

Global marine fisheries discards: A synthesis of reconstructed data

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Abstract

As part of the global marine fisheries catch reconstruction project conducted by the *Sea Around Us* over the last decade, estimates were derived for discards in all major fisheries in the world. The reconstruction process derives conservative but non-zero time-series estimates for every fisheries component known to exist, and relies on a wide variety of data and information sources and on conservative assumptions to ensure comprehensive and complete time-series coverage. Globally, estimated discards increased from under 5 million t/year ($t = 1,000$ kg) in the early 1950s to a peak of 18.8 million t in 1989, and gradually declined thereafter to levels of the late 1950s of less than 10 million t/year. Thus, estimated discards represented between 10% and 20% of total reconstructed catches (reported landings + unreported landings + unreported discards) per year up to the year 2000, after which estimated discards accounted for slightly less than 10% of total annual catches. Most discards were generated by industrial (i.e. large-scale) fisheries. Discarding occurred predominantly in northern Atlantic waters in the earlier decades (1950s–1980s), after which discarding off the West Coast of Africa dominated. More recently, fleets operating in Northwest Pacific and Western Central Pacific waters generated the most discards. In most areas, discards consist essentially of marketable taxa, suggesting a combination of poor fishing practices and poor management procedures is largely responsible for the waste discarding represents. This is important in an era of increasing food security and human nutritional health concerns, especially in developing countries.

KEYWORDS

catch estimation, catch reconstruction, ecosystem effects of fishing, fisheries impacts, overfishing, unreported catch

1 | INTRODUCTION

Total global marine fisheries catches as derived through comprehensive catch reconstructions (Zeller, Booth, Davis, & Pauly, 2007; Zeller, Harper, Zylich, & Pauly, 2015; Zeller & Pauly, 2016) peaked in the mid-1990s, and are declining more rapidly than official data reported by member countries to the Food and Agriculture Organization (FAO)

of the United Nations suggest (FAO 2016; Pauly & Zeller, 2016a,b, 2017b). Included in these reconstructed data (but omitted in official FAO statistics) are global estimates of catches discarded by fishing fleets. These discards, that is fish and other marine life that are thrown overboard are not identical to “by-catch,” that is fish and other marine organisms that are caught although they were not targeted. By-catch may or may not be discarded. When target species are discarded, this

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is called “high-grading,” a specific form of discarding often occurring in quota fisheries, but not further discussed here.

Most fisheries and their associated fishing gears catch species or individuals that are not wanted by fishers, either because they are too small, damaged, inedible, have little or no market value, or cannot be retained due to management or quota restrictions (i.e. regulatory discarding). This regulatory discarding (together with high-grading) is a major problem and shortfall of individual transferable quota (ITQ) fisheries, such as in Europe and elsewhere, if it is not curtailed via well-enforced discard bans. Active bottom-contact gears (e.g. bottom trawls), one of the most wide-spread large-scale (i.e. industrial) fishing gear around the world, are known to generally produce the highest discarding of any fishing gear, and in many countries, this has become a cause of concern. The high incidence of discarding by active bottom-contact gear was noted early in the development of industrial fishing (Kennelly & Broadhurst, 2002), for example before and during WWII fisheries in the North Sea (Gilson, 1935) or off the East Coast of the USA (Merriman & Warfel, 1948). Several countries have banned trawl gear entirely (e.g. Belize; Statutory Instrument No. 10 of 2011, Fisheries (Amendment) Regulations, 2011, <http://ambergriscaye.com/art/pdfs/fisheriesamendment0001trawling.pdf>), while others have implemented discard bans (e.g. Norway). The recent revision of the EU Common Fisheries Policy also calls for the banning of discards ([www.europarl.europa.eu/RegData/bibliotheque/briefing/2013/130436/LDM_BRI\(2013\)130436_REV1_EN.pdf](http://www.europarl.europa.eu/RegData/bibliotheque/briefing/2013/130436/LDM_BRI(2013)130436_REV1_EN.pdf)). While the declaration of Exclusive Economic Zones (EEZs) gave countries the opportunity to address (and reduce) levels of discarding, high seas waters beyond national jurisdiction face few if any such measures (Rosenberg, Mooney-Seus, & Ninnnes, 2005), even if managed by Regional Fisheries Management Organizations (Cullis-Suzuki & Pauly, 2009, 2010). Furthermore, for periods prior to the declaration of Exclusive Economic Zones by individual countries, most of these waters (beyond territorial seas of generally 3 nm) were high seas areas outside of most management interventions.

Given that the international community and a growing number of individual countries now openly call for or implement principles of “ecosystem-based fisheries management” (in a wide variety of forms and names), it behoves us to comprehensively address the issue of discarded catches in global fisheries statistics. Historically, the only global database on fisheries catches, namely that conscientiously assembled each year by the FAO based on annual reports by countries, explicitly requests its member countries to exclude discards from their reports to FAO. Thus, the database assembled by FAO is a “landings” database (or “production” database in FAO terminology) covering only catches that are retained, landed and officially registered. This definitional distinction seems to have its origin largely in the market-economics development focus of early post-WWII UN data systems (Ward, 2004). The challenges faced by FAO to annually assemble and harmonize these global landings data, as described in Garibaldi (2012), should nevertheless be recognized, and the efforts applauded, as it is a daunting task.

As part of FAO's separate efforts to provide information on discards, FAO has undertaken periodic global reviews of discarding, for

example in the early 1990s (Alverson, Freeberg, Pope, & Murawski, 1994) and again in the early 2000s (Kelleher, 2005), which updated earlier global estimates by Anonymous (1982) and Saila (1983). Currently, another discard review and update is in progress (FAO 2016). Zeller and Pauly (2005) synthesized and interpreted the findings on discards by Alverson et al. (1994), Kelleher (2005) and other authors in the context of reported landings (i.e. FAO landings or “production” data), and supported the conclusion of Kelleher (2005) that globally, discards were declining from higher levels in earlier decades. This decline in discarding was celebrated as a success of improved fisheries management, which is a welcome step in the right direction for sustainable fisheries (Pauly et al., 2002) and reduction in wastage. The suggestion by Zeller and Pauly (2005) that the declining discard trend also amplified a declining trend in total withdrawals (i.e. reported landings plus discards) has now been confirmed by the recently completed, decade-long global catch reconstruction project of the *Sea Around Us* (Zeller et al., 2016), which added comprehensive estimates of unreported catches and major discards to the reported data for every country in the world (Pauly & Zeller, 2016a,b). This global, networked effort of improving global catch statistics by over 300 colleagues around the world clearly documents that we have been catching far more fish than we previously thought; but more importantly, that global catches are declining at a rate approximately three times higher than official reported statistics such as those reported by FAO on behalf of countries suggest (Pauly & Zeller, 2016a). The main drivers of this decline from peak catches in 1996 are declining industrial (i.e. large-scale) fisheries landings, and to a much smaller extent, also declining global discards (Pauly & Zeller, 2016a,b).

Here, we will not re-emphasize the policy, governance and conservation concerns that declining global catches should raise around the world (Pauly and Zeller 2016a,b, 2017b), but focus instead on synthesizing and assessing the global discard data we assembled as part of the global catch reconstruction efforts (Pauly and Zeller 2016a,b). Catch reconstruction principles require that in the absence of detailed time-series data and information, an assumption-based approach should derive conservative minimal estimates for any fisheries component that is known to exist (Zeller et al., 2016). Thus, we consider that our global summary of discards is likely a minimal estimate.

2 | METHODS

The *Sea Around Us* reconstructed the marine fisheries catches for all countries in the world. This process focused on deriving comprehensive estimates of all unreported landings and major unreported discards, and combining these with the officially reported data as provided by countries to the Food and Agriculture Organization by FAO statistical areas (Figure 1a). Every country reconstruction derived its own independent data and information sources relevant to each country's specific situation with regard to unreported catches and discards, but all followed the general reconstruction principles and process as first outlined in Zeller, Booth, Davis, & Pauly (2007) and subsequently refined in Zeller et al. (2015) and Zeller et al. (2016).

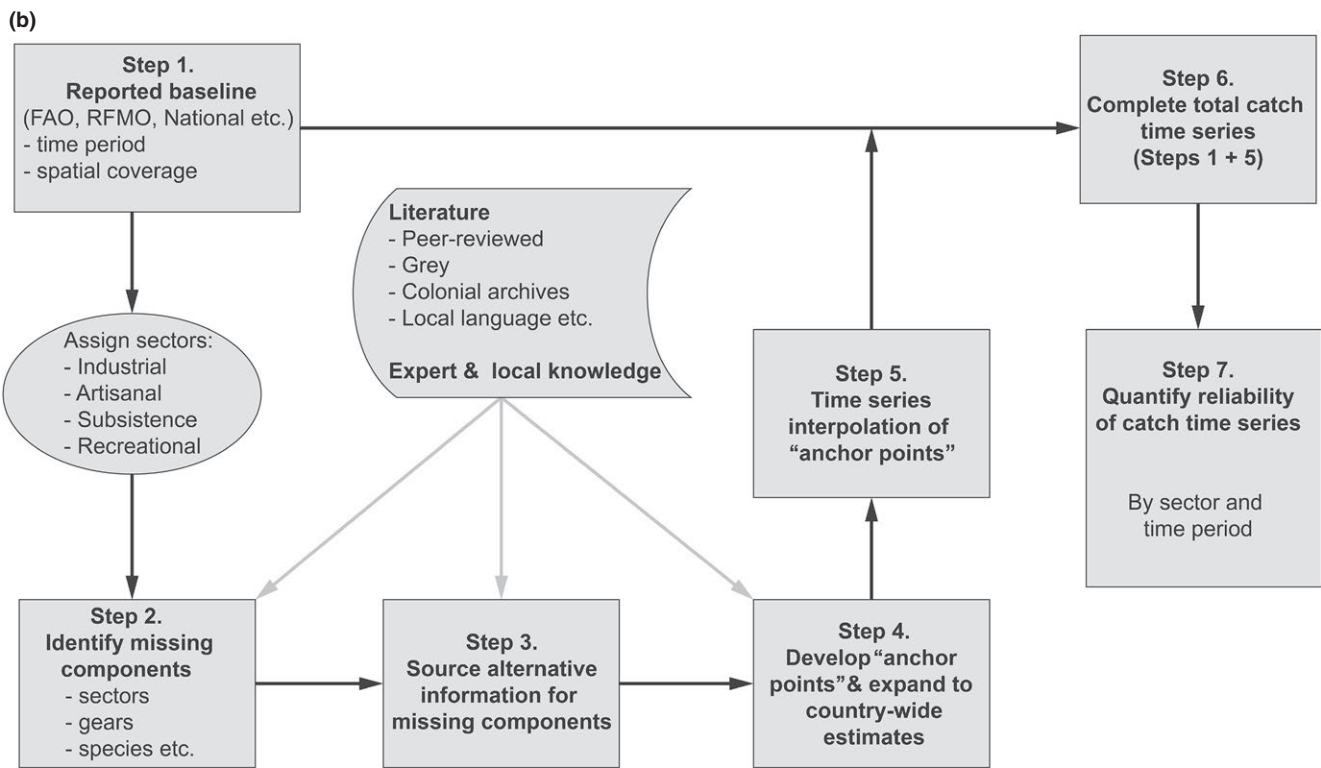
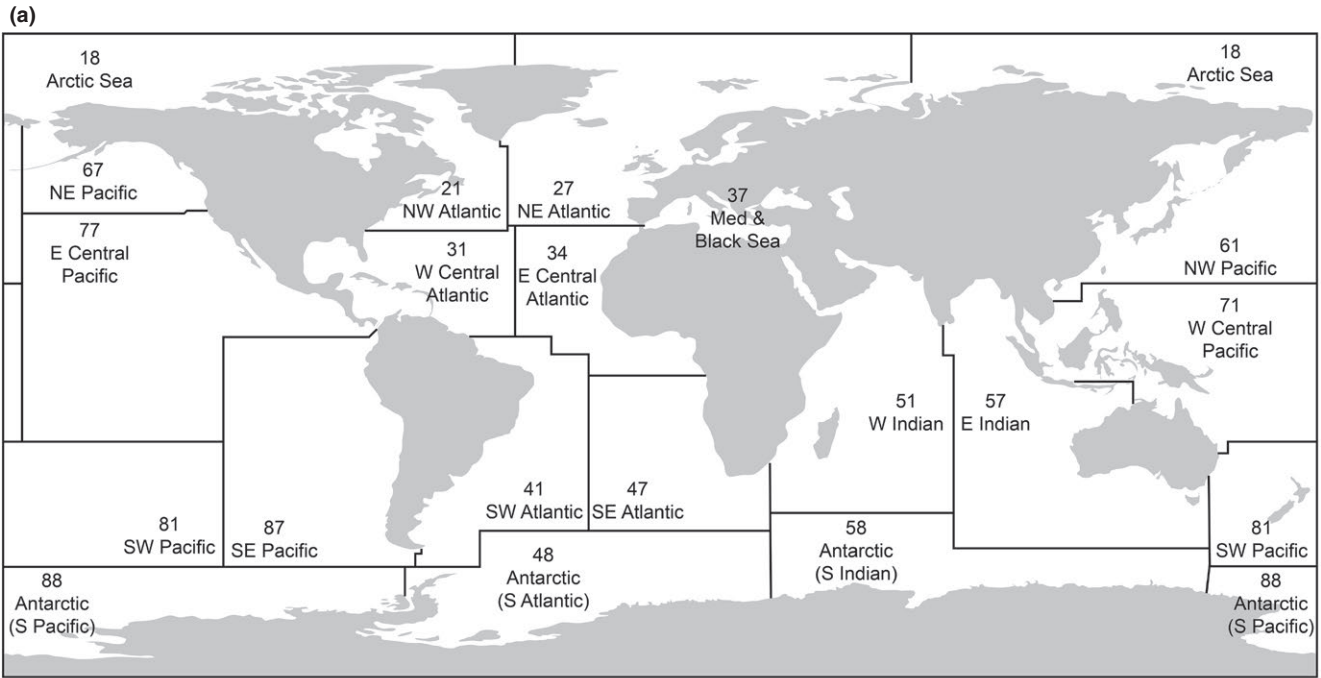


FIGURE 1 (a) Map delineating the statistical area system used by FAO for global reporting of capture statistics; and (b) Diagrammatic representation of the catch reconstruction process as first described in Zeller, Booth, and Pauly (2007) and refined in Zeller et al. (2015) and Zeller and Pauly (2016). Figure first published in Zeller et al. (2016)

The general reconstruction process is summarized in Figure 1b, and its overall integration into the *Sea Around Us* spatial database is described in Zeller et al. (2016). Details of estimation and data sources for each of the over 270 reconstructions are documented in the individual technical reports and papers underlying each country catch reconstruction. These technical reports are freely available on each country

page at www.seaaroundus.org, as are data sets which are downloadable by each country.

With regard to the estimation of major sources of discards by each country's fisheries, a variety of local primary studies and reports were used, in addition to the well-documented and comprehensive work and data provided in Kelleher (2005). For specifics on each

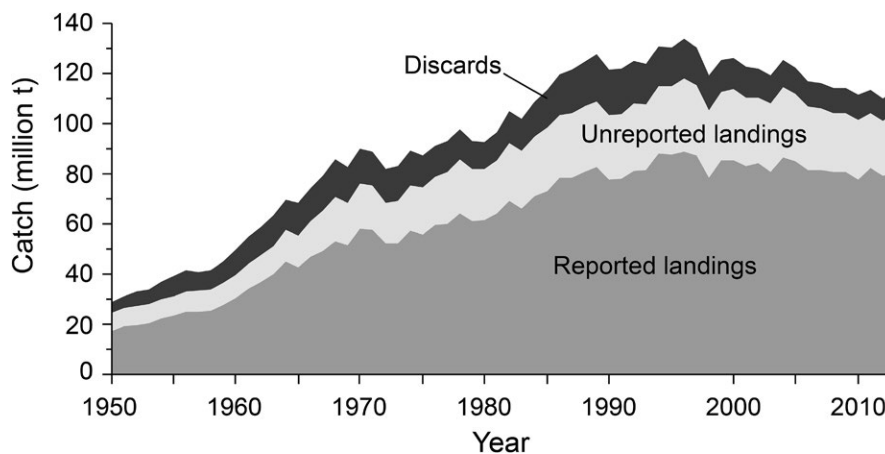
discard estimation by country, the individual technical country reconstruction reports can be consulted at www.searoundus.org. Here, we present a synthesis and overview of the global discards data as reconstructed and spatially allocated to a global $\frac{1}{2} \times \frac{1}{2}$ degree cell grid system developed by the *Sea Around Us* (Zeller & Pauly, 2016; Zeller et al., 2016). For the current synthesis, we utilize the *Sea Around Us* catch data version 45, which include global data to the year 2014, and which is available online at www.searoundus.org. Throughout all reconstructions, emphasis was placed on conservative estimation to avoid over-estimation. Generally, only major fisheries had discards estimated in each country. Furthermore, some data sources on discards only cover marketable species, while others also include non-marketable taxa. Although we tried to account for such discrepancies, some discard rates and taxonomic compositions derived from such sources may lead to considerable under-estimation of total discards. This suggests that our discard estimates are minimal estimates at the global scale.

3 | RESULTS

3.1 | Global total catch and discards

Total marine catches (i.e. reported and unreported landings + estimated discards), as derived through catch reconstructions and documented in Pauly and Zeller (2016a) increased from around 28 million t/year in 1950 (of which 17 million t were reported) to a peak of just under 130 million t/year in 1996 (86 million t reported) before declining at a rate of 1.2 million t/year thereafter (Figure 2). Reconstructed discards increased from under 5 million t/year in the early 1950s to their peak of just under 19 million t in 1989, and have gradually declined since then to levels of the late 1950s of less than 10 million t/year (Figure 2). These levels of discarding represent between 10% and 20% of total reconstructed catches per year until the year 2000, after which discards account for slightly less than 10% of total annual catches. The vast majority of discards (around 93% averaged over 1950–2014) were made by industrial (i.e. large-scale) fisheries, while small-scale fisheries contributed very little to global discarding.

FIGURE 2 Total global reconstructed catches (Pauly & Zeller, 2016a,c), separated into reported landings (data reported by FAO on behalf of member countries), unreported landings and estimated discards (both as estimated by individual country-specific catch reconstructions). Here, all data have been updated to 2014. Note that, in line with Zeller et al. (2016), these data exclude marine mammals, reptiles and plant material, as well as all freshwater catches



3.2 | Discard patterns by geographical area

Examining the distribution of estimated discards by ocean basins illustrates that discards in the Atlantic Ocean dominate the earlier decades, peaking at just over 10 million t in 1968, with a secondary peak of around 7.8 million t in the late 1980s, before declining to around 3 million t/year by the mid-2010s (Figure 3a). In contrast, after the early 1980s, most discards occurred in the Pacific Ocean, peaking at over 9 million t in 1990 before declining to just under 5 million t/year by 2014 (Figure 3a). Discards in the Indian Ocean (around 1 million t/year) and the Mediterranean and Black Seas (200,000–500,000 t/year) are relatively low in comparison.

Five FAO statistical areas (Figure 1a) in these two ocean basins (Atlantic and Pacific) dominate reconstructed global discard data over the last 60+ years. The decades prior to 1980 are entirely dominated by discards in the Northwest and Northeast Atlantic (FAO areas 21 and 27, Figure 1a), while the Eastern Central Atlantic (FAO area 34) dominates Atlantic discards since the 1980s (Figure 3b). Discards in the Pacific (Figure 3b) are predominantly coming from the Northwest Pacific (FAO area 61), and secondarily from the Western Central Pacific (FAO area 71).

Within the three Atlantic areas that contributed most to discards (Northwest, Northeast and Eastern Central Atlantic, Figure 3b), most discards in two of the areas (Northwest and Central Eastern Atlantic) were generated largely by distant-water fleets flying flags for countries outside these areas (Figure 4a,b), although several local countries also contributed as to be expected, such as Canada and the USA in the Northwest Atlantic (Figure 4a). In contrast, discarding in the Northeast Atlantic was almost exclusively by local countries in this highly industrialized FAO area (Figure 4c).

In contrast to much of the Atlantic, local countries dominate discards in the Pacific (Figure 4d,e). For example, Russia dominates discarding in the Northwest Pacific, accounting for over 50% in recent decades, on average, with Japan and South Korea (mainly in earlier decades), and more recently China also contributing substantially (Figure 4d). Similarly, in the Western Central Pacific (FAO area 71), discarding is dominated by local fishing countries, with Indonesia (40%) and Thailand (23%) accounting for most discards over the entire time

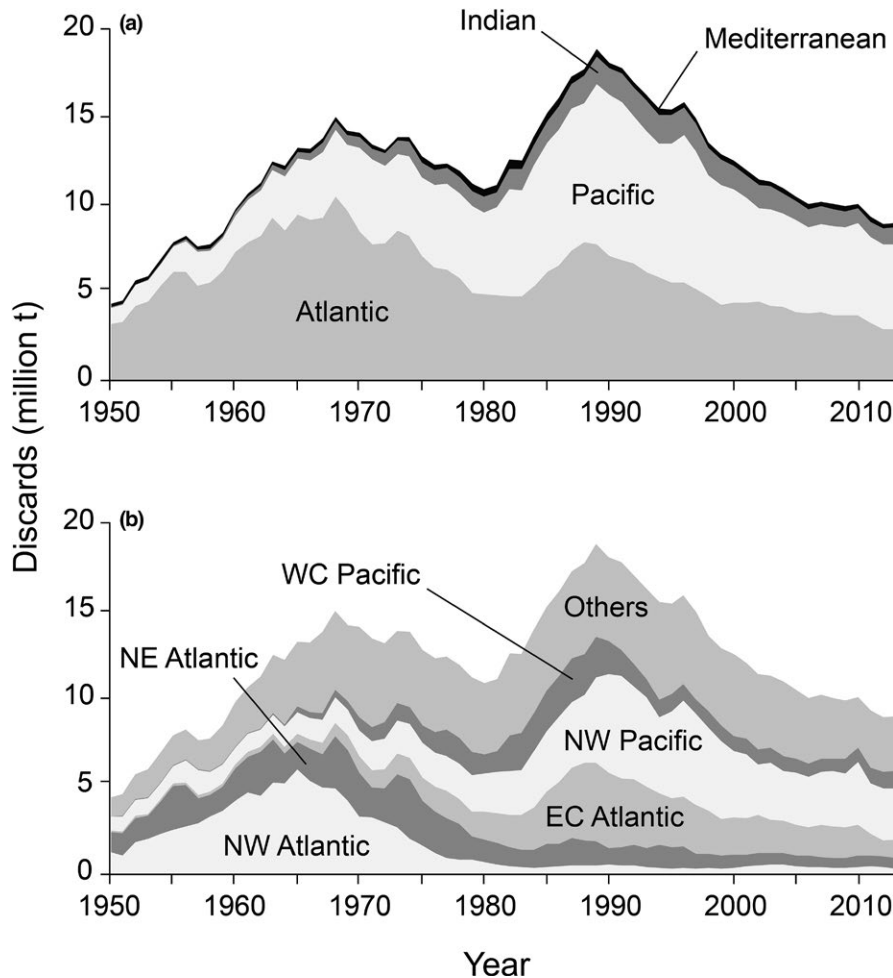


FIGURE 3 Globally estimated discards by (a) major ocean basins, documenting the shift in discarding over time from Atlantic to Pacific waters; and (b) by FAO statistical areas within ocean basins, illustrating the shift in the Atlantic from Northern (NW and NE Atlantic) to Eastern Central Atlantic waters (EC Atlantic, off West Africa), and the predominance of the Northwest Pacific (NW Pacific) in more recent time periods

period, while more recently Vietnam dominates discarding in this area (Figure 4e).

The reconstructed and spatially allocated *Sea Around Us* data permit examination of catch (and hence discard) data by EEZ versus high seas waters. Discards are predominantly associated with catches in EEZ waters, which account for 93%–98% of total global discards since 1950 (Figure 4f). However, the share of discarding in high seas waters has increased gradually over this time, from around 1% in 1950 to 6% by 2014.

3.3 | Discard patterns by taxon

The taxonomic composition of discards differs distinctly between areas and depends on several factors, foremost being the natural biodiversity patterns in a given area, as well as the fisheries types, gears and target taxa in each area. Furthermore, the quality of available data and information sources can heavily influence the taxonomic composition of reconstructed discard estimates. Data collection systems need to better account for the taxonomic composition of discarded catches.

Discards in the Northwest Atlantic (FAO area 21) were taxonomically reflective of several major target groupings, with redfish (*Sebastes* spp., Sebastidae, 19%), hake (*Merluccius* spp., Merlucciidae, 18%), American plaice (*Hippoglossoides platessoides*, Pleuronectidae, 13%)

and rays (Rajidae, 12%) dominating, while the major target species in these waters during the earlier decades, Atlantic cod (*Gadus morhua*, Gadidae) accounted for 5% of total discards in this area over the entire time period (Figure 5a). This suggests that substantial catches of potentially marketable species that were taken by fishing gears were not retained and utilized, either because of poor product quality or small size of fish caught (reflecting of poor and non-selective fishing practices), and/or due to deliberate high-grading of catches (a management failure, recognizing that for periods prior to declaration of EEZs, most of these waters were high seas areas outside of most management interventions).

The discards in the Northeast Atlantic were dominated by haddock (*Melanogrammus aeglefinus*, Gadidae, 19%), redfish (16%) Atlantic cod (11%) and hake (6%), all of which are also highly marketable taxa (Figure 5b).

Discard data from the Eastern Central Atlantic area (FAO area 34 off West Africa) have very poor taxonomic resolution due to the very limited information that data sources for discarding (as well as landings) in this region contained. This resulted in the majority of discards not being classified beyond mixed group names such as “miscellaneous marine fishes” (i.e. “marine fishes nei,” 38%) or “miscellaneous pelagic fishes” (29%) in the reconstructed data (Figure 5c). However, among taxonomically distinct entities, major fisheries target groups

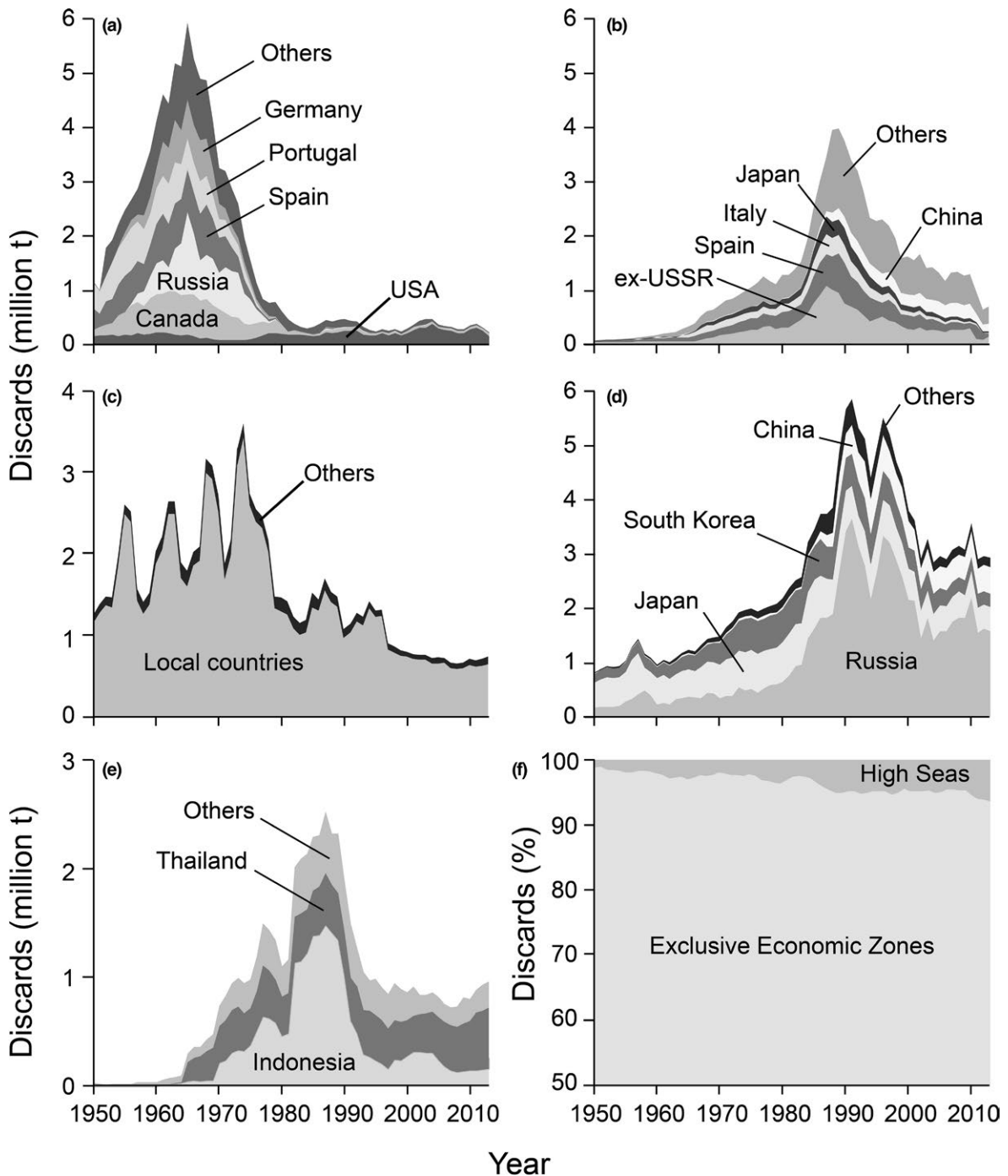


FIGURE 4 Estimated global discards by major fishing countries (i.e. vessel flag) in (a) the Northwest Atlantic (FAO 21); (b) the Eastern Central Atlantic (FAO 34); (c) the Northeast Atlantic (FAO 27); (d) the Northwest Pacific (FAO 61); and (e) Western Central Pacific (FAO 71). The predominance of distant-water fishing fleets in the two major Atlantic areas (a and b) compared to local fleet dominance in the Pacific areas (d and e) is clearly illustrated. Global discard distribution between EEZs and high seas waters (percentages) is shown in (f), note that the y-axis starts at 50% due to the small contribution by high seas

were dominant, such as cephalopods (Cephalopoda, 4% average overall), followed by small pelagic species (a major target grouping in these water) such as the European anchovy (*Engraulis encrasicolus*, Engraulidae) and the European pilchard (*Sardina pilchardus*, Clupeidae), and the coastal semi-pelagic big-eyed grunt (*Brachydeuterus auritus*, Haemulidae) with 2%–3% each (Figure 5c).

In the Northwest Pacific (FAO area 61), discards are dominated by the single major fisheries target species in the region, Alaska pollock (*Theragra chalcogramma*, now *Gadus chalcogramma*, Gadidae, see www.fishbase.org), accounting for at least 36% of total discards (Figure 5d). As in the Eastern Central Atlantic, the uninformative grouping “miscellaneous marine fishes” accounts for a considerable component in discards (24%), as well as generally non-marketable items such as starfish

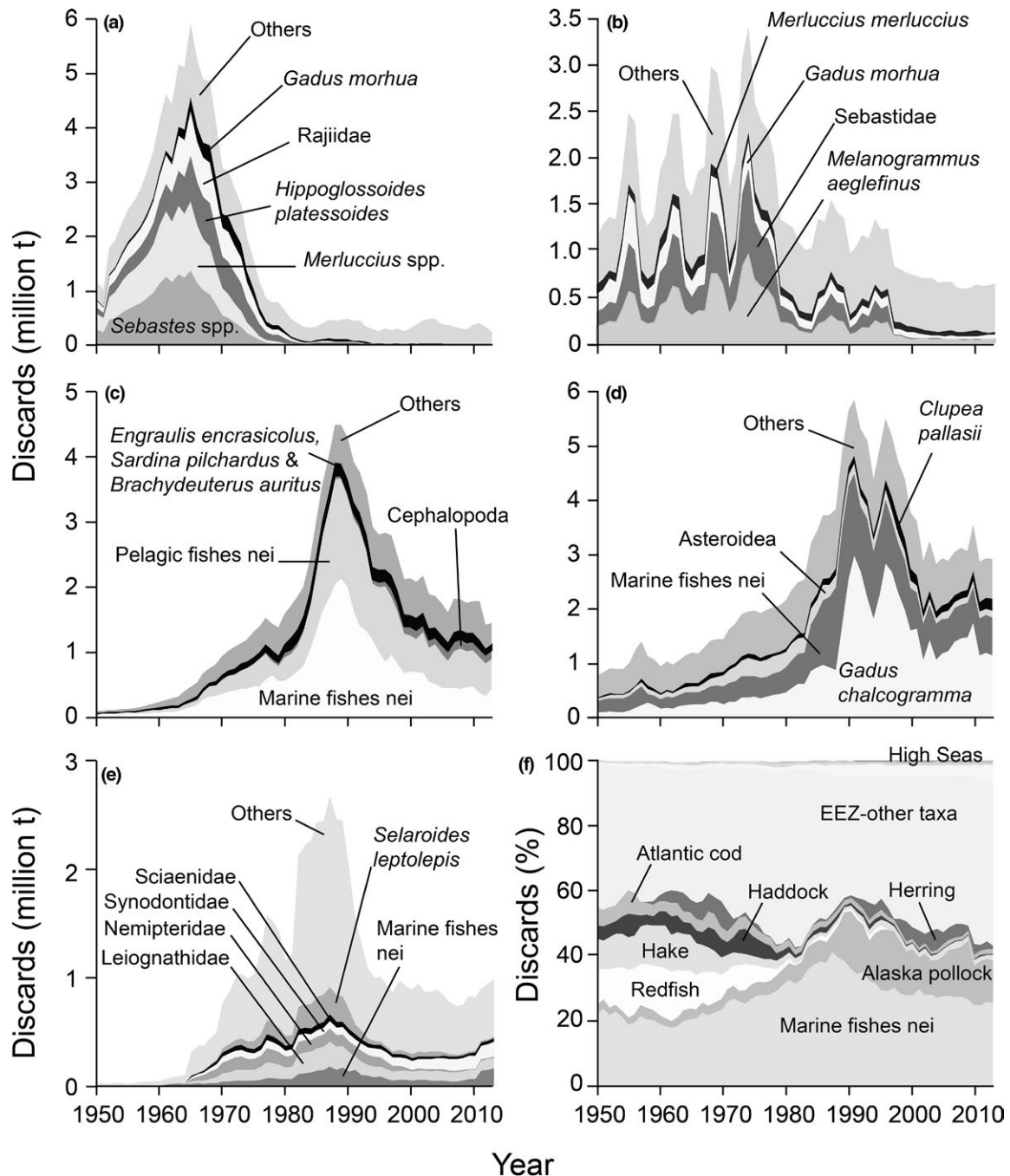


FIGURE 5 Estimated global discards by major taxa in (a) the Northwest Atlantic (FAO area 21); (b) the Northeast Atlantic (FAO 27); (c) the Eastern Central Atlantic (FAO area 34); (d) the Northwest Pacific (FAO area 61); (e) Western Central Pacific (FAO area 71) and (f) globally as percentage by EEZs versus high seas. Taxonomic composition for high seas is not presented due to space constraint, but dominated by “marine fishes nei” “nei” = “not elsewhere included” which represents “miscellaneous” fishes. “Others” represent a large number of contributing taxa, each with smaller tonnages

(Asteroidea, 6%). The second most important target species, the Pacific herring (*Clupea pallasii*, Clupeidae) also features prominently in discards, with around 4% (Figure 5d).

In the tropical waters of South-East Asia and the western Pacific (i.e. Western Central Pacific, FAO area 71), discards are dominated (besides the ever-present but uninformative “miscellaneous marine fishes,” 7%) by taxa that typically produce the bulk of the catch in trawl fisheries that are wide-spread in these tropical waters. Thus,

families such as pony fishes (Leiognathidae, 9%), threadfin breems (Nemipteridae, 6%), lizardfishes (Synodontidae, 6%) and drums (Sciaenidae, 3%) are common, although some target species such as the small pelagic yellowstripe scad (*Selaroides leptolepis*, Carangidae, 7%) also feature high in discards (Figure 5e).

Given that the majority of discarding occurs in EEZ waters (Figure 4f), it is not surprising that the taxonomic composition of discards reflects this EEZ versus high seas pattern (Figure 5f). However,

in both EEZ and high seas discarding, highly uninformative groupings (i.e. “marine fishes nei,” or “miscellaneous marine fishes”) dominate as the single largest grouping (Figure 5f). More detailed taxonomic information on discards within EEZs mirrors the geographic change over time in discarding (Figure 3), as earlier time periods contain substantial contributions of Atlantic taxa, such as redfish, hake, haddock, Atlantic cod and herring, while later periods have major contributions of Pacific taxa such as Alaska pollock (Figure 5f). Although not discernable in Figure 5f due to its small percentage contribution, discards in high seas waters (while being dominated by uninformative “marine fishes nei”) contain also considerable contributions of blue shark (*Prionace glauca*, Carcharhinidae) and tuna taxa such as skipjack tuna (*Katsuwonus pelamis*, Scombridae).

4 | DISCUSSION

The spatial trends exhibited by the globally reconstructed discard data for 1950–2014 presented here mirror the general North to South trends in the expansion of global fisheries (Gelchu & Pauly, 2007; Swartz, Sala, Tracey, Watson, & Pauly, 2010). Such discarded catch represents a generally hidden impact of fisheries. This is illustrated for the early decades in the Northwest Atlantic, where discards in the waters now known as the East Coast EEZ of Canada (i.e. most of the Grand Banks) exceeded landed catches by a substantial margin (Divovich, Belhabib, Zeller, & Pauly, 2015). This was followed in subsequent decades by the twin developments of tropical shrimp and bottom trawling in the Western Pacific, and the expansion of foreign fleets along West Africa in the 1970s and 1980s. The latest major development is the expansion of fishing fleets in the Northwest Pacific mainly for Alaska pollock, resulting in substantial discards of this target species, especially in Russian waters, where the fleets tend to land only the roe of Alaska pollock. These trends shape the global trend of discarding in marine fisheries, although there are smaller fluctuations in other areas that may be regionally important but are not examined in detail here.

The predominance of discarding from within EEZ waters, as illustrated in Figure 4f, emphasizes the responsibility of each country to better address discarding issues within their EEZ. Nevertheless, as high seas waters have seen a growing share of global discarding over the years, increasing attention to this issue needs to be levied also by Regional Fisheries Management Organizations, that generally have a high seas fisheries mandate (Cullis-Suzuki & Pauly, 2010).

Our estimate of peak global discards (around 18.8 million t/year in the late 1980s) is considerably lower than the midpoint estimate of Alverson et al. (1994), but higher than the lower 95% confidence bound estimate of 17.9 million tonnes in their study period of 1988–1990. However, our estimate for the 2000s is, unsurprisingly, close to the assessment by Kelleher (2005), as that study's sources were frequently relied upon for individual catch reconstructions as a source of discard information. Both Kelleher's and our reconstruction estimates generally used a “fishery” approach (i.e. taxon by area

by gear for each country) as the central unit for which to estimate discards, while Alverson's method used more general species and species groups (Kelleher, 2005). Kelleher acknowledges this as likely the main reason for the large difference between his and Alverson's estimate (Kelleher, 2005). Our estimate is slightly higher than Kelleher (2005) for the same period, as we applied the discard rates to our reconstructed estimates of total landings (i.e. including estimates of unreported landings) rather than reported landings only. Finally, Alverson et al. (1994) heavily concentrated on data sources for the North Atlantic (East and West) and Northeast Pacific, with these areas making up over 2/3 of their references. Kelleher (2005) substantially improved upon these regionally concentrated estimates. Through an extensive network of collaborators (including those who could access information in local languages) and occasionally assumption-based approaches, we were able to further refine these estimates and assign these to each country's EEZ waters or general high seas areas (Zeller et al., 2016). Therefore, the discard volumes derived by catch reconstructions may have partially overcome previous data limitations for discard data.

Globally, discards seem to be declining in absolute and relative terms. This is a result of globally declining industrial landings as earlier illustrated (Pauly & Zeller, 2016a; Zeller & Pauly, 2005), increasing management focus on reducing such wastage through a growing requirement to land by-catch in jurisdictions such as Norway and parts of the EU, increasing curtailing and banning of unselective and habitat-damaging fishing gears (e.g. in Belize), as well as greater retention and use of previously unused catches (Cashion, 2016; Cashion, Le Manach, Zeller, & Pauly, 2017). The greater retention is thought to be driven by two factors: an increase in selective gears likely accounting for smaller discard ratios and a rising market value for fish brought on board for use as direct feed or for reduction to fishmeal (Cashion et al., 2017). This increasing demand for feed is driven by a growing aquaculture sector (FAO 2016; but see Pauly & Zeller, 2017a,b), which is increasingly made up of species requiring protein-rich feeds such as fishmeal (Tacon & Metian, 2015).

A further likely driver of declining discards is that species that are regularly caught as unwanted by-catch (and are often discarded) may actually be declining in biomass over time at a higher rate than targeted species. Therefore, the fisheries seem to become “cleaner” in terms of declining discards, although not through a change in fishing practices or improved gear technology, but rather through a change in the populations of the species that are incidentally caught and then discarded. Thus, exploitation rates (i.e. percentage of biomass caught each year) of these species remain high, even as levels of by-catch (and discards) are decreasing, as seems to be the case for Atlantic cod off the East Coast of Canada (Divovich et al., 2015).

One aspect often raised when discussing discarding is the potential for incidentally caught but unwanted catch to survive discarding. While there are some hardy taxa that may have relatively high discard survival rates (e.g. some invertebrates, maybe some elasmobranchs), most soft-bodied fish that comprise many target species of major fisheries examined here, are unlikely to have high survival rates. Given our conservative approach to estimating total discards, we believe

our discard estimates represent total mortality of discarded catch. Furthermore, whenever the underlying country-by-country catch reconstructions had information on discard survival, these were applied during reconstruction, for example for US fisheries (McCrea-Strub, 2015).

Clearly, the declining trend in global discarding is a good thing, and efforts need to continue and be enhanced around the world to ensure this trend continues. Doing otherwise only exacerbates the enormous waste that discarding represents, especially at a time when wild capture fisheries are under global strain amidst growing demands for food security and human nutritional health (Golden et al., 2016). This food security and human health demand applies especially to developing countries, which predominate in the areas that continue to have the highest discarding rates (e.g. Eastern Central Atlantic) driven largely by distant-water fleets from highly industrialized, developed countries.

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