OCEANOGRAPHY

Global estimates of fishing gear lost to the ocean each year

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Abandoned, lost, or otherwise discarded fishing gear (ALDFG) is a major contributor to ocean pollution, with extensive social, economic, and environmental impacts. However, quantitative ALDFG estimates are dated and limited in scope. To provide current global estimates, we interviewed fishers around the world about how much fishing gear they lose annually and multiplied reported losses by global fishing effort data. We estimate that nearly 2% of all fishing gear, comprising 2963 km^2 of gillnets, 75,049 km^2 of purse seine nets, 218 km^2 of trawl nets, 739,583 km of longline mainlines, and more than 25 million pots and traps are lost to the ocean annually. These estimates represent critical baselines that can inform solutions targeted to ALDFG reduction strategies.

INTRODUCTION

Sustainable fisheries are important contributors to global food security, incomes, and economies. Abandoned, lost, or otherwise discarded fishing gear (ALDFG) is an issue of concern for fisheries' sustainability because of its negative socioeconomic and environmental impacts and exacerbation of existing pressures from overfishing, declines in fish stocks, and climate change (*1*–*5*). Lost fishing gear represents a substantial sea-based source of global marine pollution, with disproportionate negative impacts to wildlife, marine and coastal habitats, and food security (*6*–*8*). The impacts of ALDFG are increasingly recognized as exacting a substantial toll on the world's oceans (*4*, *6*–*8*). International organizations including the United Nations (UN) Food and Agriculture Organization (FAO), the International Maritime Organization, and the UN Environment Programme have developed a range of hard and soft law measures to prevent and reduce ALDFG, including supporting gear marking and tracking, gear loss reporting and recovery, regulation of destructive fishing practices, minimization of pollution events, and improvements in port reception facilities for end of life gear (*9*–*13*).

To date, empirical information on how much fishing gear is lost to the oceans has been limited (*7*, *14*, *15*), despite the outdated and ill-quoted estimate of 640,000 metric tons lost each year (*16*). This insufficient information restricts the development of global ALDFG baselines necessary to inform management and policy interventions from local to global scales. Given increases in global fishing effort and improvements in fishing technologies over the past half decade (*1*, *17*), updated global ALDFG estimates are needed that reflect the current state of global fisheries and inform targeted solutions at scale (*18*).

To fill this knowledge gap, we interviewed 451 fishers from seven countries about annual gear usage and losses (Fig. 1 and tables S1 and S2). We multiplied loss rates reported by fishers interviewed by global fishing effort data and accounted for gear loss influences from vessel size and gears contacting the seafloor to estimate global fishing gear loss rates and total amounts of gear lost each year for gillnet, purse seine, trawl, longline, and pots and trap fisheries.

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RESULTS

Annual gear loss rates

Analysis of proportions of gear loss reported by all fishers interviewed across the five main gear types revealed an average annual global gear loss rate of 1.82% (±0.20%) (Table 1). On average, 0.81% (±0.19%) of all gillnets, 1.51% (±0.42%) of all purse seine nets, 3.57% (±0.86%) of all trawl nets, 3.33% (±0.59%) of all longline mainlines, and 0.74% (±0.11%) of all pots and traps are lost around the world each year (Table 1). An analysis of proportions of gear lost reported by fishers for available subgear types revealed that, on average, 3.94% (±0.97%) of all bottom trawl nets, 0.76% (±0.62%) of all midwater trawl nets, 3.58% (±0.78%) of all longline branchlines, and 2.86% (±0.55%) of all longline hooks are lost around the world each year (Table 1).

Sizes and counts of annual gear losses per vessel

Surveys revealed that 3153 m^2 (±927.98 m^2) of all gillnets, 58,130.9 m^2 (±12,451.56 m^2) of all purse seine nets, 2084.8 m^2 (±744.95 m^2) of all trawl nets, 4930 m (±660 m) of all longline mainlines, and 232.12 (±45.19) pots and traps are lost, on average, from individual fishing vessels annually (Table 1). On average, 2120.98 m^2 (±819.33 m^2) of all bottom trawl nets, 1813 m^2 (±1643.45 m^2) of all midwater trawl nets, 74,780 m of all longline branchlines (±47,040 m), and 37,913.9 (±7146.4) longline hooks are lost by each fishing vessel around the world each year (Table 1).

Sizes and counts of annual gear losses by all fishing vessels

Linear regression models for gear losses and vessel sizes (engine power) revealed a significant negative relationship for purse seine nets and a significant positive relationship for longline hooks (Fig. 2 and table S3). While no significant relationship was observed between trawl net losses and vessel size (table S3), examination of trawl gear revealed higher gear losses for bottom trawl nets compared to midwater trawl nets. A Welch two-sample t test revealed differences in the means of bottom and midwater trawl net gear losses (mean of bottom trawls = 0.04 and mean of midwater trawls = 0.003; P = 0.053; t = 1.97; df = 60.8), which were used to predict total amounts of global gear losses for bottom, midwater, and all trawl nets (Table 1).

Multiplying the gear loss estimates obtained by the fisher surveys by global fishing effort estimates (*19*) and summing across observations, we estimate that 2962.91 km^2 of gillnets (range of 1153.09 to

Fig. 1. Countries (in black) where interviews with fishers occurred. The number of surveys conducted for major gear types/fisheries are listed (bullet points) below each country name.

4772.73 km^2) and 75,048.65 km^2 of purse seine nets (range of 49,116.13 to 100,981.2 km^2) are lost from all fishing vessels around the world each year. We estimate that 217.78 km^2 of trawl nets (range of 31.68 to 478.36 km^2), composed of 2.81 km^2 of midwater trawl nets (range of 0 to 80.1 km^2), and 214.97 km^2 of bottom trawl nets (range of 31.68 to 398.26 km^2) are lost from all trawl fishing vessels around the world each year. In addition, we estimate that 739,582.8 km of longline mainlines (range of 128,549.4 to 1,350,616 km), 15,570,273 km of longline branchlines (range of 0 to 37,442,409 km), and 13,993,141,840 of longline hooks (range of 9,892,330,880 to 18,093,955,321 hooks) are lost annually. Last, we estimate that 25,382,742 pots and traps (range of 16,198,663 to 34,566,822) are lost annually (Table 1 and Fig. 3).

DISCUSSION

Relationship of gear losses to vessel and gear sizes, bottom contact, and global gear abundance

Gear losses can be influenced by operational and environmental variables and gear characteristics that vary across the gear types examined, such as influences arising from vessel and gear sizes, gears making bottom contact, and total amounts of gears used. Proportionately, more gear was lost from smaller fishing vessels (Fig. 2 and table S3). This may reflect reduced gear loss pressures and drivers associated with higher-quality gear types and better onboard navigation and fishing tools and technologies that are typically used on larger fishing vessels (*20*, *21*).

In contrast to other vessel types, larger longline vessels reported more hook losses compared to smaller vessels but fewer losses of mainlines and branchlines compared to smaller vessels (table S3). This apparent discrepancy between longline subgear types likely arises, in part, from hook losses associated with shark, fish, and other marine wildlife bite-offs as a normal part of fishing operations (*7*, *22*, *23*). Previous analyses also found a significant negative relationship between mainline losses and mainline size (*21*), which is consistent with the relationship observed, assuming that bigger vessels use larger mainlines. With thousands of hooks often used every set (fishers surveyed reported an average of 7609 hooks per set), even relatively small proportions of gear lost on a normal basis can translate into high counts of total losses over the course of a trip and year.

The higher proportion and amount of gear losses observed for bottom trawl nets, compared to midwater trawl nets, are consistent with findings from previous analyses around higher levels of gear losses for gears that make bottom contact (*7*, *21*). While outside the scope of this study, previous analyses have noted the influences from environmental and operational variables and gear characteristics in gear losses for different gear types that are fished using different techniques, including a higher likelihood of losses for gears making bottom contact and unattended and passive nets (*7*, *18*, *21*).

The notably higher amounts (sizes) of purse seine net losses compared to other net gears is influenced by larger gear sizes and a larger fishing fleet overall. For example, the average net size reported by purse seine fishers is 49,889 m^2, compared to 728 m^2 reported by gillnet fishers and 5048 m^2 reported by trawl fishers. Similarly, the global fishing effort data contain more than double the observations (with effort measured in kWxDAYS) for purse seine vessels (4,167,428) compared to 2,018,342 observations for all gillnet vessels and 3,798,747 observations for all trawl vessels (*19*).

Despite these relatively high amounts of purse seine nets lost annually compared to other net gear types, whole gear losses are rare for purse seines and other nets. Purse seine fishers lost the smallest portion of their nets on average (average of 19% of the total net lost when losses occur), compared to an average of 43% of gillnet panels and 41% of trawl nets.

Findings in context

The proportions of gear loss reported by fishers across all gear types and countries are generally much lower than those estimated from a 2019 global meta-analysis that examined gear losses reported

Table 1. Global annual gear loss estimates for gillnets, purse seine nets, trawl nets, longlines (mainlines, branchlines, and hooks), and pots and traps. The gear type "all gears" includes combined estimates of gear losses for purse seine nets, trawl nets, longline mainlines, and pots and traps. CI, confidence interval; NA, not applicable.

Gear types	Average percent lost	Lower 95% CI	Upper 95% CI	Size lost/vessel	Lower 95% CI	Upper 95% CI	Sum of sizes lost/all vessels	Lower 95% CI	Upper 95% CI
Gillnets	0.81%	0.62%	1.00%	3153 m^2	2225.02 m^2	4080.98 m^2	2962.91 km^2	1153.09 km^2	4772.73 km^2
Purse seine nets	1.51%	1.09%	1.93%	58,130.9 m^2	45,679.34 m^2	70,582.46 m^2	75,048.65 km^2	49,116.13 km^2	100,981.2 km^2
Trawl nets: All	3.57%	2.71%	4.43%	2084.8 m^2	1339.85 m^2	2829.75 m^2	217.78 km^2	31.68 km^2	478.36 km^2
Bottom trawl nets	3.94%	2.96%	4.91%	2120.98 m^2	1301.65 m^2	2940.32 m^2	214.97 km^2	31.68 km^2	398.26 km^2
Midwater trawl nets	0.76%	0.14%	1.38%	1813 m^2	169.55 m^2	3456.45 m^2	2.81 km^2	0.00 km^2	80.10 km^2
Longlines: Mainlines	3.33%	2.78%	3.96%	4.93 km	4.27 km	5.60 km	739,582.8 km	128,549.4 km	1,350,616 km
Longlines: Branchlines	3.58%	2.80%	4.36%	74.78 km	47.04 km	102.52 km	15,570,273 km	0 km	37,442,409 km
Longlines: Hooks	2.86%	2.31%	3.41%	37,913.9 hooks (count)	30,767.5 hooks	45,060.3 hooks	13,993,141,840 hooks (count)	9,892,330,880 hooks (count)	18,093,955,321 hooks (count)
Pots and traps	0.74%	0.63%	0.85%	232.12 pots and traps (count)	186.93 pots and traps (count)	277.31 pots and traps (count)	25,382,742 pots and traps (count)	16,198,663 pots and traps (count)	34,566,822 pots and traps (count)
All gears	1.82%	1.62%	2.03%	NA	NA	NA	NA	NA	NA

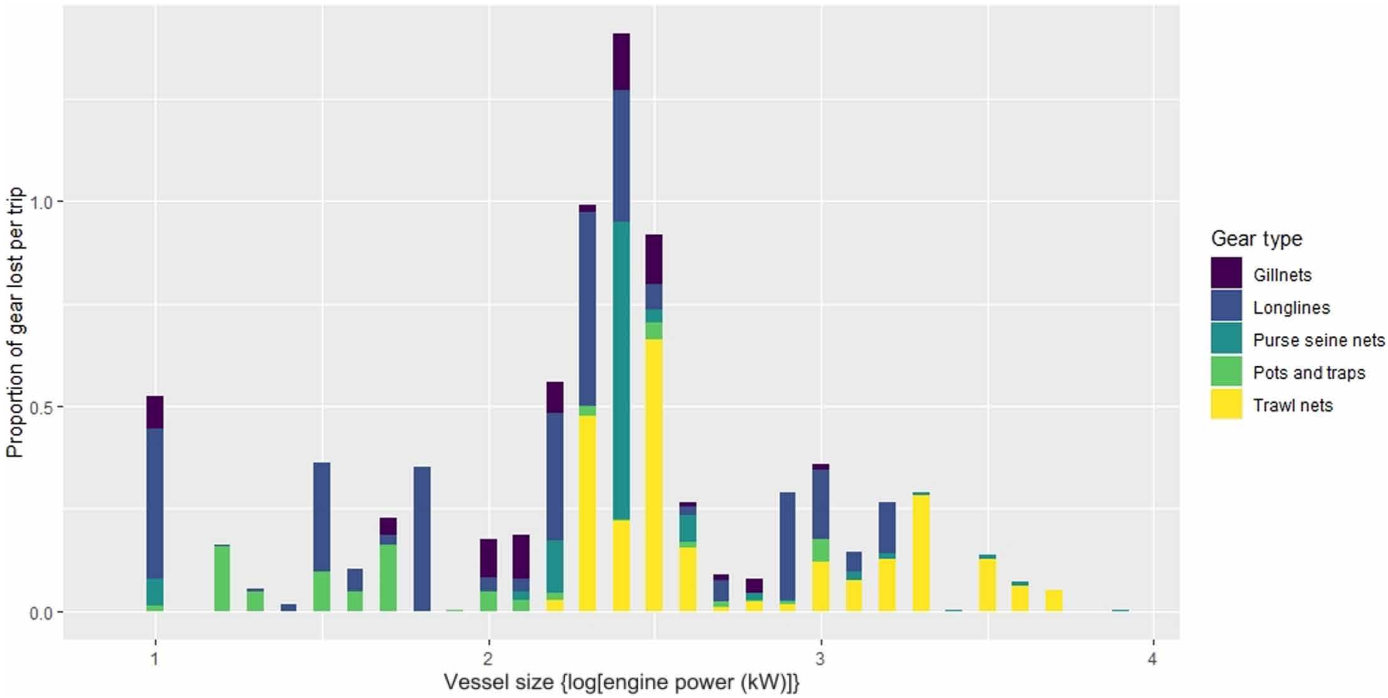

Fig. 2. Relationship of gear losses to vessel sizes [log engine power (in kW)] across each of the five gear types surveyed.

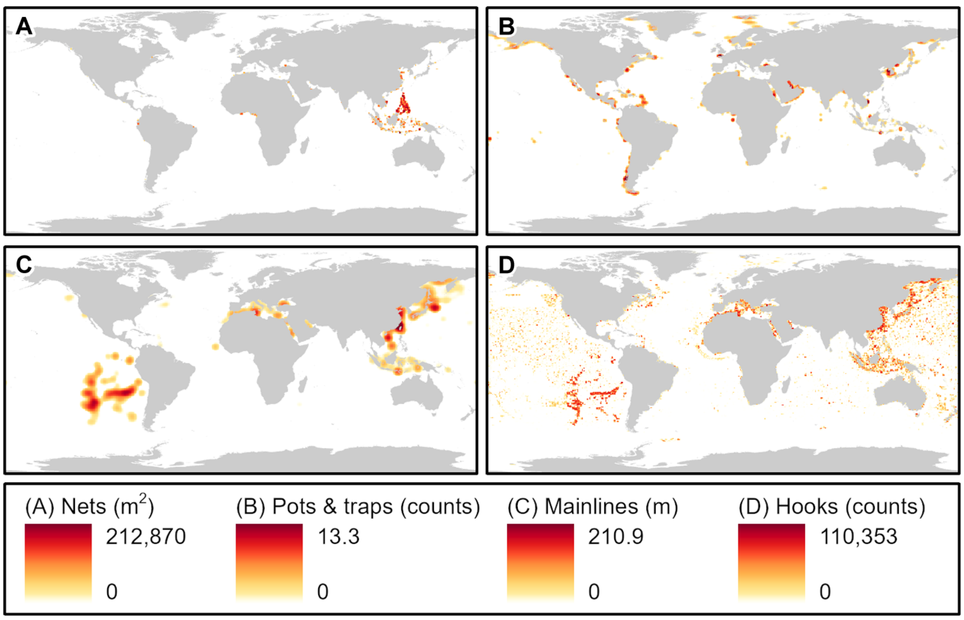

Fig. 3. Global fishing gear losses for (**A**) all nets (gillnet, purse seine net, and trawl net gears combined) (in m^2), (**B**) pots and traps (counts), (**C**) longline mainlines (m), and (**D**) longline hooks (counts). Legend scales show units of gear losses per square kilometer of ocean. Note that the gamma (heat) levels vary across maps to best contrast areas of high and low losses specific to the individual gears presented. Maps are provided for general visualization purposes, and readers should refer to Table 1 for specific gear loss estimates including how these compare across gears. Map credits: Jessica Embury, Esri 2021. Maps were created using ArcGIS software by Esri. ArcGIS and ArcMap are the intellectual property of Esri and are used herein under a license. Copyright to Esri. All rights reserved. For more information about the Esri software, please visit www.esri.com

across scientific and gray literature from 1975 to 2017 (*7*). The differences may reflect reductions in some gear loss pressures in recent years, as well as improvements in the quality of gear and vessel technologies. For example, fishers are increasingly using higher-quality and more selective gears, and improvements are increasingly seen in onboard navigation and weather forecasting technologies (*20*, *24*, *25*). Reduced gear loss estimates may also reflect fisheries' management measures that facilitate gear marking, tracking, and lost gear reporting and retrieval (*6*, *9*, *20*). Fishers may also report lower ranges of gear losses due to overall negative attitudes and repercussions associated with reporting perceived high levels of gear losses, compared to gear losses estimated by scientists, management agencies, or nongovernmental organizations (NGOs) where these negative perceptions and impacts may be less direct and acute (*26*–*28*). Other challenges associated with survey data could include response biases, such as influences from social desirability and demand biases, as well as interviewer or presence of third party effects (*29*–*31*), which can result in the presentation of more conservative estimates by respondents.

Estimates for counts of annual global pot and trap losses per vessel were very similar to those in the 2019 global ALDFG meta-analysis (232.1 ± 45.2 in this study compared to 259.8 ± 30.3 from the meta-analysis) (*7*). This may reflect robust sampling, as evidenced by the high number of pot and trap observations reviewed in the meta-analysis (n = 202 pot- and trap-specific loss records) (*7*). By contrast, sample sizes available from the published literature in the meta-analysis were more limited across a more diverse array of multiple net types (n = 279 for gillnet, purse seine net, and trawl net loss records combined) and line types (n = 92 for handline, pole-line, longline, and trolling line records combined) (*7*), which limited comparisons of estimates to the current dataset.

While this study presents gear loss estimates in proportions and sizes of gears lost, other ALDFG studies occasionally present total ALDFG estimates in masses (e.g., kilograms or tons) lost across a variety of different gear types (*6*, *14*, *15*). Given highly variable and sometimes considerable differences in masses across disparate gear types, proportions, sizes (lengths, areas, and volumes of gears), and counts of gear losses are more comparable metrics (*7*, *16*). For example, the masses of monofilament fishing lines and hooks are generally substantially less than large nets (especially trawl or purse seine nets) and pots and traps. Mass-based comparisons of losses among different gears can, thus, be misleading as to the actual amounts and sizes of gears lost. Richardson *et al.* (*16*) additionally discuss misperceptions around the oft-cited but imprecise estimate that 640,000 metric tons of ALDFG enters the oceans each year, and reasons why attempts to improve and update global ALDFG estimates, such as the estimates presented by this study, are not comparable to this unsubstantiated estimate. Some work is underway to detail typical masses associated with various fishing gears, which, once complete, can be used to translate these and other ALDFG estimates into mass-based estimates where such metrics are determined to be relevant for monitoring and assessment efforts (*32*).

The notable magnitude of some gear losses, such as the more than 13 billion longline hooks lost annually, and serious adverse impacts caused by ghost fishing are worth noting. Ghost fishing results in potentially substantial losses of protein resources, habitat damage, and the ensnarement of threatened and endangered species (*8*, *11*, *18*). For example, with a 71% decline in global shark and ray populations over the last half century (*33*), threats to shark populations can be seriously exacerbated by longline hook bite-offs and sharks becoming entangled in lost net gear. The gear loss estimates presented in this study can inform future research, aiming to quantify impacts of gear losses upon marine wildlife and ecosystem health, including impacts to threatened and migratory species in areas of high known fishing activity.

Where this study predicts that nearly 2% of all fishing gear used becomes ALDFG annually, in comparison to land-based sources of marine plastic waste, it was estimated that 1.7 to 4.6% of all plastic waste generated in coastal regions entered the oceans as mismanaged waste in 2010 (*34*) and that 11% of plastic waste generated globally entered the world's oceans in 2016 (*35*). Recognizing that fishing gear is designed to catch and kill marine life, caution should be exercised when comparing ALDFG to other types of land and ship-sourced marine plastic waste given the often-disproportionate impact of ALDFG to living marine resources through entanglement, ingestion, and ghost fishing (*8*, *11*, *18*).

While this study estimated gear losses from largely commercial fisheries, serious knowledge gaps remain around amounts of gear losses from artisanal and recreational fisheries and from illegal, unreported, and unregulated (IUU) fishing activities. While challenging to estimate, IUU fishing is an important driver and underlying cause of ALDFG (*18*, *20*). Additional gear types of concern suitable for subsequent global analysis include drifting and anchored fish aggregating devices due to their prolific numbers and associated impacts worldwide (*7*, *36*–*38*), as well as other commonly used gears around the world including pole and line and dredge gears (*17*). More work is also required to better quantify and understand amounts and impacts of ALDFG arising from aquaculture as it increases around the world (*1*, *18*, *39*).

Together, these estimates represent the most comprehensive and contemporary examination of quantitative amounts of ALDFG globally to date using data obtained directly from fisher interviews and global fishing effort data. The estimates can be used by fishers, managers, policy-makers, NGOs, and researchers to inform new risk assessments for the employment of different fishing gears, as well as to modernize and improve upon previous ALDFG risk assessments [e.g., (*40*, *41*)]. Risk assessments that consider gear loss rates, total fishing effort (including number of fishers and vessels, vessel and gear sizes, soak time, and number of sets), and gear loss pressures and drivers will be most informative. These estimates additionally modernize ALDFG baselines, which are necessary for monitoring ALDFG presence and impacts and measuring the effectiveness of interventions designed to prevent and reduce ALDFG, particularly in areas of the world where very little to no quantitative ALDFG data are otherwise available.

MATERIALS AND METHODS

Surveys

We conducted an average of 15 fisher interviews for each of the five major gear types (gillnets, purse seine nets, trawl nets, longlines, and pots and traps) in seven different countries (Fig. 1 and tables S1 and S2). One country was selected from each of seven key marine regions/continents of the world, excluding Antarctica (Africa, Asia, the Caribbean, Europe, North America, Oceania, and South America; Fig. 1). In selecting the countries where surveys were conducted, we required that a country's fisheries (i) use most or all five gears examined and (ii) have a combination of the highest amounts of capture production, number of fishing vessels, and number of fishers in the region represented as measures for overall fishing effort. Where a country did not have active commercial fisheries for all five gear types, surveys were conducted for the available gear types used in that country. Data around a country's total capture production, fishing vessels, and fishers were obtained from FAO's 2016 Fisheries and Aquaculture Statistics Yearbook (*42*). Financial, time, and human resource limitations; geopolitical considerations; and availability and access to in-country contacts to conduct surveys restricted the number of countries available for surveys to be conducted.

Countries were selected as follows: Indonesia ranked second globally for amounts of capture production and fishing effort in 2016 (selected from Asian countries). Iceland ranked 19th (selected from European countries). The United States ranked fourth (selected from North American countries). New Zealand ranked 40th (selected from Oceania countries). Peru ranked sixth (selected from South American countries), and Morocco ranked 17th (selected from African countries) (*21*). While Belize did not rank among the top countries globally for amounts of "capture production by principal producers in 2016," "number of fishing vessels," and "number of fishers," it was selected from the Caribbean region given the availability of and access to in-country contacts (*21*).

All fisher interviews used the same survey forms for each gear type, in English and in the native language(s) of the country surveyed (Arabic, Bahasa Indonesian, Berber, English, French, Icelandic, and Spanish; see Supplementary Survey Forms, English version, in data S1 to S5) (*21*). Surveys included questions about total amounts of gears used and lost per trip and annually, sizes of gears used and lost, general fishing conditions and background of fishers surveyed, and relevant fishing effort information [see data S6 for all data reported by fishers in the interviews, in response to the survey questions (data S1 to S5)]. The Tasmania Social Sciences Human Research Ethics Committee granted ethics approval for the surveys on 13 July 2018. Surveys were carried out from 21 January 2019 to 3 December 2019.

Fishers were selected randomly by interviewers at each port, dependent on which fishers happened to be present at the port on the day(s) of the interview, and were willing to spend between 5 and 15 min to answer survey questions (*21*). In rare instances where fisher presence at ports was limited and available fishers are hard to find (e.g., typically long fishing trips away from port and small or remote fishery locations), the interviewer(s) used the snowball sampling method, with research participants (fishers) suggesting other fishers available for interviews and sharing their contact information (*21*). Each survey was completed by the interviewer interviewing one individual fisher. Fishers received and/or were read a background information document regarding the study and signed confidentiality agreements for their participation in the study. Interviewers read questions to participants, and surveys were available to the fishers to follow along. Responses provided by fishers were based on individual fisher memory and knowledge. If a fisher did not understand a question, then they could ask the interviewer for clarification, who was available to clarify questions without biasing responses. If the participant still did not understand a question, then the reviewer noted this on the survey, and the question remained unanswered for the interview. All surveys included in the study were completed by the interviewer and the participant. If a survey was not completed by the interviewer and the participant, then it was not included in the study.

Summary statistics

Data obtained from surveys were used to estimate total proportions, sizes, and counts of gears lost annually for vessels and fleets on the global scale (fig. S1). Given that losses of entire nets are rare, especially for purse seine and trawl nets (*7*), we asked fishers about the average proportion of net lost when gear is lost (see gillnet, purse seine net and trawl net surveys in the Supplementary Materials). This value was then multiplied by the total number of net gear items reported lost.

To determine the proportion of gear losses, we divided the number of gear items reported as lost per trip by the number of gear items reported as used per trip. The proportion of gear loss estimations is unitless and, thus, can be applied to both trip and annual gear losses, as well as across vessel and fleet losses. The SEM was used to calculate lower and upper 95% confidence intervals (CIs) for the average proportion of gear loss estimates.

To quantify the size of gear lost per vessel annually, we multiplied the reported size of the gear item used by the count of gear items lost annually. Gillnet losses were estimated by the number of gillnet panels lost, as whole net loss is rare. Gillnet panel sizes and purse seine net sizes were calculated by multiplying panel/net lengths (in meters) by panel/net depths (in meters). We calculated trawl net sizes using the surface area of a pyramid and removing the base (given that trawl nets open at the mouth). We multiplied trawl headline length (i.e., perimeter; in meters) by the length of the trawl net from the wing end to the cod end (i.e., slant height; in meters) and divided this product by two. Longline mainline and branchline losses were reported in lengths lost (in kilometers and meters, respectively). Longline hooks and pots and traps were reported as counts of whole gear items lost. We did not include attached gear items such as buoys and lines. The SEM was used to calculate lower and upper 95% CIs for estimates of average sizes and counts of gear lost per vessel annually.

Statistical analyses

The total global annual gear loss estimates were determined by multiplying the gear loss estimates obtained from the fisher interviews by 2015 global fishing effort data (as the most recent year available for global fishing effort data) (*19*) and summing across all observations. Global fishing effort data were measured in engine power (in kilowatts) by days fished per year (days; i.e., kWxDAYS) (*19*). To work with comparable units of measurement, we divided gear loss estimates determined from the fisher surveys (measured in sizes and counts) by the product of the corresponding vessel engine power (in kilowatts) and days fished per year (days) [i.e., size(s) or count(s) of gear lost/kWxDAYS]. Missing values for vessel and gear loss metrics including engine power, tonnage, fish holding capacity, and gear sizes were imputed using the multivariate imputation by chained equations package "mice" (*43*) in the R statistical language (*44*).

We used linear regression to ask whether there was a significant relationship between gear losses and vessel size [engine power (in kilowatts)] (fig. S1). For trawl nets, we used a Welch two-sample *t* test to evaluate whether there is a relationship between gear losses and nets making bottom contact. If no significant relationship existed, then we multiplied the average gear loss estimate from the global fisher surveys [measured in size(s) or count(s) of gear lost/kWxDAYS] by global fishing effort observations (measured in kWxDAYS) and summed across all observations to obtain our global estimates for fishing gear losses, presented as sizes and counts of gears lost (fig. S1).

Where a significant relationship existed between gear losses and vessel size and for trawl net gears, gear losses, and nets making bottom contact, we tested a variety of models [including generalized additive models with smoothing splines as implemented in the mgcv package (*45*), exponential functions with and without a zero intercept as implemented in the drc package (*46*), and first-order linear functions as implemented in the base R (*41*)] to determine the best model for this relationship. The best model was determined according to best overall fit to data and the statistical significance of terms for nested models. We used the best model of the relationship between gear losses and vessel size [engine power (in kilowatts); and, for trawl net gears, gear losses and bottom contact] to predict global amounts of gear losses [measured in size(s) and count(s) of gear lost/kWxDAYS] across vessel power classes. Because the power classes in the global fishing effort data were provided in ranges (*19*), we used the midpoint of each power class range for the corresponding engine power observation in the global effort data. We used the minimum vessel size reported by global fisher interviews to determine the lowest power class range to include from the global fishing effort data. This resulted in the exclusion of loss estimates for unpowered purse seine and longline vessels, as global fisher interviews were only conducted for powered vessels. Last, we multiplied the average gear loss estimate [measured in size(s) and count(s) of gear lost/kWxDAYS] across vessel sizes derived from the fisher surveys by the global fishing effort observations (kWxDAYS) and summed these products (fig. S1).

SUPPLEMENTARY MATERIALS

Supplementary material for this article is available at https://science.org/doi/10.1126/sciadv.abq0135

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Acknowledgments: We dedicate this work to the memory of Joanna Toole for collaboration on and support for this project and commitment to decreasing global amounts of abandoned, lost, or, otherwise, discarded fishing gear. We thank CSIRO's Oceans and Atmosphere and the University of Tasmania for supporting this research. We thank A. C. Widyatmoko (Indonesia), B. I. Erquiaga (Peru), E. Bjarnason (Iceland), E. Hogan (Belize and the United States), F. Rahmani (Morocco), and S. Bishop (New Zealand) for assistance in organizing and conducting the interviews with fishers. We thank Y. Rousseau for assistance in sharing and communicating the 2015 global fishing effort data. **Funding:** This work was funded by the Arts Tasmania Graduate Research Scholarship, School of Social Sciences, College of Arts, Law, and Education, University of Tasmania (to K.R.), CSIRO Top-up Scholarship, Commonwealth Scientific and Industrial Research Organisation (to K.R.), and Commonwealth Scientific and Industrial Research Organisation (CSIRO), Oceans and Atmosphere (to B.D.H. and C.W.). **Author contributions:** Conceptualization: B.D.H., C.W., and K.R. Formal analysis: C.W. and K.R. Funding acquisition: B.D.H., C.W., J.V., and K.R. Investigation: K.R. Methodology: C.W. and K.R. Project administration: B.D.H. and J.V. Resources: B.D.H. and C.W. Software: C.W. and K.R. Supervision: B.D.H., C.W., and J.V. Visualization: B.D.H., C.W., J.V., K.R. Writing (original draft): K.R. Writing (review and editing): B.D.H., C.W., J.V., and K.R. **Competing interests:** The authors declare that they have no competing interests. **Data and materials availability:** All data needed to evaluate the conclusions in the paper are present in the paper and/or the Supplementary Materials.

Submitted 12 March 2022
Accepted 26 August 2022
Published 12 October 2022
10.1126/sciadv.abq0135