and Overfishing:
- We assume that all capacity-enhancing subsidies as defined by Sumaila et al. 2019 are prohibited to vessels fishing on the high seas, and to vessels greater than 24 m in length or with a tonnage greater than 100 GT.

S&DT:
- For IUU: Subsidies granted by developing and LDC Members shall be allowed for small scale fishing: a) within their own territorial waters and b) within their own EEZs and high seas for 7 years. For Overfished: Subsidies granted by developing and LDC Members shall be allowed for fishing a) within their own territorial waters and b) within their own EEZs for 2 years. For OCOF: Subsidies granted by LDCs shall be allowed, and subsidies granted by developing countries shall be allowed for fishing in their territorial seas, or for fishing in their EEZs and high seas unless any of the following conditions are met for three consecutive years: a) GNI per capita is greater than US $5000 (constant 2010 $USD), b) they engage in distant water fishing, or c) the contribution from Agriculture, Forestry and Fishing to their national GDP (World Bank) is greater than 10%.

5.3.21. Chair's text - Draft text

Title: Consolidated draft text
Date: This communication was circulated at the request of the Chair of the Negotiating Group on Rules on June 25, 2020.
Public: No

Summary:

This communication aims to consolidate all existing texts that have been put forth or discussed with regards to a prohibition on subsidies across all three disciplines. It was intended to provide a starting point for interactive discussion. The modeling assumptions presented below only represent one of our possible interpretations of this proposal. For example, two alternative overfished stock disciplines are presented in this text (see New Zealand/Iceland - Overfishing and overcapacity and ACP - Overfished above), and there is a blank placeholder for inclusion of a cap-based proposal (see cap-based proposals above). Users of the SubsidyExplorer toolkit can choose amongst these options.

Modeling Assumptions:

Prohibitions:

For IUU:
- 1) Final determinations are made by existing RFMO/A vessel lists, by flag, subsidizing, coastal, and port Member states.
- 2) No publicly available data exist for most flag and subsidizing Member, nor for coastal or port Members. The possible effects is a conservative interpretation of this text.
- 3) Users are free to explore a more ambitious interpretation by making their own assumptions about the expected IUU-findings.
- 4) No proportionality or the duration of prohibition is considered.

For Overfished:
- 1) There is uncertainty regarding the status of many fish stocks.
- 2) For the purposes of modeling this proposal, we assume that subsidies to fishing on stocks identified as overfished (B/Bmsy < 1) in the RAM Legacy Stock Assessment Database are prohibited.
- 3) The proportion of stocks identified as overfished in the RAM Legacy Stock Assessment Database likely underestimates the actual proportion of stocks that are overfished globally, but it is unclear whether enough evidence would exist to trigger this prohibition for stocks not included in this database.
- 4) The proposal is ambiguous about which reference points might be used to make an overfished determination, and we therefore note that this is only one very narrow possible interpretation of this text.
- 5) As written, this text includes two alternate definitions for an overfished stock subsidy prohibition - this is the more ambitious interpretation of the two.

For OFOC:
- 1) We assume that all capacity-enhancing subsidies as defined by Sumaila et al. 2019 are prohibited to vessels fishing in areas beyond that Member's national jurisdiction.
- 2) We note that this is an ambitious interpretation of this proposal, as the text makes it clear that the fact that a subsidy is granted is not reason enough for that subsidy to be prohibited. However, data does not exist at present to make this determination for subsidy programs globally.
- 3) By default, we consider all capacity-enhancing subsidies provided to vessels spending at least 5% of their total annual effort fishing on the high seas and/or in the EEZs of another coastal state to be prohibited. Users can set a different threshold on the advanced policy selection tab if they wish.
- 4) As written, this text includes a blank placeholder for inclusion of a cap-based approach. This is not represented here.

S&DT:

- For IUU: No S&DT is considered. For Overfished: Subsidies granted by developing and LDC Members for fishing within their own territorial sea shall be allowed. For OCOF: No S&DT is considered.

Figures and Tables
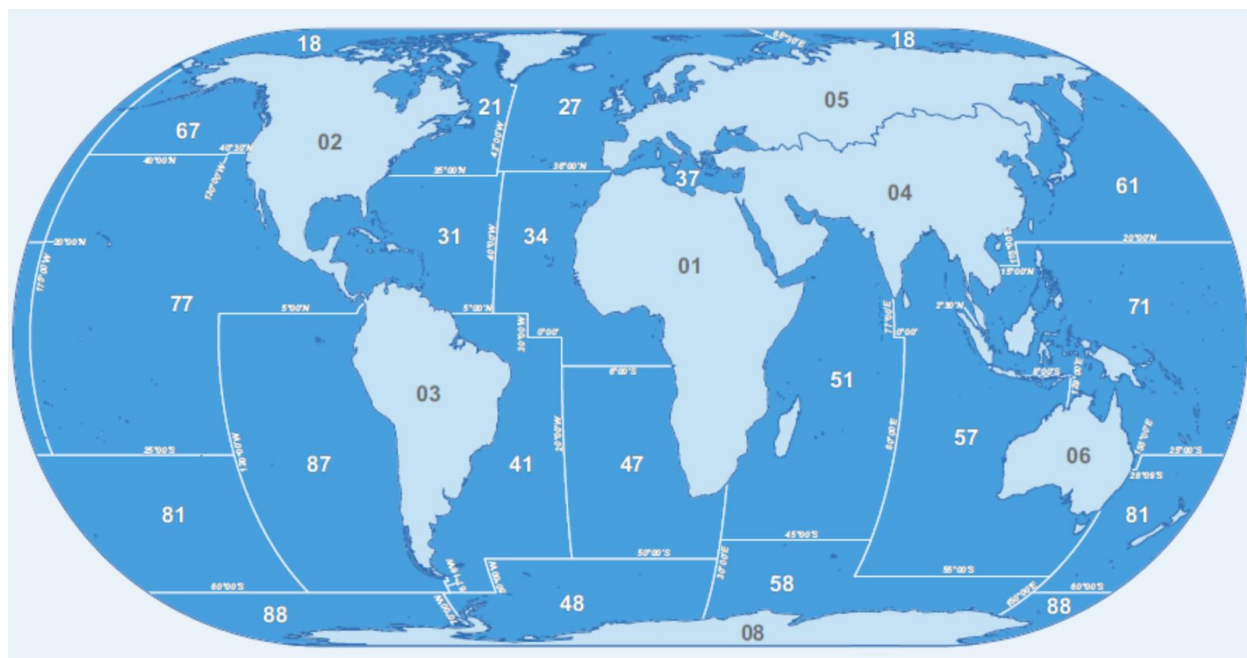
Figure 1. Map of FAO major fishing areas
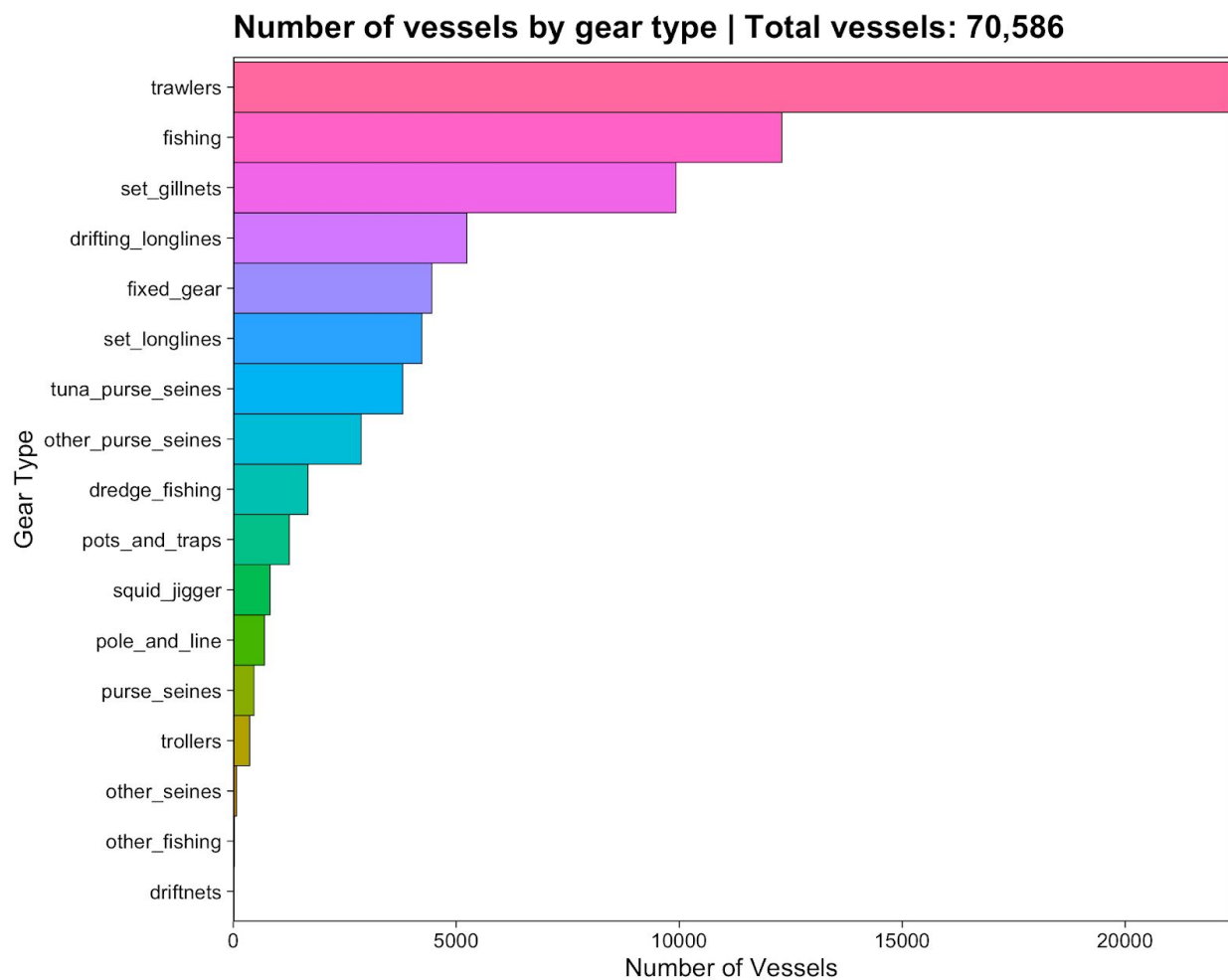
Figure 2. Number of fishing vessels by gear type included in the GFW effort dataset (2018).
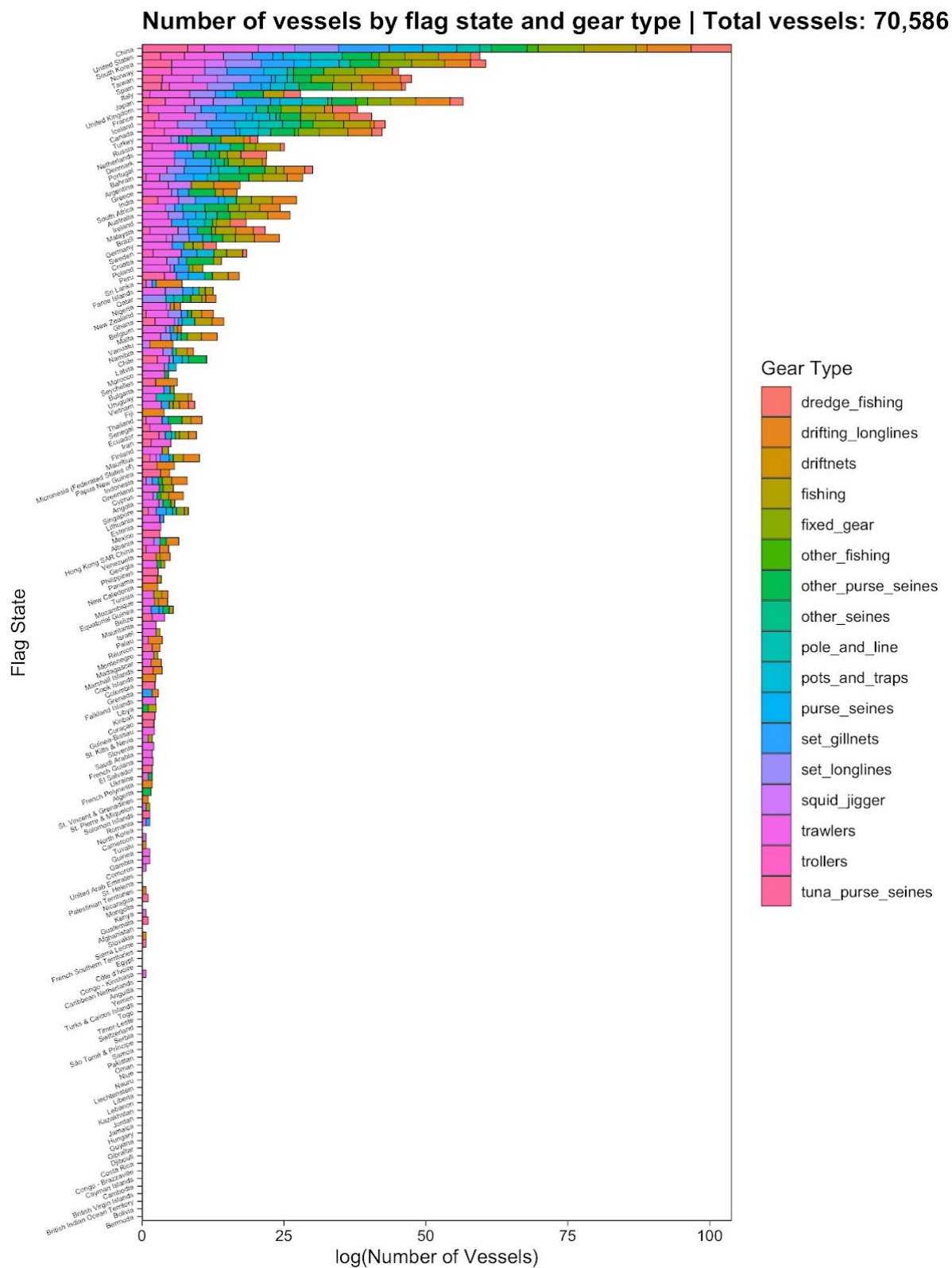
Figure 3. Number of fishing vessels by flag state and gear type included in the GFW effort dataset (2018).
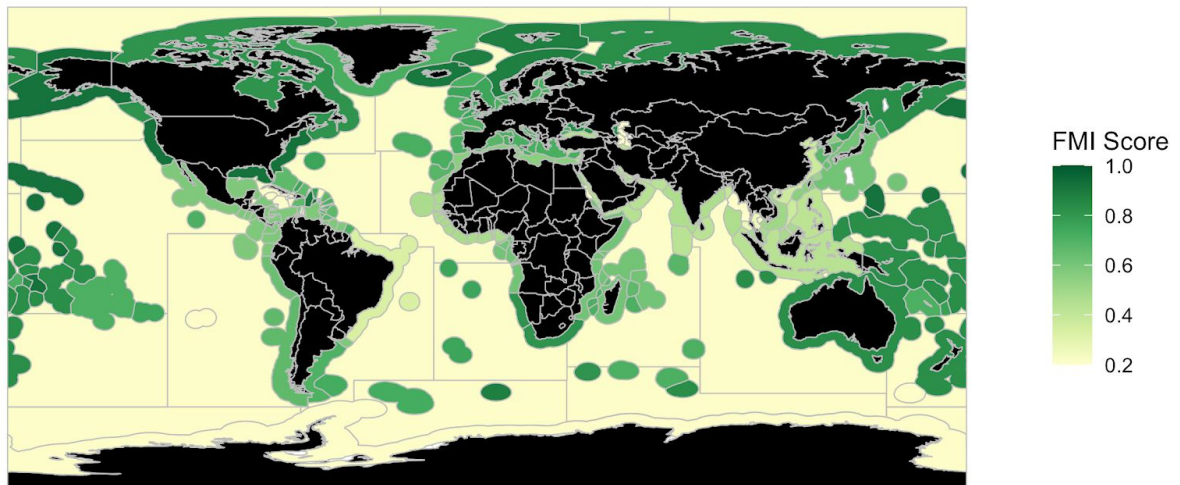
Figure 4. Fisheries management indicator (FMI) scores by EEZ (and FAO statistical areas for the high seas). Extrapolated from the FMI scores in Melnychuk et al. (14).
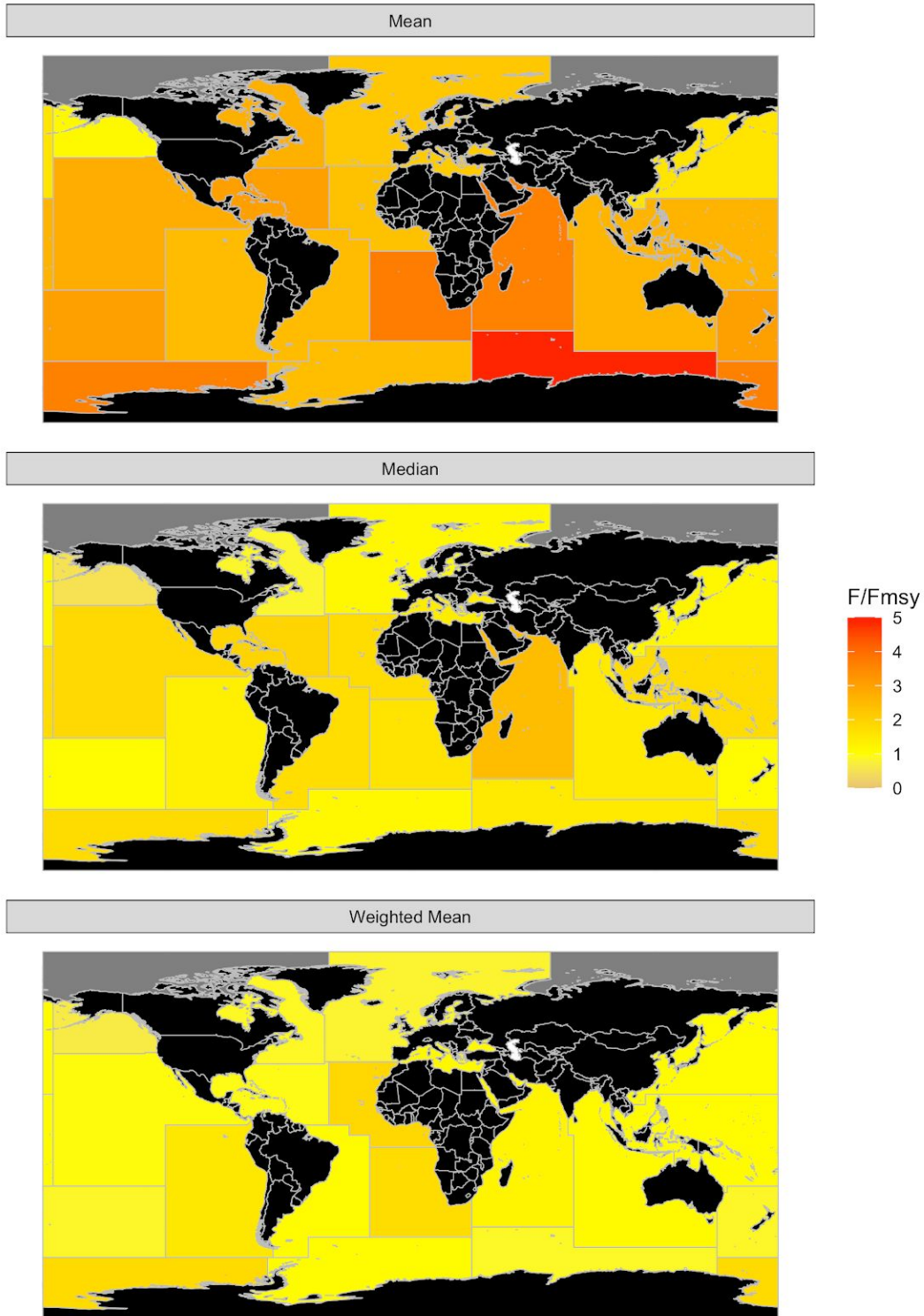
Figure 5. Fishing mortality rates relative to the fishing mortality rate at MSY (F/Fmsy) by FAO statistical area for all stocks assessed by Costello et al. (13). For the weighted mean calculation, the MSY of each stock was used as the weight.

Figure 6. Hypothetical illustration of a biomass- or price-driven rebound effect for a simple fishery with a single fish stock and two fleets.

Table 1. Fishery subsidy classification system based on the potential impact of a subsidy on the sustainability of the fishery resource from Sumaila et al. (2010).

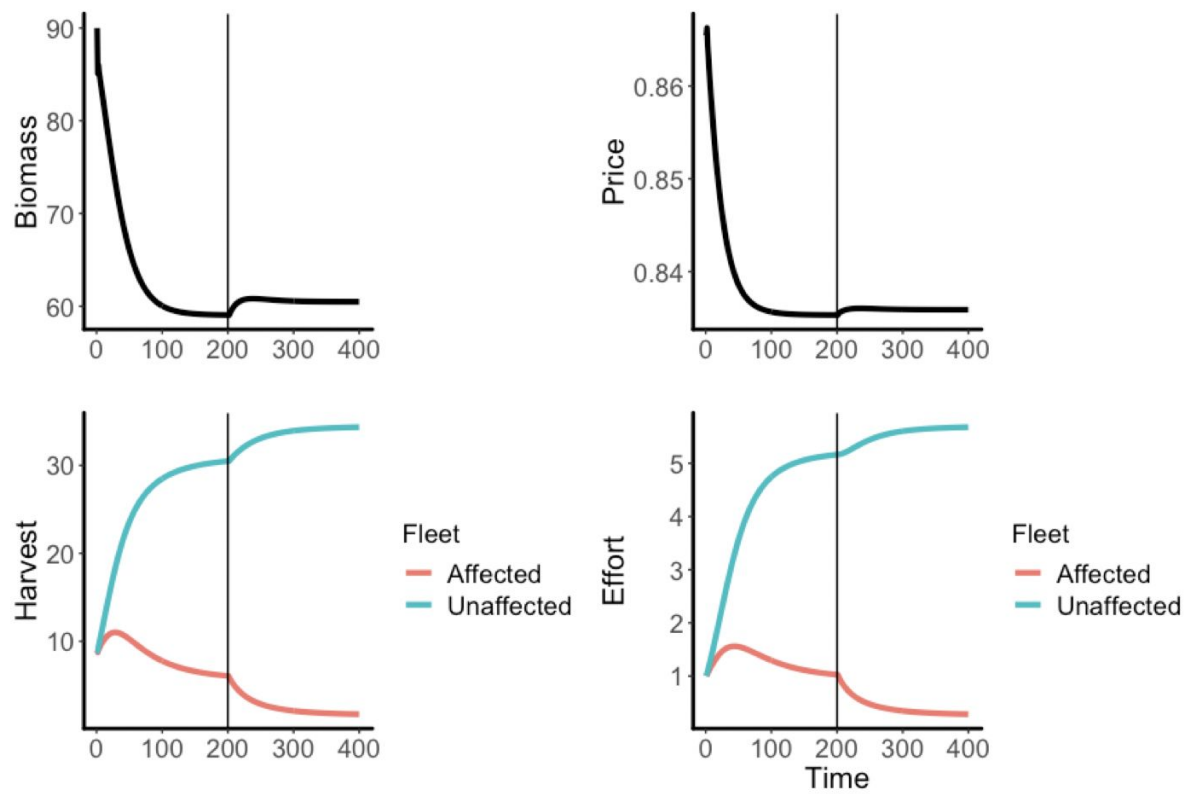| Subsidy Type	Description
A. Beneficial subsidies ("good")	
A1. Fisheries management programs and services	These may include monitoring, control, and surveillance programs, stock assessment and resource surveys, fishery habitat enhancement programs, and stock enhancement programs.
A2. Fishery research and development (R&D)	These may include programs aimed at improving methods for fish catching and processing, as well as other programs aimed at improving fishery resources through scientific or technical developments.
A3. Marine Protected Areas (MPAs)	These may include establishment, monitoring, or enforcement of areas where commercial fishing is prohibited.
B. Capacity-enhancing subsidies ("harmful")	
B1. Boat construction, renewal and modernization programs	These may include lending programs below market rate geared towards fishing vessel construction, renewal and modernization (loan guarantees, restructuring, and other lending programs) as well as public support programs to adopt new and/or improve fishing technology.
B2. Fishing port construction and renovation programs	These may include provision of public funds towards fishing landing site infrastructure, port improvements for fishing fleets, harbor maintenance, jetty and landing facilities, and reduced cost or free moorage for fishing fleets.
B3. Price and marketing support, processing and storage infrastructure programs	These may include market intervention programs such as value addition and price support, or infrastructure investment programs for processing, storage, and fish auction facilities.
B4. Fishery development projects and support services	These may include programs that support fisheries enterprises development or programs that provide institutional support and services, provision of baits, and search and rescue programs.
B5. Non-fuel tax exemptions	These may include rebate and other government funded insurance support programs that have a direct impact on profits such as income tax deferral for fishers, crew insurance, duty free imports of fishing inputs, vessel insurance programs, and other economic incentive programs.
B6. Foreign access agreements	These may include explicit monetary transfers, transfers of fishing technology, or the provision of market access in another country.
B7. Fuel subsidies	This is calculated as the difference between the price per liter of fuel paid by fishers and the national price applied to fuel purchase for other uses.
C. Ambiguous subsidies ("neutral")	
C1. Fisher assistance programs	These include payments to fishers to stop fishing temporarily or to supplement income during bad times which as income support programs, unemployment insurance, worker adjustment programs, fishery retraining, and other direct payments to fishers.
C2. Vessel buyback programs	These may include permit or gear buybacks, or license retirements.
C3. Rural fishers' community development programs	These may include programs with an overall objective of poverty alleviation and food sufficiency.

Table 2. Fishery subsidy classification system based on the implementation criteria of a transfer from the OECD.

Subsidy Type	Description
0. Non-budgetary transfers to individual fishers	
0.A. Market price support	Transfers to fishers arising from policy measures that create a gap between domestic market prices and border prices.
0.B. Fuel tax concessions	These may include programs aimed at improving methods for fish catching and processing, as well as other programs aimed at improving fishery resources through scientific or technical developments.
1. Budgetary transfers to individual fishers	
1.A. Transfers supporting fishing and vessel costs	Transfers to fishers based on the use of fishing inputs or factors of production
1.A.1. Variable costs	*Transfers reducing the cost of a specific variable input or a mix of variable inputs (not including fuel tax concessions)*
1.A.2. Fixed costs	*Transfers reducing investment costs to purchase or modernize fishing vessels, gear, or any other capital asset – can be further subdivided into transfers for 1) vessel construction or purchase, 2) modernization, or 3) other transfers*
1.B. Transfers based on a fisher's income	Transfers to fishers based on their income or revenue
1.B.1. Income support	*Transfers based on income or revenue, including direct payments to vessel owners or crew.*
1.B.2. Special insurance system for fishers	*Includes measures reducing employers' social security contributions and measures providing health insurance and pension schemes with preferential conditions or rates.*
1.C. Transfers based on the reduction of productive capacity	Transfers based on the removal of vessels and licenses from a fishery, including buyouts of quota and early retirement plans
1.D. Miscellaneous transfers to fishers	Transfers to fishers that cannot be disaggregated and allocated to the other categories
2. Transfers to the sector generally	
2.A. Payment for access to other countries' waters	These may include government-to-government payments for the right of access, for a country's fishing fleet, to operate in another country's EEZ
2.B. Provision of infrastructure	Transfers supporting the construction, management, and access to shared facilities, including port infrastructure and activities
2.B.1. Capital expenditures	
2.B.2. Subsidized access to infrastructure	
2.C. Marketing and promotion	Transfers financing assistance to marketing and promotion of fish products
2.D. Transfers supporting fishing communities	Transfers supporting the improvement of livelihoods in fisher's communities

2.E. Education and training	Transfers financing training and education in the fishery sector	
2.F. Research and development	Transfers financing research and development of activities improving production	
2.G. Management of resources	Transfers financing management activities improving the productivity or the sustainability of aquatic resources	
2.G.1. Management expenditures	*Transfers financing the expenditures associated with management program*	
2.G.2. Stock enhancement programs	*Transfers financing stock-enhancement programs*	
2.G.3. Surveillance and enforcement expenditures	*Transfers financing enforcement of management measures*	
2.H. Miscellaneous transfers to general services	Transfers financing other general services that cannot be disaggregated and allocated to the other categories	
3.	**Cost recovery charges**	
3.A. For resource access	Charges levied on fishers to grant access to a resource, including license fees, cost of permits, and other formalities	
3.B. To access infrastructure	Charges levied on fishers to grant access to infrastructure such as harbor fees and other user charges for government-provided infrastructure	
3.C. For management	Charges levied on fishers to finance management, research and enforcement expenditures, or fines levied in case of infraction	
3.D. Resource rent taxes and charges	Fees, taxes, or payments collected from individual fishers according to resource rents generated by fishing activities, including profit taxes	
3.E. Other	Other charges levied on fishers for which there is insufficient information to allocate them to appropriate categories	

Table 3. Consumer Price Index (CPI) rates used in this analysis by year (2012 - 2018)

Year	CPI Rate
2012	229.594
2013	232.957
2014	236.736
2015	237.017
2016	240.007
2017	245.120
2018	251.107

Table 4. Fixed bioeconomic model parameters for the global analysis. These parameters remain constant and are not dependent on the sizes or compositions of the different fleets.

Parameter	Description	Value	Units	Source(s)	Notes
φ	Shape parameter	0.188	---	(13, 36)	Corresponds to $B_{MSY}/K = 0.4$
MSY	Maximum sustainable yield	109,408,999	mt	(13)	MSY was adjusted to account for the 78% global coverage of the dataset
K	Biomass carrying capacity	995,621,893	mt	(36)	Global K is assumed to be 9.1 times the global MSY
g	Population growth rate	0.2747	---	---	$g = (\frac{MSY}{K})(\phi+1)^{\frac{1}{\phi}}$
r	Intrinsic growth rate	1.7361	---	---	$r = (\frac{\phi+1}{\phi})g$
h_0	Total harvest in the base year (2018)	84,928,268	mt	(9)	Portion of FAO reported catches assigned to industrial vessels in the GFW database
b_0	Biomass in the base year (2018)	212,291,690	mt	---	Estimated assuming annual biomass growth of 8 million mt/year and solving Equation 2 for the biomass that would yield observed harvests
e_0	Total fishing effort in the base year	2.42e10	kWh	GFW, see (16)	
ε	Constant elasticity of demand	-1.15	---	(13)	
p_0	Price in the base year (2018)	$1378	$USD/mt	(36)	Global starting price from (36) adjusted to 2018 $USD
δ	Demand constant	3.461e11	mt²/$USD	---	Estimated using Equation 7
β	Cost non-linearity exponent	1.3	---	(13)	
η	Speed at which effort enters and exits unmanaged fisheries	0.1	kWh/$USD	---	
ω	Speed at which effort enters and exists managed fisheries	0.001	kWh/$USD	---	

Table 5. Variable bioeconomic model parameters for the global analysis. These parameters depend on the sizes and compositions of the four fleets, which is dictated by the selected subsidy reform policy. They are therefore calculated immediately prior to each model run.

Parameter	Description	Units	Sources	Notes
$h_{j,0}$	Harvest for fleet j in the base year (2018)	mt	(9)	Portion of FAO reported catches assigned to industrial vessels in the GFW database
$e_{j,0}$	Effort for fleet j in the base year (2018)	kWh	GFW, see (16)	
q_j	Catchability for fleet j		---	Estimated from base year harvest and effort

Table 6. Breakdown of regions used for the regional bioeconomic analysis.

Region	FAO statistical areas
Atlantic Ocean	21, 27, 31, 34, 37, 41, 47, 48
Indian Ocean	51, 57, 58
Pacific Ocean	18, 61, 67, 71, 77, 81, 87, 88

Table 7. Regional biological model parameters

Parameter	Atlantic Ocean	Indian Ocean	Pacific Ocean	Source(s)
ϕ	0.188	0.188	0.188	(13, 36)
MSY	27,193,862	8,403,365	62,607,176	(13)
K	247,464,144	76,470,622	569,725,302	(13, 36)
g	0.2747	0.2747	0.2747	---
r	1.7361	1.7361	1.7361	---
h_0	24,270,674	10,215,324	50,442,270	(9)
b_0	111,815,482	30,583,660	121,107,224	---
e_0	1.08e10	1.47e9	1.20e10	GFW, see (15)
ε	-1.15	-1.15	-1.15	(13)
p_0	$1378	$1378	$1378	(36)
δ	9.891e10	4.163e10	2.055e11	---
β	1.3	1.3	1.3	(13)
η	0.1	0.1	0.1	---
ω	0.001	0.001	0.001	---

Table 8. Complementarities between subsidy types defined by Sumaila et al. (6) and certain FSE types for which the relative effects were assessed by the OECD.

OECD support type	Description	Complementary subsidy type(s) defined by Sumaila et al. (2019)
Inputs (variable costs)	Support based on the variable costs of fishing, such as payments contingent upon the purchase of gear, bait or ice, or the use of port facilities	Fishing port construction and renovation programs (B2); Fishery development projects and support services (B4); Foreign access agreements (B6)
Outputs	Support based on the price of fish (including tariffs, market interventions and consumer subsidies)	Price and marketing support, processing and storage infrastructure programs (B3)
Fuel	Payments based upon the quantity of fuel used	Fuel subsidies (B7)
Income	Payments based on fishers' income (e.g., employment insurance, disaster payments, wage subsidies, special income tax concessions)	Non-fuel tax exemptions (B5); Fisher assistance programs (C1); Rural fishers' community development programs (C3)
Capital	Payments based on fishers' own capital (e.g., concessional loans, special tax treatment on investment or returns on investment other than for capital in fishing vessels, upskilling, marketing training and assistance)	Non-fuel tax exemptions (B5); Fisher assistance programs (C1); Rural fishers' community development programs (C3)
Vessels	Payments based on the construction, modernisation, or scrapping of vessels	Boat construction, renewal and modernization programs (B1); Vessel buyback programs (C2)

Table 9. Relative performance of six fishery support types on fishing effort, fleet capacity, fishers' income, and stock size from the OECD. Impacts were assessed under two management scenarios: open-access and a total-allowable catch (TAC). Adapted from Figure 3.17 from Martini & Innes (32).

Support category	Open-access				TAC			
	Effort	Capacity	Income	Stock	Effort	Capacity	Income	Stock
Inputs	**1.00**	0.02	0.28	1.00	1.00	-0.17	0.78	1.00
Outputs	**0.87**	0.27	0.59	0.87	0.89	0.11	0.91	0.89
Fuel	**0.84**	0.12	0.11	0.84	0.96	-0.15	0.57	0.96
Income	**0.76**	0.37	0.85	0.76	0.76	0.29	1.00	0.76
Capital	**0.57**	0.04	0.98	0.57	0.53	-0.08	0.90	0.53
Vessels	**0.55**	1.00	1.00	0.55	0.62	1.00	0.92	0.62

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