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International effects of fisheries support policies

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Note by the Secretariat

This work is a component of 2019-20 PWB item 3.2.3.3.2 *Expanding OECD capacity for fisheries support policy analysis*. It builds upon work carried out in under 2017-18 PWB item 3.2.3.4.5 *Informing Fisheries-Related Trade Negotiations*. A new version of the Fisheries Policy Evaluation Model (FishPEM) with disaggregated fishing areas and regions was discussed at the 127th COFI. The model has been further revised according to input received during that Session. The report was further revised after discussion with an experts group in October.

The report was DECLASSIFIED at the 128th COFI held on 16-17 November 2021.

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Key Messages

- The environmental, economic and social benefits of fisheries support can be improved by shifting away from support based on costs or prices, even if the overall level of support does not change.
- Fuel tax concessions have smaller international effects than support measures that encourage fishers to operate in other regions, but have stronger local effects for a given quantity of support.
- Policies based on developing innovative fishing methods, better connections to value chains and sector resilience are more sustainable and provide a better distribution of benefits than do policies that reduce fishing costs.
- The effect of support policies is contingent on the fisheries management system in place. Recovering fish stocks to their optimal level requires both reform to fisheries support and improved fisheries management.

Executive Summary

Fishing nations agree in principle on the need to reduce subsidies deemed harmful to the health of our world's fisheries. Many existing fisheries policies distort markets and increase fishing capacity or effort, either deliberately or incidentally. When management systems are unable to control the resulting fishing activity, overfishing and resource depletion can result. Reform is needed not only to meet international commitments, but also to ensure that policies are sustainable and best serve the needs of fishers and fishing communities.

This work investigates how countries may design policies that achieve the objectives they have set for the prosperity of their fishing sectors while at the same time respecting their commitment to sustainability. It uses a quantitative model of fishing activity that divides the global fishery into six inter-connected continental regions. In this model, fishers from each region compete for resources in different fishing areas in the context of biological limits on fish stocks and multilateral trade in fish products. Fisheries managers can use fines to limit increased fishing effort in their fishing areas. The model is used to investigate the relative effects of five common types of support policies in terms of the spill-over effects of policies of one region on fishing opportunities and activity in other areas, the status of fish stocks and the distribution of the benefits of policy support to vessel owners, crew and other actors in the fishing sector.

The model is built to reflect the current global situation where many stocks are overfished. While this may be true for the regional aggregates represented in the model, it is not the case for all fisheries. The model should therefore be seen as depicting the broad impacts of alternative fisheries support policies for fisheries that are overfished and subject to overfishing. The results provide general insights on the nature of policy support and do not predict outcomes in individual fisheries that are subject to specific management regimes.

The analysis in this paper suggests that it is possible to have a win-win outcome where fishers and fish stocks both benefit from policy reform. The key is to focus on measures that concretely help fishers to operate their businesses efficiently, without intervening with the prices fishers pay for inputs used in fishing operations.

There is a well-established case for no-regrets policy actions that lay the foundation of a healthy fishing sector. Such policies include effective and robust control and monitoring systems, fish stock surveys and management settings that put reasonable limits on fishing activity. Nevertheless, there are many occasions where governments feel the need to assist fishers directly via financial transfers and these types of policies are the focus of this analysis.

Two types of support are found to do a better job of aiding fishers without increasing pressure on the resource. These are payments based on the human and business capital of fishing operations, and support based on the income of fishers. Payments directed at human and business capital include investments in on-vessel innovation, improved capacity to participate in the value chain, management training and anything else that helps economic performance. This form of support is the least distorting of fishing activity on many of the metrics considered, while being one of the most efficient ways to transfer income to fishers. This provides evidence that a policy focus on innovation can bring benefits to the fishing sector. However, payments based on capital (or vessels) tend to concentrate their benefits on owners to the exclusion of others.

Payments based on income may be more distorting than payments based on human and business capital, but are an effective way to transfer income to the larger fishing community in a more equitable way than other payments. Payments based on income can help improve the resilience of fishing communities by helping both business owners and crew to manage and smooth income disturbances, including those that arise from changes in the fish stocks or market disturbances as recently experienced during the COVID crisis. Payments based on income, human and business capital or vessels are all relatively more efficient at transferring income to beneficiaries than are payments based on purchased inputs or fuel tax concessions (FTCs).

Payments based on variable inputs or FTCs are designed to help fishers by reducing their operating costs. The results show that while these types of support increase fishing activity, they are relatively ineffective at helping fishers. This is because the resulting overcapacity and overfishing worsen the underlying productivity of the fisheries, while efficiency losses dissipate the potential benefits to fishers.

The results show that FTCs have the most detrimental impact on the health of the fishery in the region where they are applied, but their effects on international fishing are limited. This is because a tax-based policy does not apply outside of its tax jurisdiction, and so the scope of effect of a FTC is determined by the operating range of the fishing vessels that benefit from it. FTCs may still affect fishing elsewhere in the world through price effects transmitted through competition in trade. This effect is contingent on stock recovery effects and changes in demand and can range from inconsequential to significant.

Stock recovery effects from support reductions are modest but positive for all forms of support. Reduction in FTCs bring the largest benefit in the home region, while a reduction of payments based on variable input use is more beneficial to fish stocks elsewhere in the world. However, the results show that reforming support alone is not enough to return fish stocks to their optimal levels. Indeed, how support affects effort and harvest depends on the effectiveness of fisheries management. The model contains representations of several channels of effect of support policies, but these may not matter if the level of fishing effort or harvest is effectively controlled at the fisheries level. Improved fisheries management within Exclusive Economic Zones (EEZs) and on the high seas is a prerequisite to reducing overfishing. Reducing or reforming support can alleviate but not cure the negative consequences of inadequate fisheries management.

1. Background and data regarding international fishing

1.1. Introduction

1. Support to fishers in the form of grants, subsidies, concessions or incentives are a part of the policy framework of many countries. The unintended effects of this support on ocean ecosystems and the economic health of the fishing sector have long been a source of concern. This concern is expressed most notably in the United Nations Sustainable Development Goal (SDG) 14.6, which commits countries to “prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, and eliminate subsidies that contribute to IUU fishing, and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the WTO fisheries subsidies negotiation.”

2. Notwithstanding this commitment and the concerns that underlie it, the body of evidence regarding the effects of such policies remains scant. To address this, the OECD has developed the Fisheries Support Estimate (FSE) to collect and organise data on the level and nature of fishing support policies in participating countries (OECD, 2021^[1]). These data are available from 2008-2018.

3. A first analysis of the relative impacts of different FSE support categories was made using the Fisheries Policy Evaluation Model (FishPEM) (Martini and Innes, 2018^[2]). The original FishPEM represented a single global fishery and was designed to investigate the impact of fisheries support on overfishing, overcapacity and IUU fishing. In addition to providing guidance regarding better options for support policies, it estimated the effects of support policies on fishers' incomes and the distribution of benefits between different actors and fleet segments. It estimated, for example, that fuel subsidies delivered only 10% of their value as additional income for small-scale fishers, with most of their value lost as wasteful additional fishing effort.

4. That prior analysis compared the relative effects of policies in general terms based on their implementation (whether directed towards fuel, inputs, income, etc.) and the management system in place. The lack of a regional view of fisheries policies prevented that analysis from investigating one of the elements of fisheries support of interest to policy makers: the spillover effects of policies in one region on fishing opportunities and activity in other areas. This report builds upon that foundation by investigating how fisheries support policies may affect fishers in other regions given the global and inter-connected nature of fishing activity. It divides the world into six continental regions whose fishers compete to fish in different fishing areas as well as in the world market for fish.

1.2. The scale and nature of fisheries support

5. The FSE dataset shows that governments provide a significant aid to their fishing sectors. Over 2016-18, the 39 countries reporting government support data to the OECD together provided average annual support of USD 9.4 billion to the fisheries sector (OECD, 2020^[3]). This represented a gross transfer equating to about 10% of the average value of landings over 2016-18. Direct support to individuals and companies totalled USD 4.6 billion per year, on average, in 2016-18, compared with USD 8.6 billion in 2012-14. An important driver of this trend was a reduction in support to fuel for fisheries in the People's Republic of China (hereafter “China”) the country with the world's largest fisheries sector.

6. Across all countries and economies in the FSE dataset, over 2016-18, on average, USD 3.2 billion was spent annually on support that reduces the cost of inputs. Support to fuel was the single largest direct support policy, accounting for 25% of total support to the sector. Less than a third of what was spent to reduce the cost of inputs (USD 1.0 billion) was granted through policies directed at other aspects of the fishing enterprise, such as income support or special insurance systems.¹

7. This study does not use the full scope of policies that are recorded in the FSE dataset. It limits itself mainly to those that provide direct support to individuals and companies in the fisheries sector (DSI) plus the human capital elements of support for services to the sector (SSS) (Box 1.1). Support for services to the sector, the other major component of the FSE, contains policies such as for infrastructure and research that are not amenable to the modelling exercise carried out in this report.

Box 1.1. Structure of the FSE dataset

Based on information submitted by national authorities, the FSE dataset measures, describes and classifies fisheries support policies in a consistent and transparent way that facilitates their evaluation against defined objectives.

The FSE contains three main categories of policies, each of which are subdivided further based on factors that include implementation criteria and policy intent:

- **Support for services to the sector (SSS)** comprises support to infrastructure; management, control and surveillance; research and development; education and training; marketing and promotion; fishing communities; access to foreign waters; and other services to the sector.
- **Direct support to individuals and companies in the fisheries sector (DSI)** comprises support to income; insurance; fixed inputs (in particular vessels and gear); fuel;¹ other variable inputs; capacity reduction; and other direct support.
- **Payments made by the fisheries sector (PMS)** – that is, fees paid by service users, such as for port access or management, and taxes or fees on resource use and associated profits, which reduce the extent to which taxpayers finance support to fisheries.

The FSE dataset covers all OECD member countries as well as ten key non-OECD economies with significant marine fisheries (referred to as “emerging economies” in what follows). Together, the 39 FSE countries and economies included in the database represented just over 69% of capture fisheries production by volume in 2016-18.

The **OECD countries in the FSE dataset** are: Australia, Belgium, Canada, Chile, Colombia, Denmark, Estonia, France, Germany, Greece, Iceland, Ireland, Italy, Japan,

¹ The USD 4.2 billion in support covered in this analysis is less than the often-quoted global total of USD 30-35 billion, of which USD 20 billion is said to be fuel subsidies (Sumaila et al., 2010_[36]). The FSE dataset contains reported support data by countries that have some level of participation in the data collection process. The Seas Around Us (SAU) database that produces that other estimate on the other hand is independently compiled by a team of academic researchers and a large proportion of its content is estimated rather than observed. The differences between the SAU database and the FSE come from the broader definition of support for the SAU database, and the large share of estimated amounts in the SAU database. The different geographic coverage accounts for only a small part of the difference.

Korea, Latvia, Lithuania, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovenia, Spain, Sweden, Turkey, the United Kingdom, and the United States.

The **emerging economies in the FSE dataset** are: Argentina, Brazil, China, Costa Rica, Indonesia, Malaysia, Peru, Philippines, Chinese Taipei, and Viet Nam.

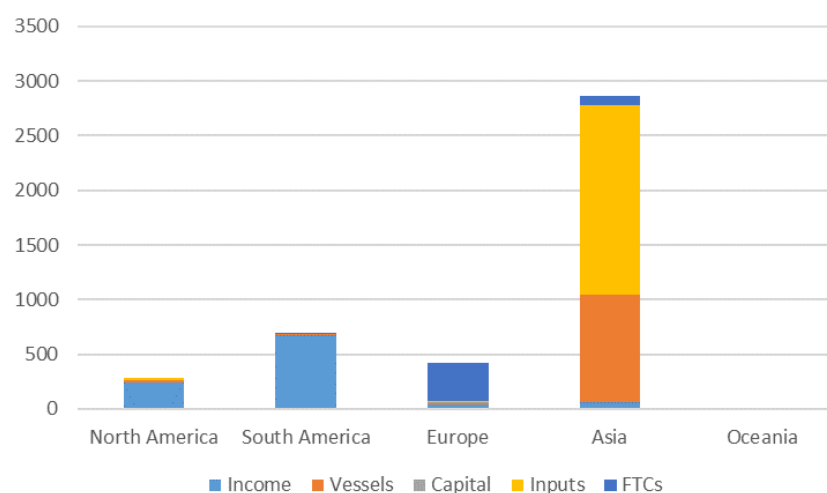
1. In the OECD dataset ‘Fisheries Support Estimate (FSE)’ (OECD.Stat), support to fuel is reported under two separate headings depending on the mechanism: fuel tax concessions are reported under ‘tax exemptions’ while direct transfers to reduce the cost of fuel are reported under ‘transfers based on input use’.

Source: (OECD, 2020_[3]).

8. The data in the FSE dataset shows considerable variation in the levels of policy support across regions and types (Figure 1.1). These differences are less pronounced when expressed as a share of value of landings. In absolute terms, OECD countries’ DSI is less than a third of the DSI reported by emerging economies, but the average level of support per fisher is much higher in the OECD, where USD 750 of support was granted per fisher in 2016-18. Payments based on variable input use and for vessel construction or modernisation are most important in Asia but relatively little used elsewhere.

Figure 1.1. Payments based on vessels and variable inputs are most seen in Asia (mainly China). North and South America make the most use of income support

Support in FSE by type, regional aggregation, 2017, USD millions



Note: “Income” is payments based on income, corresponding to FSE codes IFINC_INS, IFINIC_SIF and INFMC. “Vessels” is IFINP_FIX_M, INP_FIX_V and IFRPC. “Capital” is IFINP_FIX_O, “Inputs” is IFINP_VAR and FTCs are FTC. The size of the Asian fishery and fishing fleet is substantially larger than that of other regions.

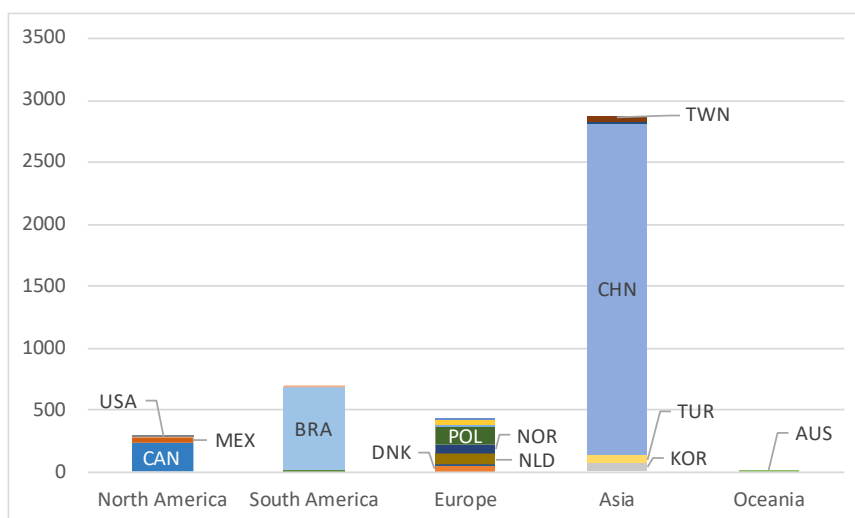
Source: OECD FSE dataset.

9. Payments based on variable input use and for vessel construction or modernisation are most important in Asia, and mostly due to policies in China. Indeed, of the subset of the FSE used in this study, which totals USD 4.27 billion, support from China represents 63% (USD 2.68 billion) and the top four countries account for 88% (USD 3.74 billion)

(Figure 1.2). In North and South America, support based on fisher's income is the largest share, while in Europe fuel tax concessions (FTCs) are the largest support category.²

Figure 1.2. China is the largest provider of support in the FSE database

Regional composition of support by source, 2017, USD millions



Note: Selected countries labelled.

Source: OECD FSE dataset.

10. Prior research on the effects of support on fishing was reviewed in (OECD, 2017^[4]) and in (Martini and Innes, 2018^[2]). In summary, large global studies contain some conclusions regarding the impact of different types of subsidies, but are based largely on a first-principles analysis (APEC, 2000^[5]; Milazzo, 1998^[6]; Sumaila et al., 2016^[7]). There have been a relatively small number of empirical studies investigating the impact of supports to fisheries, and these are usually done on a more regional or local basis (Da-Rocha et al., 2017^[8]; Heymans et al., 2011^[9]; Merayo, Waldo and Nielsen, 2018^[10]; Costello et al., 2020^[11]). A recent study investigated how subsidies to fuel, combined with below-market wage rates for crew, changed patterns of fishing on the high seas (Sala et al., 2018^[12]). The present work improves upon this past research by considering at once global fishing and a refined set of policy tools in a quantitative analysis.

1.3. Status of global fisheries

11. The OECD reports on the biological status of 1 119 individual assessed fish stocks, finding that 66% of these can be considered to have a favourable biological status (OECD, 2020^[3]). Of these, 54% (394) were meeting targets based on additional management objectives such as having fishing mortality and fish stock at the levels required to result in MSY or MEY; 13% (92) were not meeting such targets; and 31% (226) either did not have other targets defined or they were not reported.

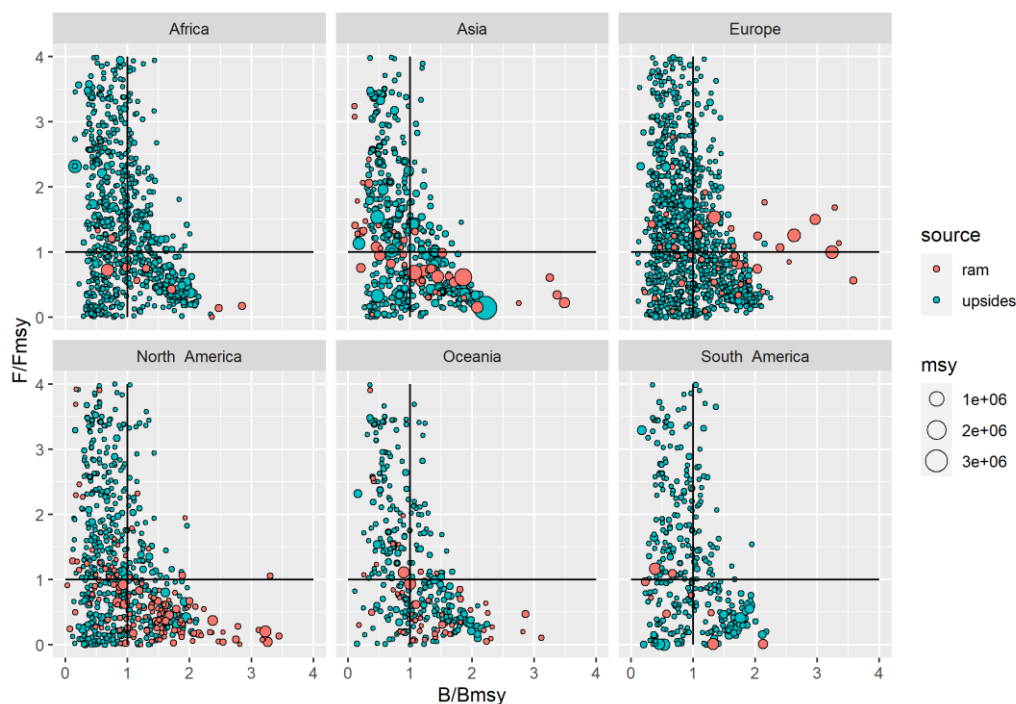
² A small number of EU member countries report the value of non sector-specific FTCs in the FSE. Such FTCs exist in most OECD countries, but reporting flexibility allows participants to decide if they should be included, and most opt not to report.

12. The FAO also estimates the fraction of fish stocks that are within biologically sustainable levels at 66% in 2017, a reduction from 90% in 1974.³ The percentage of stocks fished at biologically unsustainable levels has increased over that same period, and was 34% in 2017 (FAO, 2020_[13]). This indicates a situation where overfished stocks are yielding less than their maximum potential. Restoring fish stocks to those levels which produce maximum yield could result in catches increasing as much as 15-20% (Costello et al., 2016_[14]). When looking at the global fishery in aggregate, fishing pressure is about 50% above the optimum level and fish stocks are 22% below the level that would produce maximum fishing yields (Costello et al., 2016_[14])⁴.

13. Those global averages hide the range of overfishing and overfished statuses for the thousands of fish stocks for which estimates are available in either the RAM legacy or Upsides databases (see Costello et al., 2016_[14] for more details on the data). In each continental region there are examples of stocks where severe overfishing is taking place and of stocks that are in good biological condition (Figure 1.3).

Figure 1.3. Each fishing area contains fish stocks with a range of initial conditions

Individual stock estimates of B/B_{MSY} and F/F_{MSY} by fishing area most recent available year



Note: this Kobe plot shows each individual fishery estimate of B/B_{MSY} and F/F_{MSY} , separated by region. Colour indicates from which database the data come. Size of each bubble indicates the estimated MSY for that fishery. The crossing of the horizontal and vertical lines indicate a stable MSY level where F/F_{MSY} and B/B_{MSY} are both one. Using those horizontal and vertical lines as reference points, dots representing fish stocks in the northwest quadrant are both overfished and experiencing overfishing. Dots in the northeast quadrant are experiencing overfishing but are not overfished. Dots in the southwest quadrant have been overfished but are not currently experiencing overfishing, and dots in the southeast quadrant are neither overfished nor experiencing overfishing.

Source: (Costello, 2020_[15]).

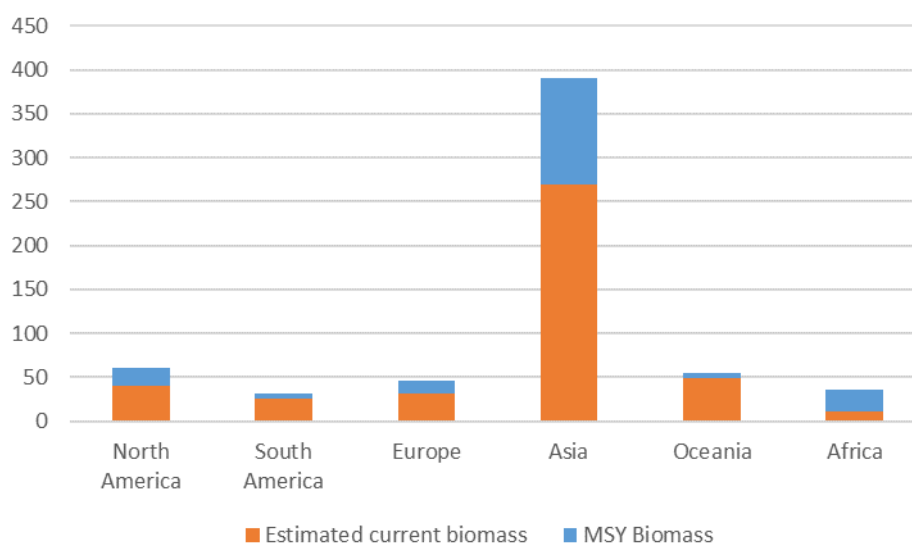
³ The set of stocks assessed by the FAO is different from that of the OECD.

⁴ The median fishing mortality is $F/F_{MSY}=1.5$ (overfishing is occurring) and biomass is $B/B_{MSY}=0.78$ (stocks are overfished).

14. The stock data show that the Asian region has the largest potential fish stock of all regions. This region is home to many species with high potential yields. In aggregate, B_{MSY} in that region is larger by an order of magnitude compared with other regions (Figure 1.4).

Figure 1.4. The aggregate size of the Asian fish stock is several times that of other fishing areas.

Fish stock at MSY and most recent estimate of biomass of included fish stocks, by region, Million metric tonnes, data for most recent available year



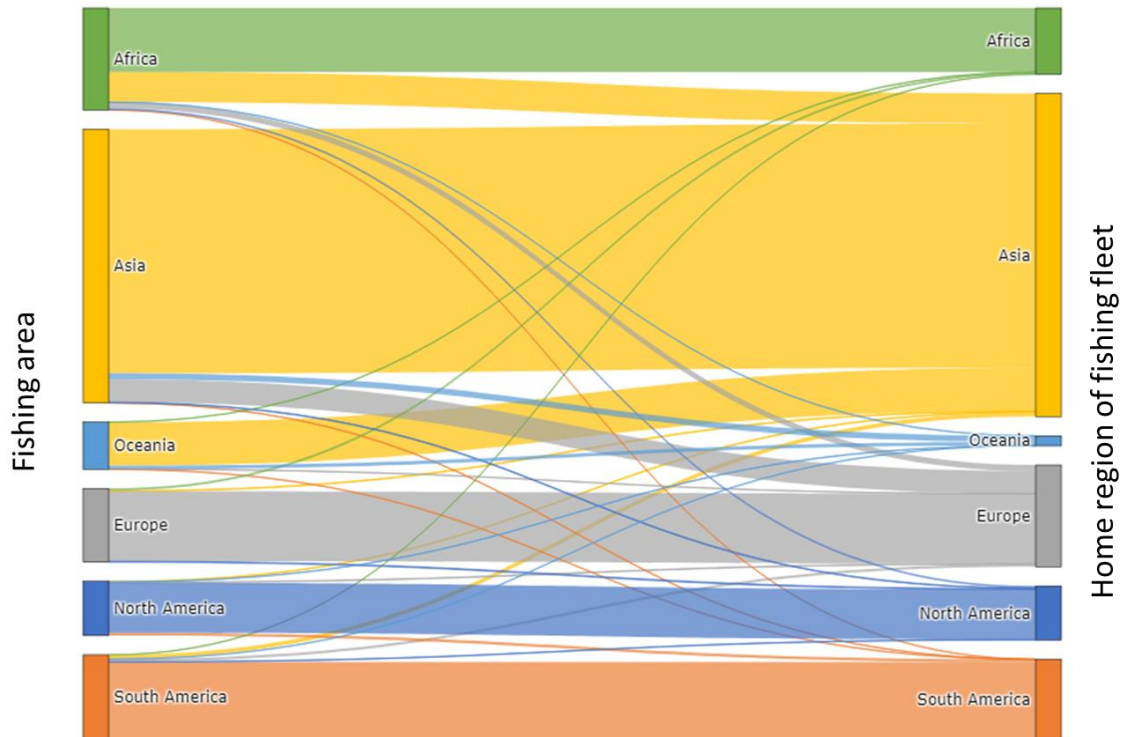
Note: For the included fish stocks total biomass in Asia would be 390 million metric tonnes, compared with the current estimated biomass of 269 million metric tonnes. MSY harvest in Asia for included stocks would be 32 million metric tonnes per year. Source: (Costello, 2020_[15]).

1.4. Global patterns of fishing

15. Fishing is a global enterprise. Fish products are among the most highly traded food products and fishers are able to operate at great distances from their home ports. Data on catches by location are reported to the FAO by participating countries and economies and are available as annual data. Aggregating this data reveals a pattern of fishing where most catches in a fishing area are taken by fishers from the same region (Figure 1.5). For example, in the FAO major fishing areas surrounding North America, 93% of the harvest in 2018 was caught by fishers who were also from North America. Asia is the only region that harvests a substantial amount in each of the six represented fishing areas in the model. The majority of global catches are made by vessels from Asia, and total catches from Asian vessels nearly match the rest of the world combined.

Figure 1.5. Asia is the largest region, and the one that is most active in other fishing areas

Catches by fisher and fishing area

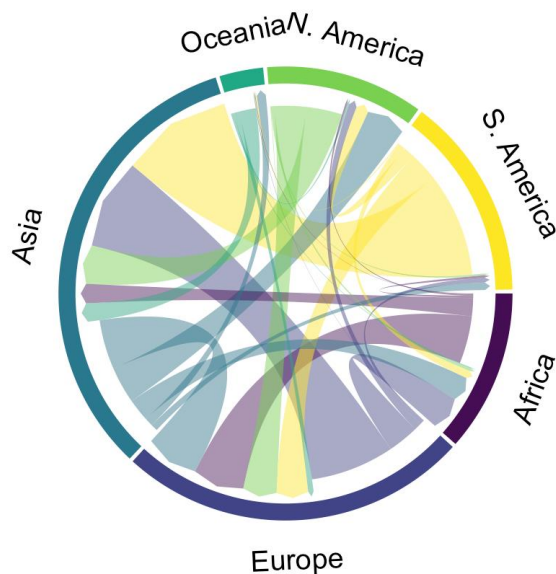


Source: FAO FishstatJ.

16. Trade is more interconnected than are catches. Asia dominates both imports and exports with large import flows from South America and Europe and exports to Europe and North America (Figure 1.6). Europe is the next largest importer after Asia and sources imports broadly from all regions. North America imports mainly from Asia. South America has the most unbalanced trade, with exports exceeding imports by volume by a wide margin.

Figure 1.6. The largest trade flows are into and out of Asia, with South America being a major exporter

Regional trade flows of marine capture fisheries products 2017-2018, million tonnes



Note: Pointed part of line shows direction of trade flow while width shows relative quantity.

Source: (Gephart, 2020^[16]).

17. The total live weight equivalent of marine capture fisheries products exported from all regions (excluding trade within regions) in 2017 and 2018 was 20.7 million tonnes and 20.4 million tonnes, respectively. South America exported the highest volume of marine capture products, with a total export of 5.5 million tonnes in 2017 and 5.5 million tonnes in 2018. Meanwhile, Asia imported the highest volume of marine capture products, with a total import of 9.5 million tonnes in 2017 and 9.1 million tonnes in 2018. The largest trade flows from 2017-2018 were from South America to Asia (7.5 million tonnes), Europe to Asia (6 million tonnes), and Asia to Europe (3.6 million tonnes).

2. Method—the Fisheries Policy Evaluation Model

18. The version of the model used in (Martini and Innes, 2018^[21]) was developed to reflect the global fishery and was based on the global bioeconomic model used in (World Bank, 2017^[17]), modified with additional features found in the model developed for (OECD, 2005^[18]). The lack of a regional view of fisheries policies prevented that analysis from investigating one of the elements of fisheries support of interest to policy makers: the spillover effects of policies in one region on fishing opportunities and activity in other areas. To address this limitation, a representation of different fishing regions was added to the model.

2.1. Data

19. The regional version of the FishPEM model developed here is designed to investigate the effect of support on the distribution of global fishing effort, and specifically how the level of support in one country may affect fishing effort and harvest by other

countries. It is constructed with six regions representing continental aggregations (Asia, Africa, Europe, North America, Oceania, South America).

20. Data for fish stocks and catches for FAO major fishing regions are mapped to these six continents, as are the FSE data and data on trade in capture fisheries products. Most of the underlying data are available at the national and species level and aggregated to regions.

21. Support information comes from the FSE dataset and uses the 2017 data year, to match the availability of stock and trade data. FSE data are divided into five support categories in much the same manner as was done for the previous analysis.

22. Data for the fish stocks used in the model come from a custom data set provided for this project (Costello, 2020_[15]). These data come from the RAM Legacy and Upsides databases, and collate most recent estimates of fish stock and fishing pressure, biological parameters, and other parameters for most of the world's fisheries. These data come from assessments, where possible, and from FAO plus supplemental calculations in some cases. The method is described in related work by the author (Costello et al., 2016_[14]). Most of the assessed data have been updated since that 2016 paper. The global maximum sustainable yield (MSY) represented in these data is 75.9 million metric tonnes (MMT) (compared to a complete global MSY of around 90-110 MMT) and there are 6 667 individual fisheries represented, each of which is associated with a single FAO fishing region.⁵

23. Fish stock data are aggregated to each of the six fishing areas in the model. The result is sensitive to the aggregation method and follows the same approach as in (Costello et al., 2016_[14]). The six aggregate fish stocks are all overfished and subject to overfishing, reflecting the average stock status in these regions (Table A A.10). As noted earlier, within these aggregations are examples of fish stocks that have good or poor status with respect to both B/B_{MSY} and F/F_{MSY} (Figure 1.3). The aggregate fish stock in Oceania is in the best condition, with stocks at 89% of MSY levels. Aggregate fish stocks in Africa are in the worst condition in the model, at 30% of MSY.⁶

24. Trade data also comes from a custom data provided for this project (Gephart, 2020_[16]). COMTRADE data was modified to include only trade in fish products that originate from capture fisheries production. To do this, the species falling under each Harmonized System (HS) 6-digit trade code were first identified. The share of global farmed and capture production and percent of marine production was calculated for each taxon using FAO global production data by source for 2017 and 2018. The average (production-weighted) percent of production from capture sources and average (production-weighted) percent of marine production was calculated for each HS code. Those HS codes where at least 90% of production comes from capture marine production were selected for inclusion, thus excluding fish products originating from aquaculture. Trade quantities were converted to the live weight equivalent and trade flows were aggregated into the six regions of the model.

⁵ The OECD also provides data on fish stocks in OECD countries and some other participating regions. This data has smaller regional coverage than that used here, but provides more detail on stock status with respect to policy objectives. See Chapter 2 of the OECD Review of Fisheries 2020 for a description of this data (OECD, 2020_[3]).

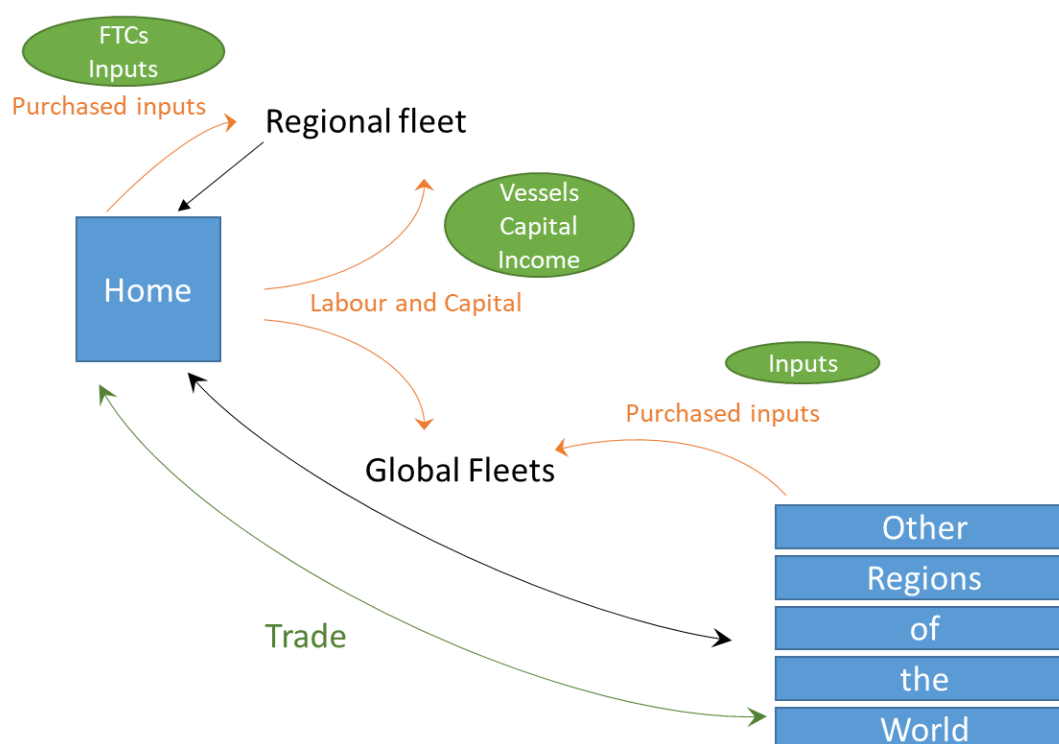
⁶ Data for Africa show a large amount of uncertainty, as the aggregate value varies strongly according to method of calculation. A low value of 30% is chosen to reflect this. This also provides the opportunity for the model to show results for a wider range of stock statuses.

2.2. Model design

2.2.1. Regional structure

25. The model represents global fishing activity where each continental region has a global fleet that operates in other regions' fishing areas and a regional fleet whose activities are confined to its home region. The "home region" is the continental aggregation of the nearest FAO major fishing areas. This includes the EEZ of the countries in the region, but also some high seas area. Fishers in the global fleet choose how much effort to apply in every fishing area optimally based on the actions of fishers from other regions. That is, fishers from the global fleet compete in each fishing area based on their relative costs and the price they receive for their harvest.⁷

Figure 2.1. Schematic structure of FishPEM



Note: Black lines show fishing activity, orange lines are supply of inputs. Green ovals are support policies Purchased inputs are fuel and other purchased inputs. Labour and capital include crew, vessels and human and business capital.

26. The regional fleet that operates exclusively within its own fishing area is assumed to have a different technology and cost structure than vessels that operate globally. Vessels that operate internationally are typically larger on average and use different gears.

27. Harvest of fish from all fishing areas is landed domestically, so catches by fishers from Asia are considered landed in Asia regardless of where in the world they are caught. This is a simplifying assumption, as there is no consistent behaviour on this. On the one hand, China provides strong policy incentives for their high seas fleet to land its catch domestically. On the other, vessels from countries like Spain land their catch worldwide,

⁷ This is called Cournot competition and is based in the mathematics of game theory. See (Friedman, 1976_[37]) for a treatment. A two-region, one fishing area model with a similar approach is described in (Fagerbakke, 2016_[38]).

and in fact may be part of vertically integrated multinational fish processing firms. Domestic landings may be consumed domestically or exported. Likewise, domestic consumption is made up of domestic landings plus imports from each region.

28. Regions also trade in fish products, with products being differentiated by region. The optimal composition of domestic versus imported fish products is determined by relative prices, following the so-called Armington assumption of product differentiation (Armington, 1969^[19]). The trade component of the model is a simplified version of that which appears in the OECD METRO model of global trade [TAD/TC/WP/RD(2020)1/FINAL].⁸

29. The choice of fishing effort in different fishing areas may be influenced by support policies, as it is based on the cost incurred and revenue achievable by adding fishing effort in any particular fishing area. Support that either reduces cost or increases revenue will affect fishing effort to varying degrees.

2.2.2. Fisheries management

30. Fisheries management systems can strongly shape fishers' incentives and the way they respond to support policies. Management systems vary in their approach (input vs output controls, for example) and in the stringency of their enforcement. The aggregate fish stocks in the model contain a large number of individual fisheries, each with its own management system and status with respect to management settings. The aggregate effect of those individual management systems is some degree of restriction on increases in effort, while effort may decrease freely.⁹

31. The initial calibration of the model is according to data reported to the FAO on harvests, and so is expected to contain only allowed harvests, any outside management controls being unreported. In this way, the initial state of the model reflects allowed harvests, but any increase in fishing effort above this baseline may be IUU in nature.

32. Fishing regions are able to control increases in fishing effort in their fishing areas. This is through a management control system that imposes a fine on increased fishing effort of a fleet over its initial amount. This makes the supply elasticity of additional effort into a fishing area by global fleets highly inelastic. The structure of this is an application the rational choice model of crime (Becker, 1968^[20]).¹⁰ The level of this fine can be set as part of a policy scenario..

2.2.3. Production structure

33. Fishing effort is converted to fishing harvest where the overall sustainable harvest level depends on the biological capacity of the resource in each region. The model is in biological equilibrium so the applied effort leads to a steady-state harvest and fish stock.

34. Fishers use five different inputs to produce fishing effort. These are two types of capital (vessels and other human and business capital), labour and two different variable

⁸ The METRO model has an information portal at: <https://community.oecd.org/community/trade/issues/metro>.

⁹ At any equilibrium point in the model and within any aggregate fish stock, there will be some fish stocks where management controls are effective and binding, some where they are effective but with some room to increase effort, and some where management is ineffective. Effort changes in each individual fishery will reflect this, and an increase in support will lead to less overall increased effort than would be the case if all the fisheries had ineffective management systems.

¹⁰ This is similar to but not the same as the IUU component of the first FishPEM module. That model had an explicit effort quota; here we assume that the current (reported) level of fishing effort by global fleets is at the allowable limit.

inputs (fuel and other purchased inputs. Fishing effort is applied to the fish stock to produce fish. The amount of fish harvested (equivalently called yield) in the model is a steady state equilibrium based on the biological capacity of the fish stock. Increasing effort above the baseline amount will decrease harvest, as the model is calibrated to an initial baseline where overfishing is occurring in all fishing areas. The growth function is a differential equation describing the stock evolution over time as a function of past stock level and quantity harvested. This is an application of the canonical Schaefer model of fishing that forms the basis of many bio-economic models of fishing (Schaefer, 1957^[21]).

35. The model contains explicit markets for inputs in each region. Fishers are assumed to purchase fuel and other purchased inputs in the area where they are fishing. For example, fishers from Europe operating in Asia purchase their supplies in Asia at the prevailing price there, adjusted by any support they may receive.¹¹ Vessels, crew and other capital are not purchased in local fishing areas and represent the total fleet capacity of each region. Therefore, if fishers in a region increase their number of fishing vessels or other capital, their capacity to fish in all fishing areas is increased.

36. Capital inputs are inelastic in supply, meaning that relative large price changes are required to increase supply. In the case of the global fleet, capital inputs and crew are purchased in the home region and determine the overall global fishing capacity of that fleet. For the regional fleet, increases in capital or crew have only a local effect, as this fleet does not operate outside the home region. Purchased inputs are elastically supplied, acquired in the fishing area where they are used, and affect fishing effort in that fishing area only.

37. The main economic parameters are:

- The way supply of each input changes with its price (input supply elasticity). These values are chosen such that purchased inputs are *elastic* in supply while vessels and capital are *inelastic*.¹² This is unchanged from the previous version of the model.
- The share of each input in total expenditure (input cost shares). This information comes from FAO technical studies of global fishing fleets. The cost structure from a representative set of vessels is used for each region, making a distinction between regional and global operators (FAO, 2020^[22]; FAO, 2020^[23]; FAO, 2020^[24]).
- The degree by which inputs may be substituted for each other in production (elasticities of substitution). Elasticities of substitution are estimated from a cost function and are the same for all regions (Mardle, 2018^[25]).

38. The model is described in detail in Annex A.

¹¹ This is a simplification of the reality that fishers purchase some but not all of their variable inputs where they are fishing. This does not greatly affect the results; more important is the fact that these inputs must be purchased in direct connection with fishing effort in each fishing area, which is not the case for capital and labour.

¹² An input that is elastic in supply will increase in price less than proportionately with an increase in quantity demanded. Inelastic inputs increase in price much more rapidly as fishers demand more of them. The same input supply elasticities are used in the PEM and METRO-PEM models.

2.2.4. Support policies

39. The model considers five support policy categories:¹³

- **Payments based on fishers' income (Income).** These are transfers made depending on the current income of the recipient. This would include employment insurance, disaster payments, wage subsidies, special income tax concessions and similar. Of the five types of support considered in this study, payments based on income are most closely connected with sector resilience. Their benefits are more broadly shared in the fishing community and they can help manage risk as they are often conditioned on or correlated with poor outcomes in the fishery.
- **Payments based on human and business capital (Capital).** These transfers are based on investment in fishing operations or working capital for operations. This category includes, for example, concessional loans, special tax treatment on investment or returns on investment other than for capital in fishing vessels. Support that increases operators' capacity to profit from the fishery, such as upskilling, marketing training and assistance fall in this category. This form of support can help promote innovation and closer connection to value chains as it is tied mainly to non-physical capital.
- **Payments based on vessels (Vessels).** These transfers are made based on the purchase, alteration, or scrapping of a fishing vessel.
- **Payments based on variable input use (Inputs).** These transfers are made based on the running costs of the fishing operation, such as payments contingent on the purchase of gear, bait or ice, or the use of port services.
- **Fuel tax concessions (FTCs).** These transfers are made based on the quantity of fuel used by the fishing operation via a reduction in the tax payable for fuel purchased. The level of FTCs in a region depends on the level of fuel taxation that would otherwise apply, as FTCs cannot lower the price of fuel below the world price.¹⁴

40. Fuel tax concessions are a reduction or rebate in excise tax on fuel (usually diesel). These concessions are enjoyed only in the relevant tax jurisdiction and only by those eligible. In the model this is reflected as a reduction of the price of fuel for fishers operating in their home region only. Other fishers in the region do not benefit, nor do fishers from that region operating elsewhere. This is an important distinction with budgetary payments, which may confer a benefit regardless of where fishers operate.

41. Support provided to inputs sourced from the home region affect local markets only, but these inputs are available for use by fishers globally. Support provided to purchased inputs reduce the price to fishers of those inputs regardless of the location where they are purchased. One exception is fuel tax concessions. As these are based in an exemption in local tax law, they affect the price of fuel in the home region only.

¹³ The previous version of the FishPEM model also included payments based on the price of fish (output). These payments are not prominent in the FSE and so are not included here. As well, while fuel support in that version was generic, here we treat this explicitly as tax concessions. This allows for a more distinct representation of FTCs.

¹⁴ . Higher observed FTCs usually reflect higher domestic taxation, not lower effective prices for fishers compared with those in other regions. The analysis in [TAD/FI(2008)10] showed that FTCs act to make prices more equal across regions – the net price for fishers is brought closer to the world price, reducing differences stemming from domestic tax systems.

3. Results

42. The purpose of the model is to identify the relative effects of fisheries support policies in the context of inter-related fisheries around the globe. These effects are different in each region according to their specific situation as captured by the database underlying the model (cost shares, pattern of harvest and trade, biology of fish stocks, etc.). These differences across regions serve to show a range of possible effects of policies according to these characteristics. This is not a formal sensitivity analysis and there is no measure of statistical significance attached to the results. The results reflect the underlying data and assumptions and are contingent on them. The results are shown as the weighted average of the results for each region.

43. Each data point is generated by averaging the effect in each of the six regions of reducing the level of support in each category by USD 100 million from its baseline value.¹⁵ That is, the model was run 30 times (five policy categories and six regions) and the average effect for each policy was used to produce the outcome indicators shown.

44. The effects of each policy category are shown both as percentage changes and as proportional to the effect of the policy category “payments based on variable input use”. This is a useful comparator as it is typically the form of budgetary support that induces the greatest increase in fishing effort. Since payments based on variable inputs is the “comparator”, its effects are always shown as one.

45. The initial fisheries stock status of the model has important implications for the results, as this determines how fishing effort and harvest are related. In the baseline calibration of the model and according to the data, fisheries in each region are overfished such that reducing fishing effort increases the amount harvested. This long-term outcome includes the effect of the recovery of fish stocks. In the short run, any reduction in effort would also reduce harvest as this stock recovery effect would not be a factor. This leads to the following general observation on the long-term effects of support policies: While support can provide short-term assistance, wherever overfishing is a problem or fish stocks are depleted, fishing support will have negative long-term impacts on the fishery.

3.1. Effects on the fleets receiving support

3.1.1. Effect on effort

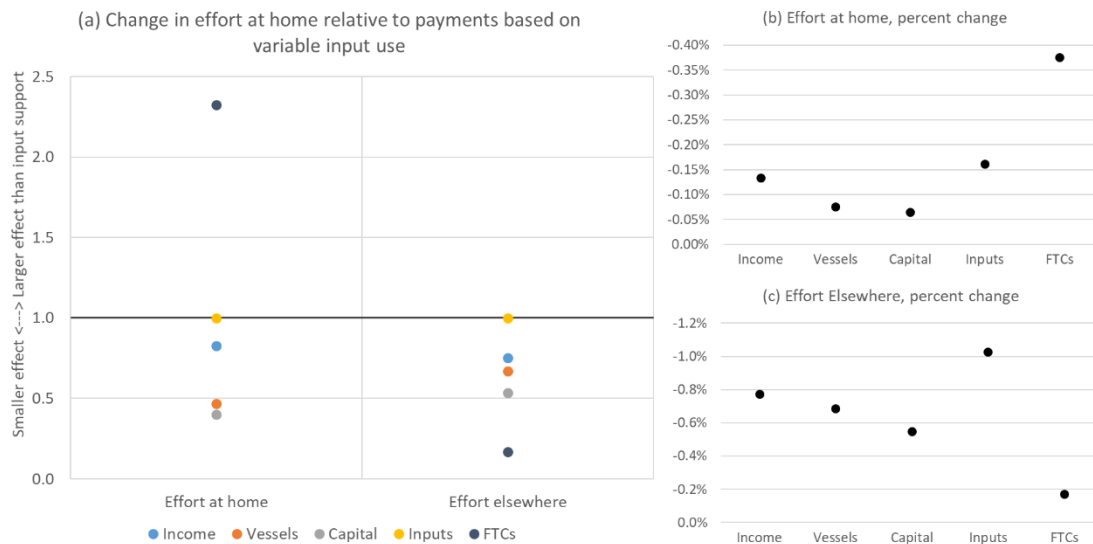
46. Effort at home refers to the level of fishing activity carried out by the regional fleet where support is changing. It does not include effort by the fishers from any other region (discussed below as “effort by others”). Effort elsewhere is the total of effort in all other regions carried out by the global fleet of the region where support is changing. FTCs have the largest effect on effort at home for a given change in the level of support (Figure 3.1, panel a). This is because FTCs concentrate support in the home fishing area, unlike support based on variable input use, which affects the price of inputs purchased by the both the

¹⁵ Whether the resulting level of support is positive or negative does not change the results. Since the results are shown in relative terms, the absolute size of the shock does not matter, except that it be the same for all regions in all scenarios. Support is reduced rather than increased in the scenario because the model is not symmetric: increased effort is controlled by the management system, which would confound observation of the effect of increased support.

regional and global fleet, the latter of which will increase effort abroad, drawing some resources away from the regional fleet.¹⁶

Figure 3.1. FTCs have the highest effect on effort in the home region while payments based on inputs have the highest effect on effort elsewhere by the global fleet receiving support

Change in effort by the supported fleet in its home region and elsewhere resulting from a reduction in support, by policy category



Note: Relative effect of reducing the rate of support by USD 100 million for each support category, average of effect for each region. Effort at home is the effort by the regional fleet where support is changing, effort elsewhere is total effort by the global fleet operating in all other regions. Regional effort changes the most from a change in support to FTCs, but effort elsewhere changes the least. While only the regional fleet benefits from FTCs, other, budgetary, supports are shared between the regional and global fleet, which dilutes the effect on effort at home. Conversely, the global fleet does not benefit directly from FTCs and its effort elsewhere changes due to secondary price effects arising from changes in total production and trade. For panels (b) and (c), vertical axis in reverse order.

Source: OECD FishPEM.

47. Payments based on vessels or on human and business capital are the least distorting of effort at home by regional fishers; these inputs are relatively inelastic in supply and so the quantity used changes less for a given change in their price. Payments based on income fall somewhere in the middle. This support accrues to not only vessel owners and capital, but also to hired crew and so the net effect is more responsive to changes in support as crew numbers can be increased or decreased relatively easily compared to changes in the fleet structure.

48. The change in “effort elsewhere” shows the potential of support to cause fishers receiving it to fish harder outside their home jurisdiction. This is an important component of understanding the effects of different forms of support on fisheries and fishers in other regions. Extrapolating the results, an increase in support of 1% for payments based on variable input use is estimated to increase effort by the global fishing fleet elsewhere by 1.7% (Figure 3.1, panel c). In some cases, FTCs can actually reduce effort elsewhere; the

¹⁶ The fact that budgetary payments like payments based on variable inputs accrue to both regional and global fleets means that it takes smaller change in total support levels to achieve the same percentage change in support rate with FTCs. In this scenario, the USD 100 million change reduces the rate of support to variable input use by 0.6%, but the rate for FTCs decreases by about 2.4% for the same change in level of support.

regional fleet responds to this support by increasing effort, bidding up the price of capital and labour in the home region and drawing resources away from the global fleet.

49. This is a good moment to look at some of the ways that fleets interact in the model. There are four primary mechanisms through which any support policy may affect fishing effort by domestic and foreign fleets:

- **Fishing competition effect.** When support increases fishing effort by the fleet from one region, fishers from other regions will tend to reduce their fishing effort in response. This is a consequence of profit maximisation as expressed through each fleet's best response function. Intuitively, when one fisher increases effort, there are less fish available to others for a given investment in fishing effort, so their optimal effort declines.
- **Input market competition effect.** Regional and global fleets from the same region compete for capital and labour, while global fleets and other foreign fishers compete for fuel and other inputs purchased in local markets. If foreign fishers increase effort, their demand for fuel and other inputs also increases. This can raise the cost of fishing for local fishers and reduce their optimal effort as a result. The scale of this effect depends on the elasticity of supply of inputs in the relevant market.
- **Trade competition effect.** Fishers are assumed to land their catch in their home region, but fish products may be traded globally. If one fishing region increases catch, they are also likely to increase exports which will affect the price of fish and therefore optimal fishing effort in other regions. Fishers operating in their home region make up the largest share of global harvest, so changes in their harvest tend to drive this result and the global fleet and other fishers are affected by it. This is a relatively indirect channel of effect and therefore has some uncertainty attached to it. It will depend on trade barriers and consumer factors such as the desirability of imports vs locally produced fish products.

50. For example, reducing FTCs leads to reduced effort by the regional fleet, resulting in some stock recovery in the home region. This stock recovery leads to increased supply of fish and so a lower price. This makes all other fishers reduce effort somewhat, including the global fleet from that region. At the same time, that reduced effort lowers demand for and the price of labour and capital, so the global fleet from that region would increase effort as a result. The net effect depends on the situation in a particular region, but the effect of FTCs on the global fleet can in principle either be positive or negative. If fish stocks are near maximum sustainable yield (MSY) levels, this effect would be much reduced or eliminated. The model also does not consider trends in consumer demand over time, which could also have an effect on effort through output price changes.

3.1.2. Effect on harvest

51. The relationship between effort and harvest in aggregate is determined by the shape of growth function of the fish stock in each fishing area and the current status of the stock. Initially, each fish stock is in an overfished condition such that the size of the stock is smaller than that which would produce the maximum sustainable yield (MSY) over time¹⁷. When the fish stock is in this condition, reducing fishing pressure will increase the size of

¹⁷ Formally, $B/B_{MSY} < 1$. This is calculated from aggregate fish stock data, as described earlier.

the fish stock.¹⁸ Increased fish stocks will produce a larger harvest for a given amount of fishing effort. The net result is that lower fishing effort increases harvest in the long run.

52. For any individual fishing fleet targeting a shared resource, their harvest will depend on their own effort as well as the effort of all others. If all fishers reduce effort, average harvest will increase, but the catch of an individual fleet may still go down if their effort reduces proportionally more than that of other fishers.

53. Reducing support levels will reduce the amount of effort by the fleet receiving support. In general, the result is that other fleets will see higher harvests, but the supported fleet may see their harvest either increase or decrease depending on their relative effort change compared with the amount of stock recovery that results.

54. In general, effects of support on the home fishery is dominated by changes in the fish stock, while for fishing abroad changes in relative costs are more important. This is in evidence in the results for effects of support on harvest, where are reduction in support increases harvests at home (from improved fish stocks) but decreases harvest elsewhere (because costs are higher) (Figure 3.2 panels b and c). The effect of support on harvest elsewhere has a broader variance in possible impact by region; this relationship is generally more complex with different factors dominating in different circumstances (Figure 3.2 panel c). Also, some regions have quite small global fisheries so percent changes can be large.

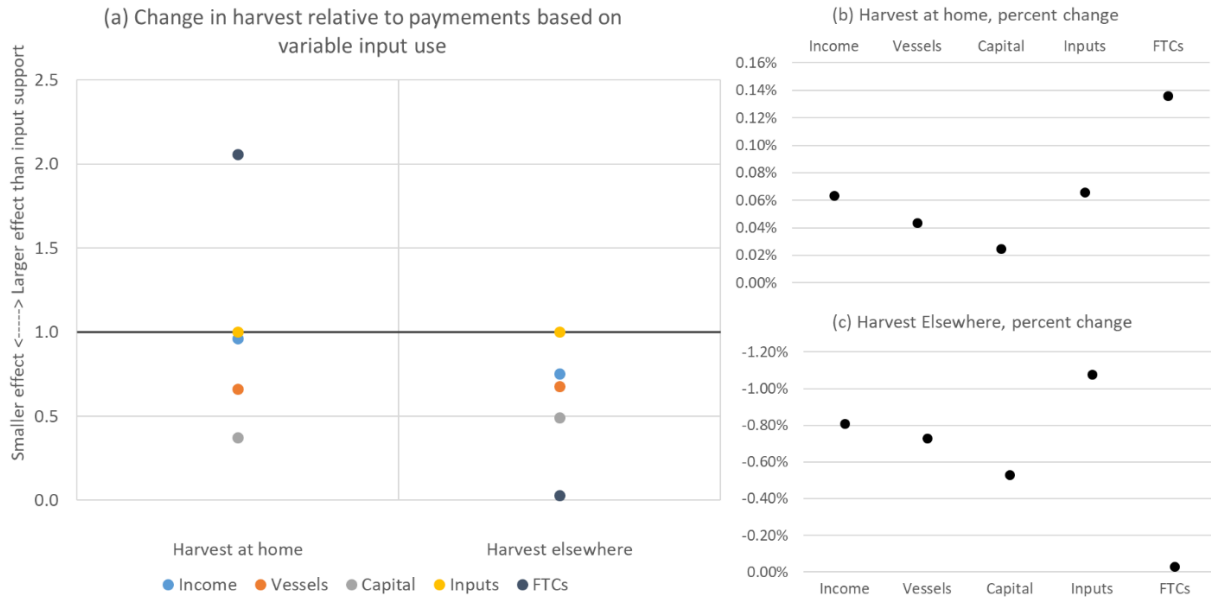
55. The effect of payments based on human or business capital or vessels is closer to that of payments based on variable input use for harvest elsewhere, while payments based on income or FTCs are relatively less distorting abroad when compared with payments based on variable input use. This is because a larger fishing fleet raises capacity in all regions where it can be deployed. FTCs have nearly zero effect on harvests abroad as they do not change relative costs for the global fleet and secondary price and stock effects tend to cancel each other out.

56. Percentage changes are larger for harvest elsewhere than for harvest at home. Reducing payments based on variable input use by USD 100 million has an average effect on harvest at home of about 0.06%, while harvest abroad decrease by more than 1%. However, the absolute size of harvest at home in most regions is substantially higher than harvest elsewhere, so the total change in harvest from home and elsewhere may be positive.

¹⁸ The increase in harvest for a given reduction in effort is larger the further away the initial stock size is from MSY. If a fish stock were above MSY, harvest would decrease if effort were reduced. The initial calibration of stock status is important in this regard.

Figure 3.2. Reducing support increases fish stocks and harvests in the home region, but reduces harvests elsewhere. Payments based on inputs have the largest effect abroad

Change in harvest by the supported fleet in its home region and elsewhere resulting from a reduction in support, by policy category



Note: Relative effect of reducing the rate of support by USD 100 million for each support category. Dots represent the weighted average effect for all regions. Harvest at home is that taken by the regional fleet where support is changing, harvest elsewhere is total effort by the global fleet operating in all other regions. Panel (c) vertical axis in reverse order.

Source: OECD FishPEM.

3.2. Effect on fishers in other regions

3.2.1. Effect on effort

57. “Effort by others” measures the change in aggregate fishing effort by regions other than the one seeing the support change in the scenario, reported separate for regional fleets operating only in the home region or their global fleets that operate abroad. Separate reporting is useful in this regard as fishers that stay mainly at home have different incentives and interests from those that are operating mainly on the high seas or other shared fisheries.

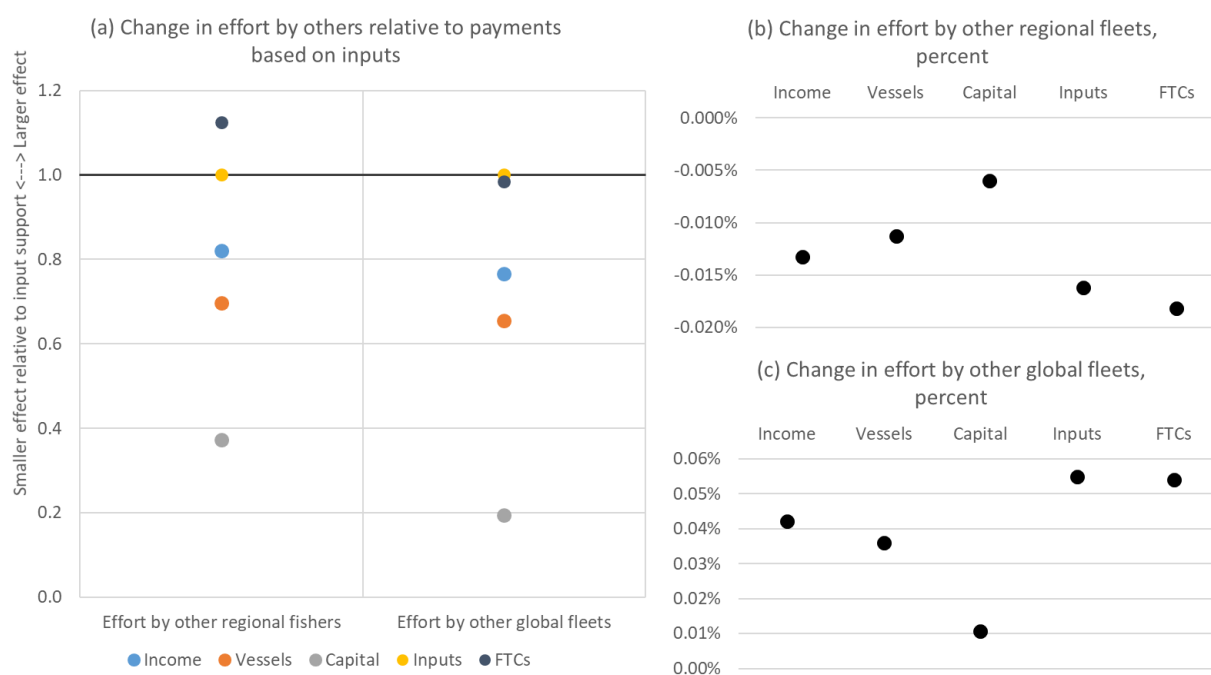
58. The main interest here is when policy support in one country can discourage fishing effort by others not receiving support. This occurs mainly when other fishers are placed at a cost disadvantage. This is shown in the effect on other global fleets, who increase their fishing effort when support in other regions is reduced (Figure 3.3, panel c). Once again, payments based on inputs provoke the strongest change in effort by other global fleets, followed by payments based on income. Other payments have relatively small impacts, including FTCs, which do not directly impact the cost-competitiveness of the supported global fleet.

59. For fishers operating only in their home regions, the fisheries competition effect based on cost is less important than the price changes coming from the trade competition effect. As mentioned, when support is reduced in a region, the fish stock there recovers, eventually leading to increased harvest. This higher harvest depresses global prices for fish, lowering the profitability of other regional fleets and reducing their desired effort (Figure 3.3 panel b). This also affects the global fleets but for them the effect on relative

costs is more important and dominates the result such that lower support elsewhere leads them to increase their effort (Figure 3.3 panel c). For other regional and global fleets, the effect on effort is small relative to the changes in effort of the fleets for whom support is changing.

Figure 3.3. Effort by other regional fishers is mainly affected by trade competition while other global fleets are more affected by competition on the water

Change in effort by regional and global fishers elsewhere resulting from a reduction in support, by policy category



Note: Relative effect of reducing the rate of support by USD 100 million for each support category. Dots represent the weighted average effect for all regions. Other regional fleets reduce effort due to lower world prices for fish, but the percentage change is small. Other global fleets increase their effort as they are now more cost-competitive with the supported fleet. Payments based on capital have the smallest impact on effort by others.

Source: OECD FishPEM.

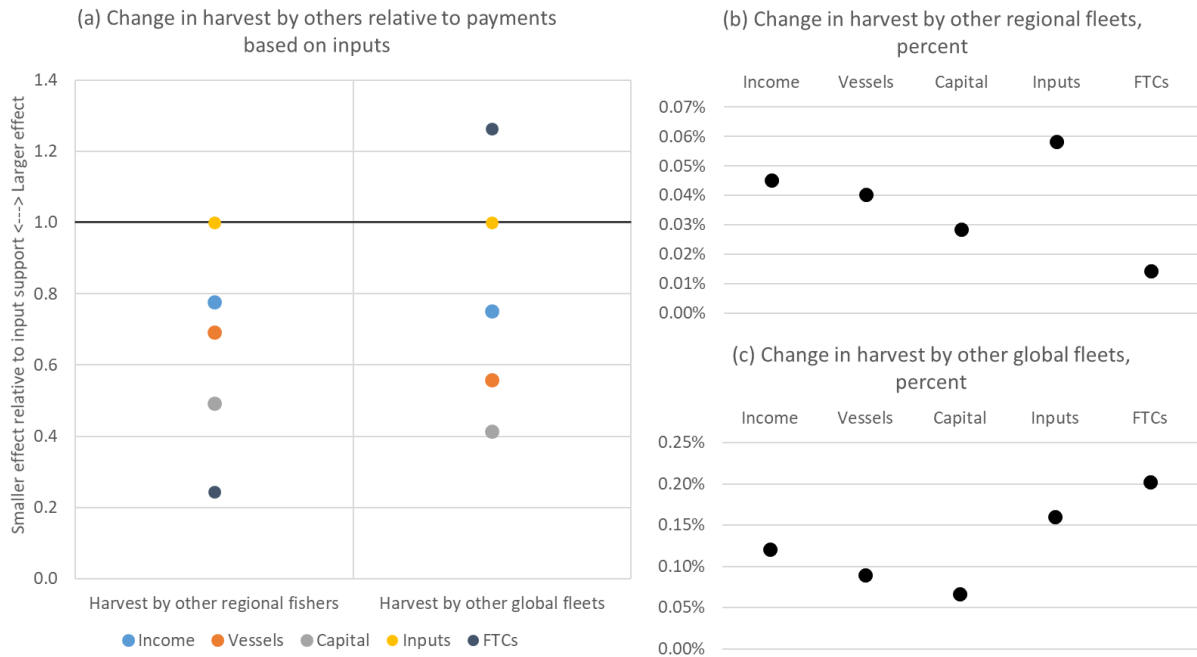
60. Reducing FTCs leads to the largest stock recovery at home, and therefore the largest change in prices for fish. As a result, this policy leads to the largest reduction in effort by other regional fleets. Payments based on human or business capital have the smallest distortionary effect in the home region, and so have the smallest spillover effects on other fishers.

3.2.2. Effect on harvest

61. The effect on harvest for fishers other than those receiving support combines the effects of their change in effort with changes in fish stocks and changes in the effort of fishers from all other regions. It was seen that effort by other regional fleets was reduced and effort by other global fleets increased when support is reduced in a different region. In the case of harvest, a reduction of support increases harvest for both regional and global fleets from other regions (Figure 3.4).

Figure 3.4. Harvest by other fishers increases when support in a region is reduced. This is most strongly the case for payments based on variable input use, but is true for all support types

Change in harvest by regional and global fishers elsewhere resulting from a reduction in support, by policy category



Note: Relative effect of reducing the rate of support by USD 100 million for each support category. Dots represent the weighted average effect for all regions. Change in harvest by other fleets is determined by change in effort combined with changes in relative costs, prices and fish stocks.
Source: OECD FishPEM.

62. The change in harvest by other regional fleets is small in percentage terms relative to the harvest by other global fleets. This has to do with the scale effect where regional harvest is larger than global harvests, and also because the main mechanism of effect is through price changes. For most policies, their effect on harvest largely follows their effect on effort, which is determined by the relative amount of market distortion each policy induces.

63. The one exception to this is the effect of FTCs on harvest by other regional fishers, which had a large effect on effort but a small effect on harvest. This difference has to do with the fact that when FTCs are reduced, demand for inputs by the regional fleet declines, lowering their prices and so reducing the cost of capital and labour for the global fleet. That is, factors of production are shifted from the regional fleet to the global fleet. The global fleet increases effort, taking away some of the harvest that would otherwise have been gained by other regional fishers.

3.3. Effects on fish stocks

64. Reducing support in a region will increase the fish stock in that region, and generally increases fish stocks in all other fishing areas as well. The effort by fishers from the supported region declines, and if the effort of others increase as a result, it is not to the same extent. This leads to a net decline in effort and an improvement in fish stocks. Some

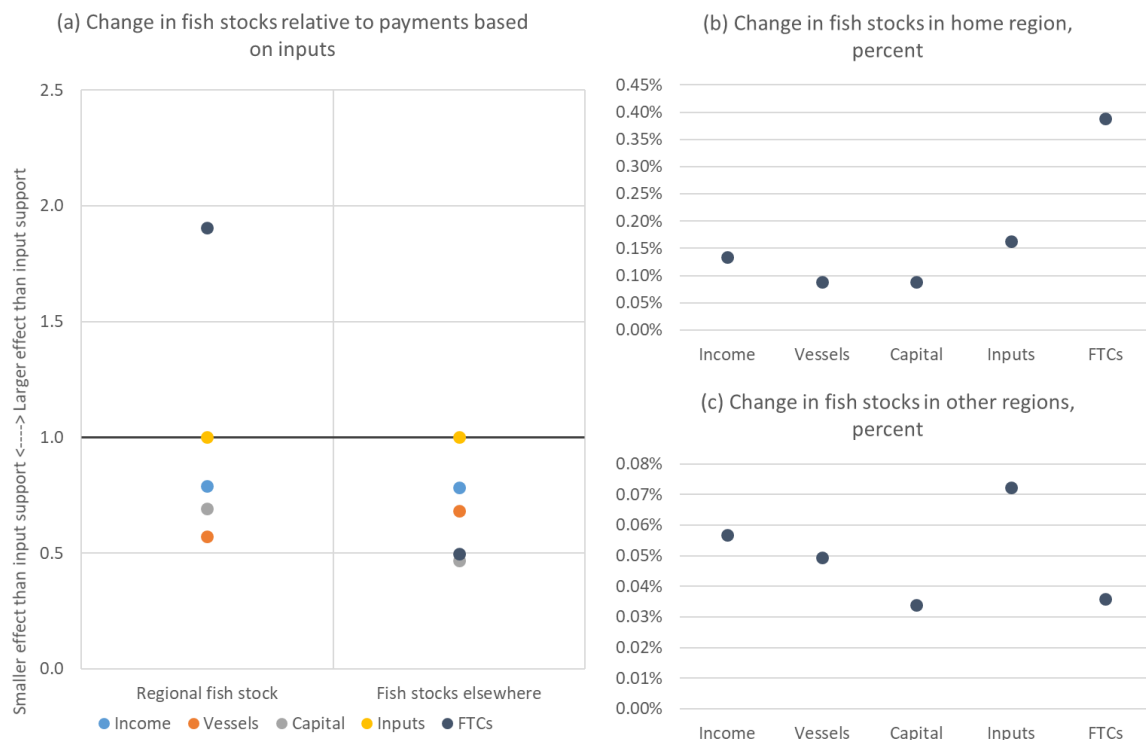
of this decline in fishing effort is due to price effects themselves connected to improved fish stocks and harvests. This is true for the home region and the total fish stocks in all other regions (Figure 3.5, panels b and c).

65. As before, the concentrated nature of FTC support results in a larger impact on the fish stock in the home region than it does elsewhere. A given level of FTC support occurs entirely in the home region, while budgetary support will be distributed across all regions.

66. The stock recovery effect observed in the model is modest despite starting B/Bmsy values generally less than 0.8. For example, reducing payments based on variable input use in a single region by USD 100 million increases the biomass of global fish stocks by about 370 thousand tonnes. That is a meaningful improvement for such a relatively small change in support, but it is unlikely that reductions in support alone are sufficient to restore fisheries to MSY levels of abundance. Improved fisheries management will be more important in this regard.

Figure 3.5. Stock recovery effects from support reductions are modest but positive for all forms of support. Reduction in FTCs bring the largest benefit in the home region, while reducing payments based on variable input use is most beneficial to fish stocks elsewhere in the world

Change in fish stocks in the home region and elsewhere resulting from a reduction in support, by policy category



Note: Relative effect of reducing the rate of support by USD 100 million for each support category. Dots represent the weighted average effect for all regions. Reducing support of any form will improve regional and global fish stocks. Fish stocks in the home region improve because of effort reductions by the regional fleet. Fish stocks abroad improve as fishing pressure declines due to reduced world prices induced by improved harvest in the region where support is reduced.

Source: OECD FishPEM

3.4. Effect on fishers' welfare

67. Two welfare indicators are produced from the model output—the relative transfer efficiency of the policies and the coefficient of variation of the amount of benefit accruing to crew, vessels, capital and rents. The results show that payments based on vessels or human and business capital have similar transfer efficiency, payments based on variable input use or FTCs have low transfer efficiency and income support is somewhere in between (Figure 3.6 panel a, left column). Payments based on vessels or human and business capital provide the least equal distribution of support, concentrating benefits to operators and owners of capital but largely leaving out hired crew (Figure 3.6 panel a, right column).

68. In general, the less distortions induced by a policy—that is, a smaller change in fishing effort resulting from a given change in support—the more efficient that policy is at transferring income to fishers. This is because market distortions lead to deadweight losses, inefficiencies that occur when the optimal level of supply and demand are not achieved.

69. Fishers' welfare in the model is measured by changes in producers' surplus for those inputs owned by fishers—vessels, capital and crew labour—plus the rents earned by the global fleets via their Cournot competition. The regional fleet is not a Cournot competitor and so earns no rents. The producers' surplus for fuel and other purchased inputs are assumed to accrue to and benefit upstream sector suppliers and not fishers themselves.

70. Vessels and human and business capital are inelastically supplied, which means that they tend to accumulate a greater change in producers' surplus for a given change in price. Crew labour is elastic in supply and accumulates less surplus for a given change.

71. When support is directed at a particular input, the producers' surplus for that input tends to increase the most relative to other inputs. However, because more inputs of all kinds are generally needed to increase effort fishing, and enterprises will change their input mix as relative prices change, the producers' surplus for all inputs will change with a change in support, no matter its initial incidence.

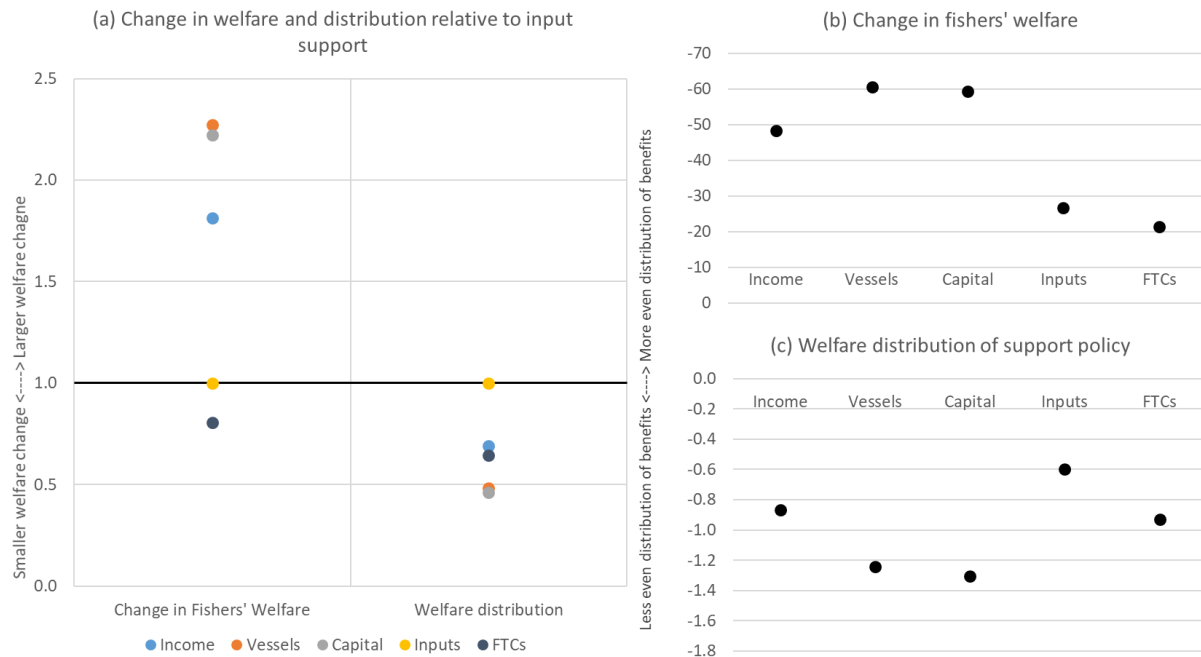
72. Transfer efficiency, the share of an amount of support that accrues as increased income for fishers, is an important indicator of the quality of a policy. Expenditures on highly distorting policies provide little benefit, as the value is lost to deadweight losses and inefficiency, including that caused when stock size declines below optimal levels.

73. The distribution of the benefits of support is also an important indicator. Broadly shared, inclusive benefits can help make fishing communities more resilient and reduce social conflict.

74. In terms of distribution, payments based on vessels or capital have the most skewed distribution of benefits, with most benefits going to vessel and business owners. FTCs and income support are better, and payments based on variable inputs distribute their low benefits relatively evenly as they come mostly from higher effort increasing use of all inputs. Income support provides a balance between reasonably good transfer efficiency and a relatively even distribution of benefits.

Figure 3.6. Payments based on vessels or capital deliver more than twice the benefits to fishers than does payments based on variable input use, but they concentrate benefits to owners at the expense of crewmembers

Welfare and distribution of benefits, by policy category relative to that of payments based on variable inputs



Note: Relative effect of reducing the rate of support by USD 100 million for each support category. Dots represent the weighted average effect for all regions. Panel (b) vertical axis reversed. “Fishers’ Welfare” measures transfer efficiency, with higher numbers being better. “Welfare distribution” is the inverse of the coefficient of variation between support recipients, with higher values indicating better (more equal) distribution of benefits.

Source: OECD FishPEM.

75. A reduction of USD 100 million in support to vessels or human and business capital reduces fishers’ welfare by about USD 60 million. That is, the transfer efficiency of these policies is about 60% (Figure 3.6 panel b). The transfer efficiency of income support is around 50%, it is 28% for payments based on variable input use. FTCs have the lowest transfer efficiency, only about 21% of the value of this support accrues as additional income for fishers, with the rest lost to the cost of excessive effort and reduced fish stocks.

76. The results point to a trade-off for fisheries policy makers: choose policies with a high capacity to increase fishers’ income, but with benefits concentrated on owners, or policies that are less efficient but with a more even distribution of benefits. Of course, this is not the only decision factor, but it points to the need to target fisheries policies to clear objectives to ensure that the desired result is most efficiently achieved. There is not a single best policy choice for all objectives.

4. Conclusions and discussion

77. This report has used a model of the economic, biological, and policy incentives facing fishers to estimate the relative effects on harvest, stocks and fishers’ incomes of five different types of direct support policies; four forms of budgetary support and fuel tax

concessions. This model is built on a database that includes *inter alia*, current levels of support, the distribution of fishing activity around the world, information on the status of fisheries resources, the costs of fishing and patterns of trade.

78. The model divides the global fishery into six inter-connected continental regions. In this model, fishers from each region compete for resources in different fishing areas in the context of biological limits on fish stocks and multilateral trade in fish products. Fisheries managers are able to control increases in fishing effort in their fishing area by imposing a fine on additional effort. The model is used to investigate the relative effects of five common types of support policies in terms of the spillover effects of policies of one region on fishing opportunities and activity in other areas, the status of fish stocks and the distribution of the benefits of policy support to vessel owners, crew and other actors in the fishing sector.

79. The model is built around a situation where there is significant overfishing taking place. While this may be true for the regional aggregates represented in the model, it is not the case for all fisheries. Fish stocks are often subject to specific management regimes that control effort or harvest, which affects the way support policies enter fishers' decision-making. The results presented here should be interpreted as being most relevant for fisheries that are overfished and subject to overfishing. The results provide general insights on the nature of policy support and do not predict outcomes in specific fisheries.

80. Two types of support are found to do a better job of aiding fishers without increasing pressure on the resource. These are payments based on the human and business capital of fishing operations, and support based on the income of fishers (Table 4.1). Human and business capital in the model represents the entrepreneurial skill and capacity of the owner and investments in the operation of the fishing enterprise. Payments directed at such capital include investments in on-vessel innovation, improved capacity to participate in the value chain, management training and anything else that helps economic performance. This form of support is the least distorting of fishing activity on many of the metrics considered, while being one of the most efficient ways to transfer income to fishers. This provides evidence that a policy focus on innovation can bring benefits to the fishing sector. However, payments based on capital tend to concentrate their benefits on owners to the exclusion of others.

Table 4.1. Rank of policy type according to selected effects

1= best performer

	Fishing effort at home	Fishing effort abroad	Fishing harvest by others	Fisher's Welfare	Welfare distribution
Payments based on human or business capital	1	2	2	2	5
Payments based on vessels	2	3	3	1	4
Payments based on income	3	4	4	3	2
Fuel Tax Concessions	5	1	1	5	3
Payments based on variable input use	4	5	5	4	1

Note: Best performers in terms of own fishing effort and harvest by others induce the smallest change for a given change in support. Best performers for fishers welfare produce the largest change in income to beneficiaries. Best performers on welfare distribution provide more equal benefits to all sector participants (crew, skippers, owners). Payments based on human or business capital or on vessels perform well in most metrics except for distribution of welfare. Fuel tax concessions perform poorly at home, but have small international effects. Payments based on variable input use perform poorly on all metrics except welfare distribution, but generate few benefits to distribute. Payments based on income fall in a middle zone in all metrics.

Source: OECD FishPEM.

81. Payments based on vessels are similar to payments based on human and business capital in that they both target relatively inelastic inputs. The differences in the quantitative model results have to do with the relative importance of these two inputs in total expenditures and their technical substitutability with other inputs. More importantly, vessels represent long-lived fixed assets in a context where overcapacity may be a concern. Finally, the beneficiaries of payments based on vessels are vessel owners, while payments based on human and business capital will benefit operators and business owners, of which vessel owners may be a subgroup.

82. Payments based on income may be more distorting than payments based on human and business capital, but are an effective way to transfer income to the larger fishing community in a more equitable way than other payments. Payments based on income can help improve the resilience of fishing communities by helping both business owners and crew to manage and smooth income disturbances, including those that arise from changes in the fish stocks or market disturbances as recently experienced during the COVID crisis. Payments based on income, human and business capital or vessels are all relatively more efficient at transferring income to beneficiaries than are payments based on purchased inputs or fuel tax concessions (FTCs).

83. Payments based on variable inputs or FTCs are designed to help fishers by reducing their operating costs. The results show that while these types of support increase fishing activity, they do little to help fishers. This is because the resulting overcapacity and overfishing worsen the underlying productivity of the fisheries, and deadweight losses and inefficiency dissipate the potential benefits to fishers.

84. The results show that FTCs have the most detrimental impact on the health of the fishery in the region where they are applied, but their effect on international fishing are limited. This is because a tax-based policy does not apply outside of its tax jurisdiction, and so the scope of effect of a FTC is determined by the operating range of the fishing vessel that benefits from it. FTCs may still affect fishing elsewhere in the world through price effects transmitted through competition in trade. This effect is contingent on stock recovery effects and changes in demand and can range from inconsequential to significant.

85. Stock recovery effects from support reductions are modest but positive for all forms of support. Reduction in FTCs bring the largest benefit in the home region, while reducing payments based on variable input use is more beneficial to fish stocks elsewhere in the world. However, the results show that reforming support alone is not enough to return fish stocks to their optimal levels. Indeed, how support affects effort and harvest depends on the effectiveness of fisheries management. The model contains representations of several channels of effect of support policies, but these may not matter if the level of fishing effort or harvest is effectively controlled at the fisheries level. Improved fisheries management within EEZs and on the high seas is a prerequisite to reducing overfishing. Reducing or reforming support can alleviate but not cure the negative consequences of inadequate fisheries management.

86. The results of this analysis show that there is a case to be made for reform from both a domestic and global perspective. Targeting support to the business needs of fishing enterprises in a way that helps them be competitive and innovative provides better long-term outcomes than using support to reduce costs. Support that improves the resilience of the broader fishing community will provide greater benefits to fishers for a given level of expenditure. Moving away from support based on purchased inputs can reduce overfishing and overcapacity and reduce international spillover effects on fishers and fish stocks.

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Annex A. Model structure

Introduction

87. International fishing is modelled as a Cournot equilibrium of fishers from six fishing regions operating in six matching fishing areas. Fishers from each region select the optimal effort to apply in each fishing area based on their costs, the price received, and the efforts applied by other fishers in the same fishing area. There is also a regional fleet that only operates in the home region, and which reacts to its own costs, price and the effort of fishers from other regions to maximise profits.

88. Fishers purchase inputs to produce fishing effort. Some inputs are purchased in the fishing area where the fisher is operating (purchased inputs), others are purchased in the home region of the fisher (capital and labour). The coastal fleet purchases and uses the same inputs as do the fleets operating globally, though perhaps in different proportions.

89. Harvested fish may be consumed domestically or traded. Fish originating from each region are differentiated (each fishing area produces an aggregate product based on the species of fish caught in that area), and exported fish products may be further differentiated by destination region. Regions chose a mix of imports by different sources according to relative prices and their preferences regarding differentiated products by source.

90. The model is calibrated to an initial state that reflects as closely as possible the actual state of the global fishery in 2017, using available data regarding fish stocks, fishing, and the costs and revenues of fishers. This calibration implicitly takes into account aspects of the global fishery that may not be explicitly included in the model. For example, the initial pattern of fishing effort reflects the allocations and agreements coming from both RFMOs and domestic management, though these arrangements are not part of the model logic.

91. From this initial state, adjustment to any introduced shock occurs smoothly to bring the model back into a balanced equilibrium where fishers and consumers in all regions are producing and consuming their optimal amounts. The rate of this adjustment is determined by the model structure and the parameters that specify the reactivity of model elements to changes in prices or quantities.

92. For the model to work properly, it requires that in this initial state, the fishery is at an equilibrium where the level of fishing pressure, F/F_{MSY} is in a stable relationship with the state of the fish stock, B/B_{MSY} . The most famous stable point is where both F/F_{MSY} and B/B_{MSY} are equal to one, shown as the crossing of the black lines in Figure 1.3. That represents maximum sustainable yield, or MSY, where fishing pressure is appropriate to deliver the largest possible harvest every year.

93. Few stocks are actually at this MSY point, and many are constantly in the process of moving towards equilibrium as fishing efforts change in response to management controls and market signals, or as a result to natural variation in the annual reproduction of the stock. Starting at such a point of flux or disequilibrium is unhelpful, as the first result of any simulation experiment would be bring the stock to its steady state, a change that would be larger than the result of any policy change that may be introduced. This return to equilibrium would thereby dominate the results and render them useless.

94. A better approach is to use the data to find in advance what the stable equilibrium would be if fishing pressures were to continue as they currently are. The long-term

implications of current practices are thereby taken into account and this becomes the starting point of the simulation analysis. The drawback is that, while the state of the fishery takes into account the fundamental sustainability limitations in the biological data, this implied equilibrium itself in some cases does not closely match the current situation, where there may be significant overfishing and therefore high harvest rates, even as the fish stock declines.

95. The model is described below according to the parameters, variables, sets and equations of which it is composed. Sets are groupings that describe the different elements of the model to which parameters and variables refer. They act as indices that specify the scope of relevance of parameters and variables (Table A A.1).

Table A A.1. Sets in the model

Set Name	Set Elements	Symbol
Regions	nar – North America sar – South America eur – Europe asr – Asia ocr – Oceania afr - Africa	r or rp
Fishing areas	naw – North America saw – South America euw – Europe asw – Asia ocw – Oceania afw - Africa	w or wp
Inputs	fu – Fuel hl – Hired labour op – other purchased ve – vessels oc – other capital	i or j fu and op are area-specific and purchased in fishing area hl, ve and op are purchased in region of origin
Fleet segments	g – global fleet c – coastal fleet	s
Policies	tinc – payments based on income tves – payments based on vessels tcap – payments based on capital tvar – payments based on variable inputs tfuel – fuel tax concessions	p or pb

Note: the trailing “p” in *wp* or *rp* and the *j* for inputs is an [alias](#) to allow certain summations to be taken over these sets *pb* is a subset of *p* containing only budgetary payments (*pb* excludes *tfuel*).

Model parameters and variables

96. Model parameters come from data or are calibrated to establish the initial equilibrium in the model. They are exogenous and do not change as a result of the operation of the model. Policy shifters are also exogenous parameters and are manipulated to produce policy experiments (Table A A.2).

Table A A.2. Parameters in FishPEM

	Symbol	Value	Source	Notes
Biological Parameters	Q_w	0.005	Choice	Catchability coefficient. Currently the same for all regions; can be important for calibration of effort
	r_w	by fishing area	(Costello, 2020 _[15])	Intrinsic growth rate of the fishery
	K_w	by fishing area	(Costello, 2020 _[15])	Carrying capacity of the fishery (million tonnes biomass)
Production parameters	$\sigma_{i,j,r}$	by input pair and region	(Mardle, 2018 _[25])	Allen elasticity of substitution between inputs. Implicitly defines production technology
	$\phi_{i,r}$	by input and region	(FAO, 2020 _[22]), national statistical agencies	Input shares , expressed as a % of revenue. Also defines production technology
	$\varepsilon_{i,r}$	0.5 for capital, 2 for purchased	Same as for FishPEM	Input supply elasticity . Capital is relatively rigid in supply.
	$esh_{r,w}$	share of harvest in area by region	Calculated from harvest data	used when harvest share < 1 percent of total in area
Trade parameters	δR_r	by region	METRO model	Constant Elasticity of Substitution (CES) parameter for imports by source . Currently same for all regions
	Ω_r	by region	METRO model	Constant elasticity of Transformation (CET) parameter for exports by destination . Currently same for all regions
Economic parameters	δ_r	by region	METRO model	Constant Elasticity of Substitution (CES) parameter for domestic vs imports . Currently same for all regions
	ΩR_r	by region	METRO model	Constant elasticity of Transformation (CET) parameter for domestic vs exports . Currently same for all regions
	η_r	by region	(Gallet, 2009 _[26])	Elasticity of demand for fish by domestic consumers
Policy Parameters	$t_{i,p,r}$	by policy category and region	FSE dataset	Fisheries support , expressed as a wedge between supply and demand price of specific inputs
	t_{S_r}	not currently used		Sales tax
	t_{X_r}	not currently used		Production tax
	t_{E_r}	not currently used		Export tariff
Management Parameters	$IUU_{f,w}$	10000	Choice	IUU fine in area w Chosen to be highly dissuasive of additional effort
	t_{constw}	1	Choice	Fine probability scaling factor optional to make probability of receiving fine non-linear in increasing effort.

97. Variables are endogenous to the model and typically represent quantities or prices. By convention, they are presented in UPPERCASE, as are parameters reflecting their initial values (Table A A.3).

Table A A.3. Variables in FishPEM

	Variable Name	Scope	Source of base value	Notes
Biology and production economics	$E_{r,w}$	by region and fishing area	Calibration	Fishing effort by global fleet. Calibrated based on share of harvest in fishing area by region
	EC_w	by fishing area	Calibration	Fishing effort by regional fleet
	$Y_{r,w}$	by region and fishing area	Calibration and (Costello, 2020 ₍₁₅₎)	Yield. Calibrated based on share of harvest in fishing area by region
	YC_w	by fishing area	Assume 80% of total	Yield by regional fleet
	$FD_{i,r,w}$	by input, region and fishing area	Calibration	Input demand
	$FDC_{i,w}$	by input and fishing area	Calibration	Input demand by regional fleet
	$WFD_{i,r,w}$	by input, region and fishing area	Calibration	Input demand price
	$FS_{i,r}$	by input and region	Calibration	Input supply (capital and labour)
	$FSA_{i,w}$	by input and fishing area	Calibration	Input supply (purchased inputs)
	$WF_{i,r}$	by input and region	set to 100	Input supply price (capital and labour)
	$WFA_{i,r}$	by input and fishing area	set to 100	Input supply price (purchased inputs)
Trade	QE_r	by region	(Gephart, 2020 ₍₁₆₎)	Exports from region
	QM_r	by region	(Gephart, 2020 ₍₁₆₎)	Composite imports composed of QMR
	PM_r	by region	Set to 1000	Price of imports into region (composite)
	PWM_w	by fishing area	PWE_r	World price of imports by source
	PWE_r	by region	1000	World price of exports by source
	$PMR_{w,r}$	by region and fishing area	1000	Price of imports from w into r
	$QMR_{w,r}$	by region and fishing area	(Gephart, 2020 ₍₁₆₎)	Imports from w into r
Domestic Market	QQ_r	by region	Calibration	Composite good CES of domestic good and imports
	QX_r	by region	Calibration	Domestic production
	QD_r	by region	Calibration	Domestic production supplied to domestic market
	QCD_r	by region	Calibration	Domestic consumption
	PQS_r	by region	1000	Supply price of composite good
	PQD_r	by region	1000	Demand price of composite good
	PX_r	by region	1000	Producer price
	PD_r	by region	1000	Supply price of domestic component of composite good

Model Equations

Biology and production economics

98. Fishers in the global fishing fleet choose effort based on the parameters of the biological growth function, their costs and prices, and the efforts of other fishers:

$$E_{r,w} = \frac{r_w}{2q_{r,w}} \left[1 - \frac{\sum_i C_{i,r,w}}{PX_r q_{r,w} k_w} \right] - \frac{1}{2q_{r,w}} \sum_{rp \neq r} q_{rp,w} E_{rp,w} \quad (1)$$

99. Note that the part of the equation after the bracket shows the response to other fishers' effort: A fisher will reduce effort in response to an increase in another's effort at by $\frac{1}{2}$ of the ratio of their catchability coefficients. The relative catchability coefficients represent technical advantage of one region over another in a specific fishing area. A fisher with a high coefficient responds less to other fishers' actions.¹⁹

100. Fishers marginal costs $C_{i,r,w}$ are a function of input cost and base input use and expenditure, plus a management term that represents the probability of paying a fine if effort is increased. The structure of this fine follows the rational choice model of crime, where the marginal expected fine is equal to marginal revenue. This is achieved by adding a fine component to the marginal cost function of the global fleet that is relevant only for increases in effort over the baseline.

$$\frac{WFD_{i,r,w}FDO_{i,r,w}}{EO_{r,w}} + IUUf * (E_{r,w} - EO_{r,w})^\tau \text{ iff } E > EO \quad (2)$$

Tau in (2) is a shape parameter currently set to one. The amount by which effort increases over the baseline is proportional to the probability that the fine will be levied.

101. If the harvest share by a region is less than 0.1% of total then the effort by that region is set to maintain a constant share of effort with respect to other global fleets, so:

$$E_{r,w} = esh_{r,w} \sum_{rp} E_{rp} \quad \forall esh < 0.001 \quad (3)$$

102. The regional fisher operates in a competitive markets and so and sets effort to solve the following condition:

$$YC_r \cdot PX_r = \sum_i WFD C_{i,r} \cdot FDC_{i,r} \quad (4)$$

103. Each fishers' yield in a fishing area is a function of the growth parameters and the total effort exerted in the fishery:

$$Y_{r,w} = q_{rw} k_w E_{r,w} \left[1 - \frac{\sum_{rp} q_{rp,w} E_{rp,w} + qc_w EC_w}{r_w} \right] \quad (5)$$

104. Using a dot above a variable name indicates percentage change. The demand for purchased inputs acquired in the area where fishing occurs is:

$$FD_{i,r,w} = \dot{E}_{r,w} + \sum_j \sigma_{i,j,r} \phi_{j,r} WFD_{j,r,w} \quad (6)$$

105. That is, the percentage change in demand for an input is equal to the percentage change in effort, modified by the percentage change in all input prices times their share in total cost times the elasticity of substitution between inputs. In the case of capital inputs, these are not differentiated by fishing area such that an increase in vessels or capital increases the availability of these inputs for all fishing areas. So changes in effort in one fishing area that increases fleet capacity does so for all fishing regions.

¹⁹ The formula for EC, the effort by the coastal fleet, is similar. When this is the case, the equation for the coastal fleet will not be repeated. A full copy of the model code in GAMS is available upon request.

$$\dot{F}D_{i,r,w} = FDO_{r,w} \left\{ 1 + \frac{[\sum_w E_{r,w} - \sum_w E0_{r,w}]}{\sum_w E0_{r,w}} + \sum_j \sigma_{i,j,r} \varphi_{j,r} W\dot{F}D_{j,r,w} \right\} \quad (7)$$

106. Note that the term in E in the brackets is the percentage change in the sum of effort in all fishing areas.

107. Input supply is a simple rearrangement of the definition of the supply elasticity, expressed in percentage terms and solved for quantity:

$$\dot{F}S_{i,r} = \varepsilon_{i,r} \dot{W}F_{i,r} \quad (8)$$

108. For those inputs purchased in the local fishing area, the formula is the same but indexed on w instead of r . Input supply must equal input demand from all sources, including the coastal fleet. For purchased inputs that is:

$$FSA_{i,w} = \sum_r FDi_{r,w} + FDC_{i,w} \quad (9)$$

109. Input prices adjust to clear the input markets in the above equation. Policy support acts as a wedge between the demand and supply price. For capital inputs purchased in home regions, this is:

$$W\dot{F}D_{i,r,w} = W\dot{F}_{i,r} \left[1 - \sum_p ti_{p,r} \right] \quad (10)$$

For purchased inputs, the only difference is that WF is indexed on w instead of r .

Domestic market and trade

110. All catches are presumed landed in home ports. The domestic quantity available in the home market is therefore²⁰:

$$QX_r = \sum_w Y_{r,w} + YC_r \quad (11)$$

111. Exports are differentiated by destination according to a two-stage Constant Elasticity of Transformation (CET) function. In the first stage an exports aggregate is differentiated from the domestic good, and in the second stage this export aggregate is differentiated by destination. This is expressed as a function of shares and relative prices as follows:

$$\frac{QE_r}{QX_r} = \frac{QE0_r}{QX0_r} \left\{ \frac{PX_r/PX0_r}{PE_r/PE0_r} \right\}^{\Omega_r} \quad (12)$$

$$\frac{QER_{r,w}}{QER0_{r,w}} = \frac{QE_r}{QE0_r} \left\{ \frac{PE_r/PE0_r}{PER_r/PER0_r} \right\}^{\Omega_{Rr}} \quad (13)$$

112. The domestic market consumes a composite good, QQ made up of a combination of domestic product QD and imports QM . QM itself is a composite commodity of imports

²⁰ For programming convenience, the regional fleet is indexed on fishing area (w) rather than region (r). In the exposition here, this is changed for clarity.

from different regions QMR . All use Constant Elasticity of Substitution (CES) functions in a similar manner as for the differentiated exports.

$$\frac{QD_r}{QQ_r} = \frac{QD0_r}{QQ0_r} \left\{ \frac{PQS_r/PQS0_r}{PD_r/PD0_r} \right\}^{\delta_r} \quad (14)$$

$$\frac{QM_r}{QQ_r} = \frac{QM0_r}{QQ0_r} \left\{ \frac{PQS_r/PQS0_r}{PM_r/PM0_r} \right\}^{\delta_r} \quad (15)$$

$$\frac{QMR_{r,w}}{QMRO_{r,w}} = \frac{QM_r}{QM0_r} \left\{ \frac{PM_r/PM0_r}{PMR_r/PMR0_r} \right\}^{\delta_{R_r}} \quad (16)$$

113. By exploiting Euler's theorem for linearly homogeneous functions, prices can be expressed as expenditure identities. The domestic supply price of the composite good, PQS , is the weighted average of the producer price of the domestic good, PD and PM , the domestic price of (composite) imported fish.

$$PQS_r = \frac{PD_r QD_r + PM_r QM_r}{QQ_r} \quad (17)$$

And for the producer price;

$$PX_r = \frac{PD_r QD_r + PE_r QE_r}{QX_r} \quad (18)$$

114. The domestic final consumer price is equal to the supply price of the composite good times the sales tax rate:

$$PQD_r = PQS_r * (1 - ts_r) \quad (19)$$

115. The price of the domestic good is equal to the world price times export tariffs times the exchange rate:

$$PD_r = PWE_r * ER_r * (1 - te_r) \quad (20)$$

116. Domestic producer price is equal to the price of the domestic good minus any taxes (or adding any subsidies):

$$PX_r = PD_r * (1 - tx_r) \quad (21)$$

117. Domestic final consumption is a function of consumer price, applying the definition of the elasticity in the same manner as was done for input supplies:

$$Q\dot{C}_r = \eta_r P\dot{Q}_r \quad (22)$$

118. Finally, the market for the composite good must clear, with supply equal to demand:

$$QQ_r = QCD_r \quad (23)$$

Data

Allocating support from FSE data

119. The FSE dataset provides the support data used in the model. It is aggregated by region and specific FSE categories assigned to the policy groupings in the model (Table A A.4).

Table A A.4. FSE policy mapping to model elements

Region	Countries	Policy	FSE category
nar – North America	CAN, USA, MEX	tinc	IFMSC – Misc. Transfers to fishers IFINC_INS – Income support IFINC_SIF – Special insurance systems for fishers
sar – South America	ARG, BRA, CHL, COL, CRI, PER	tves	IFINP_FIX_M – Support to modernisation IFINP_FIX_V – Support to vessel construction/purchase IFRPC – Transfers based on the reduction of productive capacity
eur – Europe	BEL, DNK, EST, FRA, DEU, GRC, ISL, IRL, ITA, LVA, LTU, NLD, NOR, POL, PRT, SVN, ESP, SWE, GBR	tcap	IFINP_FIX_O – Support to other fixed costs
asr – Asia	JPN, KOR, CHN, IND, IDN, MYS, PHY, TUR, VNM, TWN	tinc	IFINP_VAR – Transfers based on variable input use
ocr – Oceania	AUS	tfuel	FTC – Fuel Tax Concessions
afr – Africa	< NONE >		

120. The model uses FSE data from 2017, and the included categories amount to USD 4.2 billion (Table A A.5).

Table A A.5. FSE data by region and policy category (USD millions)

	North America	South America	Europe	Asia	Oceania
tinc payments based on income	246.3313	678.3805	40.7700	64.2322	0.2261
tves – payments based on vessels	19.7217	7.1705	15.4901	976.1454	0.2299
tcap – payments based on capital	0.1557	0	7.1927	0.8641	1.1495
tvar – payments based on variable inputs	12.8130	4.1851	3.8964	1738.4209	0.8813
tfuel – fuel tax concessions	0	10.1095	358.5920	86.1536	0

Note: FSE dataset has no information for African countries.

121. FSE data by policy category are in turn mapped to the inputs in the model to identify which input demand prices are affected by each category. All inputs affected by a policy category see the same *ad valorem* rate of support (Table A A.6).

Table A A.6. Policy category to input mapping in FishPEM

	Payments based on income	Payments based on vessels	Payments based on other capital	Payment based on purchased inputs	Fuel tax concessions
Fuel	No	No	No	Yes	Yes
Hired Crew	Yes	No	No	Yes	No
Other Purchased	No	No	No	Yes	No
Vessels	Yes	Yes	No	No	No
Other capital	Yes	No	Yes	No	No

Elasticities

122. Elasticities are measures of proportional response. Most commonly, they reflect the percentage change in quantity resulting from a percentage change in price but they can be applied more generally. Elasticity data are typically hard to find and these values are in many cases the same for all regions (Table A A.7).

Table A A.7. Elasticities in model

Percent change in quantity with respect to change in price.

Elasticity	Scope	North America	South America	Europe	Asia	Oceania	Africa
$\sigma_{i,j,r}$	fuel x hired crew	0.4 global/ 0.3 coastal	0.4 global/ 0.3 coastal	0.4 global/ 0.3 coastal	0.4 global/ 0.3 coastal	0.4 global/ 0.3 coastal	0.4 global/ 0.3 coastal
	fuel x other purchased other purchased x hired crew						
	fuel x vessels	0.6 global/ 0.4 coastal	0.6 global/ 0.4 coastal	0.6 global/ 0.4 coastal	0.6 global/ 0.4 coastal	0.6 global/ 0.4 coastal	0.6 global/ 0.4 coastal
	hired crew x vessels other purchased x vessels	0.5 global/ 0.4 coastal	0.5 global/ 0.4 coastal	0.5 global/ 0.4 coastal	0.5 global/ 0.4 coastal	0.5 global/ 0.4 coastal	0.5 global/ 0.4 coastal
	fuel x capital hired crew x capital other purchases x capital	0.6 global/ 0.5 coastal	0.6 global/ 0.5 coastal	0.6 global/ 0.5 coastal	0.6 global/ 0.5 coastal	0.6 global/ 0.5 coastal	0.6 global/ 0.5 coastal
	vessels x capital	0.5 global/ 0.4 coastal	0.5 global/ 0.4 coastal	0.5 global/ 0.4 coastal	0.5 global/ 0.4 coastal	0.5 global/ 0.4 coastal	0.5 global/ 0.4 coastal
$\varepsilon_{i,r}$	fuel, hired labour, other purchased	2	2	2	2	2	2
	vessels, capital	0.5	0.5	0.5	0.5	0.5	0.5
η_r	domestic demand x price	-1.08	-0.81	-0.68	-0.83	-0.81	-0.81

Input cost shares

123. Input cost shares help characterise the production technology by indicating how much of each input type is used in producing fishing effort. Input shares are also important in determining welfare results, which are calculated as the producers' surplus accruing to each input.

124. Input cost data come from the FAO (FAO, 2021^[27]). These data are based on 20 country-level studies of fishing fleets from Africa, Asia, Europe, North and South America and includes information from 103 major fishing fleet segments, representing approximately 240 000 fishing vessels and 39 percent of marine capture fisheries production worldwide. The fleets reviewed include 41 segments of bottom trawlers, 18 segments of purse seiners, 10 segments of longliners, 6 segments of pelagic trawlers, 4 segments each of gillnetters and squid jiggers, as well as fleet segments consisting of cast

netters, stownetters, pole-and-line vessels, pot and trap vessels, dredgers, passive gear vessels and handliners.

125. The data were cleaned of possible missing values by dropping segments where a single cost share was implausibly low, less than 9%. For each region, regional versus global fleets were identified according to vessel characteristics, with smaller vessels with more polyvalent gears allocated to the regional fleet, and others to the global fleet. The cost structures of the resulting groupings were then averaged to arrive at a set of input cost shares for the two fleets in each region. (Table A A.8). Non-production costs such as fishing licenses, permits, and the purchase of fishing rights (quotas) were removed from the cost estimates.

Table A A.8. Input cost shares in FishPEM

Percent of total revenue

Fleet Segment	Input	North America	South America	Europe	Asia	Oceania	Africa
Global	Fuel	0.20	0.14	0.15	0.12	0.13	0.23
	Hired crew	0.30	0.26	0.29	0.36	0.31	0.23
	Other purchased	0.19	0.14	0.21	0.16	0.21	0.23
	Vessel	0.15	0.34	0.21	0.17	0.21	0.11
	Other capital	0.16	0.11	0.15	0.19	0.14	0.20
Regional	Fuel	0.19	0.15	0.13	0.23	0.18	0.39
	Hired crew	0.35	0.32	0.20	0.32	0.22	0.33
	Other purchased	0.14	0.27	0.11	0.09	0.24	0.10
	Vessel	0.17	0.13	0.30	0.14	0.15	0.09
	Other capital	0.16	0.13	0.26	0.23	0.20	0.09

Trade

126. Bilateral trade in capture fisheries products has been provided via a consultant (Gephart, 2020_[16]). This data cleans existing trade data of aquaculture products, leaving only those products with a high probability of being sourced from capture fishing (Table A A.9).

Table A A.9. Trade data in FishPEM

By source and destination, million tonnes net weight

		Importer					
		North America	South America	Europe	Asia	Oceania	Africa
Exporter	North America		0.0175	0.6202	0.7527	0.0069	0.0601
	South America	0.2024		0.5245	1.4447	0.0140	0.2198
	Europe	0.1211	0.0865		2.0959	0.0072	1.0039
	Asia	0.6050	0.1338	0.8799		0.1876	0.5446
	Oceania	0.0402	0.0041	0.0946	0.4966		0.0285
	Africa	0.0257	0.0690	0.8766	0.4997	0.0073	

Biological data

127. Data on the biological capacity and status of the fisheries in each region are also provided by a consultant (Costello, 2020_[15]). The median value of B/B_{MSY} across all stocks in a region is used (Table A A.10). In the case of Africa, a value of 0.3 is used to represent a low stock status for that region less than what the data report, to server as a representation of the potential effects of reform in severely overfished regions.

Table A A.10. Biological Data in FishPEM

Carrying capacity in million tonnes, growth rate in percent

	North America	South America	Europe	Asia	Oceania	Africa
Intrinsic growth rate	0.308	0.698	0.446	0.166	0.188	0.54
Carrying capacity	120.00	63.00	91.00	780.00	110.00	71.00
B/B_{MSY}	0.68	0.83	0.68	0.69	0.89	0.3

Annex B. Extended model results

128. Model scenarios were designed to provide the same policy shock in each region, with the results by regions presented on average in the main body of the results. This provides for general conclusions on policy effects within the bounds that the data that underlie the model. Each scenario is a reduction in support by USD 100 million, which is large relative to the baseline level of support, but not relative to factor expenditures in most regions.

129. As a practical matter, the size of the shock used in the model has no significant impact on the results on the relative effects of policies presented in the main body of the report. In this Annex however, the size of the effect is proportional to the size of the shock. As the shock size is arbitrary, so is the scale of the outcome of the model. These results should be understood in this context; they are produced to establish the relative effects of support policies. Furthermore, absolute effects are much more sensitive to model data and assumptions than are relative effects.²¹

130. The results in the body of the report are presented as the weighted average of the effect of the support policy in each of the six regions of the model. The weights used for the averages are based either on the harvest of the global fleet, the harvest of the regional fleet, or the carrying capacity of the fish stock, depending on which is most relevant to the indicator at hand. Asia has the largest weighting regardless of the weights chosen (Table A B.1).

Table A B.1. Weights used for weighted averages

Percentage share of each region in total, by weighting option

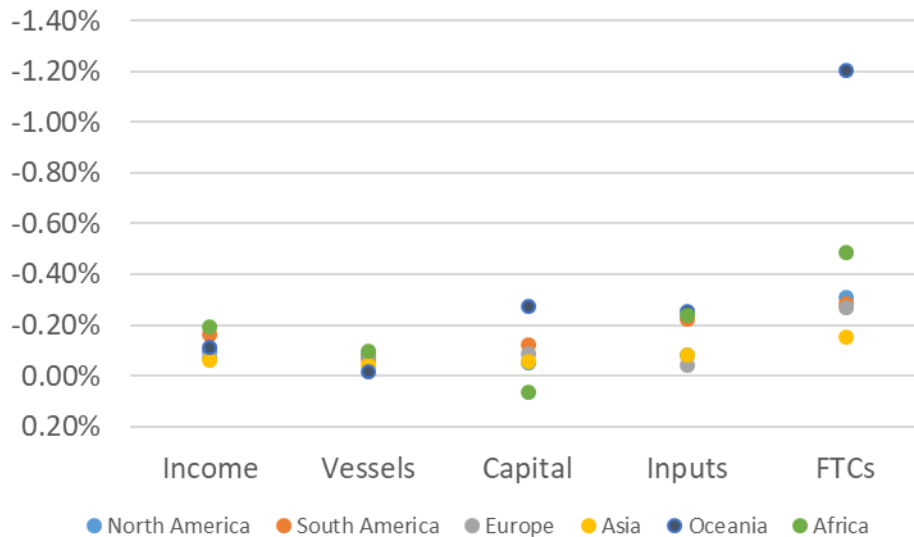
	Harvest by global fleet (Y)	Harvest by Regional Fleet (YC)	Carrying capacity of fish stock (K)
North America	12%	13%	10%
South America	16%	18%	5%
Europe	19%	15%	7%
Asia	42%	43%	63%
Oceania	5%	4%	9%
Africa	6%	6%	6%

131. Each scenario is a reduction in support. This matches the expected direction of change in support in the future given SGD 14 commitments and the potential of a WTO agreement. It also means that, generally speaking, the effects of management controls are felt by fleets from regions other than that where the shock occurs, who would otherwise increase effort in response to a decrease in effort by others. That is, it controls the fish stock competition effect from international fishers in the region where support is changing.

²¹ For example, if the output price in the model were half its current value, the value of inputs would also be halved and the change in the rate of support from a USD 100 million reduction would be doubled. All the results shown in this Annex would change in the same proportion, but the relative effects would not be affected. We can conclude that the relative effects shown in the main body are insensitive to inaccuracies in price data, so long as that inaccuracy is proportionally the same in all regions.

Figure A B.1. Change in regional effort of fleet where support is changing

Percent change in fishing effort due to USD 100 million reduction in support, by support category



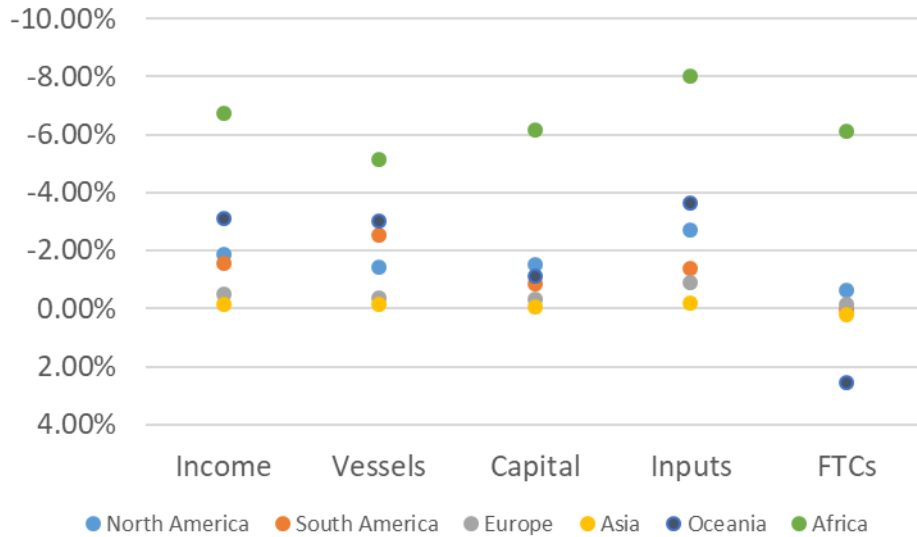
Note: Smaller regions like Oceania and Africa tend to show a larger percentage effect for the same change in support; this is because of the size of the shock in proportion to the size of the fishery.

Source: OECD FishPEM.

132. The large majority of fishing takes place by fishers operating in their home region, so the absolute size of international effort and harvest is small relative to regional effort and harvest. This leads to larger percentage changes in international effort and harvest in many cases, even if the absolute change in international effort may be smaller than regional effort. The very large negative effort change in Figure A B.2 is seen in Africa, which has a very small amount of international fishing activity (African fishers operating abroad).

Figure A B.2. Change in effort elsewhere in the world of fleet where support is changing

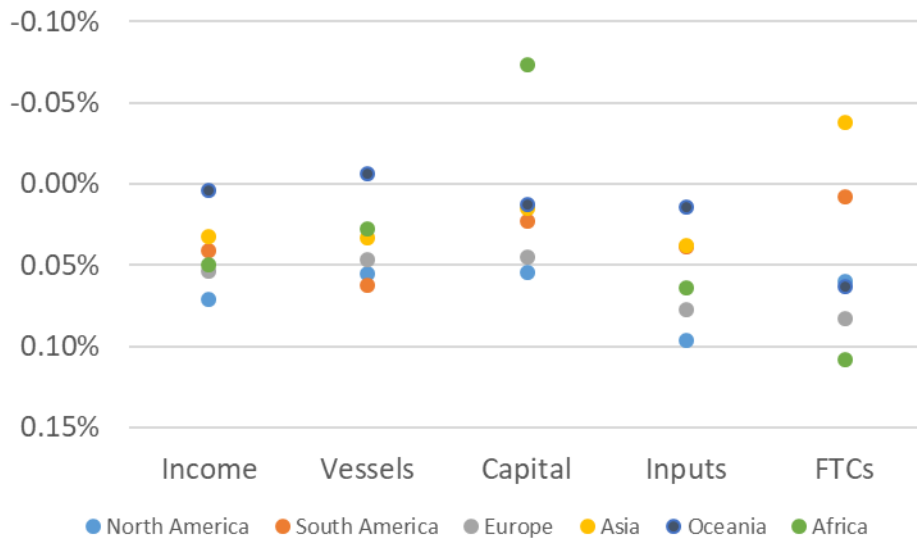
Percent change in fishing effort due to USD 100 million reduction in support, by support category



Note: Africa has a small global fishing fleet, so percentage changes are higher for a given level of support.
Source: OECD FishPEM.

Figure A B.3. Change in effort by regions other than the one where support is changing

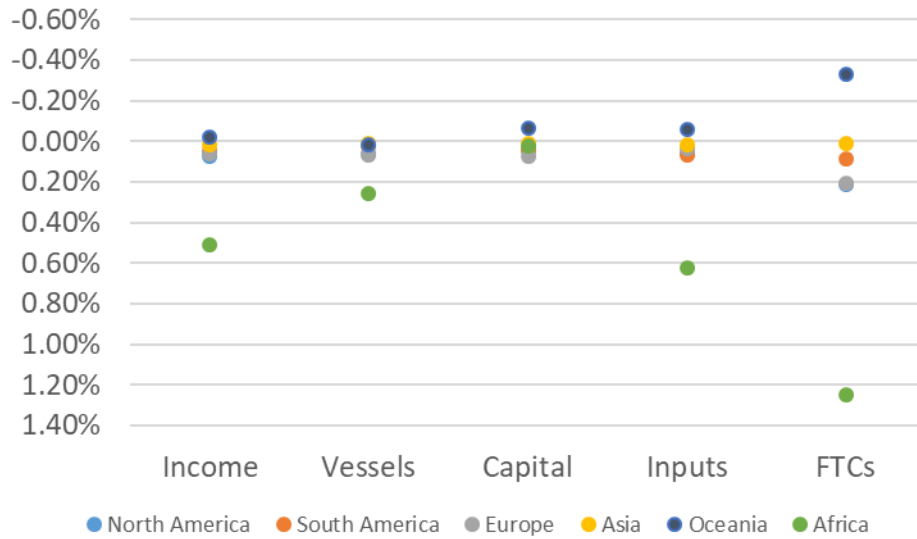
Percent change in fishing effort due to USD 100 million reduction in support elsewhere, by support category



Note: The change in effort is small in percentage terms. Effort by others is the sum of the change in effort by all other fleets in all other regions, including the relatively large regional fleets. It is large relative to international effort by the global fishery receiving the support, so the percentage change is smaller. For many support types, the net effect on other fleets' effort can be positive or negative, but in most cases a reduction in support increases effort elsewhere.
Source: OECD FishPEM.

Figure A B.4. Change in regional harvest of fleet where support is changing

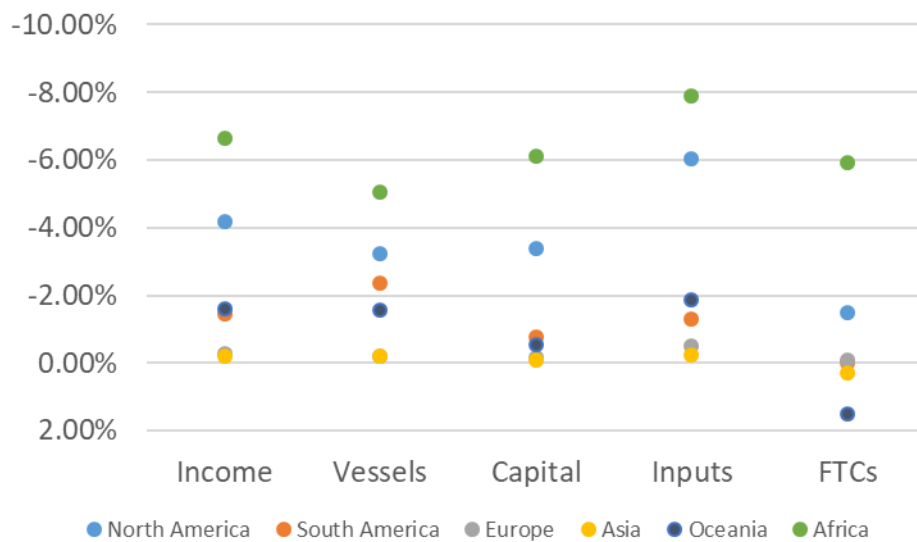
Percent change in fishing harvest due to USD 100 million reduction in support, by support category



Note: Harvest changes are a function of changes in effort, effort by others and fish stocks.
Source: OECD FishPEM.

Figure A B.5. Change in international harvest of fleet where support is changing

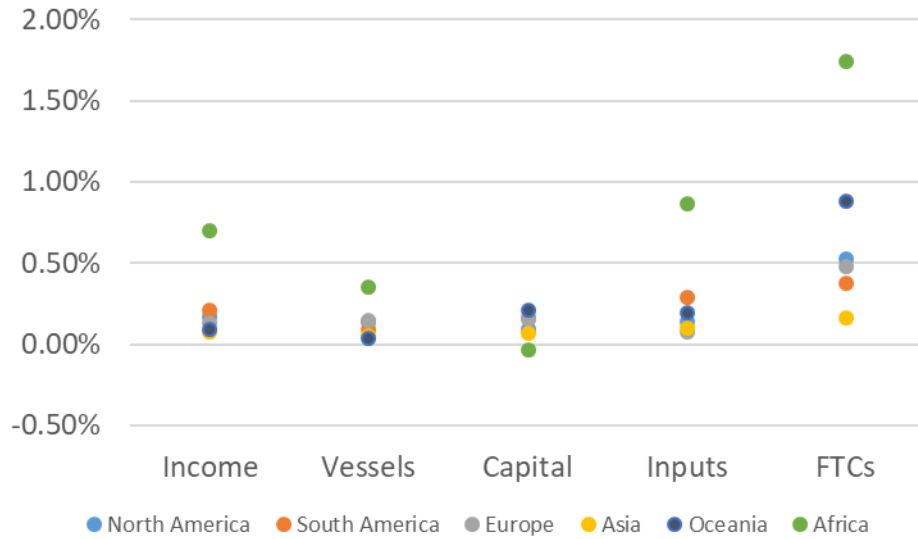
Percent change in fishing harvest due to USD 100 million reduction in support, by support category



Note: International harvest is small relative to regional harvest, so the percent change is higher. The relative size of the global fleets is also important in the result.
Source: OECD FishPEM.

Figure A B.6. Change in fish stock in region where support is changing

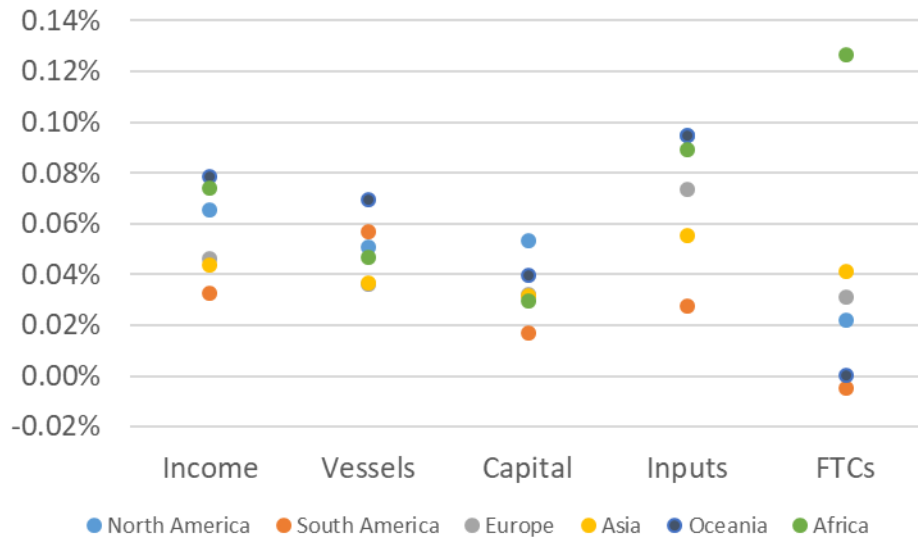
Percent change in fish stock due to USD 100 million reduction in support, by support category



Note: Africa’s fish stock is in the worst condition with respect to B/Bmsy, so it improves the most when support is reduced (slope of the growth function is steeper).
Source: OECD FishPEM.

Figure A B.7. Change in fish stock in regions other than the one where support is changing

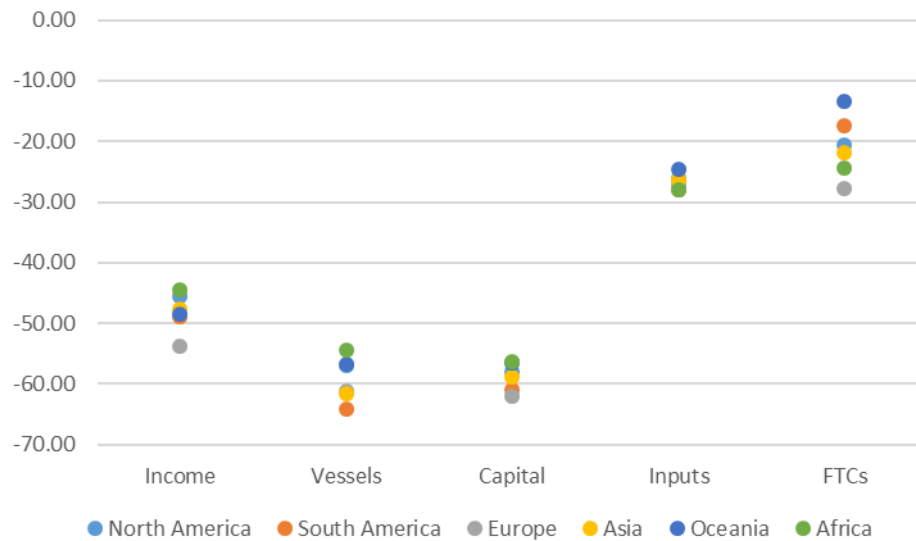
Percent change in fish stock due to USD 100 million reduction in support, by support category



Note: Sum of changes in biomass of fish stocks in all regions except the one where support is changing.
Source: OECD FishPEM.

Figure A B.8. Change in welfare of fishers in region where support is changing

Change in welfare, USD millions, by support category for a USD 100 million reduction in support

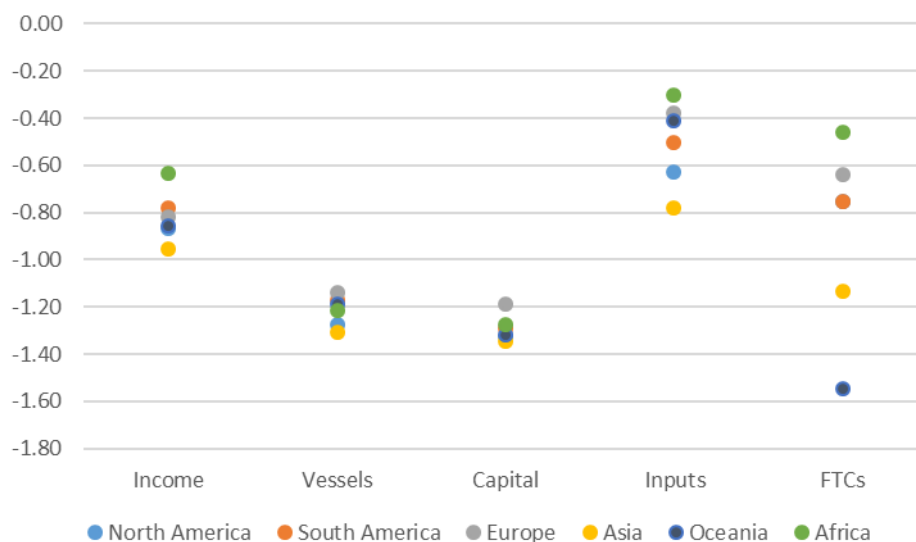


Note: The change in welfare can be read as transfer efficiency by dividing the welfare change by the change in support. That is, payments based on human or business capital have a transfer efficiency of about 60% while FTCs are about 20% transfer efficient. For every dollar given as a FTC, fishers gain around 21 cents.

Source: OECD FishPEM.

Figure A B.9. Distribution of change in welfare of fishers in region where support is changing

Coefficient of variation of welfare change by recipient, by support category



Note: Coefficient of variation is standard deviation divided by the mean. Recipients are owners of vessels or other capital, crew, and those receiving rents in the international fishery. Smaller numbers mean more equal distribution of benefits.

Source: OECD FishPEM.

Annex C. Fishery Aggregation Model for OECD (logistic growth version)²²

Introduction and purpose

133. The purpose of this document is to derive an aggregated fishery model for use by the OECD under the direction of Roger Martini. The approach use data from RAM Legacy stock assessments, FAO, and (Costello et al., 2016_[14]) for individual stocks, and aggregates those stocks into FAO regions, and ultimately into continental regions. I have made use of recent stock assessments, wherever possible, and for unassessed stocks, have relied mostly on Costello et al. The resulting dataset distinguishes between these approaches, which gives some idea of what fraction of the data are from assessed vs. unassessed fisheries.

Methods

134. The main parameters of interest are: (1) current biological status (B/B_{MSY}), (2) biological growth parameters, (3) carrying capacity, and (4) MSY. The idea is to have a single biological model for each OECD-defined continental region. OECD continental regions are aggregations of unique FAO fishing regions.

135. We will assume that each continental region can be represented by a single Pella-Tomlinson biological growth model. Note that logistic growth is a special case of the PT model, where $\phi=1$ (we will adopt this assumption below). The PT model is given as follows:

$$B_{t+1} = B_t + \frac{\phi + 1}{\phi} g B_t \left(1 - \left(\frac{B_t}{K} \right)^\phi \right) - H_t$$

136. Which has the following characteristics:

- Intrinsic growth rate: $\frac{\phi+1}{\phi} g$
- Carrying capacity: K
- $B_{MSY} = \frac{K}{(\phi+1)^{1/\phi}}$
- $MSY = \frac{gK}{(\phi+1)^{1/\phi}}$
- $F_{MSY} = g$

137. The goal, then, is to compile aggregate values of:

1. Current biomass in each region ($B=B_{MSY}$)
2. Shape parameter ϕ , (for logistic growth, we can set $\phi=1$)
3. Growth parameter, g (note that the intrinsic growth rate is: $\frac{\phi+1}{\phi} g$)
4. Maximum Sustainable Yield, MSY

²² The author of this annex is Dr. Christopher Costello. He is professor of Environmental and Resource Economics at the Bren School of Environmental Science & Management, UC Santa Barbara. This report was prepared for the OECD on 18 December 2020.

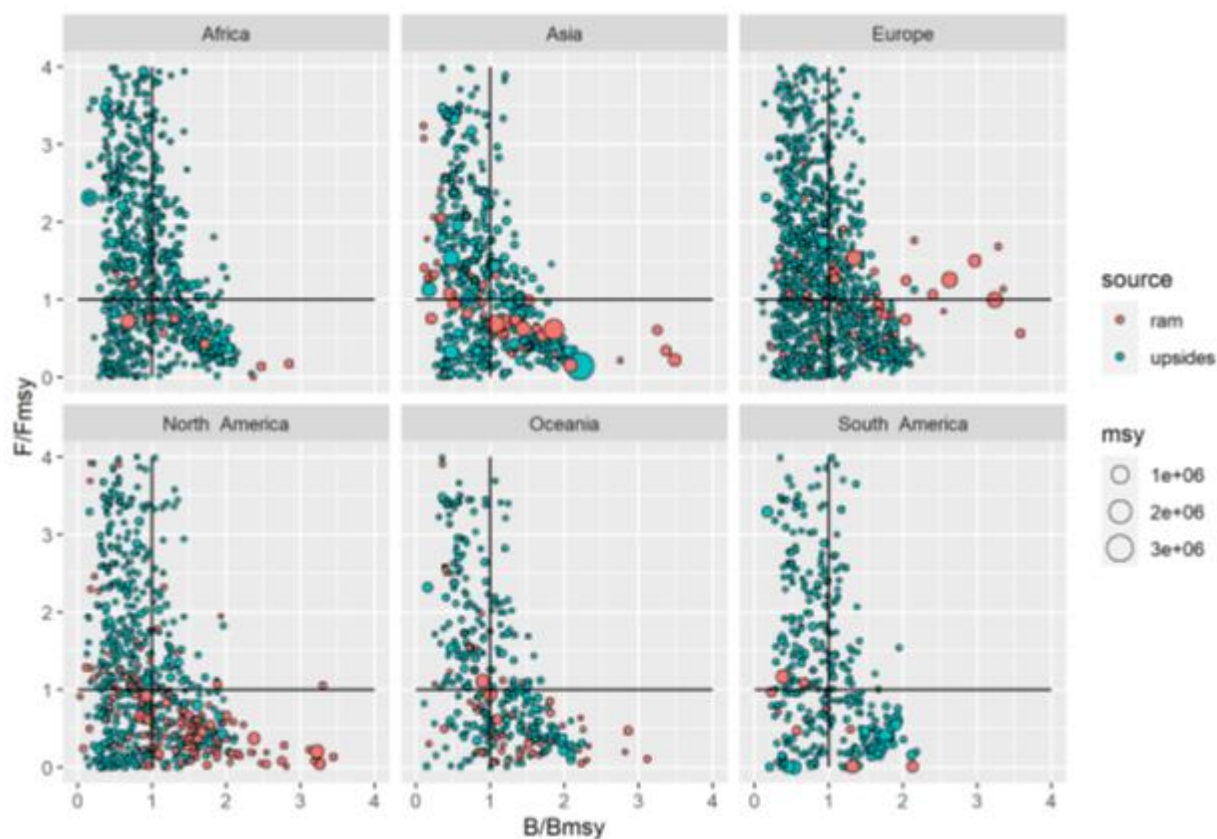
138. From these, the values B_{MSY} , K and F_{MSY} can be calculated, using the equations above. By combining data and analysis from RAM, FAO, and (Costello et al., 2016_[14]), we have estimates of g , ϕ , $B=B_{MSY}$, and MSY for individual stocks. Each individual stock is linked to a single FAO region. So the aggregate values of the parameters of interest (aggregated up to the OECD continental regions) requires aggregating parameters from individual stocks. We do so as follows:

1. To conform with logistic growth, we use $\phi = 1$.
2. For g , we take the MSY -weighted mean of g for all stocks in the continental region for which estimates are available (almost all stocks). For each stock, we use the most recent year for which g is available.
3. For MSY , we take the sum of MSY for all stocks in the continental region for which estimates are available (almost all stocks). For each stock, we use the most recent year for which MSY is available.
4. For B_{MSY} and K , we use the parameters derived above and perform the calculations for the PT model provided above.
5. For current $B=B_{MSY}$, we use three approaches.
 - a. Approach #1 is to take the MSY -weighted mean of $B=B_{MSY}$ for all stocks in the continental region for which estimates are available (this includes almost all stocks). It is denoted by b1.
 - b. Approach #2 is to take the median value of $F=F_{MSY}$ across all stocks in a region, and to use that value to calculate the implied steady-state value of $B=B_{MSY}$ in that region, assuming F stays constant through time. This approach is meant to capture the possibility that some stocks may be well outside of steady state. Invoking the PT model, this calculation is $B = B_{MSY} = \left(1 + \phi \left(1 - \frac{F}{F_{MSY}}\right)\right)^{1/\phi}$. It is denoted b2.
 - c. Approach #3 is to take the median value of $B=B_{MSY}$ across all stocks in a region. It is denoted b3.

139. We start with data compiled and cleaned at UCSB. These data collate current biomass and fishing pressure, biological parameters, and other parameters for most of the world's fisheries. These data come from assessments, where possible, and from FAO plus the Costello et al. calculations in all other cases. Most of the assessed data (labelled 'RAM' in the dataset) have been updated since the Costello et al. 2016 paper. The global MSY represented in these data is 75.9 MMT (compared to a complete global MSY of around 90-110 MMT) and there are 6,667 individual fisheries represented, each of which is associated with a single FAO fishing region. The enclosed Kobe Plot shows each individual fishery estimate of $B=B_{MSY}$ and $F=F_{MSY}$, separated by region. Colour indicates which database the data are from. Size of each bubble indicates the estimated MSY for that fishery.

140. The OECD provided their mapping of FAO fishing regions to OECD continental regions. Merging these datasets associates each fishery in the above dataset with a single OECD-defined continental region.

Figure A C.1. Kobe Plot



Results

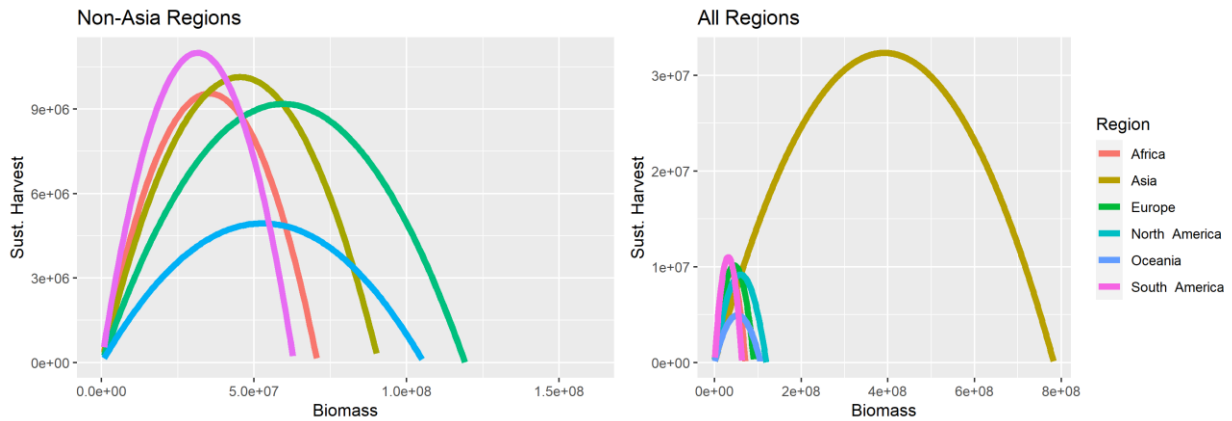
141. The calculations described above can be performed on the resulting dataframe. These calculations are given as follows:²³

OECD Region	g	$b1$	$b2$	$b3$	ϕ	B_{MSY}	K	MSY
Africa	0.270	1.0	-0.005	0.74	1	35 000 000	71 000 000	9 600 000
Asia	0.083	1.2	0.438	0.69	1	390 000 000	780 000 000	32 000 000
Europe	0.223	1.7	0.161	0.68	1	45 000 000	91 000 000	10 000 000
North America	0.154	1.5	0.579	0.73	1	60 000 000	120 000 000	9 200 000
Oceania	0.094	1.3	0.743	0.89	1	53 000 000	110 000 000	4 900 000
South America	0.349	1.3	0.527	0.83	1	32 000 000	63 000 000	11 000 000

142. The resulting PT models for each region can be seen in the following figures (the first contains all regions except Asia and the second contains all regions).

²³ Note that the parameter g is not the intrinsic growth rate. The intrinsic growth rate is $\frac{\phi+1}{\phi} g$, so for logistic growth, the intrinsic growth rate is $2g$.

Figure A C.2. Growth Functions



Additional information

143. The table below shows the five stocks with the largest MSY in each continental region. The table also provides the source of data (RAM vs. Upside (i.e. (Costello et al., 2016_[14])).

Table A C.1.Stocks with largest MSY

Region	MSY	Name	Source
Africa	320 000	Indian oil sardine	upsides
Africa	720 000	Cunene horse mackerel	ram
Africa	680 000	Jack and horse mackerel nei	upsides
Africa	60 000	Sardine	ram
Africa	640 000	Sardine	ram
Asia	3 500 000	Largehead hairtail	upsides
Asia	1 200 000	Threadfin breams nei	upsides
Asia	820 000	Scads nei	upsides
Asia	1 600 000	Skipjack Tuna	ram
Asia	970 000	Walleye Pollock	ram
Europe	720 000	Blue whiting	ram
Europe	720 000	Atlantic cod	ram
Europe	470 000	Capelin	upsides
Europe	710 000	Mackerel	ram
Europe	630 000	Sand eel	ram
North America	410 000	Gulf menhaden	upsides
North America	280 000	Atlantic menhaden	ram
North America	260 000	Northern rock sole	ram
North America	410 000	Pacific hake	ram
North America	270 000	Yellowfin tuna	ram
Oceania	340 000	Hllsa shad	upsides
Oceania	120 000	Indian mackerels nei	upsides
Oceania	510 000	Jack and horse mackerels nei	upsides
Oceania	420 000	Skipjack tuna	ram
Oceania	420 000	Yellowfin tuna	ram
South America	500 000	South American pilchard	upsides
South America	450 000	Argentine anchoita	ram
South America	470 000	Argentine hake	ram
South America	1 300 000	Chilean jack mackerel	ram
South America	3 700 000	Peruvian anchovetta	ram

Annex D. OECD FishPEM Model Capture Fisheries Trade Data²⁴

Overview

144. Fish and other aquatic foods (i.e. seafood) is among the most highly traded food, with 67 million tonnes (live weight equivalent) traded internationally in 2018, amounting to nearly 38% of all seafood caught or farmed around the world (FAO, 2020_[13]). International seafood trade has increased rapidly in recent decades, approximately doubling in terms of value and volume from 1996 to 2012 (Gephart and Pace, 2015_[28]). As a result, seafood trade increasingly plays an important role in national economies, food security, and fishery management.

145. Seafood exports already comprise a large portion of some national economies, exceeding 40% of the total value trade in Cabo Verde, Faroe Islands, Greenland, Iceland, Maldives, Seychelles and Vanuatu (FAO, 2020_[13]). This trade can directly benefit food security by providing a greater variety of seafood products to consumers and indirect benefits from employment and economic growth in the fisheries sector. Yet, the economic benefits of seafood trade do not necessarily reach the most food insecure people and the impacts of seafood trade on food security are highly context dependent (Béné, Lawton and Allison, 2010_[29]). When appropriate management structures are lacking, seafood export can contribute to overexploitation stemming from strong economic incentives to intensify fishing effort and investments in fishing and processing technologies (Crona et al., 2016_[30]). As a result, it is critical to consider seafood trade in order to understand the impacts of fishery management for meeting national economic, food security, and sustainability goals.

146. Despite the global importance of seafood trade, there are multiple data barriers to connecting seafood trade data to fishery catch and management. First, capture fisheries landings are reported as species (e.g. *Thunnus alalunga*) in terms of live weights while seafood trade is reported as commodities (e.g. canned tuna) in terms of product weight.

147. Second, commodity trade categories do not cleanly map onto species because a single species can contribute to multiple commodities (e.g. *Thunnus alalunga* can become whole frozen tuna or tuna fillets), a single commodity can be made up of multiple species (e.g. canned tuna can be made from *Thunnus alalunga* or *Katsuwonus pelamis*), and a traded commodity can be processed and exported again (e.g. imported whole frozen tuna processed into canned tuna for export). Finally, internationally reported trade data generally does not distinguish between capture and farmed seafood products, individual codes can include both capture and farmed species, and an individual species can be both farmed and caught.

148. To provide estimates of interregional marine capture fishery trade, the species falling under each Harmonized System (HS) 6-digit trade code were first identified. Then, using FAO global production data by source for 2017 and 2018, the percent of global farmed and capture production and percent of marine production was calculated for each taxon. The average (production-weighted) percent of production from capture sources and average (production-weighted) percent of marine production was calculated for each HS code. HS codes with at least 90% production from capture and 90% marine production

²⁴ The author of this annex is Dr. Jessica Gephart. She is Assistant Professor of Environmental Science at the American University. This report was prepared for the OECD on 28 August 2020.

were selected from global bilateral trade data. Trade quantities were converted to the live weight equivalent and trade flows were aggregated into six regions (Asia, Africa, Europe, North America, Oceania, South America). The data sources and analysis steps are detailed below.

Methods

Data

Production

149. Seafood production statistics come from the Food and Agriculture Organization (FAO), which provides national capture and aquaculture production from 1950 to 2016 (FAO, 2020_[31]). The FAO data reports production in tonnes (live weight equivalent) of around 550 farmed and 1600 wild capture species and species groups. Production data includes the production source (capture and aquaculture), the production environment (marine or inland), and is classified into the FAO International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAAP). Raw production data were downloaded directly from the FAO Global Statistical Collections – Global Production website (<http://www.fao.org/fishery/statistics/global-production/en>). Taxa names were standardised to enable a merge between the FAO production data and a file that matches taxa to commodity codes.

Trade

150. Bilateral trade data is sourced from the CEPII BACI world trade database, which leverages the United Nations Comtrade database. Trade data are reported to the United Nations by both importers and exporters following the Harmonized System (HS) 6-digit codes. HS codes are updated every five years and were most recently updated in 2017. As a result, trade data for 2018 is available using the HS 2017 codes, but the 2017 trade data is only available using the HS 2012 codes. For consistency, HS 2012 codes are used for both the 2017 and 2018 trade data here. The CEPII BACI database includes bilateral trade from over 200 territories and of over 5,000 products (Gaulier and Zignago, 2010_[32]). CEPII reconciles discrepancies using a weighting scheme based on each country's reporting reliability to average discrepancies in reported mirror flows. Countries that regularly report values very different from their trade partners are considered less reliable and their partner's reported value is given more weight. For this analysis, the tonnes of product traded were used and converted to the live weight equivalent, as described below.

151. All reporting territories were assigned one of six regions: Asia, Africa, Europe, North America, Oceania, or South America. A full list of territories and their assigned region is provided in (Table A D.1). Since only trade between regions are considered here, all trade flows between territories within the same region were removed.

Live weight conversion factors

152. Global trade data is reported in terms of the product weight. In order to convert from product weight (i.e. net weight) to the live weight equivalent, a live weight conversion factor must be applied for each HS code. Live weight conversion factors are sourced from the European Market Observatory for Fisheries and Aquaculture Products (EUMOFA) (EUMOFA 2019). This data reports live weight conversion factors by CN-8 codes, so the mean of the live weight conversion factors falling within each HS 6-digit code are used here. The EUMOFA data assigns products primarily destined for industrial purposes (e.g. fish meal and fish oil), co-products (e.g. caviar) and live trade a value of zero. In this analysis, co-products retained a live weight conversion factor value of zero to avoid double counting, but live animal trade was assigned a live weight conversion factor of 1 and fish

meal and fish oil was assigned an average value of 2.98 (Jackson, 2009^[33]). The live weight conversion factors applied to trade data introduce a potential source of uncertainty and error due to the fact that uncertainty in conversion factors is not reported and a single live weight conversion factor is presented per code, regardless of the region of origin. This is a limitation given that there is known geographical variation in live weight conversion factors due to differences in processing technology. Despite this limitation, the EUMOFA data offers better documentation and alignment with HS commodity codes than other live weight conversion factor data sources (Gephart, Froehlich and Branch, 2019^[34]) and is updated annually, providing documentation for changes in live weight conversion factors.

153. To convert from the product weight to the live weight equivalent, the trade quantity in terms of product weight for each HS code was multiplied by the corresponding average live weight conversion factor.

Analysis

Taxonomic groups to HS code matching

154. The species production to commodity assignment is a many-to-many matching problem, wherein one commodity can consist of multiple species and one species can be converted to multiple commodities. To identify predominantly marine, capture-sourced HS codes, it is necessary to identify the species falling within each code. All taxonomic groups reported in the FAO production data were therefore matched to the HS 6-digit codes based on the code descriptions and hierarchy. We use the HS code descriptions to identify possible species to commodity conversion.

155. The first matching step required dividing all taxonomic groups into the broad commodity groups at the 4-digit level (fish, crustaceans, molluscs and aquatic invertebrates). Within each of these groups, taxonomic groups were matched based on 6 types of matching categories:

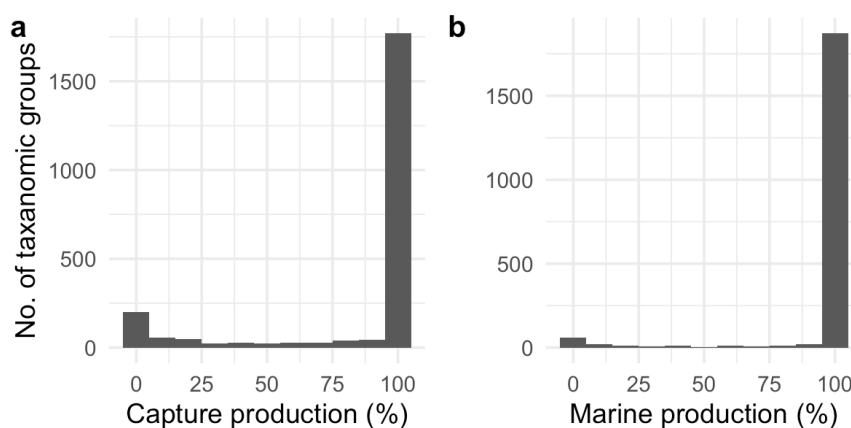
1. Explicit taxa match - Matched based on taxonomic information provided in the code description
2. NEC match - All remaining unmatched species within the 4-digit level are assigned to the “not elsewhere considered” (NEC) code
3. NEC by taxa match - When a code description signifies an NEC group, but limits this based on a taxonomic category (e.g. Salmonidae, N.E.C.), the NEC grouping occurs at this level, rather than the broad NEC match
4. Broad commodity match - Only the broad taxonomic groups inform this assignment since no further taxonomic information is provided
5. Aquarium trade match - Assigned to ornamental species trade based on species found in the aquarium/ornamental trade
6. Fish meal and fish oil match - Assigned to fish meal and fish oil codes based on reported species used in fish oils and fish meals

156. All species are matched to at least one HS code. In general, only explicit taxa matches belong to HS codes that can be grouped according to ISSCAAP group, as the other categories of matches generally match to more than one ISSCAAP group (see *Taxonomic groupings* section below).

Identifying marine and capture codes

157. In order to estimate trade stemming from marine capture fisheries, the codes consisting primarily of marine and wild-caught species must be identified. To do this, the global FAO production by source data was used to calculate the percent of production from capture and marine environments for each taxonomic group. The distribution of the percent of production by source is highly bimodal, with the vast majority of species primarily sourced from either capture or aquaculture (Figure A D.1.a). Similarly, the distribution of production by environment is similarly bimodal, with the vast majority of taxa coming almost entirely from marine production (Figure A D.1.b). As a result, the 90% threshold will exclude few species that do not meet the threshold, but still have with a majority of production from marine or capture.

Figure A D.1. Histogram of the percent of global production from wild capture and marine environment by taxonomic group for 2017-2018



158. Using the list of species falling within each HS code, the percent of global marine or capture production for the j^{th} commodity code (c_j) is calculated as:

$$c_j = \frac{\sum_{i=1}^n p_i c_i}{\sum_{i=1}^n p_i}$$

where p_i is the total production of species i and c_i is the percent of marine or capture production of species i . All HS codes with a weighted average capture percent of production from marine or capture less than 90% were excluded from the analysis (see Appendix for a list of included HS codes).

Taxonomic groupings

159. The ISSCAAP group for each species was matched to the species within each HS code based on the FAO production data. If all species falling within an HS code belong to the same ISSCAAP group, the ISSCAAP group was assigned to the HS code. If more than one ISSCAAP group matched to an HS code, the HS code was assigned “Multiple ISSCAAP groups”. Importantly, while the trade flows labelled as a particular ISSCAAP group all belong to that ISSCAAP group, the reverse is not true. Said another way, an HS code labelled as a particular ISSCAAP group does not necessarily include all trade belonging to that ISSCAAP group because some trade of an ISSCAAP group may be included in the “Multiple ISSCAAP groups.” Additionally, HS codes containing an ISSCAAP group may have been excluded entirely because they do not exceed the marine or capture fisheries threshold. For example, while there are trade flows labelled “Salmons,

trouts, smelts,” trade codes that include Atlantic salmon (*Salmo salar*) are excluded due to the high percent of production from aquaculture. As a result, trade flows for “Salmons, trouts, smelts” do not include the large exports from South America that would be expected for all salmon trade given that Chile is the second largest salmon producing country (Figure A D.4).

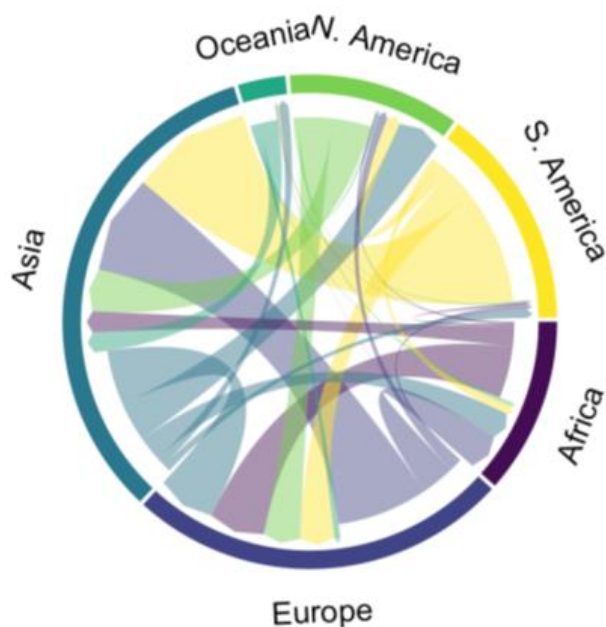
Results

Total trade flow patterns

160. Before selecting the marine capture codes and filtering out the trade flows within a region, the total exports in 2018 were calculated as 62 million tonnes (live weight equivalent). This is close to the 67 million tonnes (live weight equivalent) reported by FAO (2020_[13]) for 2018. Possible explanations for the 5 million tonne difference include the mirror trade reconciliation process required for bilateral trade data, differences in the live weight conversion factors applied, and handling of co-product trade data.

161. The total live weight equivalent of marine capture fisheries products exported from all regions (excluding trade within regions) in 2017 and 2018 was 20.7 million tonnes and 20.4 million tonnes, respectively. South America exported the highest volume of marine capture products, with a total export of 5.5 million tonnes in 2017 and 5.5 million tonnes in 2018. Meanwhile, Asia imported the highest volume of marine capture products, with a total import of 9.5 million tonnes in 2017 and 9.1 million tonnes in 2018. The largest trade flows from 2017-2018 were from South America to Asia (7.5 million tonnes), Europe to Asia (6 million tonnes), and Asia to Europe (3.6 million tonnes) (Figure A D.2).

Figure A D.2. Regional trade flows of marine capture fishery products for 2017-2018.

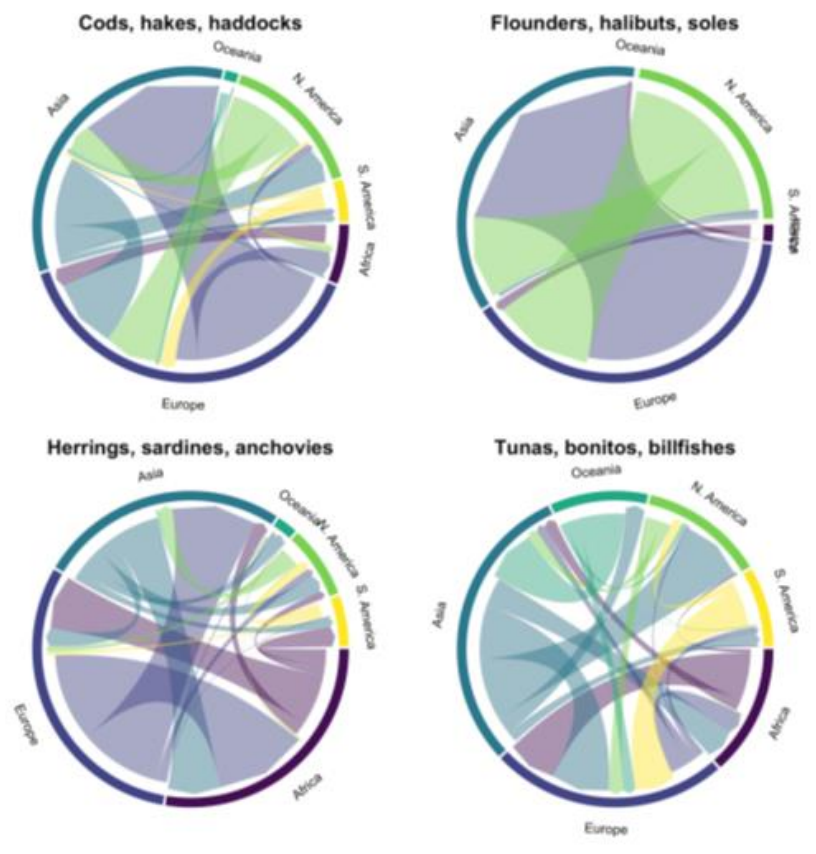


Trade flows by taxonomic group

162. The trade flows can also be viewed by ISSCAAP group, with the important caveats noted in the Taxonomic groupings section (Figure A D.3). Evaluating trade flows by ISSCAAP group provides a qualitative check on the full trade flow estimates. For example,

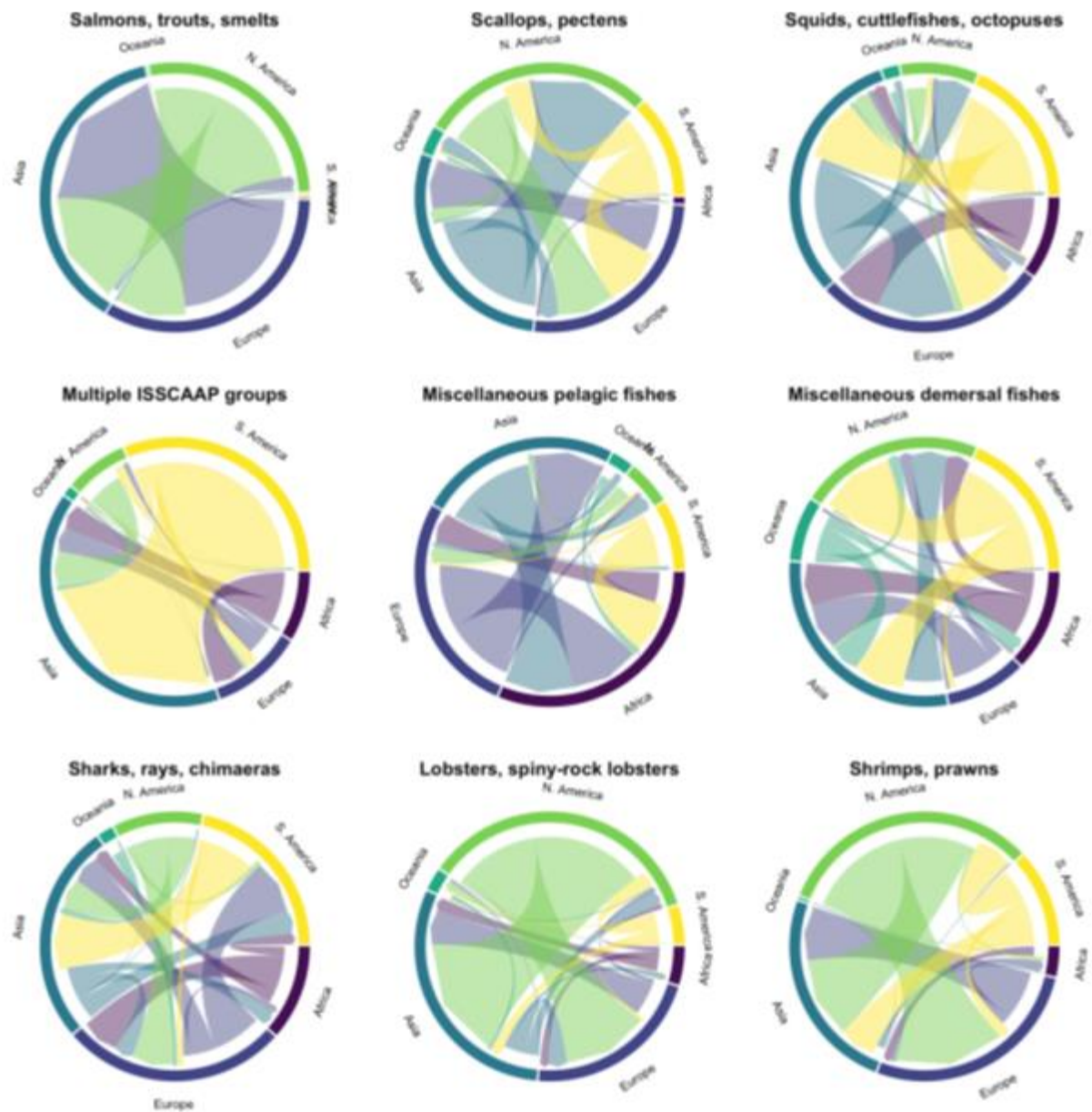
the high export quantities of tunas, bonitos and billfishes from Oceania to Asia and from Asia to Europe and North America (Figure A D.2) agree with known general tuna trade patterns (FAO, 2016_[35]). The largest exports of cods, hakes and haddocks were from North America and Europe to Asia, from Asia to Europe and from North America to Europe and from Asia (Fig. 2), which agrees with the general country-level patterns of major importers and exporters of groundfish (FAO, 2016_[35]). Notably, the herrings, sardines and anchovies group does not show a large quantity of export from South America that would be expected given that the anchovta fishery is a key fishery for the large fishmeal and fish oil exports. This is a result of the fact that ISSCAAP groups other than the herrings, sardines and anchovies group contribute to the fishmeal and fish oil trade codes. As a result, the large trade flow from South America that captures the fishmeal and fish oil exports appear in the “Multiple ISSCAAP groups” category (Figure A D.2).

Figure A D.3. Regional trade flows of marine capture fishery products by ISSCAAP group for 2017-2018.



Note: Remainder of ISSCAAP groups are presented in Figure A D.4

Figure A D.4. Regional trade flows of capture fishery products by ISSCAAP group for 2017-2018.



Note: Remainder of ISSCAAP groups are presented in Figure A D.3.

Table A D.1. Countries included within each region

Region	Country	ISO3c	Region	Country	ISO3c
Africa	Algeria	DZA	Europe	Denmark	DNK
Africa	Angola	AGO	Europe	Estonia	EST
Africa	Benin	BEN	Europe	Finland	FIN
Africa	Burkina Faso	BFA	Europe	France	FRA
Africa	Burundi	BDI	Europe	French Southern Territories	ATF
Africa	Cameroon	CMR	Europe	Germany	DEU
Africa	Cape Verde	CPV	Europe	Gibraltar	GIB
Africa	Central African Republic	CAF	Europe	Greece	GRC
Africa	Chad	TCD	Europe	Hungary	HUN
Africa	Comoros	COM	Europe	Iceland	ISL
Africa	Congo Brazzaville	COG	Europe	Ireland	IRL
Africa	Congo Kinshasa	COD	Europe	Italy	ITA
Africa	Côte d'Ivoire	CIV	Europe	Latvia	LVA
Africa	Djibouti	DJI	Europe	Lithuania	LTU
Africa	Egypt	EGY	Europe	Malta	MLT
Africa	Equatorial Guinea	GNQ	Europe	Moldova	MDA
Africa	Eritrea	ERI	Europe	Montenegro	MNE
Africa	Ethiopia	ETH	Europe	Netherlands	NLD
Africa	Gabon	GAB	Europe	North Macedonia	MKD
Africa	Gambia	GMB	Europe	Norway	NOR
Africa	Ghana	GHA	Europe	Poland	POL
Africa	Guinea	GIN	Europe	Portugal	PRT
Africa	Guinea-Bissau	GNB	Europe	Romania	ROU
Africa	Kenya	KEN	Europe	Russia	RUS
Africa	Liberia	LBR	Europe	San Marino	SMR
Africa	Libya	LYB	Europe	Serbia	SRB
Africa	Madagascar	MDG	Europe	Slovakia	SVK
Africa	Malawi	MWI	Europe	Slovenia	SVN
Africa	Mali	MLI	Europe	Spain	ESP
Africa	Mauritania	MRT	Europe	Sweden	SWE
Africa	Mauritius	MUS	Europe	Switzerland	CHE
Africa	Morocco	MAR	Europe	Turkey	TUR
Africa	Mozambique	MOZ	Europe	Ukraine	UKR
Africa	Niger	NER	Europe	United Kingdom	GBR
Africa	Nigeria	NGA	North America	Anguilla	AIA
Africa	Rwanda	RWA	North America	Antarctica	ATA
Africa	São Tomé & Príncipe	STP	North America	Aruba	ABW
Africa	Senegal	SEN	North America	Bahamas	BHS
Africa	Seychelles	SYC	North America	Barbados	BRB
Africa	Sierra Leone	SLE	North America	Belize	BLZ
Africa	Somalia	SOM	North America	Bermuda	BMU
Africa	South Africa	ZAF	North America	British Virgin Islands	VGB
Africa	South Sudan	SSD	North America	Canada	CAN
Africa	St. Helena	SHN	North America	Caribbean Netherlands	BES
Africa	Sudan	SDN	North America	Cayman Islands	CYM
Africa	Tanzania	TZA	North America	Cocos (Keeling) Islands	CCK
Africa	Togo	TGO	North America	Costa Rica	CRI
Africa	Tunisia	TUN	North America	Cuba	CUB
Africa	Uganda	UGA	North America	Curaçao	CUW

Region	Country	ISO3c	Region	Country	ISO3c
Africa	Zambia	ZMB	North America	Dominica	DMA
Africa	Zimbabwe	ZWE	North America	Dominican Republic	DOM
Asia	Afghanistan	AFG	North America	El Salvador	SLV
Asia	Armenia	ARM	North America	Greenland	GRL
Asia	Azerbaijan	AZE	North America	Grenada	GRD
Asia	Bahrain	BHR	North America	Guatemala	GTM
Asia	Bangladesh	BGD	North America	Haiti	HTI
Asia	Bhutan	BTN	North America	Honduras	HND
Asia	Brunei	BRN	North America	Jamaica	JAM
Asia	Cambodia	KHM	North America	Mexico	MEX
Asia	China	CHN	North America	Montserrat	MSR
Asia	Cyprus	CYP	North America	Nicaragua	NIC
Asia	Georgia	GEO	North America	Panama	PAN
Asia	Hong Kong SAR China	HKG	North America	Sint Maarten	SXM
Asia	India	IND	North America	St. Barthélemy	BLM
Asia	Indonesia	IDN	North America	St. Kitts & Nevis	KNA
Asia	Iran	IRN	North America	St. Lucia	LCA
Asia	Iraq	IRQ	North America	St. Pierre & Miquelon	SPM
Asia	Israel	ISR	North America	St. Vincent & Grenadines	VCT
Asia	Japan	JPN	North America	Trinidad & Tobago	TTO
Asia	Jordan	JOR	North America	Turks & Caicos	TCA
Asia	Kazakhstan	KAZ	North America	United States	USA
Asia	Kuwait	KWT	North America	NA	ANT
Asia	Kyrgyzstan	KGZ	Oceania	American Samoa	ASM
Asia	Laos	LAO	Oceania	Australia	AUS
Asia	Lebanon	LBN	Oceania	Christmas Island	CXR
Asia	Macao SAR China	MAC	Oceania	Cook Islands	COK
Asia	Malaysia	MYS	Oceania	Fiji	FJI
Asia	Maldives	MDV	Oceania	French Polynesia	PYF
Asia	Mongolia	MNG	Oceania	Guam	GUM
Asia	Myanmar (Burma)	MMR	Oceania	Kiribati	KIR
Asia	Nepal	NPL	Oceania	Marshall Islands	MHL
Asia	North Korea	PRK	Oceania	Micronesia (Federated States of)	FSM
Asia	Oman	OMN	Oceania	Nauru	NRU
Asia	Pakistan	PAK	Oceania	New Caledonia	NCL
Asia	Palestinian Territories	PSE	Oceania	New Zealand	NZL
Asia	Philippines	PHL	Oceania	Niue	NIU
Asia	Qatar	QAT	Oceania	Norfolk Island	NFK
Asia	Saudi Arabia	SAU	Oceania	Northern Mariana Islands	MNP
Asia	Singapore	SGP	Oceania	Palau	PLW
Asia	South Korea	KOR	Oceania	Papua New Guinea	PNG
Asia	Sri Lanka	LKA	Oceania	Samoa	WSM
Asia	Syria	SYR	Oceania	Solomon Islands	SLB
Asia	Tajikistan	TJK	Oceania	Tokelau	TKL
Asia	Thailand	THA	Oceania	Tonga	TON
Asia	Timor-Leste	TLS	Oceania	Tuvalu	TUV
Asia	Turkmenistan	TKM	Oceania	Vanuatu	VUT
Asia	United Arab Emirates	ARE	Oceania	Wallis & Futuna	WLF
Asia	Uzbekistan	UZB	South America	Argentina	ARG
Asia	Viet Nam	VNM	South America	Bolivia	BOL

Region	Country	ISO3c	Region	Country	ISO3c
Asia	Yemen	YEM	South America	Brazil	BRA
Europe	Albania	ALB	South America	Chile	CHL
Europe	Andorra	AND	South America	Colombia	COL
Europe	Austria	AUT	South America	Ecuador	ECU
Europe	Belarus	BLR	South America	Falkland Islands	FLK
Europe	Belgium	BEL	South America	Guyana	GUY
Europe	Bosnia & Herzegovina	BIH	South America	Paraguay	PRY
Europe	British Indian Ocean Territory	IOT	South America	Peru	PER
Europe	Bulgaria	BGR	South America	Suriname	SUR
Europe	Croatia	HRV	South America	Uruguay	URY
Europe	Czech Republic	CZE	South America	Venezuela	VEN

1. *Note by Turkey:* The information in this document with reference to “Cyprus” relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the “Cyprus issue”.

2. *Note by all the European Union Member States of the OECD and the European Union:* The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Table A D.2. HS 6-digit codes and descriptions with at least 90% production from capture and at least 90% marine production

HS6	Description	ISSCAAP Group
030221	fish; fresh or chilled, halibut (<i>reinhardtius hippoglossoides</i> , <i>hippoglossus hippoglossus</i> , <i>hippoglossus stenolepis</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Flounders, halibuts, soles
030222	fish; fresh or chilled, plaice (<i>pleuronectes platessa</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Flounders, halibuts, soles
030223	fish; fresh or chilled, sole (<i>solea</i> spp.), excluding fillets, livers, roes, and other fish meat of heading 0304	Flounders, halibuts, soles
030231	fish; fresh or chilled, albacore or longfinned tunas (<i>thunnus alalunga</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Tunas, bonitos, billfishes
030234	fish; fresh or chilled, bigeye tunas (<i>thunnus obesus</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Tunas, bonitos, billfishes
030239	fish; fresh or chilled, tuna (<i>thunnus</i> spp., <i>allothunnus</i> spp., <i>auxis</i> spp., <i>euthynnus</i> spp., <i>katsuwonus</i> spp.), n.e.c. in item no. 0302.3, excluding fillets, livers, roes, and other fish meat of heading 0304	Tunas, bonitos, billfishes
030241	fish; fresh or chilled, herrings (<i>clupea harengus</i> , <i>clupea pallasii</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Herrings, sardines, anchovies
030242	fish; fresh or chilled, anchovies (<i>engraulis</i> spp.), excluding fillets, livers, roes, and other fish meat of heading 0304	Herrings, sardines, anchovies
030243	fish; fresh or chilled, sardines (<i>sardina pilchardus</i> , <i>sardinops</i> spp.), sardinella (<i>sardinella</i> spp.), brisling or sprats (<i>sprattus sprattus</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Herrings, sardines, anchovies
030244	fish; fresh or chilled, mackerel (<i>scomber scombrus</i> , <i>scomber australasicus</i> , <i>scomber japonicus</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Miscellaneous pelagic fishes
030245	fish; fresh or chilled, jack and horse mackerel (<i>scomber scombrus</i> , <i>scomber australasicus</i> , <i>scomber japonicus</i>) (<i>trachurus</i> spp.), excluding fillets, livers, roes, and other fish meat of heading 0304	Miscellaneous pelagic fishes
030247	fish; fresh or chilled, swordfish (<i>xiphias gladius</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Tunas, bonitos, billfishes
030251	fish; fresh or chilled, cod (<i>gadus morhua</i> , <i>gadus macrocephalus</i> , <i>gadus macrocephalus</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Cods, hakes, haddocks
030252	fish; fresh or chilled, haddock (<i>melanogrammus aeglefinus</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Cods, hakes, haddocks
030253	fish; fresh or chilled, coalfish (<i>pollachius virens</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Cods, hakes, haddocks
030254	fish; fresh or chilled, hake (<i>merluccius</i> spp., <i>urophycis</i> spp.), excluding fillets, livers, roes, and other fish meat of heading 0304	Cods, hakes, haddocks
030255	fish; fresh or chilled, alaska pollock (<i>gadus chalcogrammus</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Cods, hakes, haddocks
030256	fish; fresh or chilled, blue whittings (<i>micromesistius poutassou</i> , <i>micromesistius australis</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Cods, hakes, haddocks
030259	fish; fresh or chilled (<i>rastrelliger</i> spp., <i>scomberomorus</i> spp., <i>caranx</i> spp., <i>pampus</i> spp., <i>cololabis saira</i> , <i>decapterus</i> spp., <i>mallotus villosus</i> , <i>euthynnus affinis</i> , <i>sarda</i> spp., <i>istiophoridae</i> , <i>bregmacerotidae</i> , <i>euclichthyidae</i> , <i>gadidae</i> , <i>macrouridae</i> , <i>melanonidae</i> , <i>merlucciidae</i> , <i>moridae</i> , <i>muraenolepididae</i> n.e.c. in item no. 0302.5, excluding fillets, livers, roes, and other fish meat of heading 0304	Multiple ISSCAAP groups
030281	fish; fresh or chilled, dogfish and other sharks (<i>carcharhiniformes</i> , <i>heterodontiformes</i> , <i>hexanchiformes</i> , <i>lamniformes</i> , <i>orectolobiformes</i> , <i>pristiophoriformes</i> , <i>squaliformes</i> , <i>squantiniformes</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Sharks, rays, chimaeras
030282	fish; fresh or chilled, rays and skates (<i>rajidae</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Sharks, rays, chimaeras
030283	fish; fresh or chilled, toothfish (<i>dissostichus</i> spp.), excluding fillets, livers, roes, and other fish meat of heading 0304	Miscellaneous demersal fishes
030311	fish; frozen, pacific salmon, sockeye salmon (red salmon) (<i>oncorhynchus nerka</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Salmons, trouts, smelts
030331	fish; frozen, halibut (<i>reinhardtius hippoglossoides</i> , <i>hippoglossus hippoglossus</i> , <i>hippoglossus stenolepis</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Flounders, halibuts, soles
030332	fish; frozen, plaice (<i>pleuronectes platessa</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Flounders, halibuts, soles

HS6	Description	ISSCAAP Group
030333	fish; frozen, sole (<i>solea</i> spp.), excluding fillets, livers, roes, and other fish meat of heading 0304	Flounders, halibuts, soles
030341	fish; frozen, albacore or longfinned tunas (<i>thunnus alalunga</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Tunas, bonitos, billfishes
030342	fish; frozen, yellowfin tunas (<i>thunnus albacares</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Tunas, bonitos, billfishes
030343	fish; frozen, skipjack (<i>katsuwonus pelamis</i>) or stripe-bellied bonito, excluding fillets, livers, roes, and other fish meat of heading 0304	Tunas, bonitos, billfishes
030344	fish; frozen, bigeye tunas (<i>thunnus obesus</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Tunas, bonitos, billfishes
030349	fish; frozen, tuna (<i>thunnus</i> spp., <i>alothunnus</i> spp., <i>axis</i> spp., <i>euthynnus</i> spp., <i>katsuwonus</i> spp.), n.e.c. in item no. 0303.4, excluding fillets, livers, roes, and other fish meat of heading 0304	Tunas, bonitos, billfishes
030351	fish; frozen, herrings (<i>clupea harengus</i> , <i>clupea pallasii</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Herrings, sardines, anchovies
030353	fish; frozen, sardines (<i>sardina pilchardus</i> , <i>sardinops</i> spp.), sardinella (<i>sardinella</i> spp.), brisling or sprats (<i>sprattus sprattus</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Herrings, sardines, anchovies
030354	fish; frozen, mackerel (<i>scomber scombrus</i> , <i>scomber australasicus</i> , <i>scomber japonicus</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Miscellaneous pelagic fishes
030355	fish; frozen, jack and horse mackerel (<i>scomber scombrus</i> , <i>scomber australasicus</i> , <i>scomber japonicus</i>) (<i>trachurus</i> spp.), excluding fillets, livers, roes, and other fish meat of heading 0304	Miscellaneous pelagic fishes
030357	fish; frozen, swordfish (<i>xiphias gladius</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Tunas, bonitos, billfishes
030363	fish; frozen, cod (<i>gadus morhua</i> , <i>gadus macrocephalus</i> , <i>gadus macrocephalus</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Cods, hakes, haddocks
030364	fish; frozen, haddock (<i>melanogrammus aeglefinus</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Cods, hakes, haddocks
030365	fish; frozen, coalfish (<i>pollachius virens</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Cods, hakes, haddocks
030366	fish; frozen, hake (<i>merluccius</i> spp., <i>urophycis</i> spp.), excluding fillets, livers, roes, and other fish meat of heading 0304	Cods, hakes, haddocks
030367	fish; frozen, alaska pollock (<i>gadus chalcogrammus</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Cods, hakes, haddocks
030368	fish; frozen, blue whittings (<i>micromesistius poutassou</i> , <i>micromesistius australis</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Cods, hakes, haddocks
030369	fish; frozen, of bregmacerotidae, eulichthyidae, gadidae, macrouridae, melanonidae, merlucciidae, moridae, muraenolepididae, other than cod, haddock, coalfish, hake, alaska pollock, blue whittings, excluding fillets, livers, roes, other fish meat of 0304	Cods, hakes, haddocks
030381	fish; frozen, dogfish and other sharks (<i>carcharhiniformes</i> , <i>heterodontiformes</i> , <i>hexanchiformes</i> , <i>lamniformes</i> , <i>orectolobiformes</i> , <i>pristiophoriformes</i> , <i>squaliformes</i> , <i>squantiniformes</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Sharks, rays, chimaeras
030382	fish; frozen, rays and skates (<i>rajidae</i>), excluding fillets, livers, roes, and other fish meat of heading 0304	Sharks, rays, chimaeras
030383	fish; frozen, toothfish (<i>dissostichus</i> spp.), excluding fillets, livers, roes, and other fish meat of heading 0304	Miscellaneous demersal fishes
030444	fish fillets; fresh or chilled, of the families bregmacerotidae, eulichthyidae, gadidae, macrouridae, melanonidae, merlucciidae, moridae, and muraenolepididae	Cods, hakes, haddocks
030445	fish fillets; fresh or chilled, swordfish (<i>xiphias gladius</i>)	Tunas, bonitos, billfishes
030446	fish fillets; fresh or chilled, toothfish (<i>dissostichus</i> spp.)	Miscellaneous demersal fishes
030453	fish meat, excluding fillets, whether or not minced; fresh or chilled, of the families bregmacerotidae, eulichthyidae, gadidae, macrouridae, melanonidae, merlucciidae, moridae, and muraenolepididae	Cods, hakes, haddocks
030454	fish meat, excluding fillets, whether or not minced; fresh or chilled, swordfish (<i>xiphias gladius</i>)	Tunas, bonitos, billfishes
030455	fish meat, excluding fillets, whether or not minced; fresh or chilled, toothfish (<i>dissostichus</i> spp.)	Miscellaneous demersal fishes
030471	fish fillets; frozen, cod (<i>gadus morhua</i> , <i>gadus macrocephalus</i> , <i>gadus macrocephalus</i>)	Cods, hakes, haddocks
030472	fish fillets; frozen, haddock (<i>melanogrammus aeglefinus</i>)	Cods, hakes, haddocks

HS6	Description	ISSCAAP Group
030473	fish fillets; frozen, coalfish (<i>pollachius virens</i>)	Cods, hakes, haddocks
030474	fish fillets; frozen, hake (<i>merluccius</i> spp., <i>urophycis</i> spp.)	Cods, hakes, haddocks
030475	fish fillets; frozen, alaska pollock (<i>gadus chalcogrammus</i>)	Cods, hakes, haddocks
030479	fish fillets; frozen, of the families bregmacerotidae, euclichthyidae, gadidae, macrouridae, melanonidae, merlucciidae, moridae and muraenolepididae other than cod, haddock, coalfish, hake, and alaska pollock	Cods, hakes, haddocks
030484	fish fillets; frozen, swordfish (<i>xiphias gladius</i>)	Tunas, bonitos, billfishes
030485	fish fillets; frozen, toothfish (<i>dissostichus</i> spp.)	Miscellaneous demersal fishes
030486	fish fillets; frozen, herrings (<i>clupea harengus</i> , <i>clupea pallasii</i>)	Herrings, sardines, anchovies
030487	fish fillets; frozen, tunas (of <i>thunnus</i> spp.), skipjack (<i>katsuwonus pelamis</i>) or stripe-bellied bonito	Tunas, bonitos, billfishes
030491	fish meat, excluding fillets, whether or not minced; frozen, swordfish (<i>xiphias gladius</i>)	Tunas, bonitos, billfishes
030492	fish meat, excluding fillets, whether or not minced; frozen, toothfish (<i>dissostichus</i> spp.)	Miscellaneous demersal fishes
030494	fish meat, excluding fillets, whether or not minced; frozen, alaska pollock (<i>gadus chalcogrammus</i>)	Cods, hakes, haddocks
030495	fish meat, excluding fillets, whether or not minced; frozen, of the families bregmacerotidae, euclichthyidae, gadidae, macrouridae, melanonidae, merlucciidae, moridae and muraenolepididae, other than alaska pollock (<i>gadus chalcogrammus</i>)	Cods, hakes, haddocks
030510	fish; flours, meals and pellets, fit for human consumption	Multiple ISSCAAP groups
030532	fish fillets; dried, salted or in brine, but not smoked, of the families bregmacerotidae, euclichthyidae, gadidae, macrouridae, melanonidae, merlucciidae, moridae and muraenolepididae	Cods, hakes, haddocks
030542	fish; smoked, whether or not cooked before or during smoking, herrings (<i>clupea harengus</i> , <i>clupea pallasii</i>), includes fillets, but excludes edible fish offal	Herrings, sardines, anchovies
030551	fish; dried, whether or not salted but not smoked, other than edible fish offal, cod (<i>gadus morhua</i> , <i>gadus macrocephalus</i> , <i>gadus macrocephalus</i>)	Cods, hakes, haddocks
030561	fish; salted or in brine, not dried or smoked, other than edible fish offal, herrings (<i>clupea harengus</i> , <i>clupea pallasii</i>)	Herrings, sardines, anchovies
030562	fish; salted or in brine, not dried or smoked, other than edible fish offal, cod (<i>gadus morhua</i> , <i>gadus macrocephalus</i> , <i>gadus macrocephalus</i>)	Cods, hakes, haddocks
030563	fish; salted or in brine, not dried or smoked, other than edible fish offal, anchovies (<i>engraulis</i> spp.)	Herrings, sardines, anchovies
030571	fish; edible offal, shark fins (<i>carcharhiniformes</i> , <i>heterodontiformes</i> , <i>hexanchiformes</i> , <i>lamniformes</i> , <i>orectolobiformes</i> , <i>pristiophoriformes</i> , <i>squaliformes</i> , <i>squantiniformes</i>)	Sharks, rays, chimaeras
030611	crustaceans; frozen, rock lobsters and other sea crawfish (<i>palinurus</i> spp., <i>panulirus</i> spp., <i>jasus</i> spp.), in shell or not, smoked, cooked or not before or during smoking; in shell, cooked by steaming or by boiling in water	Lobsters, spiny rock lobsters
030612	crustaceans; frozen, lobsters (<i>homarus</i> spp.), in shell or not, smoked, cooked or not before or during smoking; in shell, cooked by steaming or by boiling in water	Lobsters, spiny rock lobsters
030615	crustaceans; frozen, norway lobsters (<i>nephrops norvegicus</i>), in shell or not, smoked, cooked or not before or during smoking; in shell, cooked by steaming or by boiling in water	Lobsters, spiny rock lobsters
030616	crustaceans; frozen, cold-water shrimps and prawns (<i>pandalus</i> spp., <i>crangon</i> <i>crangon</i>), in shell or not, smoked, cooked or not before or during smoking; in shell, cooked by steaming or by boiling in water	Shrimps, prawns
030621	crustaceans; not frozen, rock lobsters and other sea crawfish (<i>palinurus</i> spp., <i>panulirus</i> spp., <i>jasus</i> spp.), in shell or not, smoked, cooked or not before or during smoking; in shell, cooked by steaming or boiling in water; edible flours, meals, pellets	Lobsters, spiny rock lobsters
030622	crustaceans; not frozen, lobsters (<i>homarus</i> spp.), whether in shell or not, smoked, cooked or not before or during smoking; in shell, cooked by steaming or by boiling in water; edible flours, meals, and pellets	Lobsters, spiny rock lobsters
030625	crustaceans; not frozen, norway lobsters (<i>nephrops norvegicus</i>), in shell or not, smoked, cooked or not before or during smoking; in shell, cooked by steaming or by boiling in water; edible flours, meals, and pellets	Lobsters, spiny rock lobsters
030626	crustaceans; not frozen, cold-water shrimps and prawns (<i>pandalus</i> spp., <i>crangon</i> <i>crangon</i>), in shell or not, smoked, cooked or not before or during smoking; in shell, cooked by steaming or by boiling in water; edible flour, meals, and pellets	Shrimps, prawns

HS6	Description	ISSCAAP Group
030721	molluscs; scallops, whether in shell or not, including queen scallop (<i>aequipecten opercularis</i>)s, of pecten spp., chlamy spp., or placopecten spp., live, fresh or chilled	Scallops, pectens
030729	molluscs; scallops, whether in shell or not, including queen scallop (<i>aequipecten opercularis</i>)s of pecten spp., chlamy spp., or placopecten spp., frozen, dried, salted, in brine, or smoked, cooked or not before or during the smoking process	Scallops, pectens
030741	molluscs; cuttle fish (<i>sepiida</i>) and squid (<i>teuthida</i>), whether in shell or not, live, fresh or chilled	Squids, cuttlefishes, octopuses
030749	molluscs; cuttle fish (<i>sepiida</i>) and squid (<i>teuthida</i>), whether in shell or not, frozen, dried, salted, in brine, or smoked, cooked or not before or during the smoking process	Squids, cuttlefishes, octopuses
030751	molluscs; octopus (<i>octopus</i> spp.), live, fresh or chilled	Squids, cuttlefishes, octopuses
030759	molluscs; octopus (<i>octopus</i> spp.), frozen, dried, salted, in brine, or smoked, cooked or not before or during the smoking process	Squids, cuttlefishes, octopuses
050410	oils of fish; fish-liver oils and their fractions, whether or not refined, but not chemically modified	Multiple ISSCAAP groups
150420	fats and oils and their fractions; of fish, (excluding liver-oils)	Multiple ISSCAAP groups
060412	fish preparations; fish prepared or preserved, whole or in pieces (but not minced), herring (<i>clupea harengus</i> , <i>clupea pallasii</i>)	Herrings, sardines, anchovies
160413	fish preparations; fish prepared or preserved, whole or in pieces (but not minced), sardine (<i>sardina pilchardus</i> , <i>sardinops</i> spp.)s, sardinella (<i>sardinella</i> spp.), brisling or sprat (<i>sprattus sprattus</i>)s	Herrings, sardines, anchovies
160414	fish preparations; fish prepared or preserved, whole or in pieces (but not minced), tuna (<i>thunnus</i> spp., <i>allothunnus</i> spp., <i>auxis</i> spp., <i>euthynnus</i> spp., <i>katsuwonus</i> spp.)s, skipjack (<i>katsuwonus pelamis</i>) and bonito (<i>sarda</i> spp.)	Tunas, bonitos, billfishes
160415	fish preparations; fish prepared or preserved, whole or in pieces (but not minced), mackerel (<i>scomber scombrus</i> , <i>scomber australasicus</i> , <i>scomber japonicus</i>)	Miscellaneous pelagic fishes
160416	fish preparations; fish prepared or preserved, whole or in pieces (but not minced), anchov (<i>engraulis</i> spp.)ies	Herrings, sardines, anchovies
160530	crustacean preparations; lobster (<i>homarus</i> spp., <i>palinurus</i> spp., <i>panulirus</i> spp., <i>jasus</i> spp., <i>ephrops norvegicus</i>)	Lobsters, spiny rock lobsters
160552	mollusc preparations; scallops (including queen scallop (<i>aequipecten opercularis</i>)s of pecten spp., chlamy spp., or placopecten spp.), prepared or preserved	Scallops, pectens
160554	mollusc preparations; cuttle fish (<i>sepiida</i>) and squid (<i>teuthida</i>), prepared or preserved	Squids, cuttlefishes, octopuses
160555	mollusc preparations; octopus (<i>octopus</i> spp.), prepared or preserved	Squids, cuttlefishes, octopuses
230120	flours, meals and pellets; of fish or of crustaceans, molluscs or other aquatic invertebrates	Multiple ISSCAAP groups