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Industrial fishing and its impacts on food security: a systematic review

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This systematic review seeks to answer the question: how have previous studies conceptualized and measured food security in relation to industrial fishing? Following the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) methodology, initial searches yielded 983 publications, which were distilled to 55 relevant articles for in-depth analysis after the screening process. These studies span from 1997 to 2024, covering a diverse range of geographical contexts, and cover a variety of scales from local community impacts to national and global trends. Overall, four principal themes related to the perceived positive and negative and direct and indirect impacts of industrial fishing on food security were identified: (1) Industrial fishing activities provide jobs to local populations of which earnings are used to purchase other food items; (2) Industrial fishing activities provide fisheries products to local markets which are used as a common food source; (3) Industrial fishing activities damage the environment, leading to a decrease in the availability of catch for food or livelihood; (4) Industrial fishing activities outcompete local users and export catch to distant markets, thereby decreasing available food to local communities. The methodologies used in these studies mainly took a singular methods approach rather than a mixed-methods approach. Specific methodologies were rooted in diverse fields such as econometrics, policy, geography, fisheries science, and public health. The most frequently used data types were fisheries production, consumption, trade, economic, and fisher behavior data. A notable gap in the research is the lack of integration of complex data on industrial fishing, such as detailed catch records and fishing efforts, with the multifaceted aspects of food security, including detailed household consumption trends. This separation has often led to studies focusing on either fishing activities or food security outcomes in isolation, which can oversimplify the relationship between fisheries production and food security. The findings highlight the need for a more integrated research approach that combines fisheries or ecosystem data with a thorough examination of household consumption behaviors and broader food systems. Such an approach is essential for creating effective policies and interventions to support and improve the livelihoods of communities reliant on fisheries.

KEYWORDS

industrial fishing, food security, food system, Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), blue economy

1 Introduction

Food security is commonly defined as: "when all people at all times have physical, social and economic access to food, which is safe and consumed in sufficient quantity and quality to meet their dietary needs and food preferences, and is supported by an environment of adequate sanitation, health services and care, allowing for a healthy and active life" (FAO, 2000). The concept is often conceptualized as resting on four dimensions: availability, access, stability, and utilization. Food availability refers to the quantity and quality of available food. It is determined by stock levels, food production, and net trade, and can be improved by sustainable farming practices and policies increasing productivity (McCarthy et al., 2018). Food access encompasses people's physical, economic, and social access to food. All four dimensions of food security all interdependent (McCarthy et al., 2018). For example, changes in food availability may have negative impacts on food access and food stability (e.g., price), thereby decreasing an individual's ability to utilize food to meet biological and cultural requirements.

Food security can be studied at multiple scales (e.g., individual, household, regional, national) and assessed across different time scales (e.g., chronic, transitory, seasonal, etc.) (El Bilali et al., 2019). For example, in some places, households experience increased food insecurity during certain times of the year (Sibhatu and Qaim, 2017). Common methods to study food security include using household food recall surveys to estimate consumption. Food security can also be measured through proxy indicators, such as dietary diversity, geographic distance to markets, anthropogenic measurements, food prices, or food production and trade data (Jones et al., 2013). Due to its complexity and inter-relationships, the changing and dynamic nature of food systems, and the multitudes of ways food security can be conceptualized, food security is difficult to measure and quantify especially in terms of generating robust comparative studies (Barrett, 2010; Carletto et al., 2013; Jones et al., 2013; Pérez-Escamilla et al., 2017). Such difficulty in measuring food security consequently makes it difficult to assess how social or environmental changes can consequently impact food security.

For instance, ecosystem changes driven by industrial fishing activities or via the direct competition that occurs between industrial fishing and local users has been thought to negatively impact coastal communities' food security (Shiva, 2001; Pauly et al., 2005; Srinivasan et al., 2010; Vianna et al., 2020). Industrial fishing are defined as capital-intensive fisheries using relatively large vessels with a high degree of mechanization and advanced fish finding and navigational equipment (Lauria et al., 2018). At the global scale, industrial fishing generates about 84 million metric tons of fish and $119 billion annually, generating more than three times the amount of biomass and twice the revenue of small-scale fisheries (SSF) (Pauly and Zeller, 2016). Recent research has shown that the most common type of industrial fishing activity is trawlers followed by fixed gears, purse seiners drifting longliners and squid jiggers (Guiet et al., 2019). Wealthier nations tend to have a larger commercialized fishing industry due to the high level of technical and financial capacity needed to operate industrial fishing fleets (Mccauley et al., 2018). In distant water fishing arrangements, lower-income countries often allow foreign fishing in their waters in return for a portion of the revenue and fish catch generated (Kaczynski and Fluharty, 2002; Nichols et al., 2015). This type of fishing arrangement contributed to almost 80% of all fishing effort in waters under the jurisdiction of lower-income countries (Mccauley et al., 2018).

Yet, and almost contrarily to other narratives, some research suggests that industrial fishing play a crucial role in global food security by providing a significant portion of the world's aquatic animal production. In 2022, the global capture fisheries (including both industrial and SSF) production reached ~91.0 million tons. This production contributes toward the global demand for seafood and aquatic products, which are essential sources of protein and nutrients for populations worldwide. The annual growth of the supply of aquatic animal foods has outpaced population growth, with per capita consumption increasing from 9.1 kg in 1961 to 20.6 kg in 2021 (FAO, 2024).

Thus, while the development of industrial fishing ventures has become an important source of revenue and food for some nations, and may be sustainable based on the species targeted and gears used, industrial fishing has also been associated with the overexploitation and depletion of resources (Kent, 1986; Sahrhage and Lundbeck, 1992; Pauly et al., 2002). Evidence shows that industrial fishing may impact ecosystems through overfishing (Mansfield, 2010). Overfishing occurs when fish are being taken from the environment faster than they can reproduce leading to declines in the abundance of that species (Murawski, 2000). Overfishing not only decreases target species, but also leads to potential habitat destruction from the fishing activity itself, biodiversity loss through the mortality of unintended by-catch, and changes in entire ecosystem structures through trophic cascades (Pauly et al., 1998; Jackson et al., 2001; Scheffer et al., 2005; Coll et al., 2008; Link and Watson, 2019). Coastal communities whose food security is dependent on fisheries are particularly vulnerable to the impacts of anthropogenic shocks such as overfishing and poor fisheries management (Pauly et al., 2005; Garcia and Rosenberg, 2010; Mcclanahan et al., 2015; Ding et al., 2017).

Maintaining food security remains a pressing challenge in fishery-dependent coastal communities where vulnerability to climate change and other stressors is high and fish constitute a significant proportion of the local diet (Katikiro and Macusi, 2012; The World Bank, 2012; Barange et al., 2014; Savo et al., 2017; Bell et al., 2018; Bennett et al., 2018; Lauria et al., 2018; Cabral et al., 2019; Galappaththi et al., 2021). However, existing research on fisheries-based food security and systems research is disconnected from larger food security initiatives or oversimplified (Fabinyi et al., 2017; Bennett et al., 2021).

TABLE 1 Search terms applied in literature search of Web of Science and Scopus databases.

Fisheries related keywords	Connecting operator	Food security related keywords
"industrial" OR "commercial" OR "distant water" AND "Fish*"	AND	"nutrition" OR "food security" OR "production" AND "food"

As demand for fish increases and fisheries continue to become more industrialized, it is important to understand how industrial fishing may impact food security, particularly in those lower-income countries or places where fishing livelihoods are an integral part of communities (Golden et al., 2016). Thus, the purpose of this systematic review is to better understand the intersection between food security and industrial fishing. This nexus is particularly complex due to the multifaceted nature of food security and the varied impacts of industrial fishing activities. The review seeks to answer the question: how have previous studies conceptualized and measured food security, in relation to industrial fishing?

2 Methods

The review is based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method. The PRISMA method provides a structured approach to researchers in conducting evidence-based systematic reviews (Page et al., 2021).

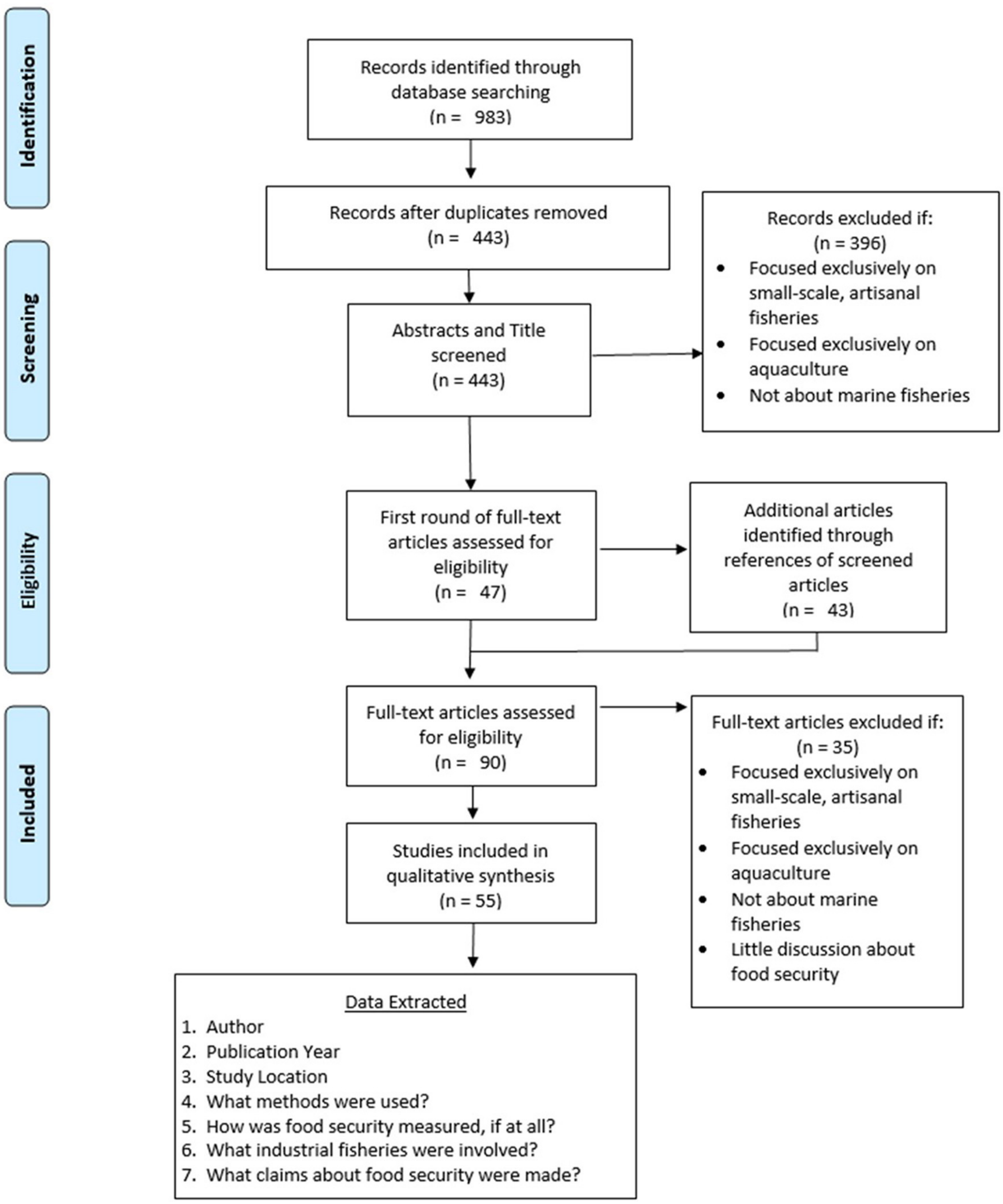

FIGURE 1
The PRSIMA flow diagram. Adapted from Moher et al. (2009).

Web of Science and Scopus databases were systematically searched for articles that studied the relationship between industrial fishing and food security (Table 1). There were no geographical or time constraints regarding the scope of the review. All journals returned in the search were considered equivalent. Initially, 983 records were identified through a comprehensive search in various databases. After removing duplicates, 443 unique records remained. These records' titles and abstracts were screened for relevance, resulting in the exclusion of 396 records that focused exclusively on small-scale, artisanal fisheries, aquaculture, or were not about marine fisheries. The first round of full-text review included 47 articles. An additional 43 articles were identified through the references of the initially screened articles, bringing the total to 90 full-text articles assessed for eligibility in the second round. Of these, 45 articles were excluded for reasons similar to the initial exclusion criteria: focusing exclusively on small-scale, artisanal fisheries, aquaculture, not about marine fisheries, or having little discussion about food security.

Ultimately, 55 studies were included in the qualitative synthesis. Data extracted from these studies included information on the author, publication year, study location, methods used, how food security was measured (if at all), industrial fishing involved, and claims made about food security (Figure 1).

3 Results and discussion

3.1 Research trends

Overall, we found 55 studies that related food security impacts to industrial fishing activities published between 1997 and April of 2024 (Figure 2). The full list of studies is available in the Annex. From 1997 to 2003, the research output in this area remained relatively low, with only one article in 1997 and one in 2000, gradually increasing to three in 2003. The period between 2004 and 2007 saw slight fluctuations in the number of articles, ranging from one to three. The years 2008 to 2010 witnessed another dip in research activity, with just one article in 2008, but a subsequent increase to three articles in 2010. From 2012 to 2015, there were modest fluctuations in the number of publications, typically between two and three articles. However, from 2016 onwards, there was a notable upward trend, peaking at eight articles in 2018. In the years 2022 and 2023, the number of articles remained relatively consistent at around three to six per year.

Articles covered a wide range of geographical contexts (Figure 3). Africa emerged as a focal point, with 18 studies dedicated to the region. Following closely, Southeast Asia had the second-highest attention, with nine studies underscoring the significance of this region in the discourse on fisheries and food security. Fifteen studies took a global perspective, addressing overarching concerns in the field. The Pacific region only had seven studies dedicated to it despite it being such a large area. South America and Europe receive comparatively less focus, with two studies each, indicating a moderate research presence. In contrast, North America, the Gulf region, and Asia have the fewest studies, with only one each.

This review showed that the geographic distribution of studies is notably uneven, with Africa and Southeast Asia having a higher concentration of research compared to other regions. This disparity could be attributed to the prominence of food security discourse within the realm of international development. Countries with lower GDP often face more acute food security challenges, making them frequent subjects of such studies. In contrast, countries with higher GDP might not be as heavily represented in the literature, potentially due to a different set of priorities or narratives. The dominance of English in the academic publishing world also skews the representation of research. Many national reports and studies on fisheries and food security might be published in local languages or as government white papers, thus not captured in this review. Consequently, important insights from non-English-speaking regions may be overlooked. The global concern for industrial fishing and food security spans across all geographies, yet the current review does not fully encompass this diversity. Future reviews should aim to include non-English literature and gray literature to provide a more comprehensive understanding of the global landscape of industrial fishing and food security.

3.2 How does industrial fishing affect food security?

Based on this review, we were able to code each literature reviewed to four broad themes in regard to how industrial fishing activities were assumed to affect food security. These affects can be described as positive or negative, or direct and indirect (Figure 4). This framework can be further visualized in the graphic (Figure 5).

The first theme that emerged from the literature review was that industrial fishing activities may provide jobs to local populations, with the earnings used to purchase other food items (Feidi, 2003; Trondsen, 2003; Al-Habsi et al., 2010; Garcia and Rosenberg, 2010; Bondad-Reantaso et al., 2012; Lowitt, 2014; Fabinyi et al., 2017; Asiedu et al., 2018; Bennett et al., 2018; Teneva et al., 2018; Vianna et al., 2020; Marco et al., 2021; Warren and Steenbergen, 2021; Alsaleh, 2023; Elzaki, 2024). In this case, industrial fishing indirectly supports food security in a positive way by increasing the financial resources available for the purchase of diverse food items.

The second theme recognized is that industrial fishing activities may provide fisheries products to local markets, which are used as a common food source. This direct provision of fish enhances food availability within communities, positively impacting food security (Hotta, 2000; Trondsen, 2003; Al-Habsi et al., 2010; Bondad-Reantaso et al., 2012; Lowitt, 2014; Fabinyi et al., 2017; Wamukota and McClanahan, 2017; Asiedu et al., 2018; Bennett et al., 2018; Teh and Pauly, 2018; Teneva et al., 2018; Vianna et al., 2020; Marco et al., 2021; Sampantamit et al., 2021; Alsaleh, 2023; Elzaki, 2024).

The third theme indicated that industrial fishing activities may damage the environment, leading to a decrease in the availability of catch for food or livelihood. This environmental degradation, documented in numerous studies (Alder and Sumaila, 2004; Atta-Mills et al., 2004; MRAG, 2005; Neiland, 2006; Salayo et al., 2006; van Mulekom et al., 2006; Cruz-Trinidad et al., 2014; Belhabib et al., 2015, 2020; Gillett, 2016; Golden et al., 2016; Pomeroy et al., 2016; de Abreu-Mota et al., 2018; James et al., 2018; Mccauley et al., 2018; Merem et al., 2019; Taylor et al., 2019; Danquah et al.,

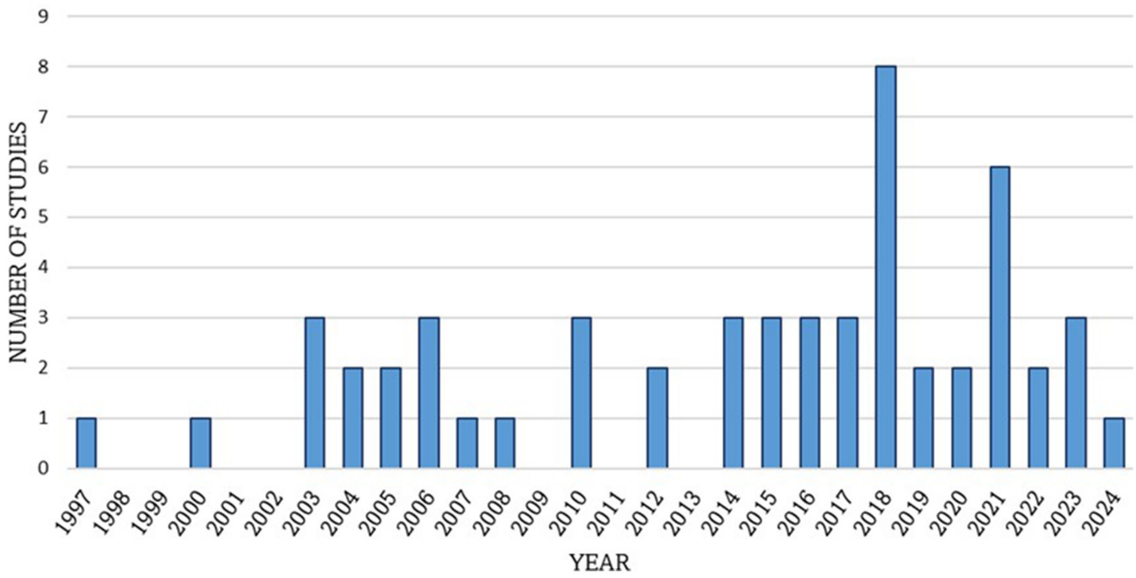

FIGURE 2
Publications related to industrial fishing and food security by year.

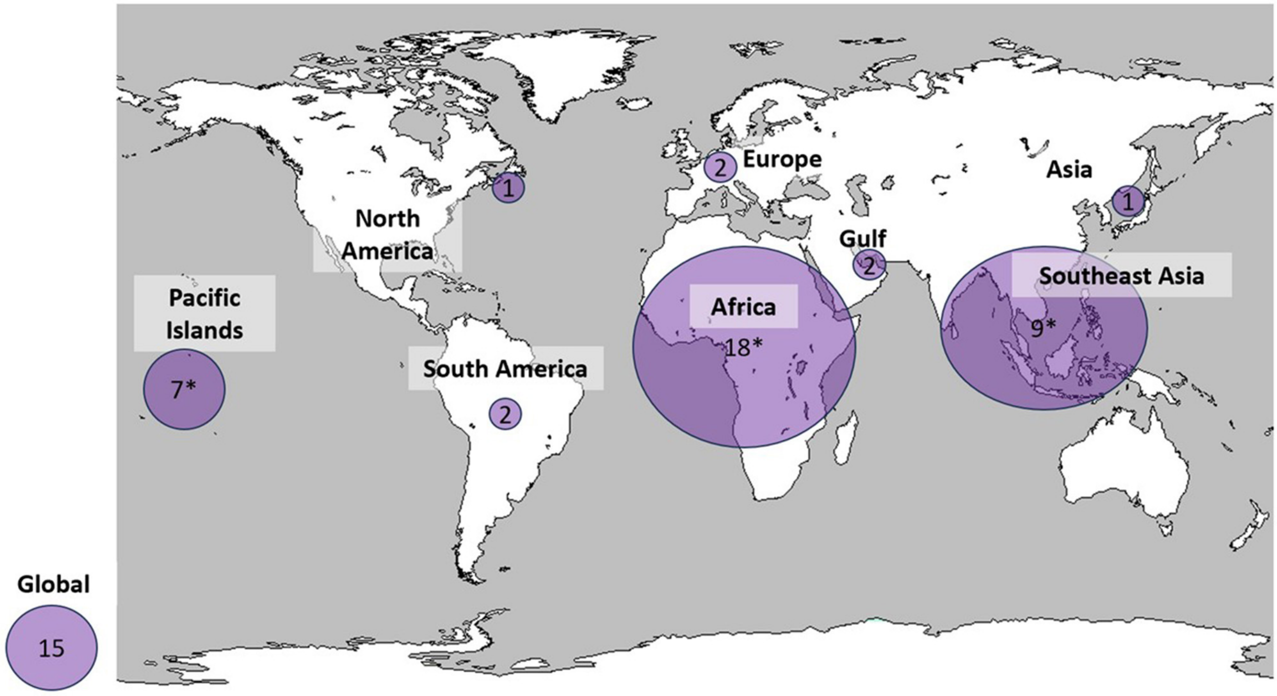

FIGURE 3
Geographic scope of studies returned from literature review on industrial fishing and food security. Note the * symbolizes that a study contained more than one geographic region and was counted multiple times.

2021; White et al., 2022; Ayilu et al., 2023), indirectly threatens food security by reducing the populations of both target species and other species important for maintaining ecosystem health and local livelihoods.

The final theme from the literature review suggested that industrial fishing activities may outcompete local users and export catch to distant markets, thus decreasing the available food for local communities. This competition and exportation, often linked to foreign actors or illegal, unreported, and unregulated (IUU) fishing practices, negatively impact local food security (Kent, 1997, 2003; Alder and Sumaila, 2004; Atta-Mills et al., 2004; MRAG, 2005; Pauly et al., 2005; Neiland, 2006; Salayo et al., 2006; van Mulekom

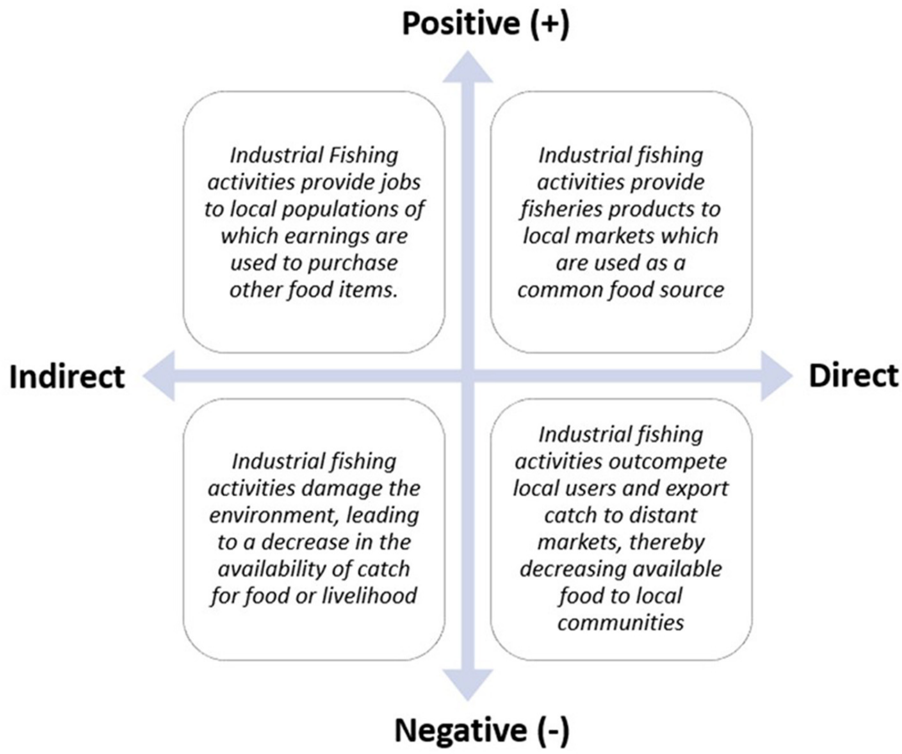

FIGURE 4
Conceptual diagram organizing the impacts of industrial fishing on food security as positive or negative and direct or indirect.

et al., 2006; Ovetz, 2007; Garcia and Rosenberg, 2010; Srinivasan et al., 2010; Le Manach et al., 2012; Campbell and Hanich, 2014; Cruz-Trinidad et al., 2014; Belhabib et al., 2015, 2020; Mcclanahan et al., 2015; Gillett, 2016; Golden et al., 2016; Pomeroy et al., 2016; Teh et al., 2017; Bell et al., 2018; Bennett et al., 2018; de Abreu-Mota et al., 2018; James et al., 2018; Mccauley et al., 2018; Schiller et al., 2018; Merem et al., 2019; Taylor et al., 2019; Vianna et al., 2020; Carlson et al., 2021; Danquah et al., 2021; Warren and Steenbergen, 2021; Nash et al., 2022; Touron-Gardic et al., 2022; White et al., 2022; Ayilu et al., 2023).

A notable observation was the often-ambiguous definition of "industrial fishing" in the existing literature. Only a handful of studies clearly articulate the specific characteristics or types of industrial fishing they focus on. This lack of precise definition is a concern, given the diversity of fishing methods and operations encompassed under the umbrella of industrial fishing. The term can include a wide range of activities, from large-scale trawling operations to long-lining and purse-seining, each with distinct environmental impacts and implications for local communities and food security. Without a clear understanding of what constitutes industrial fishing activities in each study, drawing generalized conclusions or comparisons across different research works becomes difficult. While this review defined four overarching themes that describe the relationship between industrial fishing and food security, it should be noted that more positive and negative, direct and indirect relationships likely exist. For example, many industrial fishing activities produce fishmeal for the aquaculture or livestock industry which also has implications for food security.

3.3 Previous methods and data types used to draw conclusions about industrial fishing and food security

To understand the rationale and process in determining the four general themes identified, various methodological approaches and data sources were identified based on the research design (Figure 6). The majority of studies employed a singular method (49 studies), while only eight studies utilized a mixed-methods approach. These methodologies spanned econometric models, anthropological studies, catch reconstruction, conceptual frameworks, value chains, food balance, meta-analysis and review, policy analysis, geospatial analysis, coupled models, and fisheries performance indicators (Figure 5).

Econometric methods applied statistical and mathematical modeling to economic datasets for hypothesis testing and forecasting (MRAG, 2005; Béné, 2008; Wamukota and McClanahan, 2017; James et al., 2018; Alsaleh, 2023; Elzaki, 2024). In contrast, anthropological methods are deeply qualitative and typically involved ethnographic techniques, including participant observation and interviews (Atta-Mills et al., 2004; Fabinyi et al., 2017; Asiedu et al., 2018; Merem et al., 2019; Danquah

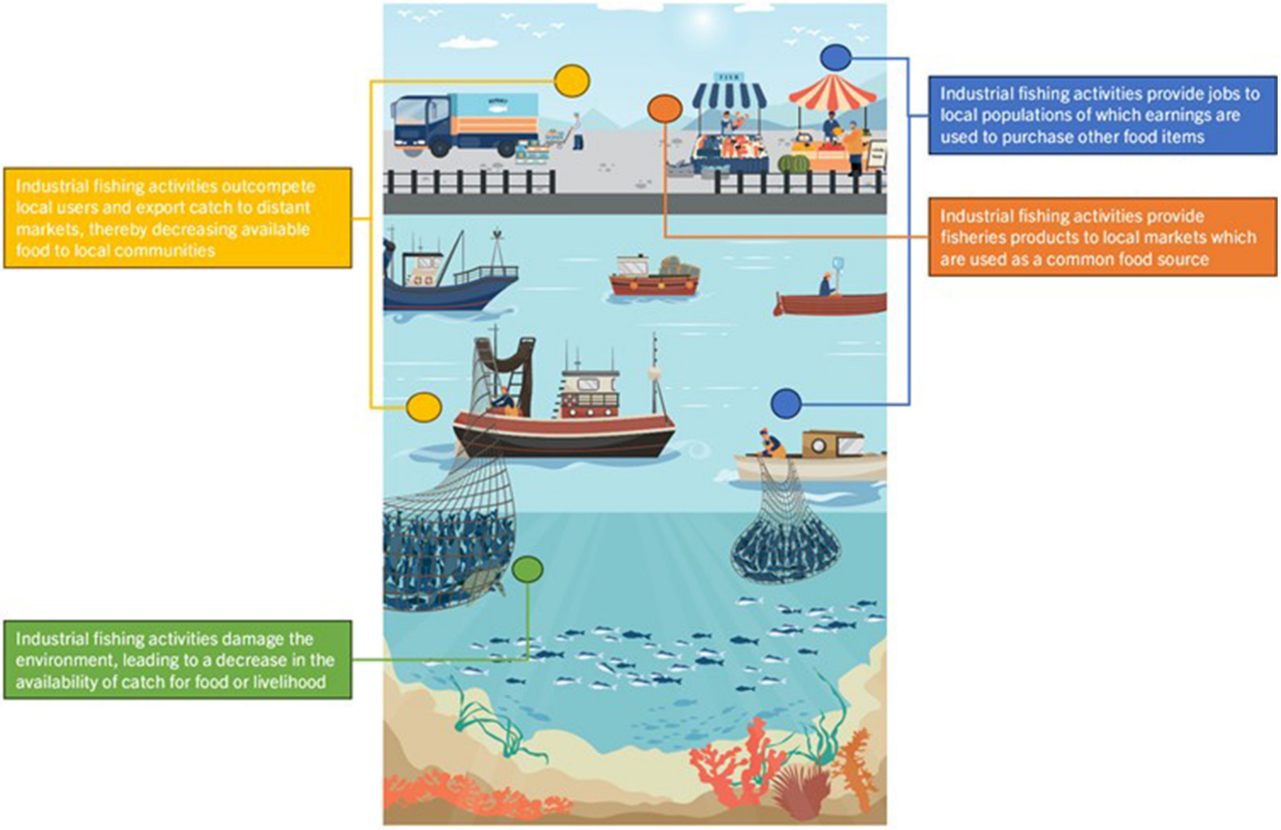

FIGURE 5
An illustration of the four themes detailing the relationship between industrial fishing and food security.

et al., 2021; Warren and Steenbergen, 2021; Ayilu et al., 2023). The catch reconstruction method was characterized by the analysis of historical catch data, often reconstructing records to include underreported or missed data in order offer insights into past fisheries trends (Le Manach et al., 2012; Belhabib et al., 2015, 2018; Teh and Pauly, 2018). Studies utilizing conceptual frameworks deployed theoretical constructs to structure their research or arguments, providing a basis for both singular and mixed-method analyses (Trondsen, 2003; Salayo et al., 2006; Lowitt, 2014; Pomeroy et al., 2016; de Abreu-Mota et al., 2018; Taylor et al., 2019; Roberts et al., 2023). Value chain studies examined the sequence of fish products from catch to consumer, shedding light on production processes and access to fisheries resources (Schiller et al., 2018; Touron-Gardic et al., 2022; Roberts et al., 2023). The food balance method focused on assessing nutrient availability and potential nutritional deficiencies (Srinivasan et al., 2010; Gillett, 2016; Golden et al., 2016; Sampantamit et al., 2021; Nash et al., 2022). Meta-analysis/review/policy-oriented studies synthesized existing literature or presented descriptive statistics as a foundation for their discussions (Kent, 1997, 2003; Hotta, 2000; Feidi, 2003; Alder and Sumaila, 2004; Pauly et al., 2005; Neiland, 2006; van Mulekom et al., 2006; Ovetz, 2007; Al-Habsi et al., 2010; Garcia and Rosenberg, 2010; Bondad-Reantaso et al., 2012; Campbell and Hanich, 2014; Cruz-Trinidad et al., 2014; Mcclanahan et al., 2015; Bell et al., 2018; Bennett et al., 2018; Vianna et al., 2020). These types of papers were purposefully included and lumped together as this category because they made assumptions about industrial fishing and food security but not necessarily based on new data or through a clear methodology. Geospatial studies employed spatial data to discern patterns and trends, particularly in fisher behavior (James et al., 2018; Mccauley et al., 2018; Merem et al., 2019; Belhabib et al., 2020; White et al., 2022). A single study implemented a coupled social-ecological systems model, integrating ecological and social frameworks to interpret the interplay between marine ecosystems and human communities (Carlson et al., 2021). Another distinct study assessed fisheries using Fisheries Performance Indicators, evaluating triple bottom line outcomes regarding sustainability, profitability, and community impact (Marco et al., 2021).

In terms of data types, diverse datasets were used to make conclusions about industrial fishing and food security (Figure 5). Fisheries production data was the most commonly used, including fisheries catch or landings data, often collected from national statistics (Alder and Sumaila, 2004; Pauly et al., 2005; Garcia and Rosenberg, 2010; Le Manach et al., 2012; Campbell and Hanich, 2014; Belhabib et al., 2015; Teh and Pauly, 2018; Sampantamit et al., 2021). Consumption data were also quite commonly used, encompassing household food recall surveys, higher-level food security indicators, perceptions about food security, consumer behavior information, or nutrient information (Asiedu et al., 2018;

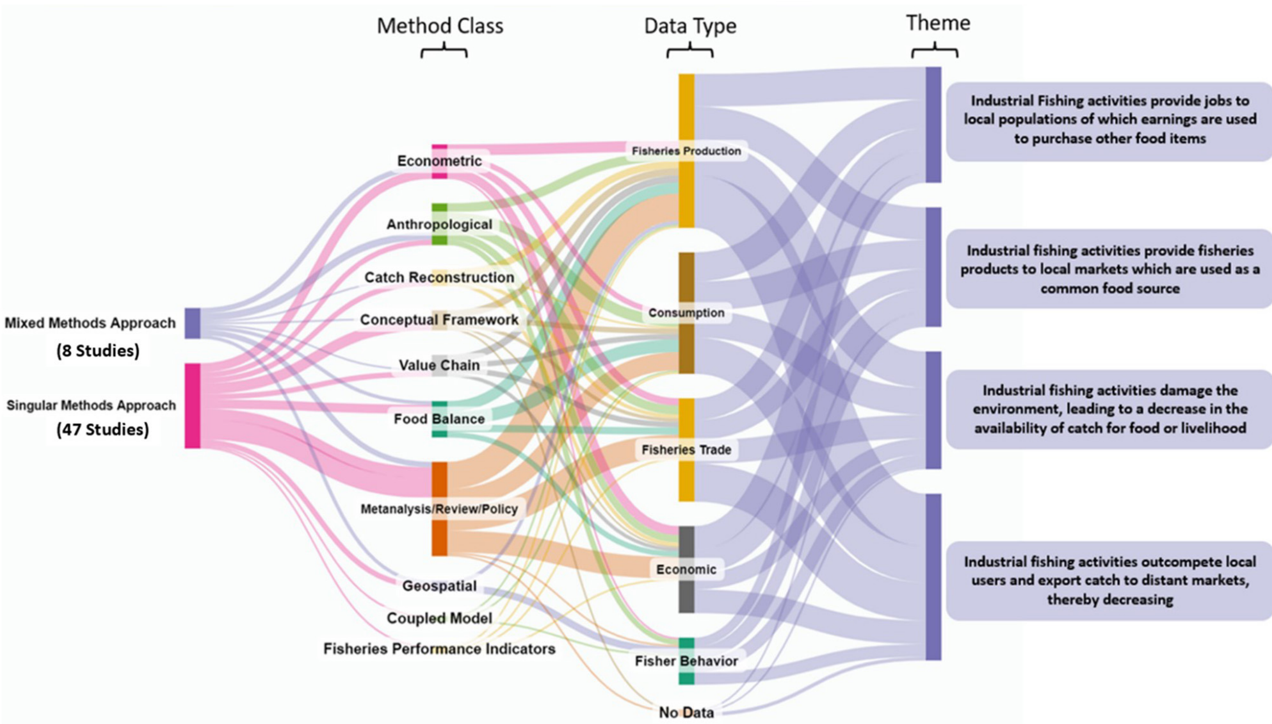

FIGURE 6
Sankey diagram showing the breakdown of methods and data types used in the studies reviewed and the resulting theme of the study.

Taylor et al., 2019; Danquah et al., 2021; Nash et al., 2022; Ayilu et al., 2023). Fisheries trade data included import or export data, usually derived from national statistics, or through questionnaires to individual households or stakeholders to understand the flow of fisheries products within their community (Feidi, 2003; Trondsen, 2003; Bondad-Reantaso et al., 2012; Schiller et al., 2018; Teneva et al., 2018; Touron-Gardic et al., 2022). Economic data, encompassing fish price, gross domestic product, and household income, provided insights into the economic impacts of fisheries on local and national economies (Trondsen, 2003; MRAG, 2005; Béné, 2008; Wamukota and McClanahan, 2017; Alsaleh, 2023; Elzaki, 2024). Fisher behavior presented data that showed the patterns in fishing effort of industrial fishers and sometimes local users or the preferences of local users. This type of data offered insights into the dynamics between different fishing practices and their impact on fisheries sustainability and community livelihoods (James et al., 2018; Belhabib et al., 2020; Warren and Steenbergen, 2021; White et al., 2022).

This review showed that the majority of studies used a single methods approach, rather than a mixed methods approach to address industrial fishing and food security. Further, the majority of studies used fisheries production data in their analysis. However, a critical limitation of studies focused primarily on fisheries production is their potential oversimplification of the food security equation (Béné et al., 2016a,b; Fabinyi et al., 2017; Bennett et al., 2021). While it is true that many communities are heavily dependent on fisheries, the assumption that reduced fish catch directly equates to food insecurity does not always hold. Food systems are dynamic, adaptive systems of which food security is a complex issue, influenced by a myriad of factors beyond immediate access to fish (Ericksen, 2008; Hall and Clark, 2010). Households in fisheries-dependent communities often exhibit resilience and adaptability in the face of changing circumstances (Coulthard, 2008; Blythe et al., 2014; Leite et al., 2019; Satumanatpan and Pollnac, 2020). For instance, in scenarios of low fish harvests, these communities may shift their dietary reliance to terrestrial foods. This adaptability is a crucial aspect of food security that needs to be considered in any comprehensive analysis. Additionally, these communities may leverage other coping strategies, such as seeking governmental support services or relying on social networks like friends and family for assistance. These strategies reflect the broader socio-economic and cultural contexts that influence food security. Therefore, while fisheries production data is undoubtedly valuable, it represents only a part of the broader food system.

A major finding of this research is that despite previous studies making claims about the relationship between food security and industrial fishing very few of these studies managed to produce empirical results to actually support these claims. It is clear that addressing the linkage between industrial fishing activities and food security is difficult due to the lack of comprehensive, long-term datasets that encapsulate both the intricacies of industrial fishing and local resource users (such as catch data and fishing effort) and the multifaceted nature of food security (including household consumption patterns). This data gap has led researchers to often concentrate on one side of the equation—either industrial fishing or food security—before attempting to theorize or establish connections to the other side. The rarity of studies that empirically link industrial fishing activities directly to food security outcomes highlights a significant gap in current research.

4 Conclusion

To truly understand the impact of industrial fishing on food security, an integrated, mixed-methods approach rooted in specific local contexts will be essential. Such an approach must consider not only the direct effects of fishing activities but also household behavior, community resilience, and socio-economic structures. Future studies that combine detailed fisheries and ecosystem data with household consumption patterns, coping strategies, social safety nets, and the local food system will provide a more nuanced and accurate picture of this complex relationship. This holistic approach is crucial for developing effective policies and interventions to ensure food security in fisheries-dependent communities especially as fishing continues to be industrialized.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

SF: Writing – original draft, Writing – review & editing. NH: Funding acquisition, Project administration, Supervision, Writing – review & editing. FM: Conceptualization, Project administration, Supervision, Writing – review & editing. EW: Supervision, Writing – review & editing. RA: Supervision, Writing – review & editing. MC: Supervision, Writing – review & editing. JK: Supervision, Writing – review & editing.

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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.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/focsu.2024.1419236/full#supplementary-material

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