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Stephen J Newman,
Department of Primary Industries and Regional Development of Western Australia (DPIRD), Australia

*CORRESPONDENCE
Nazli Demirel
ndemirel@istanbul.edu.tr

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Editorial: Fishing effort and the evolving nature of its efficiency

Nazli Demirel[1*], Cornelia E. Nauen[2] and Maria Lourdes D. Palomares[3]

[1]Institute of Marine Sciences and Management, Istanbul University, Istanbul, Türkiye, [2]Mundus maris asbl, Brussels, Belgium, [3]Institute for the Oceans and Fisheries, Faculty of Science, University of British Columbia, Vancouver, BC, Canada

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Editorial on the Research Topic
Fishing effort and the evolving nature of its efficiency

Introduction

The earth is currently facing a biological crisis with an unprecedented 1 million species currently at risk of going extinct (IPBES, 2019). Our improvements in technology have come at a cost, which have eroded natural systems faster than they can recuperate. By avoiding laws and chasing profits, overfishing remains the biggest threat to the oceans and the largest culprit to biodiversity loss, with 1/3 of fish stocks considered overfished, and the remaining 2/3rds fished at or near their maximum sustainable yield (Palomares et al., 2020).

Historically, fisheries have been thought of as being similar to agriculture, where the more effort you put in, the more harvest you should be able to extract. This was true until capacity and massive deployment of fossil fuels particularly after WWII outpaced regeneration times. Peak fish landings were reached in Europe in the late 1970s. The global peak catch was reached in the mid-1990s (Pauly and Zeller, 2016) and has since been declining (Figure 1). This assumption and the notion that investment in increasingly sophisticated location and catching technologies would generate higher yields has not been updated. The net result of this sort of 'arms race' impacts biodiversity (Palomares et al., 2020), and generates waning profitability, driven mostly by public subsidies, primarily in the case of industrial fisheries (Sumaila et al., 2019).

Biodiversity and functioning aquatic ecosystems act as a safety net, buffering us from changes affecting ecosystem function and the economies we have been able to build during long times of relative stability. In addition to excessive fishing, there are a range of threats to aquatic ecosystems, including climate change (such as global warming), in combination with ocean acidification and lowered levels of dissolved oxygen, river and ocean pollution, increasing dead zones as a result of overfertilization from runoff generated by industrial agriculture and untreated sewage, and massive influxes of invasive species (IPBES, 2019).

Unfortunately, the world's dominant measure of success is still based on gross domestic product (GDP), which counts any economic activity on the positive side of the balance sheet, even if it is destructive and it is not reflective of human welfare (Stiglitz, 2020). The underlying demand is continual growth of resource consuming economic activities, a feature clashing with the finite nature of resources, as reported by the Club of Rome 50 years ago

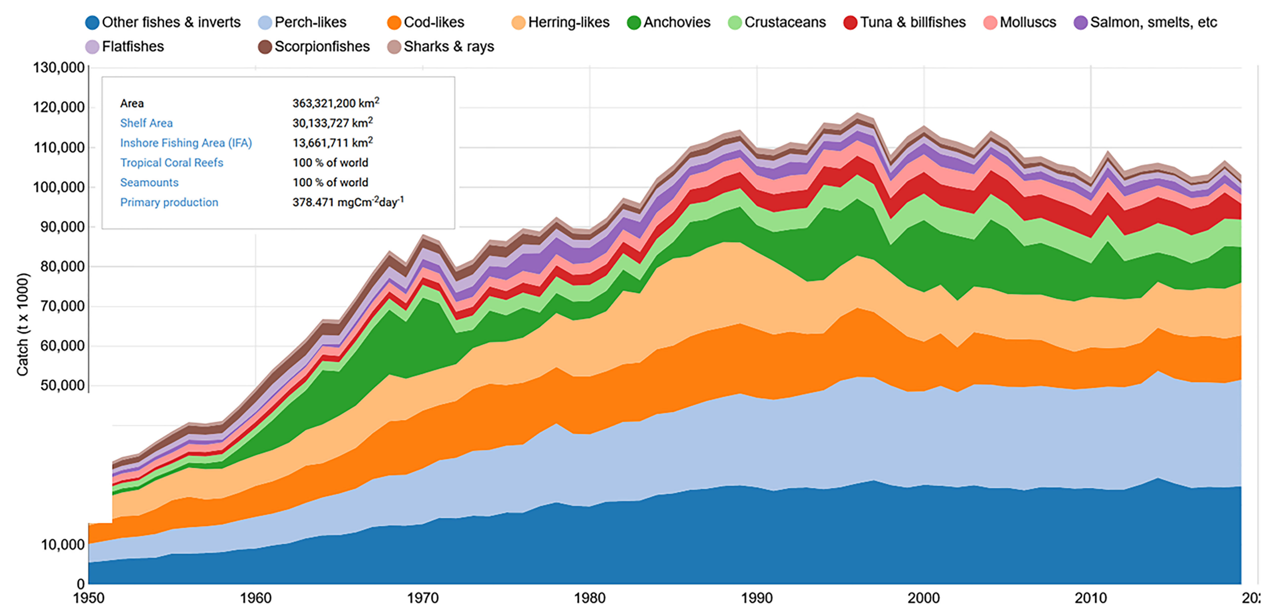

FIGURE 1
Catches (tonnes) by commercial groups in the Global Ocean (www.seaaroundus.org).

(Meadows et al., 1972) and reported contemporaneously as humanity exceeding the planetary boundaries (Steffen et al., 2015).

We are improving our understanding of those planetary boundaries and exploring the mix of measures that might be adopted and effective in recovering systems. Clearly, emerging technologies have a role to play, but the way we think about them, develop, and deploy them need to be grounded in a much greater understanding of human behaviour, greater awareness of risk and an explicit drive to prevent any unintended consequences (Jasanoff, 2007). In times of multiple and overlapping crises and large implementation deficits of existing agreements, laws, and rules, connecting local institutions and mobilizing place-adapted capacities to these larger issues is important to operationalize general rules and insights (Nauen, 2021).

This Frontiers Research Topic (RT) "Fishing Effort and the Evolving Nature of its Efficiency" explores the evolution of fishing effort, notably in coastal artisanal fisheries presenting time series analyses of fishing effort and their impact on coastal habitats or on the functioning of those ecosystems. Overall, 10 articles were authored by 54 researchers from eight different countries, presenting critical insights from across the globe—from Seychelles to Peru, and from the South Atlantic to the Mediterranean. Here we review the contributions from these studies and identify remaining challenges. Based on findings from the ten papers, we provide an overview of the lessons-learned and key recommendations for sustainable management measures. Hence, we have organized the content in two thematic areas: (i) trends in fishing effort from across the globe, and ii) fishing impacts on different ecosystems considering interactions with climate change.

Trends in fishing effort

Vianna et al. investigated long term catch and effort trends and reported that total catches of the Republic of the Marshall Islands (RMI) were 27% higher than the data officially reported by FAO. The fisheries in RMI are mainly artisanal, and there has been a gradual shift from predominantly non-commercial to commercial small-scale fisheries in the past decades. From 1950 to 1990 total catch and effort was found to be stable, however in the late 2000s, the continued increase in fishing effort corresponded with a gradual reduction in total catch, which also affects the overall production and the economics. Since the RMI is one of the archipelago areas in the Pacific Ocean, climate change impacts on marine and terrestrial life is increasing, additional adaptive coastal fisheries management measures need to be explored.

From the other side of the globe, Demirel et al. investigated the stock status of 54 commercial fish stocks from the eastern Mediterranean and Black Sea. The region was classified as "data-poor", with a low number of assessed stocks in comparison to the reported biodiversity and the number of exploited species (FAO, 2022; Froese et al., 2018). In their study, the catch-based assessment algorithm CMSY (Froese et al., 2017) was used to obtain fisheries reference points and future scenarios to rebuild fisheries. Of the 54 stocks, 94 percent was found to be overexploited. Recovery times were estimated at 15 years for 60 percent of the stocks if fishing pressure is reduced by 50 percent. Regardless of the assumptions using this assessment approach, under a business-asusual fishing scenario, all stocks are likely to be impacted.

Christ et al. examined the historical development of catch and effort in the Republic of Seychelles as a case study on current and future options of resource sustainability for island countries. The fishing industry is crucial for food supply and employment provision in many island countries. The paper highlights that the reconstructed catch was 1.5 times higher than that officially reported by FAO and that fishing effort greatly increased from 1950 to 2017. However, the trend of artisanal catch per unit of effort (CPUE) was declining over time, suggesting a reduction in relative abundance of fish populations within the Seychelles' EEZ or targeted fishing areas.

De la Puente et al. focused on reconstruction of long-term fishing effort in Peruvian smallscale fisheries from 1950 to 2018. The paper analyzed changes in the fleet's fishing efficiency and economic performance and revealed that fishing effort increased at much faster rates than catches, particularly in the period since 2006. Peru is one of the world's leading fishing countries, smallscale fisheries are an important contributor to national employment, food security and gross domestic product. De la Puente et al. reported that the expanding fishing effort has become unsustainable and uneconomical, with fisheries essentially 'growing into poverty'. A key aspect of the study was exploring the social, legal and economic drivers fostering fleet growth, and the importance of a bottom-up governance approach for the well-being of small-scale fishers.

Zeller et al. reconstructed long term fishing effort of small-scale fisheries in Mozambique. They found fishing effort increased by nearly 60 times, while CPUE in the small scale fleet showed a strong decline. The increase in fishing effort is driven by motorization and growth in vessel numbers. The continuing increase in the fishing capacity of small-scale fisheries in the absence of effective and restrictive management actions may exacerbate overexploitation.

Farquhar et al. investigated the impact of weather conditions on the duration of active fishing hours for small scale fishers in Madagascar. The study combined fishers' knowledge on meteorological conditions and long-term remotely sensed data to analyse the impact of weather trends on fishing effort for over 40 years. The increase in adverse weather conditions led to a decreasing fishing trend in effort with a loss of 21.7 available fishing hours per year. This study demonstrated the impact of changing weather conditions on fishers' well-being and food security, with ongoing impacts expected under climate change.

Fishing impacts

White et al. highlighted concerns on changes in fishery resources due to climate and current fishing practices leading to declining abundance of reef fishes. The changes in fishery resources may adversely affect the well-being of small-scale fisheries. Their investigations into Tokelau's reconstructed catch and CPUE over 50 years indicate that the domestic catch was greatly underreported. Since 2010, extractions are estimated to be nearly four times larger than the data reported by FAO. The lesson-learned by Tokelau's case is that high uncertainty and reporting problems of the fishing resources contributes to ineffective management practices in which changing catch composition may alter local people's every-day habits and traditional practices in the short term.

Kripa et al. examined fishing impacts on the Indian oil sardine *Sardinella longiceps* in the Arabian Sea. It constitutes the fifth largest sardine fishery in the world. During the 2010s the fishery experienced a dramatic collapse in relation to an increase in fishing effort due to changes in gear size and engine capacity, prior to El Nino Southern Oscillation in 2015. The paper highlights the negative climate impact on the maturation process of Sardinella caused by a mismatch of its larval development and phytoplankton bloom periods. The collapse of this fishery affected the livelihood of thousands of small-scale fishers. This paper illustrates the importance of a more responsive fisheries administration with timely restrictions on fishing effort and protection of spawning stocks (e.g., through a closure) in order to minimize the combined impacts of excessive fishing effort and environmental change.

Ferra et al. focused on one of the novel technologies, namely using the mandatory automatic identification system (AIS) originally intended to avoid collisions at sea, to check its efficiency for quantifying unobserved trawling activity in the Mediterranean Sea. Although this technology can be useful in marine spatial planning, it has limitations, namely transmission gaps (e.g., periods of weak signal detection), interference with other signals or deliberately switching off the system, to conceal fishing activities. The paper illustrates that determining duration and distance of transmission gaps in bottom trawlers from their harbor enabled quantifying unobserved fishing and its effects on overall trawling pressure. The authors conclude that their results may help to revise the estimation of fishing effort from AIS data to understand actual fishing.

Jalali et al. focused on the spatio-temporal dynamics of recreational fishing in Australia. As one of the lesser researched parts of fisheries, the authors emphasize that recreational fishing is a popular pastime and multi-billion-dollar industry in Australia. It plays an important economic role in some regions of the continent. Data was derived from boat-based creel surveys during a 10-year period from 2010 to 2019, and used their survey data as an input for geospatial modeling. Their study highlights the importance of spatially explicit approaches to inform fisheries management for minimizing the impact on coastal communities but maximizing benefits for local businesses.

Conclusions

The contributions of this Research Topic illustrate the local articulations of a general trend of increasing fishing effort in a wide range of fisheries. The papers follow the global trend of fully or overexploited, even collapsing resources (Pauly and Zeller, 2016). The corollary of decreasing income and increasing insecurity is another common observation. Several studies also indicate breakpoints or shifts in ecological systems as species specific or environmental forcing such as climate change adds pressure. High uncertainty and reporting problems of the catches contribute to the breakdown of management practices in which changing catch composition may alter local people's every day-habits and traditional practices in the short term (White et al.). Under a business-as-usual scenario, many stocks are on the brink of collapse with uncertain prospects of recovery (Demirel et al.). Declining catches over time suggest a decline in relative abundance of fish populations (Christ et al.; Zeller et al.). Increased fishing effort is a counterproductive response, resulting in small-scale fishers growing into poverty in some circumstances (De la Puente et al.). More responsive fisheries administration with timely restrictions on fishing effort and protection of spawning stocks is essential (Kripa et al., 2018), particularly in conjunction with trust-building measures of bottom-up governance. New approaches, such as analyzing AIS data of fishing fleets, can contribute to reducing data gaps (Ferra et al.; Jalali et al.) and could support increased management measures against IUU fishing and excessive build-up of capacity. Climate change impacts on marine and terrestrial life is becoming more visible and concerning, hence coastal fisheries management needs to consider a range of adaptive measures (Vianna et al.). Fishers' well-being, safety and food security do not only depend on classical fisheries management but also needs climate change adaptation strategies (Farquhar et al.). Fishing in the absence of management controls, combined with other human-induced effects (e.g., climate change, pollution), diminishes the resilience of marine ecosystems. The continued benefits that humans derive from the seas require tangible counter measures that help rebuild depleted resources and re-establish prosperous small-scale fisheries. The efforts around the world to improve data quality, to understand changes from past to present, and to develop management recommendations with that information are a useful contribution. It is essential to share such research insights broadly beyond the scientific community. When scientists, managers, artisanal fishers, and other citizens bring their different experiences and analyses to discussions and interactions, there is a greater chance of positive change for aquatic resources and communities. That change must not only support resource recovery but needs to be equitable in the distribution of costs and benefits perceived as fair by stakeholders. In a few fisheries encouraging experiences are progressing. The key elements of these case studies are that they are established based on sound, robust science that feeds into practicable and adaptive management systems. These examples need to be more widely adapted to the local context for many systems.

Author contributions

All authors listed, have made substantial, direct and intellectual contribution to the work, and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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