

Supplementary Materials for

Benefits of the Paris Agreement to ocean life, economies, and people

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This PDF file includes:

Fig. S1. Projected differences taken between outcomes of meeting Paris Agreement targets.

Fig. S2. Sensitivity analysis of economic indicators (FR, SWI, and HSE) to changes in price flexibilities aggregated globally, by region, and for select species.

Table S1. Projected differences of indicators relative to 2001–2010 period between outcomes of meeting Paris Agreement targets (+1.5°C) and maintaining high greenhouse gas concentrations trajectory (+3.5°C) relative to preindustrial levels.

Table S2. Current (2001–2010 average) annual values for fisheries indicators of the top 10 revenue-generating species for each country, grouped by continent.

Table S3. Year in which target warming temperature is reached for each RCP within each ESM.

Table S4. Price flexibility by marine species group and country development group.

Table S5. Number of countries and their share in world marine capture catch, by share of exports volume in total domestic supply (2011–2015).

Table S6. Estimated and observed domestic price percent changes for fish with 13% decrease in world price.

Table S7. Multipliers used to determine impacts on SWI and HSE.

Table S8. List of countries by geographic region and FAO development grouping.

Table S9. Projected differences for the top 10 species by landed value globally taken between outcomes of meeting Paris Agreement targets (+1.5°C) and maintaining high emissions (+3.5°C).

References (41–58)

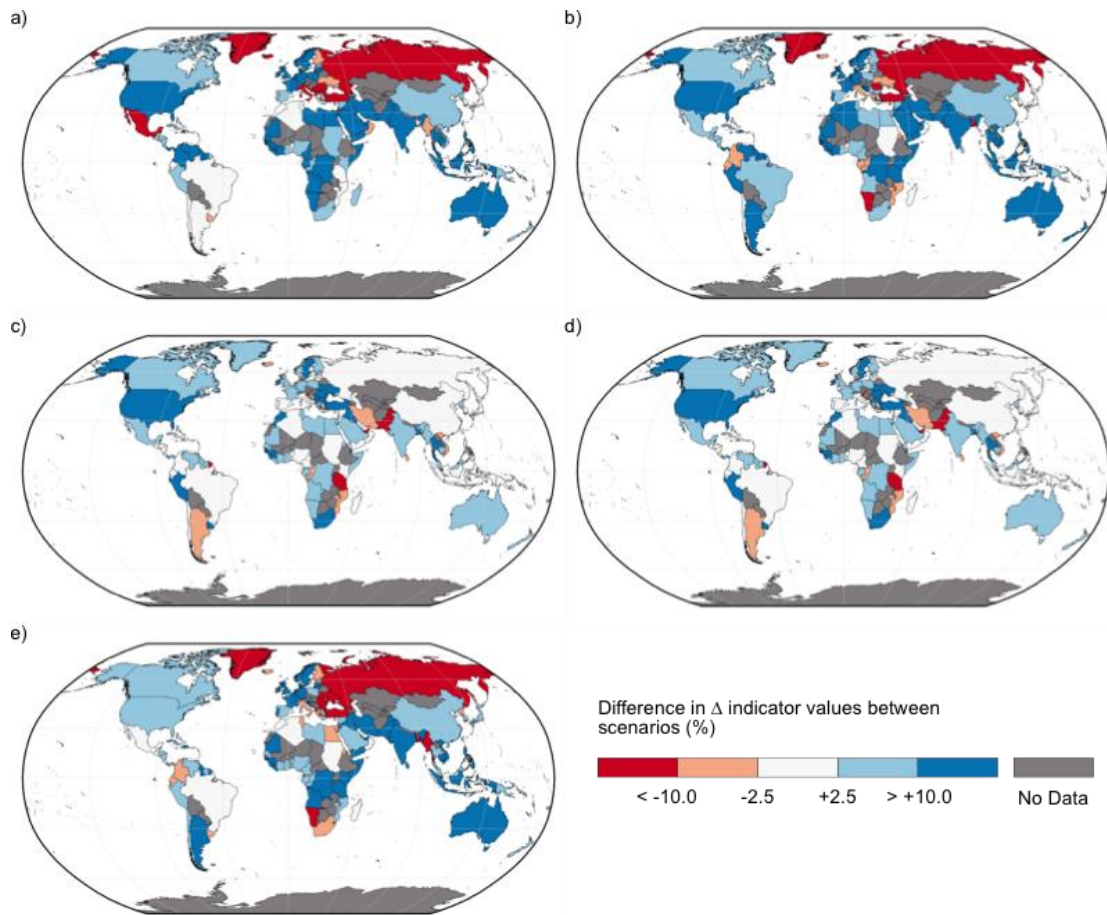


Fig. S1. Projected differences taken between outcomes of meeting Paris Agreement targets.

Projected differences taken between outcomes of meeting Paris Agreement targets (+1.5°C warming) and +3.5°C warming for each fishing country (relative to 2001-2010 average) for **a)** fish biomass; **b)** maximum catch potential; **c)** fishers' revenues; **d)** seafood workers' income; and **e)** households' seafood expenditure.

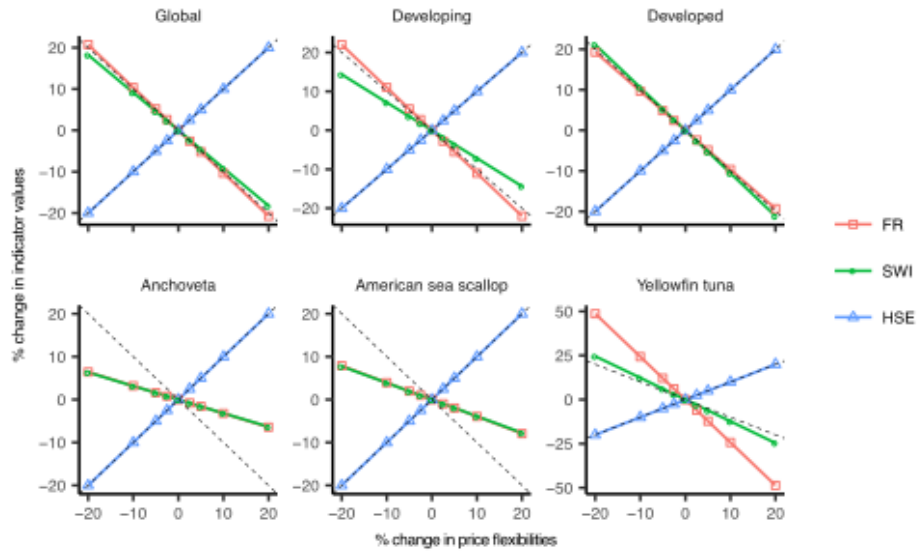


Fig. S2. Sensitivity analysis of economic indicators (FR, SWI, and HSE) to changes in price flexibilities aggregated globally, by region, and for select species.

Table S1. Projected differences of indicators relative to 2001–2010 period between outcomes of meeting Paris Agreement targets (+1.5°C) and maintaining high greenhouse gas concentrations trajectory (+3.5°C) relative to preindustrial levels[†].

	FB gains (%)[*]	MCP gains (million tonnes)	FR gains (billion \$)^{††}	SWI gains (billion \$)^{††}	Savings in HSE (billion \$)^{††}
<u>Global</u>	6.5 (1.4, 9.1)	3.31 (0.06, 6.41)	4.58 (3.27, 5.81)	3.69 (2.97, 5.05)	5.40 (-1.38, 8.83)
<u>Region</u>					
Developing	8.4 (5.1, 12.2)	3.36 (1.93, 4.86)	2.80 (1.75, 3.34)	1.85 (1.26, 2.35)	1.69 (-1.85, 3.53)
Developed	-0.4 (-11.9, 12.3)	-0.05 (-1.87, 1.55)	1.78 (1.35, 2.47)	1.84 (1.12, 2.70)	3.71 (0.47, 5.35)
Africa	8.4 (6.7, 10.3)	0.36 (0.29, 0.40)	0.25 (0.18, 0.30)	0.17 (0.12, 0.22)	0.31 (0.00, 0.73)
Asia	10.1 (7.4, 11.7)	0.96 (0.51, 1.40)	1.31 (0.57, 2.44)	0.68 (0.31, 1.25)	1.24 (-1.71, 3.09)
Europe	-1.7 (-15.4, 13.1)	-0.48 (-2.03, 0.86)	0.75 (0.39, 0.94)	0.61 (0.35, 0.83)	1.19 (-1.85, 2.96)
North America	9.1 (0.5, 19.5)	0.41 (0.09, 0.71)	1.02 (0.59, 1.40)	1.21 (0.60, 1.72)	1.13 (0.12, 1.81)
Oceania	5.0 (2.9, 6.2)	0.06 (0.05, 0.06)	0.05 (0.03, 0.07)	0.04 (0.02, 0.06)	0.27 (0.19, 0.33)
South America	5.3 (3.9, 6.3)	1.89 (0.94, 2.95)	1.22 (0.57, 2.13)	0.98 (0.43, 1.73)	1.26 (1.00, 1.66)

[†]Values calculated from outputs of DBEM multi model mean changes in abundance and catch are in bold, while values from outputs of DBEM lower and upper bounds are in brackets below. [FB – fish biomass; MCP – maximum catch potential; FR – fishers’ revenues; SWI – seafood workers’ income; HSE – households’ seafood expenditure].

^{††}All dollar amounts are expressed as real 2010 USD.

*FB gains are the same percentage change values as Table 1. FB values are still represented as percentages as actual absolute biomass would assume that we know the biomass of all species in the oceans. Other indicators can be represented in absolute values because we apply the percent changes in catch potential to current (2001-2010) catch amounts.

Table S2. Current (2001–2010 average) annual values for fisheries indicators of the top 10 revenue-generating species for each country, grouped by continent. Catch and revenue values are taken from the *Sea Around Us* (www.seaaroundus.org) and combined with economic multipliers (table S7) (19).

Continent	Catch (million tonnes)	FR (billion USD)	SWI (billion USD)	HSE (billion USD)
Africa	2.78	3.6	2.30	8.74
Asia	12.6	19.3	13.0	49.5
Europe	11	11.7	9.71	38.5
North America	4.2	11.1	12.5	33.7
Oceania	0.572	1.16	0.921	3.81
South America	13.4	12.2	9.12	33.5
Total of top-revenue species	45.4	61.9	47.5	168.0
Global total - all species	130.0	177.3	136.2	480.3
Protected value with achieving Paris Agreement - all species*	9.5	13.1	10.6	18.3

FR=fishers' revenues; SWI=seafood workers' income; HSE=households' seafood expenditure.

*This is extrapolated and equal to global projected percent changes (Table 1) multiplied by "Global total of all species".

Table S3. Year in which target warming temperature is reached for each RCP within each ESM.

		<u>Warming target</u>	
<u>Earth system model</u>		<u>+1.5°C</u>	<u>+3.5°C</u>
<i>RC</i>	GFDL	2038	2092
<i>P</i>	IPSL	2012	2055
8.5	MPI	2019	2066
<i>RC</i>	GFDL	2072	-
<i>P</i>	IPSL	2012	-
2.6	MPI	2022	-

*Earth system models: GFDL – Geophysical Fluid Dynamics Laboratory; IPSL – Institut Pierre Simon Laplace; MPI – Max Planck Institute.

Table S4. Price flexibility by marine species group and country development group.

Average Price Flexibility (Min. – Max.)					
Species group	Developed	Developing	n	Source	
Abalones, winkles, conchs	1.79 (-)	1.79 (-)	1	(41)	
Clams, cockles, arkshells	0.68 (-)	1.79 (-)	2	(42,43)	
Cods, hakes, haddocks	0.69 (0.25 - 0.63)	0.94 (0.25 - 3.13)	7	(43-32)	
Crabs, sea-spiders	0.74 (0.74 - 0.74)	2.73 (2.73 - 2.73)	2	(45,77)	
Flounders, halibuts, soles	0.96 (0.25 - 2.48)	1.32 (0.25 - 2.87)	8	(43-32,47)	
Herrings, sardines, anchovies	0.58 (0.49 - 0.8)	2.19 (0.56 - 3.13)	8	(14,43,49)	
King crabs, squat-lobsters	1.31 (-)	4.17 (-)	2	(43,50)	
Krill, planktonic crustaceans	1.40 (-)	2.17 (-)	2	(42,43)	
Lobsters, spiny-rock lobsters	0.60 (-)	4.17 (-)	2	(43,32)	
Other	1.29 (0.48 - 3.27)	1.29 (0.48 - 3.57)	5	(42,50)	
Salmons, trouts, smelts	0.73 (-)	1.34 (1.10 - 1.59)	3	(42,43,51)	
Scallops, pectens	0.59 (-)	1.79 (-)	2	(42,43)	
Sharks, rays, chimaeras	0.87 (0.04 - 1.71)	0.87 (0.04 - 1.71)	2	(44,52)	
Shrimps, prawns	0.64 (-)	1.08 (0.88 - 1.28)	3	(41,42,49)	
Squids, cuttlefishes, octopuses	0.90 (-)	2.13 (1.64 - 2.38)	4	(43,49)	
Tunas	If the - (-)	0.96 (0.22 - 1.82)	4	(43,48)	
Total	0.9 (0.04 - 3.57)	1.56 (0.04 - 4.16)	57		

Table S5. Number of countries and their share in world marine capture catch, by share of exports volume in total domestic supply (2011–2015).

	Developed		Developing		Total		
	Share in world marine capture, (%)	No. of countries	Share in world marine capture, (%)	No. of countries	Share in world marine capture, (%)	No. of countries	
(i) Special trade							
	>50	7.13	19	6.7	20	13.83	39
	40-50	0	1	0.2	5	0.2	6
Share in total	30-40	6.35	1	1.56	4	7.91	5
domestic supply, %	20-30	0.18	1	0.69	2	0.87	3
	10-20	0	0	7.74	6	7.74	6
	0-10	0	2	2.43	21	2.43	23
	0	0	0	0	2	0	2
	Total	13.66	24	19.32	60	32.98	84
(ii) General trade							
	>50	5.51	8	1.4	17	6.91	25
	40-50	5.11	1	6.62	7	11.73	8
Share in total	30-40	0.89	2	4.5	8	5.39	10
domestic supply, %	20-30	4.71	2	0.32	3	5.03	5
	10-20	0	0	35.49	11	35.49	11
	0-10	0	0	2.42	22	2.42	22
	0	0	3	0.03	18	0.03	21

Total	16.23	16	50.79	86	67.02	102
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Source: Authors' calculation.

This section describes the steps involved in estimating the share exports volume in total domestic supply in 2011-2015. We rely on the “FAO global commodities production and trade database” provided by FishStatJ (53) for statistics on the annual production, imports and exports of fisheries commodities and included all the commodity categories from the International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAAP) groupings except: aquatic plants, aquatic animal products and aquatic mammals. Trade data in this database relates to general trade for all countries except nearly half, which report on the basis of special trade. General trade is a system which records total imports and total exports including re-exports. While, special trade is a system of recording imports for domestic consumption on the one hand and exports of domestic goods on the other.

Because trade data are not available by production environments (i.e., aquaculture/fisheries), we adopted the approach suggested by Bush et al. (54) and assumed that the fish exports (volume) composition by aquaculture and fisheries of a particular country is similar to their domestic production (volume) composition by aquaculture and fisheries. The FishstatJ reports production and trade data in live weight and product weight, respectively. Hence, the next step was to convert the trading volume into live-weight equivalents using the live weight conversion factors suggested by several published sources (55-58).

Table S6. Estimated and observed domestic price percent changes for fish with 13% decrease in world price. Data from (37).

Country	% domestic price	
	transmission	Count
Armenia	0	1
Bangladesh	0	2
Belize	0	3
Malawi	0	4
Nepal	0	5
Nigeria	0	6
Nigeria	0	7
Pakistan	0	8
Panama	0	9
Rwanda	0	10
Timo Liste	0	11
Uganda	0	12
Viet.Nam	0	13
Zambia	0	14
Côte.dIvoire	0.1	1
India	0.1	2
Indonesia	0.1	3
Peru	0.1	4
Yemen	0.1	5
Cambodia	0.2	6

Ecuador	0.2	7
Guatemala	0.3	8
Sri.Lanka	0.3	9
Nicaragua	0.4	10
Mongolia	0.6	11
Tajikistan	0.7	12
Moldova.Republic.of	1.2	13
Albania	5.3	1

Table S7. Multipliers used to determine impacts on SWI and HSE.

Fishing entity	Fishers' income multipliers	Fisheries economic impact multipliers	Fishing entity	Fishers' income multipliers	Fisheries economic impact multipliers
Albania	0.54	1.63	Libya	0.25	1.19
Algeria	0.25	1.19	Lithuania	0.63	3.79
American Samoa	0.65	3.34	Madagascar	0.77	2.34
Angola	0.73	3.54	Madeira Isl. (Portugal)	1.52	4.78
Anguilla (UK)	0.28	1.21	Malaysia	0.7	2.58
Antigua & Barbuda	0.28	1.22	Maldives	0.77	2.97
Argentina	0.85	2.97	Malta	0.61	2.54
Aruba (Netherlands)	0.29	1.23	Marshall Isl.	0.65	3.34
Australia	1.1	3.69	Martinique (France)	0.28	1.21
Azores Isl. (Portugal)	1.52	4.78	Mauritania	0.32	1.52
Bahamas	0.28	1.22	Mauritius	0.5	1.62
Bahrain	0.25	1.02	Mayotte (France)	0.72	2.95
Bangladesh	0.88	2.97	Mexico	0.12	0.61
Barbados	0.29	1.21	Micronesia	0.65	3.34
Belgium	1.57	6.22	Montenegro	NA	NA
Belize	0.78	3.46	Montserrat (UK)	0.27	1.2
Benin	0.32	1.52	Morocco	0.91	2.81
Bermuda (UK)	1.31	7.34	Mozambique	0.74	1.83
Bonaire (Netherlands)	0.68	2.95	Myanmar	0.32	0.85
Bosnia & Herzegovina	NA	NA	Namibia	0.87	4.82

Brazil	0.81	2.39	Nauru	0.63	3.31
Brit. Indian Ocean Terr. (UK)	NA	NA	Netherlands	0.68	2.95
British Virgin Isl. (UK)	0.28	1.21	New Caledonia (France)	0.65	3.34
Brunei Darussalam	0.62	2.16	New Zealand	0.65	2.58
Bulgaria	0.69	18.34	Nicaragua	0.41	1.5
Cambodia	0.54	1.73	Nigeria	0.05	0.28
Cameroon	0.76	2.96	Niue (New Zealand)	0.65	3.35
Canada	1.07	3.3	Norfolk Isl. (Australia)	NA	NA
Cape Verde	0.32	1.52	North Cyprus	0.19	0.61
Cayman Isl. (UK)	0.28	1.22	North Marianas (USA)	0.64	3.35
Channel Isl. (UK)	NA	NA	Norway	0.87	3.36
Chile	0.55	2.44	Oman	0.25	1.02
China	0.79	3.34	Pakistan	0.58	2.16
Colombia	1.43	3.14	Palau	0.65	3.34
Comoros	0.72	2.95	Panama	0.91	2.56
Congo (ex-Zaire)	0.73	3.53	Papua New Guinea	0.65	3.34
Congo, R. of	0.76	2.96	Peru	0.82	2.95
Cook Islands	0.65	3.34	Philippines	0.34	1.19
Costa Rica	0.52	2.16	Poland	0.75	4.27
Côte d'Ivoire	0.32	1.52	Portugal	1.52	4.78
Croatia	0.78	3.27	Puerto Rico (USA)	0.28	1.21
Cuba	0.28	1.22	Qatar	0.25	1.02
Curacao	NA	NA	Réunion (France)	0.71	2.95

Denmark	1.04	3.72	Romania	0.87	3.73
Djibouti	0.71	3	Russian Federation	0.5	2.5
Dominica	0.29	1.22	Saba and Saint Eustaius (Netherlands)	0.68	2.95
Dominican Republic	0.28	1.21	Saint Helena (UK)	0.29	1.53
Ecuador	0.67	3.25	Saint Kitts & Nevis	0.28	1.22
Egypt	0.73	2.42	Saint Lucia	0.28	1.22
El Salvador	0.78	3.46	Saint Pierre & Miquelon (France)	1.32	7.37
Equatorial Guinea	0.77	2.97	Saint Vincent & the Grenadines	0.28	1.22
Eritrea	0.72	2.95	Samoa	0.65	3.34
Estonia	0.51	3.81	Sao Tome & Principe	0.77	2.96
Faeroe Isl. (Denmark)	0.56	2.1	Saudi Arabia	0.25	1.02
Falkland Isl. (UK)	0.45	2.12	Senegal	0.84	2.21
Fiji	0.65	3.34	Seychelles	0.72	2.95
Finland	0.43	1.56	Sierra Leone	0.32	1.52
France	1.13	4.11	Singapore	0.7	4.01
French Guiana	0.45	2.12	Sint Maarten	NA	NA
French Polynesia	0.65	3.34	Slovenia	1.63	6.23
Gabon	0.76	2.96	Solomon Isl.	0.65	3.34
Gambia	0.32	1.52	Somalia	0.72	2.95
Gaza Strip	0.25	1.02	South Africa	0.66	3.13
Georgia	0.53	2.04	South Cyprus	0.19	0.61
Germany	0.9	3.28	Spain	1	3.86

Ghana	0.32	1.52	Sri Lanka	0.32	1.01
Greece	0.96	3.31	St Barthelemy (France)	1.13	4.11
Greenland	1.32	7.38	St Martin	NA	NA
Grenada	0.28	1.21	Sudan	0.72	2.95
Guadeloupe (France)	0.28	1.21	Suriname	0.45	2.12
Guam (USA)	0.65	3.36	Sweden	0.68	2.66
Guatemala	0.52	1.87	Syrian Arab Republic	0.25	1.02
Guinea	0.32	1.52	Taiwan	0.97	3.28
Guinea-Bissau	0.32	1.52	Tanzania	1.1	2.72
Guyana	0.45	2.12	Thailand	0.24	2.12
Haiti	0.28	1.22	Timor Leste	0.59	2.11
Honduras	0.78	3.46	Togo	0.32	1.52
Hong Kong	0.46	2.59	Tokelau (New Zealand)	0.65	3.35
Iceland	0.51	2.49	Tonga	0.65	3.34
India	0.53	1.36	Trinidad & Tobago	0.28	1.22
Indonesia	0.52	1.66	Tristan da Cunha Isl. (UK)	0.29	1.53
Iran	0.14	1.94	Tunisia	0.28	1.46
Iraq	0.25	1.03	Turkey	0.51	1.59
Ireland	0.38	2.15	Turks & Caicos Isl. (UK)	0.28	1.21
Israel	0.25	1.03	Tuvalu	0.65	3.34
Italy	0.51	1.75	Ukraine	1.05	5.56
Jamaica	0.28	1.22	United Arab Emirates	0.25	1.02
Japan	0.86	2.75	United Kingdom	1.09	4.26

Jordan	0.28	1.06	Uruguay	0.63	2.63
Kenya	0.72	2.95	US Virgin Isl.	0.28	1.22
Kiribati	0.65	3.34	USA	1.29	3.1
Korea (North)	0.71	3.04	Vanuatu	0.65	3.34
Korea (South)	0.62	2.91	Venezuela	0.44	1.06
Kuwait	0.25	1.02	Viet Nam	0.77	3.47
Latvia	1.11	4.31	Wallis & Futuna Isl. (France)	0.63	3.33
Lebanon	0.25	1.02	Yemen	0.25	1.02
Liberia	0.32	1.52			

Table S8. List of countries by geographic region and FAO development grouping.

Continent	Developing	Country	Developed	
Africa		Algeria	South Africa	
		Angola		
		Benin		
		Cameroon		
		Cape Verde		
		Comoros		
		Congo (ex-Zaire)		
		Congo, R. of		
		Côte d'Ivoire		
		Djibouti		
		Egypt		
		Equatorial Guinea		
		Eritrea		
		Gabon		
		Gambia		
		Ghana		
		Guinea		
		Guinea-Bissau		
		Kenya		
		Liberia		
		Libya		
		Madagascar		
		Mauritania		
		Mauritius		
		Mayotte (France)		
		Morocco		
		Mozambique		
		Namibia		
		Nigeria		
		Réunion (France)		
		Saint Helena (UK)		
		Sao Tome & Principe		
		Senegal		
		Seychelles		
		Sierra Leone		
		Somalia		
		Sudan		
		Tanzania		
		Togo		
		Tristan da Cunha Isl. (UK)		
		Tunisia		
	Asia		Bahrain	Israel
			Bangladesh	Japan
			Brit. Indian Ocean Terr. (UK)	
			Brunei Darussalam	
			Cambodia	
			China	
		Gaza Strip		
		Georgia		
		Hong Kong		
		India		
		Indonesia		
		Iran		
		Iraq		
		Jordan		
		Korea (North)		
		Korea (South)		
		Kuwait		
		Lebanon		
		Malaysia		
		Maldives		
	Myanmar			
	North Cyprus			

Oman	
Pakistan	
Philippines	
Qatar	
Saudi Arabia	
Singapore	
South Cyprus	
Sri Lanka	
Syrian Arab Republic	
Taiwan	
Thailand	
Timor Leste	
Turkey	
United Arab Emirates	
Viet Nam	
Yemen	
Europe	Albania
	Azores Isl. (Portugal)
	Belgium
	Bonaire (Netherlands)
	Bosnia & Herzegovina
	Bulgaria
	Channel Isl. (UK)
	Croatia
	Denmark
	Estonia
	Faeroe Isl. (Denmark)
	Finland
	France
	Germany
	Greece
	Iceland
	Ireland
	Italy
	Latvia
	Lithuania
	Madeira Isl. (Portugal)
	Malta
	Montenegro
	Netherlands
	Norway
	Poland
	Portugal
	Romania
	Russian Federation
	Saba and Saint Eustaius (Netherlands)
	Slovenia
	Spain
	St Barthelemy (France)
	Sweden
	Ukraine
	United Kingdom
North America	Anguilla (UK)
	Canada
	Antigua & Barbuda
	USA
	Aruba (Netherlands)
	Bahamas
	Barbados
	Belize
	Bermuda (UK)
	British Virgin Isl. (UK)

	Cayman Isl. (UK)	
	Costa Rica	
	Cuba	
	Curacao	
	Dominica	
	Dominican Republic	
	El Salvador	
	Greenland	
	Grenada	
	Guadeloupe (France)	
	Guatemala	
	Haiti	
	Honduras	
	Jamaica	
	Martinique (France)	
	Mexico	
	Montserrat (UK)	
	Nicaragua	
	Panama	
	Puerto Rico (USA)	
	Saint Kitts & Nevis	
	Saint Lucia	
	Saint Pierre & Miquelon (France)	
	Saint Vincent & the Grenadines	
	Sint Maarten	
	St Martin	
	Trinidad & Tobago	
	Turks & Caicos Isl. (UK)	
	US Virgin Isl.	
Oceania	American Samoa	Australia
	Cook Islands	New Zealand
	Fiji	
	French Polynesia	
	Guam (USA)	
	Kiribati	
	Marshall Isl.	
	Micronesia	
	Nauru	
	New Caledonia (France)	
	Niue (New Zealand)	
	Norfolk Isl. (Australia)	
	North Marianas (USA)	
	Palau	
	Papua New Guinea	
	Samoa	
	Solomon Isl.	
	Tokelau (New Zealand)	
	Tonga	
	Tuvalu	
	Vanuatu	
	Wallis & Futuna Isl. (France)	
South America	Argentina	
	Brazil	
	Chile	
	Colombia	
	Ecuador	
	Falkland Isl. (UK)	
	French Guiana	
	Guyana	
	Peru	
	Suriname	
	Uruguay	
	Venezuela	

Table S9. Projected differences for the top 10 species by landed value globally taken between outcomes of meeting Paris Agreement targets (+1.5°C) and maintaining high emissions (+3.5°C).[†]

	Landed value			
	(billion USD) ^{††}	SFB gains (%)	MCP gains (%)	Savings in price (%)
Anchoveta	7.8	11.2 (3.1, 27.7)	17.5 (11.1, 28.3)	9.9 (6.1, 15.6)
American sea scallop	4.7	21.2 (13.7, 25.2)	25.2 (13.7, 26.4)	14.9 (8.1, 5.6)
Skipjack tuna	4.4	8.0 (7.5, 10.6)	10.1 (7.5, 10.6)	14.6 (10.9, 15.8)
Yellowfin tuna	4.4	7.2 (5.6, 10.6)	8.8 (5.6, 10.6)	9.2 (5.4, 11.6)
Bigeye tuna	2.6	1.0 (-0.3, 5.7)	3.0 (-0.3, 5.6)	3.5 (-1.1, 7.3)
Largehead hairtail	2.2	7.0 (6.5, 9.2)	7.0 (6.3, 9.2)	8.6 (7.5, 11.1)
Atlantic cod	1.6	5.3 (4.3, 7.9)	6.4 (4.3, 7.9)	4.1 (3.4, 4.8)
American cupped oyster	1.5	4.1 (2.1, 4.5)	4.5 (2.5 to 5.5)	9.1 (2.9, 10.8)
Alaska pollock	1.5	-18.7 (-36.3, -8.9)	-16.2 (-36.3 to -8.9)	-7.7 (-17.9, -3.9)
Pacific saury	1.1	9.1 (7.0, 14.4)	7.0 (6.5, 14.4)	11.0 (9.2, 20.9)

[†]Values calculated from outputs of DBEM multi model means are in bold, while values from outputs of DBEM lower and upper bounds are in brackets below. Abbreviations: SFB – standing fish biomass; MCP – maximum catch potential.

^{††}Average 2001-2010 landed value in real 2010 USD.