frontiers in Sustainable Food Systems

REVIEW
published: 05 January 2022
doi: 10.3389/fsufs.2021.703152

Seafood in Food Security: A Call for Bridging the Terrestrial-Aquatic Divide

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Specialty section:
This article was submitted to Agroecology and Ecosystem Services, a section of the journal Frontiers in Sustainable Food Systems

Received: 30 April 2021
Accepted: 25 November 2021
Published: 05 January 2022

Citation:
Stetkiewicz S, Norman RA, Allison EH, Andrew NL, Ara G, Banner-Stevens G, Belton B, Beveridge M, Bogard JR, Bush SR, Coffee P, Crumlish M, Edwards P, Eltholth M, Falconer L, Ferreira JG, Garrett A, Gatward I, Islam FU, Kaminski AM, Kjellevold M, Kruijssen F, Leschen W, Mamun A-A, McAdam B, Newton R, Krogh-Poulsen B, Pounds A, Richardson B, Roos N, Röös E, Schapper A, Spence-McConnell T, Suri SK, Thilsted SH, Thompson KD, Tlusty MF, Troell MF, Vignola R, Young JA, Zhang W and Little DC (2022) Seafood in Food Security: A Call for Bridging the Terrestrial-Aquatic Divide. Front. Sustain. Food Syst. 5:703152. doi: 10.3389/fsufs.2021.703152

The contribution of seafood to global food security is being increasingly highlighted in policy. However, the extent to which such claims are supported in the current food security literature is unclear. This review assesses the extent to which seafood is represented in the recent food security literature, both individually and from a food systems perspective, in combination with terrestrially-based production systems. The results demonstrate that seafood remains under-researched compared to the role of terrestrial animal and plant production in food security. Furthermore, seafood and terrestrial production remain siloed, with very few papers addressing the combined contribution or relations between terrestrial and aquatic systems. We conclude that far more attention is needed to the specific and relative role of seafood in global food security and call for the integration of seafood in a wider interdisciplinary approach to global food system research.

Keywords: food security, seafood, food system, food and nutrition security, interdisciplinary

INTRODUCTION

Seafood, including the full range of animals and plants produced in water and encompassing both marine and freshwater environments, makes an important contribution to global food security—an estimated 59.6 million people depend on capture fisheries and aquaculture for their livelihoods and nutrition, and a further 3.2 billion people rely on fish to provide 20% or more of their average per capita intake of animal protein (FAO, 2018). This consumption of seafood is particularly important for low income regions of the world where plant and animal seafoods are a major source of essential nutrients including long-chained polyunsaturated omega-3 fatty acids (Michaelsen et al., 2011; Lund, 2013), and vitamins and minerals such as calcium (Larsen et al., 2000), iron, zinc, and vitamin A (Roos et al., 2007).

Despite the importance it makes to the global diet, attention has only recently turned to the importance of "sea-food security." The role that seafood plays, both currently and into the future, has been highlighted in several recent global science-policy documents (e.g., HLPE, 2014; United Nations, 2015). The overall message encapsulated in these reports, complimented by a growing academic literature, is that the role of seafood in food security is not only significant but also largely underestimated. However, much of the literature on seafood security is "siloed" with attention given to the role of marine and freshwater animal and plant production consumption largely in isolation from the terrestrial food with which it is consumed (Béné et al., 2015).

Isolating out seafood from the rest of the food system is problematic for several reasons. First, aquatic and terrestrial food production is intrinsically linked, given their use of the same finite resources and the feedback cycles which connect them—perhaps most obvious when agricultural water pollution impacts on aquatic food production systems (Parris, 2011), and given the increasing reliance of fed aquaculture on terrestrial feed ingredients (Naylor et al., 2021). Second, understanding the relative impact of aquatic and terrestrial foods, in terms of climate emissions, land use, and resource use is essential to enable "whole plate" sustainability assessment and planning (Hilborn et al., 2018; Parker et al., 2018; Poore and Nemecek, 2018; Tsakiridis et al., 2020). Third, understanding sustainable nutrition also means understanding the relative contribution of seafood in contrast and combination with terrestrial foods—both in absolute nutritional terms (Willett et al., 2019) and in terms of replacing terrestrial proteins such as beef (Tilman and Clark, 2014; Davis et al., 2016). While growing attention is being given to the importance of understanding the role of seafood from an integrated food systems perspective (Béné et al., 2015; Blanchard et al., 2017; Gephart et al., 2017; Cottrell et al., 2018; Bogard et al., 2019; Halpern et al., 2019; Tlusty et al., 2019; Tezzo et al., 2020; Bennett et al., 2021), it is not clear to what extent the contribution of seafood is considered in the context of food security both alone and in combination with terrestrial food production.

In this paper we fill these gaps by reviewing the ways in which the academic literature on food security published between 2007 and 2017 has addressed the contribution of aquatic and terrestrial food production to food security within the wider global food system. In doing so we consider food security from a food system perspective (Ericksen, 2008; Ingram, 2011) that integrates production, processing, distribution, and consumption of food with food security outcome categories of availability, access, and utilization, as well as impacts on environmental, social, and economic sustainability dimensions. We also explore how the contribution of seafood has been treated in this literature in terms of weighing the contribution of fisheries and aquaculture to nutrition with its wider social, economic, and environmental impacts in different parts of the world. Finally, following the ambitions of food systems research to recognize the multi-faceted nature of food production, trade and consumption, we explore the degree to which sea-food security has been taken up through interdisciplinary research approaches (following Horton et al., 2017).

The following section describes the scoping review methodology we adopted for this study as well as the parameters used to delimit our literature search and document analysis. We then present the results of the review, focusing on the prevalence of seafood in relation to terrestrial livestock and crops in the light-touch review and the content of papers specifically focused on seafood in terms of the importance given to seafood, the quality of this analysis and the degree to which an interdisciplinary food systems perspective is currently applied. Finally, we discuss the potential for future research to integrate the role of seafood more centrally in global food systems research.

METHODS

We adopt a scoping review methodology to map key areas of recent literature related to seafood's role in food security and identify research gaps in the existing literature (Arksey and O'Malley, 2005). Following Munn et al. (2018), we determined that a scoping review is better suited to our objectives than other types of literature synthesis, such as systematic reviews, because we are interested in providing an overview or map of the current evidence rather than addressing the feasibility, appropriateness, meaningfulness, or effectiveness of the methods within this literature. A further benefit of a scoping review is that while they make use of an *a priori* protocol and aim to be transparent and reproducible, they allow more flexibility for including review papers as well as qualitative and quantitative research. As argued by Peterson et al. (2017), this makes scoping reviews particularly well suited to complex and interdisciplinary areas of literature such as food security.

We delimited the scoping review to seven key themes related to food security: "production," "nutrition," "behavior," "consumption," "modeling," "resource use," and "safety." These themes were inductively generated by the Sustainable Seafood Consumption Initiative (SSCI)[1e] based on interdisciplinary research experience, and agreed at the first SSCI international meeting, which brought together and provided input from over 50 experts representing more than 15 countries across Europe, South East Asia, Africa, and North America, from a diverse range of disciplines and a mixture of terrestrial and aquatic food research backgrounds. These themes were intended to ensure papers were incorporated in the review from a variety of disciplines and with a number of different disciplinary perspectives on food security.

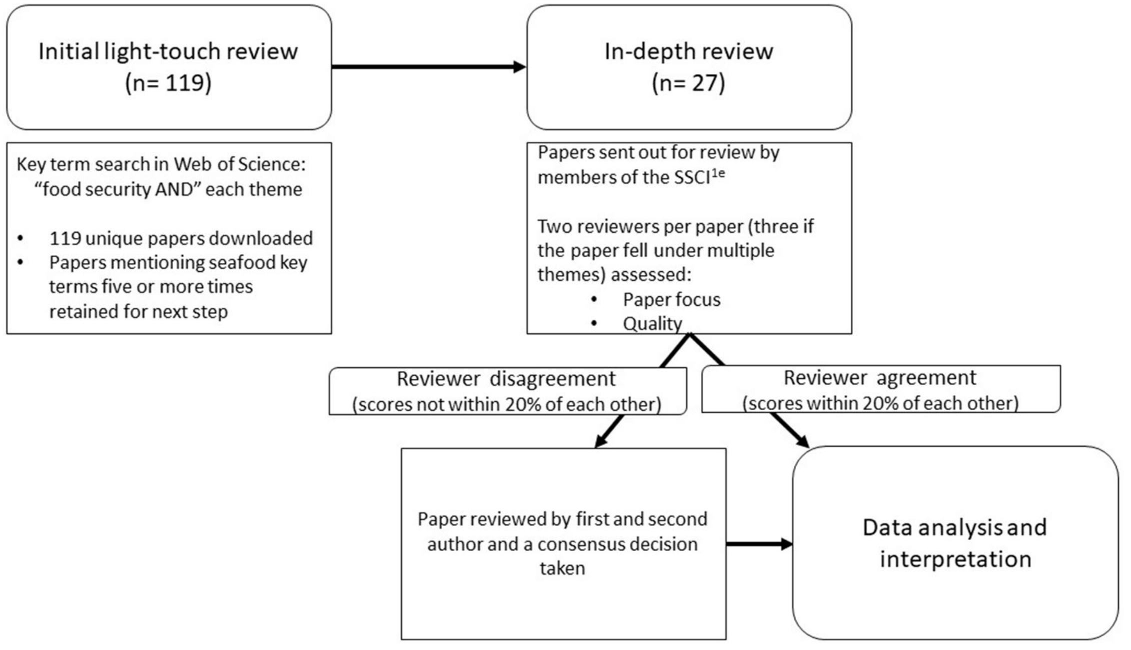

FIGURE 1 | Overview of scoping review methodology used in this paper. Themes included in the key term search: nutrition, behavior, production, consumption, modeling, resource use, and safety.

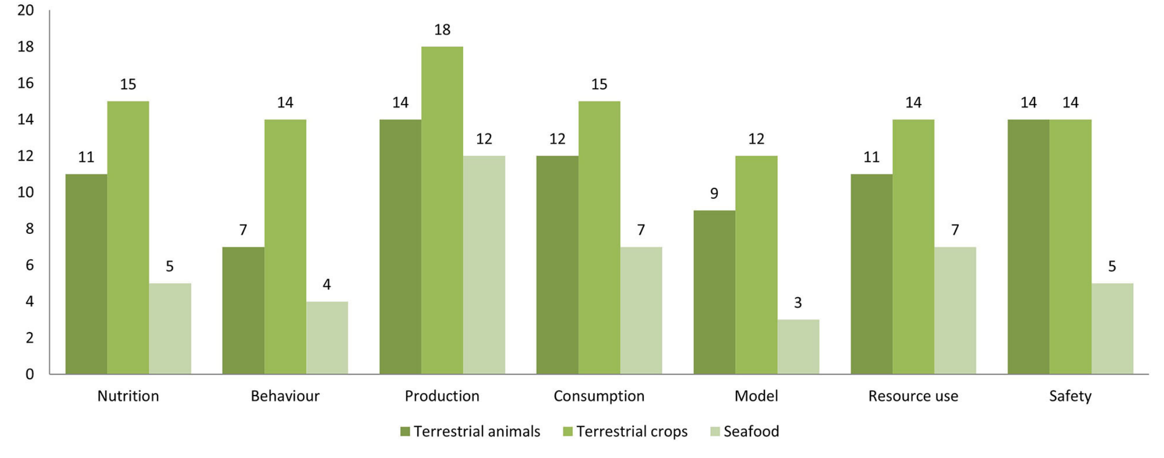

FIGURE 2 | Number of papers mentioning each food category five or more times, by theme.

The analysis aimed to identify differences in representation of seafood compared to terrestrial food among these themes and was implemented in two stages: 1. an initial light-touch review that identified potentially relevant papers to the topic, and 2. an in-depth review of papers for a range of important characteristics (**Figure 1**).

Initial Light-Touch Literature Review

The Web of Science, one of the fourteen academic search engines found to meet all performance requirements to be suited to being a principal literature search source (Gusenbauer and Haddaway, 2020), was selected as the database for this project due to its inclusion of over 73 million pieces of data, replicability of search strings, and advanced search settings. For works published from 2007 to January 2018, the first 20 papers available in English, sorted by relevance, were downloaded for seven combinations of keywords—"food security" AND each individual theme: "nutrition," behavior (searched as "behavi*r", to include both UK and US spellings), "production," "consumption," modeling (searched as "model"), "resource use," and "safety." This resulted in 140 papers, 21 of which were duplicates (i.e., these papers were in the first twenty papers listed for two or more themes), giving a total of 119 unique papers across the seven themes (see **Supplementary Materials** for a full list of papers and themes).

Using the Web of Science "topic" search function meant that the key words from this review were searched for within the paper's title, author-selected keywords, keywords plus (words or phrases that frequently appear in the titles of an article's references), and abstract, allowing for a broader sample than if only those papers with the review keywords in their titles or author-selected keywords were returned.

Each paper was manually reviewed to determine the number of times key terms relating to seafood (fish, seafood, seaweed, etc.), terrestrial crops (rice, wheat, vegetable, etc.), and terrestrial animal-source foods (beef, chicken, dairy, etc.) were used. Five or more mentions of any combination of key terms for the seafood category was set as the threshold for further review; where a paper mentioned key terms relating to seafood, terrestrial crops, or terrestrial animals five or more times, it was deemed possible that this food category was a core component of this paper. Where a paper mentioned a given food category less than five times, this was assumed not to be a substantive element of the paper, for example in reference to the use of similar methods in another system, or in introduction or discussion sections as an area for further study.

Comparisons were made of the number of papers mentioning each food category five or more times by theme (**Figure 2**). In order to determine whether papers were focusing on only one food category, or whether papers were more likely to consider multiple food categories, the number of papers mentioning only one food category five or more times, those mentioning two food categories five or more times, and those mentioning all three food categories five or more times were quantified (**Figure 3**).

In-depth Paper Reviews

A total of 27 papers mentioned seafood key terms five or more times and were reviewed in-depth. Expert reviewers were sought through the SSCI[1e] and each paper was assigned for review according to area of expertise. Reviewers were asked to answer

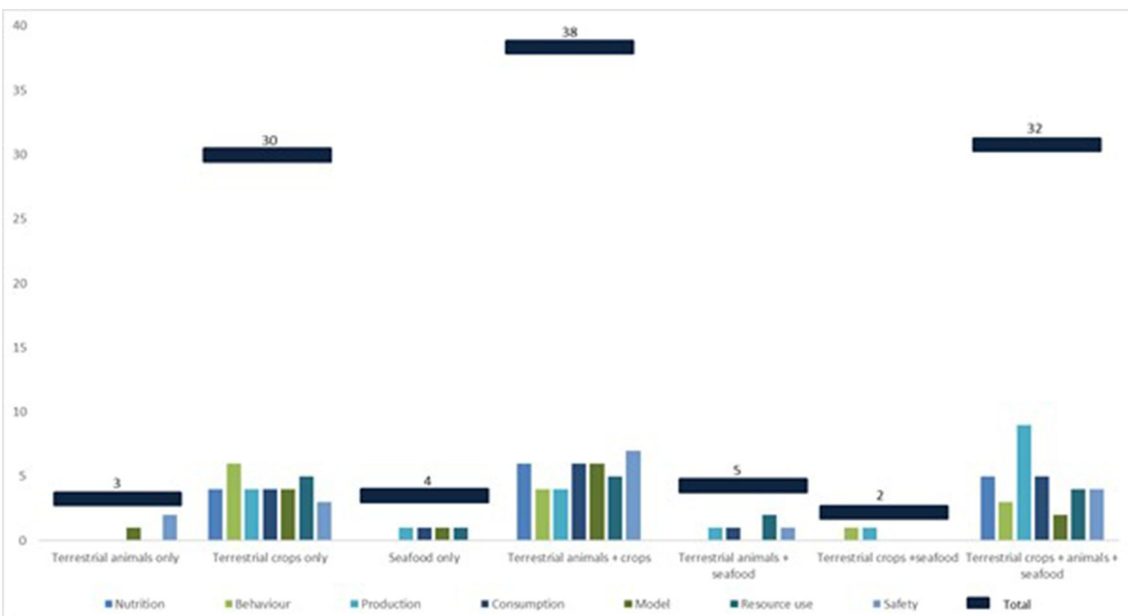

FIGURE 3 | Number of papers mentioning each food category and/or combination of food categories five or more times. Duplicated papers, those which appeared in multiple themes' literature reviews, are counted only once. Total refers to the total number of papers mentioning each food category and/or combination five or more times.

TABLE 1 | Reviewer template for considering paper focus.

	Possible responses
How integral is seafood to this paper?	1— Not very, e.g., seafood is only mentioned in introduction and discussion in passing 2— Moderately, e.g., paper uses seafood as an example, but doesn't provide much detail/analysis 3— Very, e.g., seafood is a core topic of the paper
Which countries/ geographical areas are the focus of this paper?	Free text response
Is the focus on over- or under-consumption of food?	Underconsumption, overconsumption, neither under nor overconsumption, both under and overconsumption
Level of interdisciplinarity?	1— mono-disciplinary, e.g., paper uses standard biological methods without discussion of other areas 2— paper includes some interdisciplinary elements, e.g., paper uses biological methods but includes a brief economic analysis 3— paper is highly interdisciplinary, e.g., paper uses biological outputs to inform an economic model

TABLE 2 | Reviewer template for considering paper quality [adapted from Béné et al., 2016].

	Criteria	Possible responses
Validity	Are the findings substantiated by the data and has consideration been given to limitations of the methods that may have affected the results?	Yes, No, Partially
	Are there problems in applying the method to some research question(s)?	Yes, No, Partially
Rigor	Is the context or setting adequately described?	Yes, No, Partially
	Is (are) the research question(s) clear?	Yes, No, Partially
	Is the method used appropriate to answer the research question(s)?	Yes, No, Partially
	Is the method applied correctly?	Yes, No, Partially
	Is there evidence that the data collection was rigorously conducted to ensure confidence in the findings?	Yes, No, Partially
Reliability	Is the data analysis rigorously conducted to ensure confidence in the findings?	Yes, No, Partially
	Is the methodology adequately described to ensure confidence in the findings?	Yes, No, Partially
Any other comments or notes		

a series of questions relating to paper focus (**Table 1**) and quality (**Table 2**).

Quality was assessed using the methods presented by Béné et al. (2016), which calculate a percentage score based on answers to nine questions in the categories of validity, rigor, and reliability. Where this method was not suitable for a given paper (e.g., theoretical papers or reviews), quality was not assessed. An overall quality score was calculated for each paper, based on each reviewer's answers. Where differences between reviewer answers were >20%, the lead and second author reviewed the paper and took a consensus decision regarding quality. Overall quality levels were classed as: high quality—required the paper to have scores of over 0.75 for all three of validity, rigor, and reliability; moderate quality—had at least one score below 0.75, but at least two scores above 0.5; and low quality—where at least two of the scores fell below 0.5.

Where reviewers disagreed about issues relating to paper focus, the first author reviewed the paper in question and took a final decision. The majority of data regarding paper focus and quality were summarized according to theme and across the whole dataset. As no papers were listed as having a focus on overconsumption of food alone, this is not reported further.

Final scores were calculated by taking an average of the responses to the question "How integral is seafood to this paper." Where this score was below 1.5, the answer was deemed to be "Not very integral" between 1.5 and 2.49 was deemed to be "Moderately" integral and ≥2.5 was deemed to be "Very" integral. The same method was used to assess the level of interdisciplinarity, based on the use of, or discussion of, multiple discipline perspectives on the research question. For example, a paper which used only standard biological methods would be considered mono-disciplinary, while a paper which used biological analysis to inform an economic analysis and presented both results would be considered highly interdisciplinary. In order to determine to what extent the representation of seafood in the literature is simply a result of local importance in the diet, for countries/geographical areas, comparisons are drawn between the level of importance of seafood in the paper and the importance of fish to diets in that country in terms of % total protein supply coming from seafood.

RESULTS

Prevalence of Seafood in Relation to Terrestrial Livestock and Crops in the Light-Touch Review

The results of the light touch review reveals that terrestrial crops were the most frequently represented in the sampled papers across all themes with the exception of food safety, where terrestrial animals (generally the second most commonly represented) were represented in an equal number of papers. In contrast, the number of papers mentioning seafood accounted for less than half of those reviewed in each theme (**Figure 2**).

The majority of papers, however, were not specific to a single food category and included key terms for two or three categories of food. The most common combination of these terms, for 32% of papers, related to terrestrial animals and crops (**Figure 3**). Twenty-two papers mentioned all three food categories at least five times. The least common combination was terrestrial crops and seafood, accounting for only two papers, followed

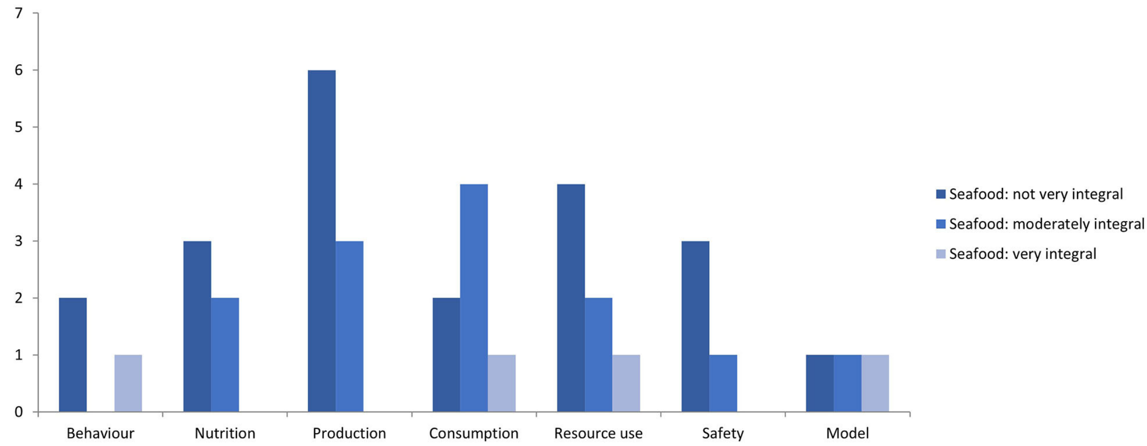

FIGURE 4 | Importance of seafood to the papers, by theme.

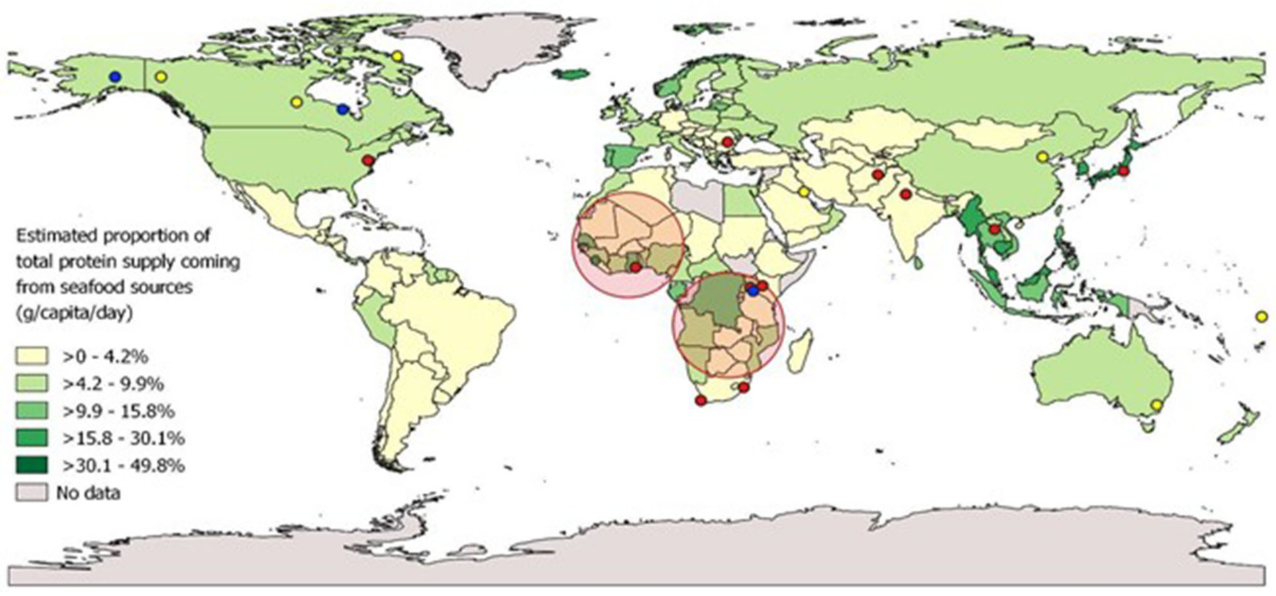

FIGURE 5 | Geographic distribution of papers reviewed in-depth. Papers with a global scope are not represented. Where papers focused on an entire country, their geographic location is given as the capital city. Two papers considered multi-country regions—these are indicated by the two large circles (these circles do not delineate the exact area covered), one of which was relating to West Africa, and one relating to Sub-Saharan Africa. Colors show how integral seafood was to this paper—blue dots indicate seafood was very integral, yellow that seafood was moderately integral, and red that seafood was not very integral. Green country shading indicates the estimated proportion of total protein supply derived from seafood (calculated as the sum of total fish and total other aquatic protein supply) in 2013, as per FAOSTAT food balance sheet data (FAO, 2017). The map was prepared in QGIS and values were categorized using Jenks natural breaks classification to show groups in the data.

by terrestrial animals and seafood (five papers). This indicates a general lack of research cutting across both terrestrial and aquatic systems in comparison with terrestrial-terrestrial systems (**Figure 3**). The least common food category was terrestrial animals, though both terrestrial animals and seafood were discussed individually far more rarely than terrestrial crops (three papers on terrestrial animals only, as compared with four for seafood only, and 30 for terrestrial crops only).

In-depth Analysis of Papers Mentioning Seafood key Terms Five or More Times

Level of Importance of Seafood

Seafood was "very integral" to only three out of the 27 papers subject to in-depth review, and moderately integral to a further eight of these papers. It was not deemed integral to the remaining majority of papers. Some variation exists by theme, both in terms of total number of papers reviewed and in respect to seafood

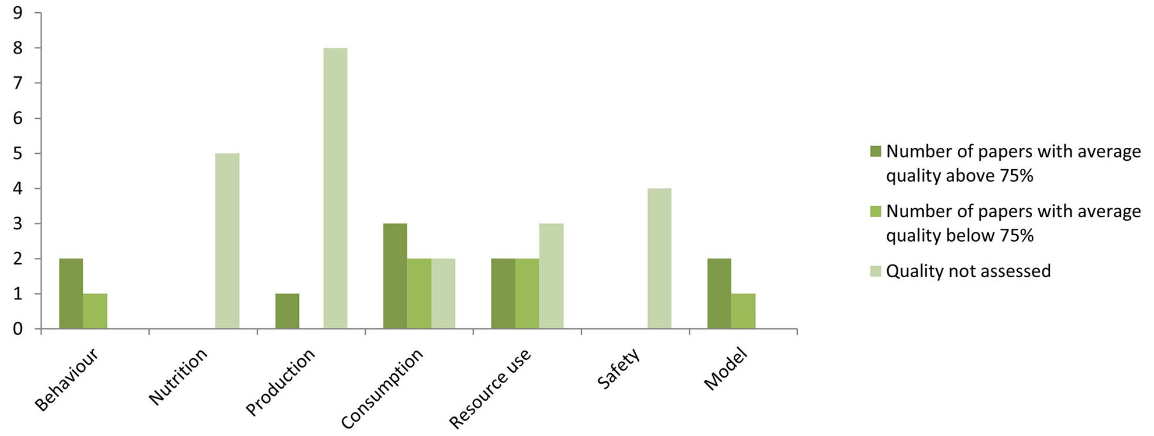

FIGURE 6 | Quality assessment by theme. Note that due to some papers being present under multiple themes, the number of papers in this figure does not add up to 27.

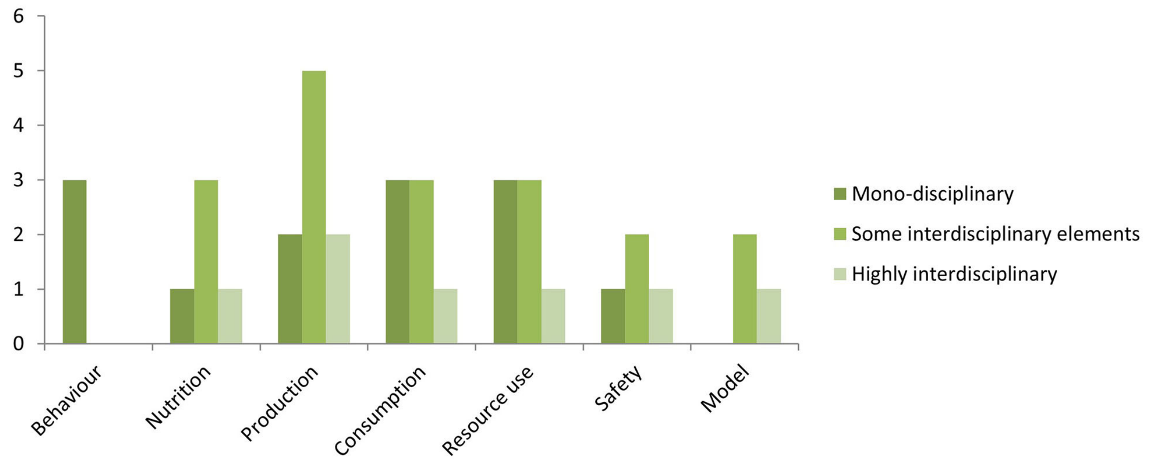

FIGURE 7 | Level of interdisciplinarity, by theme.

integrality, with papers in the "Modeling" theme equally split between not very integral, moderately integral, and very integral, and more than half of papers in the "Consumption" theme rated seafood as moderately integral (**Figure 4**). The "Production" theme, by contrast, has no papers where seafood was deemed very integral, despite having more papers reviewed than any other theme.

Geographic Distribution

Papers reviewed came primarily from North America, Africa, and Asia, with few papers from Europe and Australia, and none from South America (**Figure 5**). Seafood was very integral to all but one of the North American papers; this is in sharp contrast to the papers from Africa, where seafood was not very integral to all but one. It is therefore not simply the case that seafood was very integral in papers from countries where it plays an important role in diets, and not integral in countries where it does not. Three papers were considered to be global in scope—these are not included in **Figure 5**, but in all cases, seafood was classed as not very integral.

Paper Quality

Out of the 27 papers reviewed in depth, 13 were review or theoretical papers, and so were not given a quality score. The high proportion of review papers in this sample highlights the depth of primary literature relating to food security. Of the remaining 14 papers, 8 had an average quality score of over 75% and were deemed to be of high quality, and 6 of under 75%. For themes where papers could be assessed by quality, the number of papers with an average quality below 75% never exceeded the number of papers with an average quality above 75% (**Figure 6**).

Paper Interdisciplinarity

Over 70% of papers reviewed in-depth were considered to be mono-disciplinary, with six papers having some interdisciplinary elements, and only two papers being considered highly interdisciplinary. Some variation among themes is evident, with all "Behavior" papers being mono-disciplinary, while more than half of the papers from the "Nutrition" and "Production" themes had some interdisciplinary elements (**Figure 7**). "Model" was the only theme which did not contain any mono-disciplinary papers.

DISCUSSION

Seafood was not integral to the majority of the 27 papers reviewed in-depth across all themes, and appears to be particularly under-represented in relation to nutrition, production, and safety, themes where no papers were deemed to have seafood as a very integral component. However, seafood is not totally absent from the reviewed literature, as evidenced by the fact that key seafood terms were mentioned at least five times in multiple papers under each theme. Given the importance of terrestrial crops to food security, it is unsurprising that these production systems are most prevalent in the food security literature reviewed.

Overall, the review reveals a low degree of integrated food-systems thinking as represented by the few papers that combined seafood with both terrestrial crops and terrestrial animals. The terrestrial food security literature does in contrast integrate terrestrial plant and animal production more substantially. The lack of attention given to understanding the interlinked role of seafood for food security highlights a clear set of gaps in the recent food security literature. First, it currently fails to adopt a whole-plate approach to nutrition that would enable a clearer understanding of the relative importance of water and land-based foods and the future challenges of changing patterns of availability. Second, at the production end, there is an ongoing need to understand the consequences of further feed-based intensification as aquaculture continues to grow and depend on a growing share of both terrestrial and aquatic plant-based feed stock (Troell et al., 2014). Third, it fails to draw attention to the multiple facets of transitioning to a holistic understanding of sustainable food systems that considers the relative consequences of terrestrial and aquatic foods in terms of food safety, feedback from land and sea-based behavioral change and the wider ecosystem level feedback from resource use.

The lack of an integrated food systems approach is also evidenced by the geographical spread across the papers reviewed. The lack of attention to seafood in the papers reviewed was not a function of where the research had been undertaken. In more than half the papers with a single country focus, seafood made up at least 5% of total protein supply—for context, seafood makes up 5% or more of the protein supply in 89 countries, and <5% in 88 countries (FAO, 2017). Further, the local importance of seafood in diets did not link clearly with the importance of seafood in the reviewed papers, despite the fact that seafood can be critical to communities vulnerable to poverty and nutritional insecurity (de Roos et al., 2018) and could continue to support food security as the global population increases, particularly in the Global South (Béné et al., 2015). Further study, specifically assessing the representation of seafood in the food security literature from these regions could help to clarify these findings. Such an understanding is important because regions where fish is a key component of the diet, such as South East Asia (FAO, 2017), are often also areas where climate change is expected to have a disproportionately high impact on public health, as well as economic, political, and resource security (Kumaresan, 2011). Specific groups, such as coastal indigenous peoples, who are highly vulnerable to climate change, are also highly reliant on seafood, with a per capita consumption which is 15 times higher than their non-indigenous counterparts (Cisneros-Montemayor et al., 2016). For Pacific Island countries and territories, for example, where subsistence fishing provides a key source of dietary protein, forecasts predict that even well-managed fisheries will struggle to meet demand in 2030 (Bell et al., 2009). In this region, redistribution of fish due to climate change poses a serious threat to food security, one which may require policy intervention and negotiations to ensure long-term resource conservation (Bell et al., 2021). Such region-specific research is needed to ensure local seafood system sustainability, with knowledge sharing across regions allowing best practice to spread rapidly and underpin global sustainability. Seafood from aquaculture may increasingly support food systems as they become more sustainable (Béné et al., 2019). In this context, it is worth noting that there is at best a weak connection between fisheries and aquaculture policies; given the products of each are often considered substitute goods by the consumer (and this can extend to terrestrial goods such as chicken), better integration seems key to policy-making for food security. The lack of papers focusing on South America is also worth noting, and may reflect either a lack in publications relating to (sea)food security in this area, or a lower number of papers relating to South America published in English during the time frame selected for this review.

The weak interdisciplinarity observed in the reviewed papers suggests that important components from a food systems perspective, such as sustainable seafood in a dietary context, may be lacking integrated attention. Similarly, research on seafood needs to better contextualize the role of aquatic products within the broader food system, including consideration of the trade-offs for different food types in a balanced diet. Despite calls for interdisciplinary research to address the challenge of food security (Ingram, 2011; Yu et al., 2012; Horton et al., 2017; Bogard et al., 2019), and calls for researchers to move outside the epistemic bubbles of a single research discipline in order to increase accountability (Huutoniemi, 2016), this finding highlights the dominance of research in single discipline silos. Therefore, despite the evolution in problem context over the period assessed in this literature review—broadly toward the need for integrated and interdisciplinary research (e.g., United Nations, 2015; FAO, 2019; Willett et al., 2019)—the papers reviewed do not reflect this, highlighting an important research gap and raising the question of structural issues which may be preventing the widespread uptake of interdisciplinary research in the area of (sea)food security. Of interest, however, is the fact that none of the papers where seafood was deemed very integral included author affiliations to research institutes with seafood key terms in their names, suggesting these issues are of some interest to more generalist organizations.

One limitation not addressed in this paper is the question of whether seafood is under-represented in the food security literature because of a lack of research, or, whether seafood research was not included due to a lack of the use of the term "food security" in the seafood literature. However, given that a search in Web of Knowledge for "food security" (alone giving 25,123 papers) *and* "crop" gives 6,998 results, "livestock" gives 1,200, "fish" gives 1,052, it seems unlikely that it is a lack of the use of this keyword alone which has given rise to this outcome. The similarity in number of papers returned for "livestock" and "fish" is particularly interesting, and suggests that researchers in these areas are equally likely to highlight the food security aspects of their work.

Due to the time scale of the papers assessed in this work (2007–January 2018) a number of important publications which were published after this date are, by definition, excluded from this analysis. Work done on the potential for fish to provide key micronutrients for sustainable diets (Hicks et al., 2019), and the inclusion of seafood in recent conceptualisation of sustainable food systems (Bogard et al., 2019; Halpern et al., 2019), as well as the inclusion of seafood as a potentially important component of the EAT-Lancet reference diet (Willett et al., 2019), all point to a growing literature working to integrate seafood more fully into sustainable food systems discussions. This paper should therefore be seen as offering insight into a particular slice of time, which could, in future work, be compared to later periods of time to assess the growth and integration of this area of research in the wider sustainable food systems discourse. This study is also limited in scale, assessing 119 papers taken from a vast corpus, and while 118 papers is the average sample size seen in a review of 494 scoping studies (Tricco et al., 2016), further analysis may identify additional research gaps of interest.

While it is difficult to assess what proportion of the literature would constitute an ideal representation of seafood, it is clear from this review that seafood is rarely included as a core component of the food security papers reviewed, despite the fact that seafood forms a potentially important component of a healthy and sustainable diet. The significant growth in fisheries and aquaculture production since the middle of the twentieth century, and especially in the past two decades, has enhanced the world's capacity to consume diverse and nutritious food. Global apparent fish consumption has, on average, increased faster than population growth since 1961 (3.2% as compared to 1.6%), and exceeded terrestrial animal meat consumption for all categories other than poultry (FAO, 2018)—though concern has been raised over such comparisons of fish and meat figures, particularly around differing reporting processes and a lack of comparison made on an edible portion basis (Edwards et al., 2018). Food fish consumption has increased from 9.0 kg per capita per year in 1961 to 20.2 kg per capita per year in 2015, with preliminary estimates suggesting even higher rates of consumption in 2016 and 2017, at 20.3 and 20.5 kg per capita per year, respectively (FAO, 2018). These figures do not, however, highlight the large variation in annual consumption both globally (with, for example, an estimated 58 kg consumed per capita in Japan, and 2.4 kg per capita in Yemen) and within continents (27.3 kg per capita in Ghana as compared with 4.6 kg per capita in Kenya) (Guillen et al., 2019). While increasing seafood consumption can play an important role in providing sufficient protein, it is also particularly valuable for preventing micronutrient deficiencies, with high production scenarios having the potential to prevent an estimated 166 million cases of inadequate micronutrient uptake by 2030 with important improvements in areas of low food security such as Sub-Saharan Africa and Southeast Asia (Golden et al., 2021).

Understanding and acknowledging seafood's role in addressing global and regional food security issues must be accompanied by efforts to ensure that seafood production is sustainable. The FAO estimates that world marine fish stocks within biologically sustainable levels decreased from 90% in 1974 to 68.6% in 2013 (FAO, 2019). More work is needed, in research and in practice, to reverse this trend by adequately managing wild and farmed seafood to reduce the overfishing, biodiversity loss, and ecosystem disruption that can result from poorly managed seafood production. Understanding the role of seafood is important for several interrelated Sustainable Development Goals, including zero hunger, good health, and well-being, climate action, and life below water (United Nations, 2015). While progress has been made toward sustainability in aquaculture in recent years (Naylor et al., 2021), more research is needed into the role of seafood for food security in relation to implementation of these goals. Increasing the sustainability of seafood production systems relies on research that bridges the terrestrial-aquatic divide—this review shows that this critical junction has many opportunities for food systems researchers. Further work, including systematic reviews in order to obtain a comprehensive view of the state of the literature in this area can help to identify research priorities and guide policy decisions. Research on aquaculture, which has the potential to enhance the resilience of global food systems through diversification and improved efficiency (Belton and Thilsted, 2014; Troell et al., 2014), is also essential in order to ensure adequate seafood production in a sustainable manner. Greater recognition and understanding of the role of plant and animal aquatic foods in global and local food security could result in more resources to support these efforts.

AUTHOR CONTRIBUTIONS

SS, RAN, and DL contributed to conception and design of the study. SS conducted the initial light-touch review, conducted the analysis, and wrote the first draft of the manuscript. SS, RAN, EA, NA, GA, GB-S, BB, MB, JB, SB, PC, MC, PE, ME, LF, JF, AG, IG, FI, AK, MK, FK, WL, A-AM, BM, RN, BK-P, AP, BR, NR, ER, AS, TS-M, SKS, ST, KT, MTr, MTl, RV, JY, and WZ conducted the in-depth reviews. SS and RAN agreed paper classification where reviewers disagreed. LF created the GIS map. All authors contributed to manuscript revision, read, and approved the submitted version.

FUNDING

This work was supported by funding from ARCH-UK and the University of Stirling's Global Food Security programme, which was invaluable for organizing the SSCI's 2018 meeting and developing this paper.

ACKNOWLEDGMENTS

This paper made use of the Sustainable Seafood Consumption Initiative's (SSCI) member base to source reviewers from different disciplinary backgrounds for the in-depth literature review reported here. The SSCI is an interdisciplinary forum based at the University of Stirling, but with partners at a range of institutions internationally. This paper also benefited from initial feedback from attendees at the SSCI's first international meeting, held in June 2018, where the key words used in this paper were agreed. We would like to thank a number of members and attendees for their input here: Angus Hunter, Anton Immink, Catherine Hennessy, Cori Critchlow-Watton, Richard Quilliam, Trevor Telfer, Aaron Zipp, Alan Sneddon, Baukje De Roos, Christine Edwards, Craig Anderson, Francis Amagloh, Janet Brown, Joanna Gosling, John Bostock, Joseph Nagoli, Kiel Edson, Kuong Khov, Matthew Sprague, Maxine Clark, Michael Leaver, Mike Warner, Mina Chiang, Miriam Odour, Pamela Marinda, Pauline Bell, Roy Clarke, Stuart Bunting, Suleiman Isa, Tania Mendo, Tara Garnett, and Derek Johnson.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2021.703152/full#supplementary-material

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Conflict of Interest: JF was employed by the company Longline Environment Ltd., BK-P was employed by the company Poulsen Consulting.

The remaining 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.