https://doi.org/10.1038/s44183-024-00049-7

Poverty line income and fisheries subsidies in developing country fishing communities

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Eradicating poverty and harmful fisheries subsidies are two pressing challenges frequently addressed in international agendas for sustainable development. Here we investigate a potential solution for addressing both challenges simultaneously by asking the hypothetical question: to what extent can harmful fisheries subsidies provided by a country finance the cost of lifting fishers out of poverty? Focusing on 30 coastal least developed countries, we find that fishers in 87% of these countries do not earn sufficient income to satisfy the extreme poverty line income of USD 1.90/person/day, and that it would cost an estimated USD 2.2 to 2.6 billion to lift these fishers to different levels of poverty line incomes. Our analysis further suggests that at the country level, redirected harmful fisheries subsidies can cover the entire cost of covering the poverty income gap for between 37 to 43% of assessed countries. Our results provide quantitative evidence that can be used to support simultaneous progress towards achieving several Sustainable Development Goals, including those dealing with poverty reduction, food insecurity, and ocean sustainability.

Marine fisheries play a crucial role in supporting global employment, livelihoods, and food security[1–4]. As a major source of food for over 3 billion people worldwide[5], fish provide essential micronutrients that are particularly important for supporting the nutritional needs of rural coastal communities in developing countries[6,7], where they are relatively cheap and accessible[8–11]. Fish is particularly important for the world's least developed countries (LDCs), where about a quarter (26%) of the world's 3.2 billion people who acquire 20% of animal protein intake from fish and seafood live[12]. Fisheries and trade play a key economic role in LDCs, as fish and seafood rank among the top 5 merchandise exports in 30% of LDCs, while making up the largest food export for all LDCs as a group[12]. Moreover, with 97% of small-scale fishers living in the Global South[2], fisheries are crucial for supporting coastal livelihoods in LDCs.

The immense importance of fisheries is, however, threatened by the current trend of ocean unsustainability and overexploited fish stocks, which puts marine biodiversity and the social-cultural, economic, food security, and human well-being of millions at risk worldwide[5,13–16]. The depletion of marine resources and biodiversity is a barrier to sustainable livelihoods for fishers, who are frequently the poorest and most marginalised segment of society[17–20]. Poorest rural households, in particular, rely heavily on fishery income in coastal areas[21,22]. Fishing gains greater significance in LDCs where opportunities for employment are limited, and fisheries are often the only available option for earning a livelihood. At the same time, poverty also motivates excessive fishing pressure, leading to a poverty trap that ensnares fishing communities in poverty[23,24], so much so that the phrase 'poverty rhymes with fishery' is commonly used to describe fisheries[25]. This is exacerbated by the fact that small-scale fishers, who account for 90% of the world's fishers[2], tend to be excluded from social protection interventions, i.e., programmes and policies that aim to ensure basic income security and other support to address poverty and inequality for the poor and vulnerable[26–28].

Poverty among fishing communities has serious impacts on people and marine social-ecological systems[20,29,30]. The urgency for addressing fisheries poverty vividly came to the fore during the COVID-19 pandemic, which disrupted employment and economies globally[31,32], and plunged fishing communities into further hardship[33–35]. Solving poverty in fishing communities goes hand in hand with improving marine and fisheries management to enable resilient marine social-ecological systems that can support sustainable and socially just fisheries[24,30,36,37].

One of the major contributors to overfishing is the provision of harmful fisheries subsidies, which makes fishing more profitable than it otherwise would be[38,39], thereby encouraging excessive fishing effort that can potentially lead to overexploitation of fisheries resources over time[40,41]. Furthermore, subsidies promote an inequitable distribution of societal

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resources[13], especially since more than 80% of current global fisheries subsidies go to the large-scale sector, the bulk (64%) of which are harmful subsidies[42]. LDCs stand to benefit from the eradication of fisheries subsidies because the subsidised fleets of major fishing nations are a driving force behind the overexploitation of fisheries resources in the Exclusive Economic Zones of many LDCs in western Africa and the Pacific islands[43,44].

Within this context, we see an opportunity for a solution that can potentially overcome the challenges of eliminating fisheries poverty and harmful fisheries subsidies simultaneously. Specifically, our research aims to examine a hypothetical scenario in which countries divert harmful fisheries subsidies to help fishers get out of poverty. Doing so would not change the total cost to governments, while at the same time remove the incentive to overfish, thus leading to potential positive impacts on marine resources, fishers, and distribution of wealth among different fishery sectors[42,45]. We argue that this is a promising solution that can produce both social and biodiversity gains. To assess the economics of doing this, our study aims to answer two questions: (1) How much would it cost to bring fishers out of poverty? and (2) To what extent can harmful fisheries subsidies finance the cost of bringing fishers out of poverty?

Poverty is multidimensional in that it encompasses a range of deprivations, including poor health, lack of education, disempowerment, discrimination, racism and poor quality of work[25,46,47]. In this paper, however, we focus on income poverty, which is relatively easier to measure compared to other social and institutional aspects of fisheries poverty. A barrier to reducing income poverty in fisheries is incomplete understanding of fishing income levels[30,48]; this hampers poverty alleviation decisions, such as the investment required to close the poverty gap for fishers and fishing households. Recent studies have started to shed light on the extent of fishers living in poverty[48]: found that incomes of fishers in approximately one third of 89 assessed countries were below national poverty lines, while[49] estimated that, even with well-managed fisheries, the average income of up to 70% of fishers worldwide (equivalent to 39.9 million fishers) would not meet minimum living wages.

In this study, we quantify the level of fishing income poverty among LDCs, where falling below the poverty line would have the biggest livelihood, food security, and nutritional impacts. We assume that income poverty occurs when an individual or household falls below a certain poverty threshold, which is defined by the aggregate cost for meeting minimum subsistence needs, such as food, clothing, education, health, and housing. Our specific objectives are to: (i) assess the extent of poverty among fishers; (ii) estimate the cost of covering the poverty gap for fishers; and (iii) evaluate whether harmful fisheries subsidies are sufficient for covering the costs of providing a poverty line income for fishers.

To achieve our study objectives, we collect data on poverty lines, fisher income, and fishery subsidies to generate results for: (a) the extent of poverty among fishers, as measured by the gap between fishing income and two levels of poverty line income; (b) the cost of covering the poverty gap for fishers; (c) the magnitude of harmful fisheries subsidies provided by the assessed countries and whether this amount is sufficient for covering the income gap for fishers in each country. We group the 30 LDCs according to their World Bank income classification (https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups) to facilitate comparisons across countries. By bringing together these three elements, this study provides a novel, quantitative output that can guide policy decisions on social welfare and fisheries sustainability. In particular, our results provide a timely option for World Trade Organisation Member countries, as an Agreement on Fisheries Subsidies to end prohibited subsidies was recently adopted in June 2022.

We recognise that redirecting harmful subsidies requires substantial investment in designing the right delivery mechanisms, but that this is beyond the scope of this paper. Nevertheless, our study has the potential to inform progress towards several Sustainable Development Goals, among them the goals to end poverty (SDG1), hunger (SDG2), ensuring and promoting human well-being (SDG3), as well as directly addressing SDG 14.6 aimed at prohibiting harmful fisheries subsidies by 2020.

Results

Extent of poverty among fishers

Fishers' income. There was a wide range in fishers' monthly income, ranging from a low of USD 6 in Democratic Republic of Congo to a high of USD 290 in Gambia, with a mean (±standard error) of USD 111.1 ± 13.3 per fisher per month (SI Table 5). This was equal to an average per capita daily fishing income of USD 0.64 ± 0.07, which is less than 50% of the extreme poverty line income of USD 1.90/person/day.

Gap between fishing income and poverty line income measures

Extreme poverty line (USD 1.90/person/day). Fishers' income did not meet the USD 1.90 PLI in all the assessed countries (Fig. 1). The average poverty gap was USD 1.26 ± 0.01, and in 77% of the countries that did not meet the PLI, fishers' income was less than half the PLI level (i.e., USD 0.95 or less per day). Three of the top 5 countries with the biggest gap between fishers' income and the PLI were in Africa, with Congo (Democratic Republic) having the largest gap (Fig. 1). As expected, the average poverty gap (in USD/person/day) was highest in low income countries, followed by lower middle and upper middle income countries (Table 1).

National Minimum Living Wage (MLW). On average, per capita daily fishing income in 90% of assessed countries were below the national MLW. Fishing income exceeded the MLW in only 3 countries – Angola, Gambia, and Tanzania (Fig. 2). In contrast to the USD 1.90 PLI, the largest poverty gap occurred in lower and upper-middle income countries; this gap (average of USD 1.6/person/day) was about 77% higher than that of the low income country group (Table 1).

Number of people affected by fishing poverty. Based on average household sizes (SI Table 2), the estimated 6.98 million fishers across all the 30 assessed countries represented 33.20 million fishing household members supported by fishing income. The number of fishers potentially living below the USD 1.90 and MLW poverty lines were 6.96 million and 6.63 million, respectively. This was equivalent to at least 95% of total estimated fishers across all assessed countries. When accounting for fishing household members, the estimated number of people living below the USD 1.90 and MLW poverty lines rose to 33.20 million and 31.52 million people, respectively.

Cost of covering the poverty line income gap

The estimated cost of covering the USD 1.90 PLI gap for fishers was USD 2.65 billion per year (Table 2). Bangladesh, Sierra Leone, Congo Democratic Republic, Cambodia, and Myanmar were among the top 5 countries with the highest estimated total annual cost for all fishers to attain the USD 1.90 PLI. Cumulatively, the top 5 countries made up 74% of the total cost (SI Table 6). The total estimated cost for closing the national MLW gap for fishers was slightly lower at USD 2.24 billion per year, with Myanmar, Congo Democratic Republic, and Guinea-Bissau having the highest costs (SI Table 6). Across country income groups, lower middle income countries incurred the highest cost for meeting both PLIs for fishers (Table 2).

Adjusting for the number of countries per income group resulted in lower middle income countries accounting for the biggest cost per country (USD 110 million /country) to meet the USD 1.9 PLI, followed by low income (USD 76 million/country) and upper middle income (USD 1 million/country) countries. For closing the MLW gap, lower middle income countries again incurred the largest cost per country (USD 111 million/country), followed by low income (USD 50 million/country), and upper middle income (USD 2 million/country) countries.

Financing the poverty income line gap

Harmful fisheries subsidies provided by each of the 30 assessed countries ranged from a low of USD 91,000 to a high of USD 246 million per year (SI Table 7). Eleven countries provided sufficient harmful subsidies for covering the entire USD 1.90 poverty gap, while 13 countries could cover the MLW poverty gap (Fig. 3). This could help 402,756 and 744,685 fishers reach the

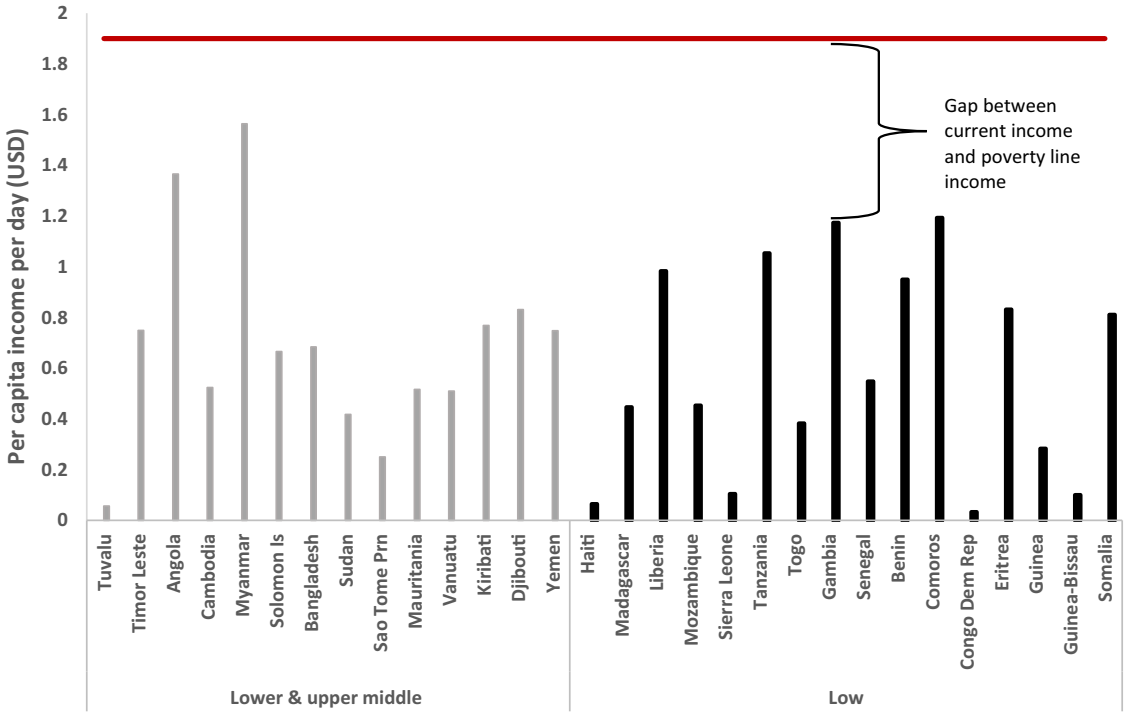

Fig. 1 | Income per capita per day (in USD) by country income group. Countries where daily per capita income falls below the extreme poverty line income (USD 1.90/person/day), indicated by the red horizontal line.

USD 1.90 and MLW poverty lines, respectively. For countries where harmful subsidies were insufficient for covering the poverty gap, the magnitude of subsidies provided by each country could still contribute anywhere from a low of less than 1% up to 92% towards covering the different PLI gaps (Table 3).

Sensitivity analysis

The estimated cost of closing the fishing poverty gap was fairly sensitive to the presence of multiple livelihoods. If fishing only contributed 50% to household income, the estimated cost of closing the USD 1.90 PLI and MLW income gaps fell by 42% and 73%, respectively (SI Table 6). This would result in harmful fisheries subsidies in 16 and 22 countries being sufficient to cover the USD 1.90 and MLW PLI income gaps, respectively. On the other hand, if fishing contributed to 85% of household income, the overall cost of closing both the USD 1.90 PLI and MLW income gaps decreased by 15% and 29%, respectively (SI Table 6). This would enable harmful fisheries subsidies in 13 and 14 countries to cover the entire USD 1.90 and MLW PLI income gaps, respectively.

Discussion

Our study examines a potential solution that can contribute to achieving both poverty and ocean sustainability goals that rank high on international agendas. Specifically, diverting the USD 850 million that the 30 least developed countries provide annually in harmful fisheries subsidies can, at the minimum, cover the USD 1.90 and Minimum Living Wage income gap for fishers in 11 and 13 countries, respectively.

Closing the poverty gap can potentially benefit around 7 million fishers and up to 33 million people if accounting for fishers and their household members. Indeed, it is concerning that the average fisher in all the assessed countries do not earn sufficient income to satisfy the extreme poverty line of USD 1.90/person/day when fishing is the only income source. Further, the average income of fishers in 90% of the assessed countries fall below their national minimum living wage. These findings are consistent with earlier narratives about poverty among fishers[30,50], and the consequent social, health, and economic repercussions fishers and their households and communities face[20,51].

The immense social and economic benefits fisheries provide in LDCs underlines the importance of ensuring the sustainability of their fishery resources. In particular, 57% of the assessed countries are highly fish dependent, which reinforces the urgency for ensuring sustainable fisheries in the assessed LDCs. Within this context, we see an opportunity for countries to use poverty alleviation as a vehicle to redirect harmful fishery subsidy funds, which are a major driver of overfishing.

While we have not come across a real-world example where harmful fisheries subsidies have been redirected to poverty alleviation, some countries have removed environmentally damaging subsidies when implementing social protection measures for the poor in general. For instance, Ghana targeted social spending programmes at lower-income households when it eliminated fuel subsidies in 2005[52]. Similarly, the Egyptian government targeted a social assistance programme that guaranteed a minimum income to the poor when it reduced electricity and fuel subsidies in the mid-2010s[27]. Some countries, such as Mexico and Ghana, have already considered applying fuel subsidies to pay for income supplements or insurance and pension schemes for fishers instead[53,54]. Thus, there is a strong potential for uptake of our proposed redirection of harmful fisheries subsidies.

Having said that, a feasible policy for redirecting harmful subsidies will have to consider how the cash transfers will be distributed, and the effect of these transfers on long-term poverty alleviation. Although this is beyond the scope of this paper to address, channels do exist for distributing funds across countries, e.g., development aid, such as that provided by governments to the United Nations World Food Programme. At the country level, digital technology is making it easier to deliver cash transfers to rural recipients, which typify a large proportion of fishers (e.g.,[55]). In terms of alleviating poverty, studies have shown that other social assistance initiatives, such as universal basic income (i.e., unconditional monetary transfers from the government to every individual in a society) can help stave off poverty for households at the margins of society[56] and address existing economic and social inequalities[57,58]. An important point here is that for any subsidy reform, there is a need to carefully consider trade-offs, especially the impact on vulnerable groups[45].

Table 1 | Average fishing poverty gap (USD/person/day) under each poverty line income measure for different country income groups

Poverty line measure	Country income group[a]	Average poverty Gap (USD/person/day)
USD 1.9/person/day	Low	1.3
	Lower & upper middle	1.2
Minimum Living Wage	Lower & upper middle	1.6
	Low	0.9

Countries are arranged with the largest poverty gap at the top.
[a]The number of countries in each group is: Low = 16, Lower & upper middle = 14 (13 Lower middle and 1 upper middle).

Table 2 | Cost of covering the gap between fishing income and the USD 1.90 and Minimum Living Wage poverty line incomes (millions real 2016 USD) per year

Country income group	Poverty line	
	1.90 (million USD)	MLW (million USD)
Fishers		
Low	1214	797
Lower middle	1430	1443
Upper middle[a]	0.91	2.45
Total	**2645**	**2240**

Results are grouped by country income group.
[a]Upper middle income group consists of only one country (Tanzania).

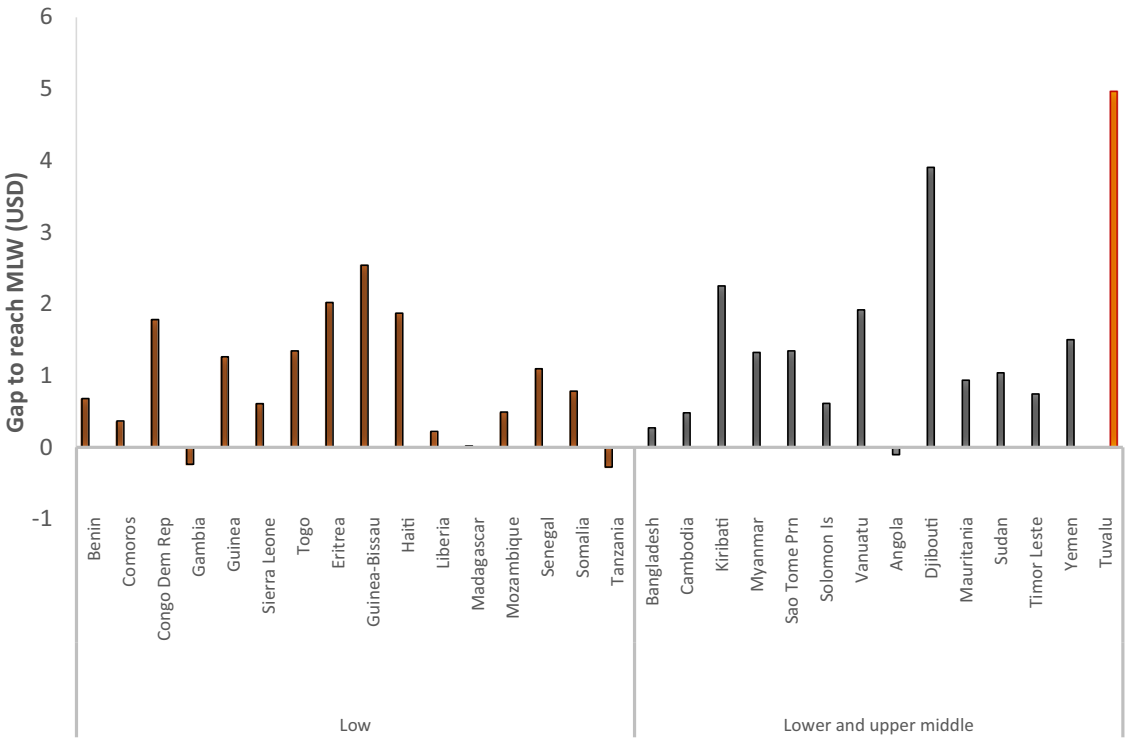

Fig. 2 | Amount (USD/person/day) required to close the gap between fishing income and the Minimum Living Wage (MLW) PLI. Negative gaps indicate that fishing income exceeds the MLW.

Our results suggest that fishing alone is not sufficient for keeping people out of income poverty in countries that are most vulnerable in terms of low income and high fish dependency. We acknowledge that we cannot ascertain what proportion of fishers may already be receiving social assistance, and who may thus either have income sources that put them above the poverty line, or have access to food resources that mitigates the food insecurity impact of being below the poverty line. Costa Rica, Brazil, and Peru, for example, have nationally funded insurance that provide payments to small-scale fishers during closed fishing seasons[28], while a food compensation scheme provided wheat to the 'poorest and most vulnerable' fishers affected by fishing bans in Bangladesh[59]. Overall however, the proportion of fishers receiving social assistance is unlikely to be high, given that social protection coverage of fishing communities remains sparse[26–28].

A limitation of this study is that, due to the general paucity of data on fishers' income[48], the fishing incomes we present here are not consistent across countries in terms of scale (small vs. large-scale fisheries), fishery or gear type, or type of fisher (crew or owner-operator). These data gaps mean that our best available option was to apply a national average income to all fishers in a country, while acknowledging that income levels and distribution are usually variable, even within a country or fishing community[60,61]. We found that across the assessed countries, the variation in fishers' income ranged from 1.3 to 2.5 fold, with an average of 1.9 fold variation (SI Table 8). This is in line with a study by[62], which found a 2 to 3 fold variation in sea cucumber fishers' incomes among regions in Fiji.

Our use of a national average fisher income may not properly reflect wealth distribution among fishers. For instance[49], demonstrated that the proportion of global fishers under the minimum living wage could increase by 5-10% when accounting for uneven wealth distribution. Meanwhile[63], showed that income distribution among sea cucumber fishers was much more equal than that of octopus fishers within the same site in Kenya. Indeed, out of the 10 assessed countries with lowest fishers' income, six had a national Gini index of more than 40 (SI Table 9), which indicates a high disparity in income distribution (A Gini index of <0.2 is generally considered to correspond with perfect income equality, 0.2–0.3 with relative

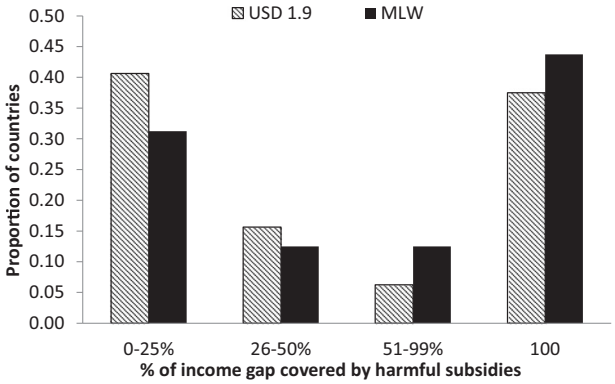

Fig. 3 | Income gap covered by harmful subsidies. The extent to which harmful subsidies can cover the cost of closing the poverty income gap for assessed countries under the USD 1.90/day (USD 1.9) and Minimum Living Wage (MLW) poverty income line measures.

Table 3 | The percentage of each PLI poverty gap that could be covered by harmful subsidies provided by each country

	% of poverty gap covered by harmful subsidies	
Country	**USD 1.90**	**MLW**
Angola	100	100
Bangladesh	11	48
Benin	4	6
Cambodia	4	11
Comoros	100	100
Congo Dem Rep	<1	< 1
Djibouti	100	100
Eritrea	100	100
Gambia	100	100
Guinea	25	32
Guinea-Bissau	<1	<1
Haiti	4	4
Kiribati	100	92
Liberia	51	100
Madagascar	35	100
Mauritania	100	100
Mozambique	19	55
Myanmar	35	9
Sao Tome Prn	74	91
Senegal	100	100
Sierra Leone	2	6
Solomon Is	100	100
Somalia	3	5
Sudan	13	19
Tanzania	5	100
Timor-Leste[a]	0	0
Togo	49	55
Tuvalu	43	16
Vanuatu	100	100
Yemen	100	100

[a]No harmful subsidies recorded for Timor-Leste.

equality, 0.3–0.4 with a relatively reasonable income gap, 0.4–0.5 with high income disparity, and > 0.5 with severe income disparity (https://www.unicef.cn/en/figure-27-national-gini-index-20032017). We assume that the national Gini index is applicable to fishing communities). This suggests that income for a large proportion of fishers may be below the average level, thereby suggesting that our estimated cost of closing the poverty gap is likely on the conservative side.

The provision of harmful fisheries subsidies incentivises excessive fishing effort that drives the overexploitation of fish stocks, resulting in detrimental environmental and socio-economic consequences. This economic rationale is behind the push to eliminate harmful fisheries subsidies in the global arena. Within this context, our study has put forward a potential solution that can simultaneously address the challenges of eliminating harmful fisheries subsidies while alleviating fishers' poverty. By using the best available fisheries income and subsidy data to date, we provide the quantitative evidence policy makers need for targeting financial and other resources towards poverty alleviation interventions.

We find that diverting harmful fisheries subsidies to finance the cost of lifting fishers out of poverty can provide economic benefits that translate to social, human health and environmental gains associated with getting people out of poverty[22,64], while ending the unsustainable fishing practices arising from harmful subsidies[38]. This not only contributes directly to achieving SDG 14.6, aimed at eliminating harmful fisheries subsidies, but can also contribute to other SDGs, particularly SDGs 1 (zero poverty) and SDG 2 (zero hunger), due to the linkages of SDG14–life underwater–, to all other SDGs[65].

Our main message is that there is a need, and also a potential revenue source, for mobilising resources towards alleviating poverty for the world's most vulnerable fishers. This finding has impactful policy applications since the World Trade Organisation agreement on fisheries subsidies reached in June 2022 is paving the way for practical policies to tackle the removal of harmful fisheries subsidies. Our present study is particularly timely at the time of writing in January 2024, given the upcoming World Trade Organisation Ministerial Meeting in February 2024.

Methods

Country coverage

As this study focuses on the intersecting issues of fisheries and income poverty, it covers 30 coastal countries that are categorised as 'least developed' by the United Nations (Note that the United Nations list of 46 least developed countries includes those that are landlocked, which are not covered in this analysis (https://www.un.org/development/desa/dpad/least-developed-country-category/ldcs-at-a-glance.html).): Angola, Bangladesh, Benin, Cambodia, Comoros, Democratic Republic of the Congo, Djibouti, Eritrea, Gambia, Guinea, Guinea-Bissau, Haiti, Kiribati, Liberia, Madagascar, Mauritania, Mozambique, Myanmar, Sao Tome and Principe, Senegal, Sierra Leone, Solomon Islands, Somalia, Sudan, Timor-Leste, Togo, Tuvalu, United Republic of Tanzania, Vanuatu, and Yemen. For each of these 30 coastal LDCs, we calculate the national fish dependency, which is the percentage of total animal protein supply obtained from fish and seafood, based on food balance sheet data from the United Nations Food and Agriculture Organization (FAO) Statistics Division (http://faostat3.fao.org) (SI Table 1). FAO's food balance sheet includes a separate category for freshwater fish, which we did not include in our calculation of fish dependency rate given our focus on marine fisheries. Out of the 30 LDCs, 17 (57%) are considered to be highly fish dependent, meaning that they have a fish dependency rate of more than 30%[9].

Fishing income

The basis for evaluating the extent of poverty was an individual fisher's monthly fishing income. In order to maximise consistency of reported income levels across the 30 assessed countries, we used global or regional studies of fishing income that provided as many data points as possible from a single study. The most recent and complete set of fishers' income data at the

time of this study was a global study of fishers' income by[48], from which we obtained data for 7 out of the 30 countries (SI Table 2). The second source was[66], which provided estimates of fishers' income for 9 West African countries. For the remaining 14 countries, we obtained fishers' income data through desk-based research (SI Table 2). We searched the databases of international and regional institutions (e.g., International Labour Organisation, FAO), online repositories such as Mendeley, and primary and secondary literature. We used online and academic search and indexing engines (e.g., Google Scholar, Aquatic Sciences and Fisheries Abstracts) to search for the key terms "fishing income", "fisher income", "fishermen income". We also used alternative terms for "income", such as "wage", "salary", "earnings", and "revenue". To be consistent with the methodology of[48], we excluded studies that were conducted prior to 1990, and those where the method used to estimate fishers' income was not fully explained. In cases where no data for a country were available, we based fishing income for the particular country on the geographical regional average calculated from all other countries included in this study. This applied only to 1 country – Djibouti.

We report all fishing income in terms of per capita monthly rate in 2016 USD, as per[48]. This required first standardising fishing income data that were provided in different units by pro-rating to a monthly rate; this was done for 2 countries (SI Table 3). We used the frequency of fishing reported in the respective studies for pro-rating. A default of 4 weeks fishing per month and 20 fishing days per month was used if no fishing frequency was provided. We then converted data reported in local currency to US dollars (USD) using exchange rates supplied by the World Bank[67], and adjusted to 2016 dollars using the Consumer Price Index[68].

We assumed that all fishers live within a household; thus, monthly fishing income was divided by average household size to derive per capita daily income in fishing households. This assumed that fishing is the only source of household income; we also considered the case of multiple livelihoods within a fishing household (see 'Multiple livelihoods' section below). Our approach also assumed that there was only one fisher per household. We recognise the shortcoming of this assumption, particularly in fishing households where women also contribute to fishing income (e.g.,[69,70]). Nevertheless, the wide geographical scope of this analysis necessitated this assumption because as far as we know, there is no data source which provides a consistent set of demographic data specific to fishing households worldwide. As such, our analysis reflects a 'worst case' scenario since the presence of more than one fisher per household would increase household income and hence increase per capita daily income in fishing households.

Household size data was taken either from the United Nations database on household size and composition for the most recent available year[71], or from case studies of fishing households. For West African countries where fishers' income data are based on[66], we followed the authors in using an average household size of 6 (SI Table 2).

Since we compiled data from diverse sources, fishers' incomes were reported as gross income in 7 countries, net income in 19 countries, and not specified in 4 countries (SI Table 4). Comparing gross income to the poverty line measures may result in an overly optimistic assessment given that it does not consider fishing costs; however, in all cases reported gross fishing income was already below the minimum USD 1.90/person/day extreme poverty line income. This implies that our estimates for the 7 countries reporting gross income reflect the minimal cost for covering the poverty gap.

Multiple livelihoods

While many fishers rely on fishing as their only source of income[72], in many localities, fishing is part of a multiple livelihood strategy[11,29], i.e., fishers may also participate in alternative food producing activities, such as farming or aquaculture, or engage in non-fishing work (e.g., construction, tourism). This multi-livelihood approach is a means of coping with fluctuating resource levels and minimising income risk, and means that fishing income by itself cannot determine whether a fisher is above or below the poverty line. To account for multiple income sources, we searched the literature to find out the contribution that fishing makes to total household income.

While numerous studies on fishing livelihoods provide a descriptive breakdown of the income generating activities fishers engage in (e.g.,[73–75]), very few quantify the proportion of total household income derived from each livelihood activity. For those that did, the contribution of fishing to total household income varied widely, even for cases where fishing is the primary source of income. For example, fishing accounted for 82-100% of total household income in the Philippines[76], 93% in Vietnam[77], 84% in Kenya[78], 63% in Myanmar[79], and 55% in Brazil[80]. Based on these studies, we conducted a sensitivity analysis involving multiple livelihoods – a low fishing contribution scenario in which fishing contributes 50% to total household income, and a high scenario, in which fishing contributes 85% to total household income. Due to the limited data points, we applied these percentages to fishers' fishing income across all countries to derive total income from all livelihoods. This total income was then compared to two different poverty line levels, described below.

Cost of providing poverty line income

Per capita daily fishing income was compared to two different poverty line incomes (PLI): an absolute poverty line defined by the World Bank, and one based on national poverty lines. Absolute, as opposed to relative poverty lines (i.e., poverty lines set at a certain percentage of a country's national median income), provide a consistent way to compare across countries[62]. The absolute PLI we used was the international poverty line income of USD 1.90/person/day, which is also the level used to define extreme poverty[81]. The second PLI was based on the national minimum living wage (MLW) of each country, and was used to assess the state of fishers' income within countries. Country specific MLW data were obtained from a recent global study by[49]. These MLW were provided in 2018 USD; to be consistent with the income data taken from[48], which was provided in 2016 dollars, we adjusted the MLW data to 2016 real USD using the Consumer Price Index.

For those countries where per capita daily fishing income did not meet any one of the two PLIs, we estimated the cost of providing all fishers with a PLI by multiplying the difference between PLI and fishing income by the number of fishers in each country. This assumed that the average fisher income estimated for each country applied to all fishers in the country, and was a necessary assumption as we did not have information about the distribution of income among fishers across countries. Data for the number of fishers was taken either from[3,82], or national fishery statistics. For each country, we assumed that the number of fishers reported from these sources were those who would benefit from being provided with a PLI. The gap between each PLI measure and per capita daily fishing income was multiplied by 365 days to estimate the annual cost of providing PLI.

Potential source of revenue for closing the PLI gap

Harmful fisheries subsidies were extracted from a global dataset consisting of 13 fisheries subsidy types from across 152 maritime countries[83]. Annual subsidy amounts for each country in the dataset were either based on reported or modelled data; harmful subsidies were inclusive of payments for boat construction, renovation and modernisation, fisheries development programmes, fishing port development, marketing and storage infrastructure, tax exemptions, fuel, and fishing access agreements. In total, global fisheries subsidies amounted to USD 35.4 billion in 2018 dollars, of which USD 22.2 billion was spent on harmful subsidies[84]. We adjusted the subsidy amounts to 2016 real USD using the Consumer Price Index. For each country, we compared the magnitude of harmful fisheries subsidies to the cost of providing fishers with a PLI.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Received: 24 March 2023; Accepted: 20 February 2024;
Published online: 07 March 2024

References

1. Garcia, S. M. & Rosenberg, A. A. Food security and marine capture fisheries: characteristics, trends, drivers and future perspectives. *Philos. Trans. R. Soc. B* **365**, 2869–2880 (2010).
2. Kelleher, K. et al. *Hidden Harvest: The Global Contribution of Capture Fisheries* (World Bank, 2012).
3. Teh, L. C. L. & Sumaila, U. R. Contribution of marine fisheries to worldwide employment. *Fish Fish* **14**, 77–88 (2013).
4. Tacon, A. G. J. & Metian, M. Food matters: fish, income, and food supply—a comparative analysis. *Rev. Fish. Sci. Aquac.* **26**, 15–28 (2018).
5. FAO. *The State of World Fisheries and Aquaculture 2018.* (FAO, 2018).
6. Thilsted, S. H. et al. Sustaining healthy diets: The role of capture fisheries and aquaculture for improving nutrition in the post-2015 era. *Food Policy* **61**, 126–131 (2016).
7. Hicks, C. C. et al. Harnessing global fisheries to tackle micronutrient deficiencies. *Nature* **574**, 95–98 (2019).
8. Srinivasan, U. T., Cheung, W. W. L., Watson, R. & Sumaila, U. R. Food security implications of global marine catch losses due to overfishing. *J. Bioeconomics.* **12**, 183–200 (2010).
9. Kawarazuka, N. & Béné, C. The potential role of small fish species in improving micronutrient deficiencies in developing countries: building evidence. *Public Health Nutr*. **14**, 1927–1938 (2011).
10. Foale, S. et al. Food security and the Coral Triangle Initiative. *Mar. Policy* **38**, 174–183 (2013).
11. Martin, S. M., Lorenzen, K. & Bunnefeld, N. Fishing farmers: fishing, livelihood diversification and poverty in Rural Laos. *Hum. Ecol.* **41**, 737–747 (2013).
12. UNCTAD. *Building Capacity in the Least Developed Countries to Fully Harness the Potential of Fisheries and Aquaculture.* Training manual (United Nations Conference on Trade and Development, 2020).
13. Schuhbauer, A., Chuenpagdee, R., Cheung, W. W. L., Greer, K. & Sumaila, U. R. How subsidies affect the economic viability of small-scale fisheries. *Mar. Policy* **82**, 114–121 (2017).
14. Teh, L., Cheung, W., Christensen, V. & Sumaila, U. R. Can we meet the Target? Status and future trends for fisheries sustainability. *Curr. Opin. Environ. Sustain.* **29**, 118–130 (2017).
15. Allison, E. H., Kurien, J., & Ota, Y. *The Human Relationship with Our Ocean Planet* (World Resources Institute, 2020).
16. Sumaila, U. R. *Infinity Fish: Economics and the Future of Fish and Fisheries* (Academic Press, 2021).
17. Jentoft, S., & Eide, A. *Poverty Mosaics: Realities and Prospects in Small-scale Fisheries*. (Springer Netherlands, 2011).
18. Béné, C. & Friend, R. M. Poverty in small-scale fisheries: old issue, new analysis. *Prog. Dev. Stud.* **11**, 119–144 (2011).
19. Nayak, P., Oliveira, L. & Berkes, F. Resource degradation, marginalization, and poverty in small-scale fisheries: threats to social-ecological resilience in India and Brazil. *Ecol. Soc.* **19**, 73 (2014).
20. FAO. *Voluntary Guidelines for Securing Ssustainable Small-scale Fisheries in the Context of Food Security and Poverty alleviation*. (FAO, 2015).
21. Kumar, D., Ramasubramanian, K., Krishnan, M. & Ananthan, P. Socio-economic status of fishers of coastal India. *Int. J. Curr. Microbiol. Appl. Sci.* **6**, 2267–2280 (2017).
22. De La O Campos, A., Vilani, C., Davis, B., & Takagi, M. *Ending Extreme Poverty in Rural Areas – Sustaining Livelihoods to Leave No One Behind* (FAO, 2018).
23. Cinner, J. E. Poverty and the use of destructive fishing gear near east African marine protected areas. *Environ. Conserv.* **36**, 321–326 (2009).
24. Sumaila, U. R. & Tai, T. C. End overfishing and increase the resilience of the ocean to climate change. *Front. Mar. Sci.* **7**, 1–8 (2019).
25. Béné, C. When fishery rhymes with poverty: a first step beyond the old paradigm on poverty in small-scale fisheries. *World Dev.* **31**, 949–975 (2003).
26. Béné, C., Devereux, S., & Roelen, K. *Social Protection and Sustainable Natural Resources Management: Initial Findings and Good Practices from Small-scale Fisheries*. FAO Fisheries and Aquaculture Circular. No 1106 (FAO, 2015).
27. FAO. *Social Protection for Small-scale Fisheries in The Mediterranean Region – A Review.* (FAO, 2019).
28. FAO. *Social Protection in Small-scale Fisheries and Aquaculture in Latin America and the Caribbean* (FAO, 2019).
29. Allison, E. H. & Ellis, F. The livelihoods approach and management of small-scale fisheries. *Mar. Policy* **25**, 377–388 (2001).
30. Kalikoski, D. C., Jentoft, S., McConney, P. & Siar, S. Empowering small-scale fishers to eradicate rural poverty. *Marit. Stud.* **18**, 121–125 (2019).
31. ILO. *COVID-19 and the World of Work*. Second edition. (International Labour Organization, 2020).
32. The World Bank. *Poverty and Shared Prosperity 2020: Reversals of Fortune*. (The World Bank, 2020). https://www.worldbank.org/en/research/brief/poverty-and-shared-prosperity-2020-reversals-of-fortune-frequently-asked-questions.
33. Bennett, N. J. et al. The COVID-19 pandemic, small-scale fisheries and coastal fishing communities. *Coast. Manage.* **48**, 336–347 (2020).
34. Stokes, G. L. et al. COVID-19 pandemic impacts on global inland fisheries. *Proc. Natl. Acad. Sci.* **117**, 29419–29421 (2020).
35. Campbell, S. et al. Immediate impact of COVID-19 across tropical small-scale fishing communities. *Ocean Coast. Manage.* **200**, 105485 (2021).
36. Froese, R., Winker, H., Gascuel, D., Sumaila, U. R. & Pauly, D. Minimizing the impact of fishing. *Fish Fish* **17**, 785–802 (2016).
37. Cohen, P. J. et al. Securing a just space for small-scale fisheries in the blue economy. *Front. Mar. Sci* **171**, 1–8 (2019).
38. Sumaila, U. R. et al. A bottom-up re-estimation of global fisheries subsidies. *J. Bioecon.* **12**, 201–225 (2010).
39. Sumaila, U. R. et al. WTO must ban harmful subsidies. *Science* **374**, 544 (2021).
40. Munro, G. & Sumaila, U. R. The impact of subsidies upon fisheries management and sustainability: the case of the North Atlantic. *Fish Fish* **3**, 233–250 (2002).
41. Clark, C. W., Munro, G. & Sumaila, U. R. Subsidies, buybacks, and sustainable fisheries. *J. Environ. Econ. Manage.* **50**, 47–58 (2005).
42. Schuhbauer, A., Skerritt, D. J., Ebrahim, N., Le Manach, F. & Sumaila, U. R. The global fisheries subsidies divide between small- and large-scale fisheries. *Front. Mar. Sci.* **7**, 1–9 (2020).
43. Pauly, D. et al. China's distant-water fisheries in the 21st century. *Fish Fish* **15**, 474–488 (2014).
44. Gutiérrez, M. et al. *China's Distant Water Fishing Fleet. Scale, Impact and Governance* (Overseas Development Institute, 2020).
45. Merayo, E., Porras, I., Harper, S., Steele, P., & Mohammed, E.Y. *Subsidy Reform and Distributive Justice in Fisheries* (IIED, 2019).
46. Jentoft, S. et al. Working together in small-scale fisheries: harnessing collective action for poverty eradication. *Marit. Stud.* **17**, 1–12 (2018).
47. UNDP & OPHI. *Global Multidimensional Poverty Index 2020. Charting Pathways Out of Multidimensional Poverty: Achieving the SDGs* (United Nations Development Programme and Oxford Poverty & Human Development Initiative, 2020).
48. Teh, L. C. L., Ota, Y., Cisneros-Montemayor, A. M., Harrington, L. & Swartz, W. Are fishers poor? Getting to the bottom of marine fisheries income statistics. *Fish Fish* **21**, 471–482 (2020).
49. Giron-Nava, A. et al. Sustainable fisheries are essential but not enough to ensure well-being for the world's fishers. *Fish Fish* **22**, 1–10 (2021).
50. Béné, C., Macfayden, G., & Allison, E. H. *Increasing the Contribution of Small-scale Fisheries to Poverty Alleviation and Food Security.* FAO Fisheries Technical Paper 481 (FAO, 2007).

51. Jönsson, J. H. Overfishing, social problems, and ecosocial sustainability in Senegalese fishing communities. *J. Commun. Pract.* **27**, 213–230 (2019).
52. Clements, B. et al. *Energy Subsidy Reform: Lessons and Implications* (International Monetary Fund, 2013).
53. Tobey, J., Normanyo, K., Osei, P., & Beran, K. *Subsidies in Ghana's Marine Artisanal Fisheries Sector* (USAID and University of Rhode Island, 2016).
54. Cisneros-Montemayor, A. M., Sanjurjo, E., Munro, G. R., Hernández-Trejo, V. & Sumaila, U. R. Strategies and rationale for fishery subsidy reform. *Mar. Policy* **69**, 229–236 (2016).
55. Pavanello, S. *Digital Cash Transfers in Lao PDR. A Scoping Exercise*. (World Food Programme, 2021). https://docs.wfp.org/api/documents/WFP-0000133643/download/.
56. Banerjee, A., Niehaus, P., & Tavneet, S. *Universal Basic Income in the Developing World.* Working Paper 25598 (National Bureau of Economic Research, 2019). https://doi.org/10.3386/w25598.
57. Misztal, P. Unconditional basic income as an instrument for reducing income inequalities. The Case of Poland. *Acta Oecon*. **69**, 63–79 (2019).
58. Lombardozzi, L. Gender inequality, social reproduction and the universal basic income. *Polit. Q.* **91**, 317–23 (2020).
59. Bladon, A. J. et al. Evaluating the ecological and social targeting of a compensation scheme in Bangladesh. *PLOS ONE* **13**, e0197809 (2018).
60. Purcell, S. W. et al. Multiple factors affect socioeconomics and wellbeing of artisanal sea cucumber fishers. *PLOS ONE* **1**, e0165633 (2016).
61. Purcell, S. W., Lalavanua, W., Cullis, B. R. & Cocks, N. Small-scale fishing income and fuel consumption: Fiji's artisanal sea cucumber fishery. *ICES J. Mar. Sci.* **75**, 1758–1767 (2018).
62. Ferreira, F., Sanchez-Paramo, C. *A Richer Array of International Poverty Lines*. World Bank Blogs (The World Bank, 2017). https://blogs.worldbank.org/developmenttalk/richer-array-international-poverty-lines.
63. Wamukota, A., Brewer, T. D. & Crona, B. Market integration and its relation to income distribution and inequality among fishers and traders: The case of two small-scale Kenyan reef fisheries. *Mar. Policy* **48**, 93–101 (2014).
64. Ferraro, P. J. & Simorangkir, R. Conditional cash transfers to alleviate poverty also reduced deforestation in Indonesia. *Sci. Adv* **6**, eaaz1298 (2020).
65. Singh, G. G. et al. A rapid assessment of co-benefits and trade-offs among Sustainable Development Goals. *Mar. Policy* **93**, 223–231 (2018).
66. Belhabib, D., Sumaila, U. R. & Pauly, D. Feeding the poor: Contribution of West African fisheries to employment and food security. *Ocean Coast. Manage.* **111**, 72–81 (2015).
67. The World Bank. *The World Bank DataBank Official Exchange Rate (LCU per US$, period average)* (The World Bank, 2021). https://data.worldbank.org/indicator/PA.NUS.FCRF.
68. The World Bank. *The World Bank DataBank Consumer Price Index (2010 = 100)* (The World Bank, 2021). https://data.worldbank.org/indicator/FP.CPI.TOTL.
69. Thomas, A. et al. Why they must be counted: Significant contributions of Fijian women fishers to food security and livelihoods. *Ocean Coast. Manage.* **205**, 105571 (2021).
70. Tilley, A. et al. Contribution of women's fisheries substantial, but overlooked, in Timor-Leste. *Ambio* **50**, 113–124 (2021).
71. United Nations. *Database on Household Size and Composition 2019* (United Nations, 2019). https://www.un.org/development/desa/pd/data/household-size-and-composition.
72. Teh, L., Cabanban, A. S. & Sumaila, U. R. The reef fisheries of Pulau Banggi, Sabah: A preliminary profile and assessment of ecological and socio-economic sustainability. *Fish. Res.* **76**, 359–367 (2005).
73. Benansio, J. S., Wolff, M., Breckwoldt, A. & Jiddawi, N. S. Have the fishing communities of Zanzibar Island benefitted from increasing tourism development? *J. Dev. Agric. Econ.* **8**, 95–107 (2016).
74. Cinner, J. E. & Bodin, O. Livelihood diversification in tropical coastal communities: a network-based approach to analyzing 'livelihood landscapes'. *PLOS ONE* **5**, e11999 (2010).
75. Amevenku, F. K. Y., Asravor, R. K. & Kuwormu, J. K. M. Determinants of livelihood strategies of fishing households in the Volta basin, Ghana. *Cogent Econ. Finance* **7**, 1 (2019).
76. Samonte, G. P. & Ortega, R. S. A Survey of small-scale fishermen's credit practices in Panay, Philippines. *Philipp. Q. Cult. Soc.* **20**, 300–316 (1992).
77. Betcherman, G. & Marschke, M. Coastal livelihoods in transition: How are Vietnamese households responding to changes in the fisheries and in the economy? *J. Rural Stud.* **45**, 24–33 (2016).
78. Olale, E. & Henson, S. The impact of income diversification among fishing communities in Western Kenya. *Food Policy* **43**, 90–99 (2013).
79. Khaing, W., Akester, M., Merayo, G. E., Bladon, A., & Mohammed, E. Y. *Socioeconomic Characteristics of Hilsa Fishers in the Ayeyarwady Delta, Myanmar: Opportunities And Challenges* (IIED, 2018).
80. Borges, L. M. M., Maulin, G. C. & Andriguetto, J. M. Analysis of income sources of fishers' families on the coast of the State of Paraná, Brazil. *J. Coast. Res.* **39**, 1267–1269 (2006).
81. The World Bank. *Poverty and Shared Prosperity 2018: Piecing Together the Poverty Puzzle* (The World Bank, 2018). https://www.worldbank.org/en/publication/poverty-and-sharedprosperity-2018.
82. FAO. *FAO Yearbook. Fishery and Aquaculture Statistics 2018* (FAO, 2020).
83. Sumaila, U. R. et al. A global dataset on subsidies to the fisheries sector. *Data Br* **27**, 104706 (2019).
84. Sumaila, U. R. et al. Updated estimates and analysis of global fisheries subsidies. *Mar. Policy* **109**, 103695 (2019).

Acknowledgements

LSLT and URS acknowledge financial support from the *OceanCanada* and the *Solving FCB* Partnerships funded by the Social Science and Humanities Research Council of Canada. URS also acknowledges support from the Killam Awards Committee, Pew Charitable Trusts and Oceana.

Author contributions

L.S.L.T. conceptualized the framework for this paper, analysed data, wrote, reviewed and revised the manuscript. L.C.L.T. contributed data and analysis of fishers' income, reviewed, and revised the manuscript. U.R.S. contributed to conceptualizing the idea for this paper, reviewed, and revised the manuscript. A.G.N. contributed data on fishers' income and reviewed the manuscript.

Competing interests

The authors declare no competing interests.

Additional information

Supplementary information The online version contains supplementary material available at https://doi.org/10.1038/s44183-024-00049-7.

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