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Nudging fisheries and aquaculture research towards food systems

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Abstract

Food system is a powerful concept for understanding and responding to nutrition and sustainability challenges. Food systems integrate social, economic, environmental and health aspects of food production through to consumption. Aquatic foods are an essential part of food systems providing an accessible source of nutrition for millions of people. Yet, it is unclear to what degree research across diverse disciplines concerning aquatic foods has engaged food systems, and the value this concept has added. We conducted a systematic review of fisheries, aquaculture and aquatic food literature (2017–2019) to determine the following: the characteristics of this research; the food systems components and interrelations with which research engaged; and the insights generated on nutrition, justice, sustainability and climate change. Sixty five of the 88 reviewed articles focussed on production and supply chains, with 23 considering human nutrition. Only 13% of studies examined low- and middle-income countries that are most vulnerable to undernutrition. One third of articles looked beyond finfish to other aquatic foods, which illuminated values of local knowledge systems and diverse foods for nutrition. When aggregated, reviewed articles examined the full range of food system drivers—biophysical and environmental (34%), demographic (24%) and socio-cultural (27%)—but rarely examined interactions between drivers. Future research that examines a diversity of species in diets, system-wide flows of nutrients, trade-offs amongst objectives, and the nutritional needs of vulnerable social groups would be nudging closer to the ambitions of the food systems concept, which is necessary to address the global challenges of equity, nutrition and sustainability.

Fiona A. Simmance and Philippa J. Cohen should be considered joint first author.

KEYWORDS
aquatic foods, fish, food security, nutrition, policy, sustainability

1 | INTRODUCTION

Nourishing 10 billion people by 2050 within planetary boundaries is one of the greatest challenges facing humanity (McDermott & Wyatt, 2017; Springmann et al., 2018). Inequalities in distribution and access to resources still underpin and perpetuate food and nutrition insecurity (World Bank, 2020). Global commitments towards food and nutrition security (e.g. Decade of Action on Nutrition) and sustainable development (e.g. 2030 Agenda on Sustainable Development) recognize that transformation in the ways in which food is produced, distributed and consumed will be necessary to reduce inequality, to eradicate all forms of malnutrition, and to sustain natural environments for the well-being of future generations (HLPE, 2017). Food systems has become a powerful and popular concept that reflects the interconnected dimensions of food supply, nutrition outcomes, and social and environmental sustainability, and pushes research and policy beyond the persistent narrow emphasis on increasing production (Tezzo et al., 2020). As defined by the High Level Panel of Experts on Food Security and Nutrition (HLPE), a food system "*gathers all the* [components or] *elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food, and the outputs of these activities, including socio-economic and environmental outcomes*" (HLPE, 2017, p. 23). The food systems concept should enable complex dynamics, feedbacks and trade-offs to be accounted for across socio-ecological system, allowing for the identification of the entry points, across levels, to address the interrelated goals of sustainability, equity and food and nutrition security (Downs et al., 2020).

A powerful rationale for the integrated perspective food systems brings is that although we produce enough food to feed the world in terms of energy needs (i.e. calories), in many contexts food consumed is of insufficient quality to improve nutrition (Willett et al., 2019), with vast inequalities in distribution and access to quality foods (Béné et al., 2019; Ingram, 2011). Multiple forms of malnutrition now exist in nearly every country, with the rise in undernourishment and obesity rates driving up the global burden of disease (Development Initiatives, 2018; FAO et al., 2020). In sub-Saharan Africa, one in four people experience hunger and undernourishment (FAO et al., 2020). In Pacific Island nations, the transition of diets towards imported, nutrient-poor foods contributes to rising overweight and obesity (Albert et al., 2020). Simultaneously, current food production and distribution practices are amongst the greatest human-induced tolls on the planet in terms of land use, water use and greenhouse gas emissions (Myers et al., 2017; Willett et al., 2019; WWF, 2020). Shocks and crises, caused by climate change, conflict and political instability, and the COVID-19 pandemic are driving ecosystem change (Cooke et al., 2021), poverty, and food and nutrition insecurity, as well as exacerbating social and gender inequalities (FAO et al., 2020). In sum, the sustainability of socio-ecological systems on which healthy people and ecosystems depend is being undermined (Béné, 2020).

The food systems concept presented by the HLPE (2017, 2020) sets an ambitious framework for researchers and policymakers to shape research design, data interpretation, policy, investment and action. Adopting the framework has the potential to improve research and policy understanding of drivers of change and their impacts across all stages from food production to health and nutrition outcomes, and as such can help determine how various investment, action or policy adjustments might affect sustainability, equity and food and nutrition security. Given fisheries, aquaculture and aquatic foods are a key part of many food systems, it is timely to take stock of the degree to which the research community is embracing food system challenges, and which new insights are emerging from doing so.

For thousands of years, aquatic foods have been a constituent of human diets (Braun et al., 2010). Capture of fish and other aquatic foods from the wild continues to be the major source of aquatic foods from most low- and middle-income countries (FAO, 2020). In emerging and high income economies, farming of aquatic foods (aquaculture) is one of the fastest growing food sectors (FAO, 2020). Globally, fish are one of the most widely traded food commodities (FAO, 2020). Finfish are one of many aquatic foods alongside other diverse animals, plants and micro-organisms that grow in marine, brackish and fresh water bodies. Aquatic foods can have a very high density of bioavailable nutrients, and so are considered key to addressing undernutrition in some contexts, particularly for nutritionally vulnerable groups (HLPE, 2014b; Ramu Ganesan et al., 2020; Thilsted et al., 2016). Fisheries and aquaculture can be managed in environmentally sustainable ways, particularly relative to other animal-source food production systems (Hallström et al., 2019; Troell et al., 2019). Aquatic foods are relatively accessible and affordable to vulnerable populations in rural and remote regions, across a diversity of cultures and contexts, and often remain so even in the face of natural disasters or political shocks, and recent market failures due to COVID-19 (Béné, 2020; Eriksson et al., 2017; Funge-Smith & Bennett, 2019). The future demand for aquatic foods is projected to grow globally (Chan et al., 2019; Tran et al., 2019; World Bank, 2013) driven by population increase, income growth, urbanization and from a rising appreciation of the human health benefits when consumed as part of a diverse diet (Thurstan & Roberts, 2014). Nonetheless, visions of the transformation of food systems to meet nutrition and sustainability goals have yet to fully consider the opportunities of aquatic foods and the role of fisheries and aquaculture (Bennett et al., 2021; Halpern et al., 2019; Seto & Fiorella, 2017).

In this paper, we evaluate how fisheries, aquaculture and aquatic foods literature has engaged with the concept of food systems. Specifically, we undertook a systematic review of fisheries, aquaculture and aquatic foods literature to ascertain: (1) What are the characteristics (scope, methods employed, geography) of research that invokes food systems? (2) How comprehensively has this research engaged with the food system components, relationships and broader concept? (which we refer to the systemicity of the research) (3) What insights have emerged on particular challenges that affect and are influenced by food systems? After presenting findings from our review, we draw on the broader fisheries, aquaculture, food and nutrition literature to identify methodological approaches, thematic priorities and research gaps that represent opportunities to further enhance the use of the food systems concept and framework. Our objective in doing so is to contribute to an agenda for fisheries, aquaculture and aquatic foods research that more effectively leverages the potential of the food systems concept and framework.

2 | THE PROGRESSION TOWARDS FOOD SYSTEMS

The definition of food and nutrition security has evolved since the Second World War, being first defined in 1974, with a focus on food production and availability. From the 1960s to 1980s, the focus on food supply intensified with a growing appreciation that addressing access (and barriers to access) was critical to combat famine, malnutrition and food insecurity (Pingali, 2012; Sen, 1981). Development efforts followed suite with a focus on removing physical and economic barriers to access food, as well as addressing behaviour, socio-cultural factors and food quality (Ericksen, 2008). In 1996, the United Nations revised the definition of food security to: "*Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life*" (FAO, 1996). This represented an expansion to four dimensions (pillars) of food security; physical availability or quantity of food; economic and physical access to food; food utilization (e.g. food preparation and ability of person to absorb nutrients); and stability of the other three dimensions over time. In 2012, the terms "food security" and "nutrition security" were combined in recognition of overlapping concepts, as well as the underlying determinants of nutrition (CFS, 2012).

The concept of "food systems" drew upon food security, as well as systems science, rural development, global environmental change and value chain perspectives, in an appreciation that activities from "field to table" shape food security (Ericksen, 2008). Food systems moved beyond the value chain perspective by addressing multiple outcomes (social, economic and environmental), drivers, scales and levels, stakeholders and food sectors (e.g. crops, livestock and fisheries) (van Bers et al., 2019; Ingram, 2011), as well as the interactions and feedbacks between them (HLPE, 2014a). In addition to nutrition outcomes, food systems also reflected an explicit interconnect with all aspects of sustainability (Ingram, 2011). The term "sustainable food systems" reflected "a food system that ensures food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition of future generations are not compromised" (HLPE, 2014a). However, the use and interpretation of "sustainability" in food systems research remains poorly defined, with different uses and interpretations between disciplines (Béné et al., 2019).

In recent years, food systems have become a prominent framing to address the interconnected challenges of malnutrition and environmental sustainability. In recognizing this interconnection, the food systems framing identifies, and implicates a broader set of governance actors and actions (Béné et al., 2019). The political landscape has shifted to favour policies that integrate systems perspectives, and the inclusion of social, economic, environmental and rights-based dimensions to tackle sustainability and food security across its pillars (CFS, 2017; HLPE, 2020; Ingram, 2011). In working towards the Sustainable Development Goals, food systems and their transformations are now regarded as central to the eradication of hunger and malnutrition in all its forms (Sustainable Development Goal 2) (Fanzo, 2019; FAO et al., 2020), with influence on interconnected targets (FAO et al., 2020).

Several conceptual frameworks have been developed to illustrate and describe food systems (Ericksen, 2008; Global Panel on Agriculture & Food Systems for Nutrition, 2016; HLPE, 2017, 2020). In 2017, the HLPE compiled what is, arguably, the most comprehensive and widely acknowledged conceptualization of food systems (HLPE, 2017) (Figure 1), with additions made in 2020 (HLPE, 2020). The framework presents food systems as comprising diverse components and relationships, for example, illustrating food environments (i.e. a range of personal and external factors that mediate food acquisition and consumption, spoilage and waste of food) as a critical determinant between food supply and nutrition outcomes. In addition, the framework specifies drivers (environmental, technological, political and economic, socio-cultural, demographic, institutional) that act upon the entire system or parts of the system.

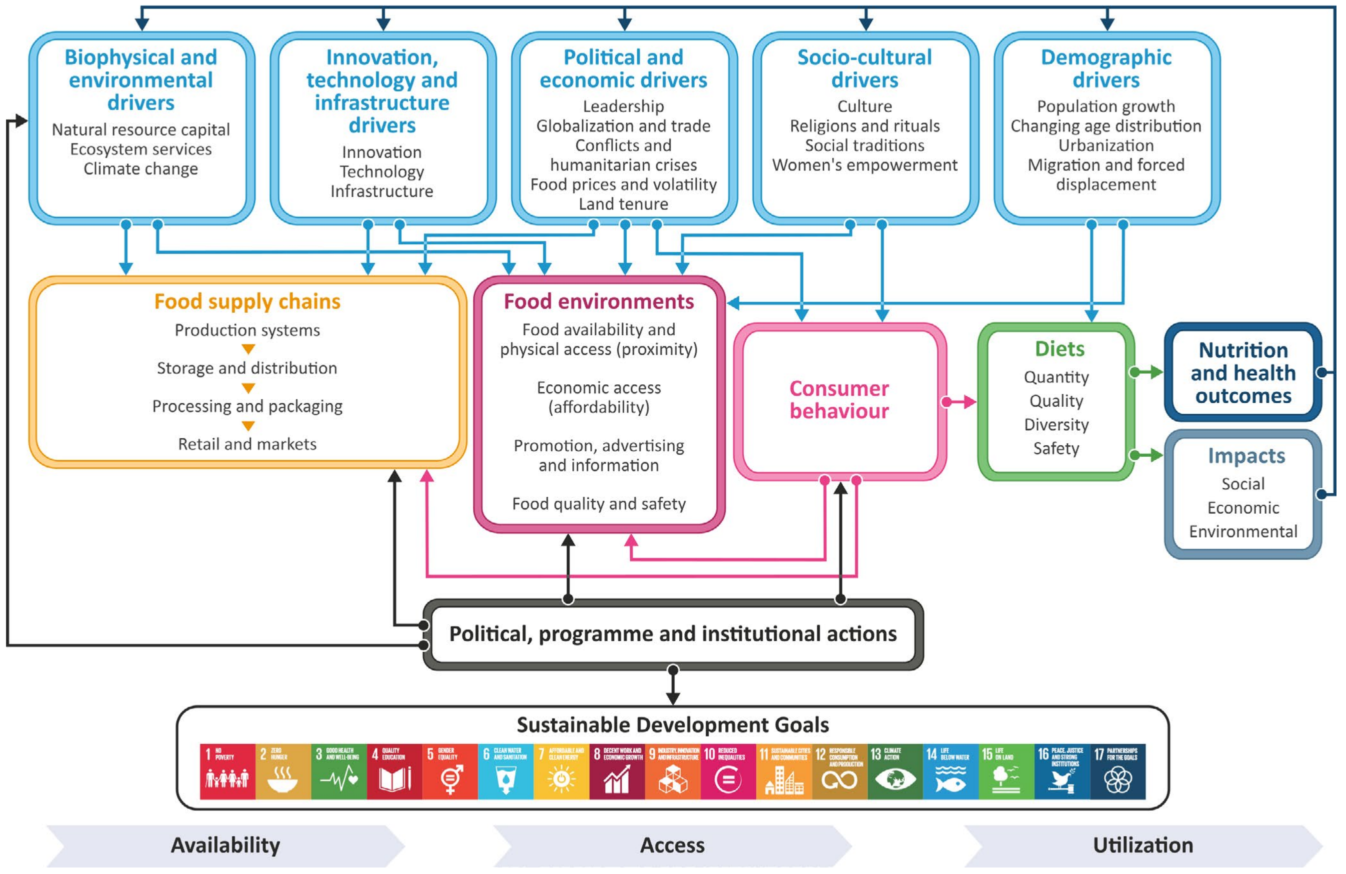

FIGURE 1 The food systems framework. Source (HLPE, 2017, p. 26). Reproduced with permission

The food systems concept, and the frameworks that illustrate it, are not intended to be a "model of everything," but rather, aims to make key components and relationships explicit (Ericksen, 2008; Ingram, 2011). Ingram (2011) argues that a food systems framing can improve explanatory power and policy impact by guiding more integrated analyses that accounts for the impact of drivers on the whole system, and trade-offs and feedbacks within the system. Ericksen (2008) suggests that "the framework can be used to identify and describe the determinants of any particular outcome and relate them to the broader food system" where actors can utilize the framework according to their interest and goals. Research does not need to investigate all components or relationships to engage effectively with food systems, but does need to, at least, position findings and interpretations amidst the components and relationships, and nutrition and sustainability outcomes. This review seeks to illuminate how, where, and for what knowledge gain, fisheries, aquaculture and aquatic foods research has invoked and engaged with the concept of food systems.

3 | METHODS

3.1 | Literature search

We conducted a systematic review of fisheries, aquaculture and aquatic foods literature that invokes food systems. We first conducted this exploratory search of articles published since 1970 that considered aquatic foods, fisheries and aquaculture alongside food systems. This search allowed us to see the uptake or prevalence of the term food systems since the time food security was put on the global agenda (Maxwell, 1996). For this search we used the Scopus search engine. We searched for articles that used the term "food system*" within the title, abstract and/or keywords in articles published since 1970 (we plot these number of articles per year since 1970; black line in Figure 4). Within these articles, we then searched for those that considered fisheries, aquaculture and/or aquatic foods using the search string aqua* OR fish* OR mollusc* OR crustacean* OR "aquatic plant*" OR seaweed* OR invertebrate* OR "marine mammal*" OR reptile* OR seafood* OR "blue food*" AND "food system*" (blue line Figure 4).

For our detailed review, we repeated the same search string in both Scopus and Web of Science for the time period 2017–2019. We focussed on this time period to understand trends in the most current research. The time period also provides a substantial sample from the last decade; accounting for nearly half (49%) of the literature published (2010–2019). After removing duplicates, this search identified 218 unique articles that we retained for screening (Figure 2). Bibliographic data of these 218 articles were imported into Endnote X9. We scanned titles, abstracts and keywords and excluded 89 articles due to one or more of the following reasons: (1) article was not accessible or not available in English; (2) the article

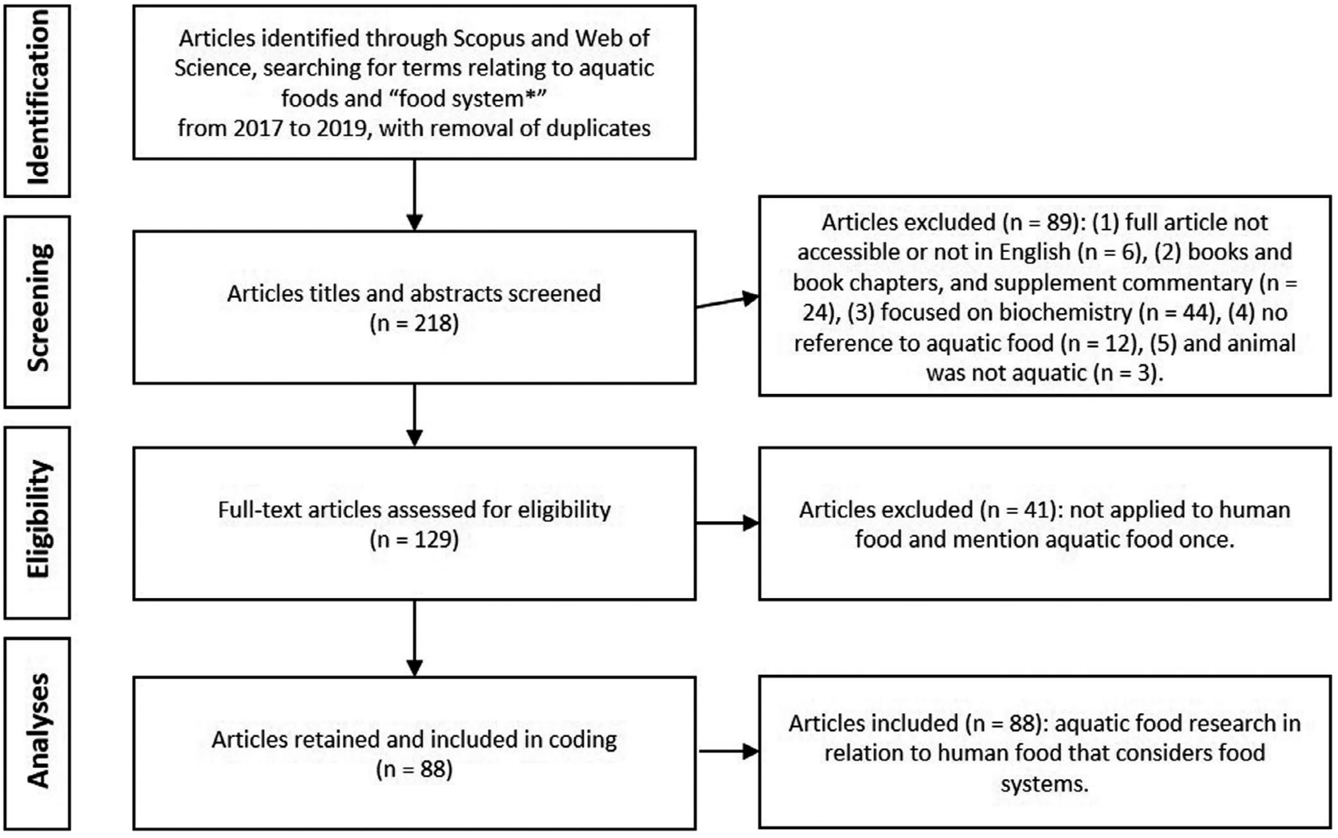

FIGURE 2 PRISMA flow chart illustrating the literature search process with stages of review and number of articles excluded or included for each different level of analysis

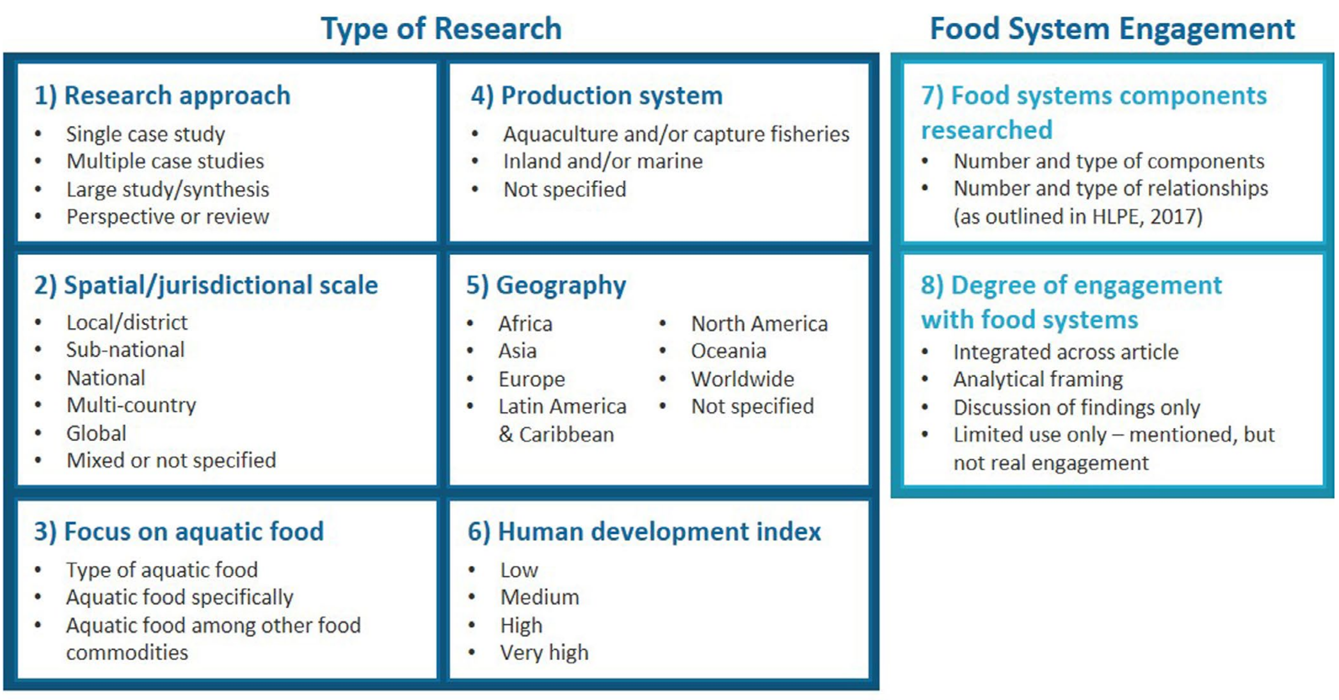

FIGURE 3 Articles retained through the screening process were coded with five criteria for *type of research*, and two criteria for *food system engagement*

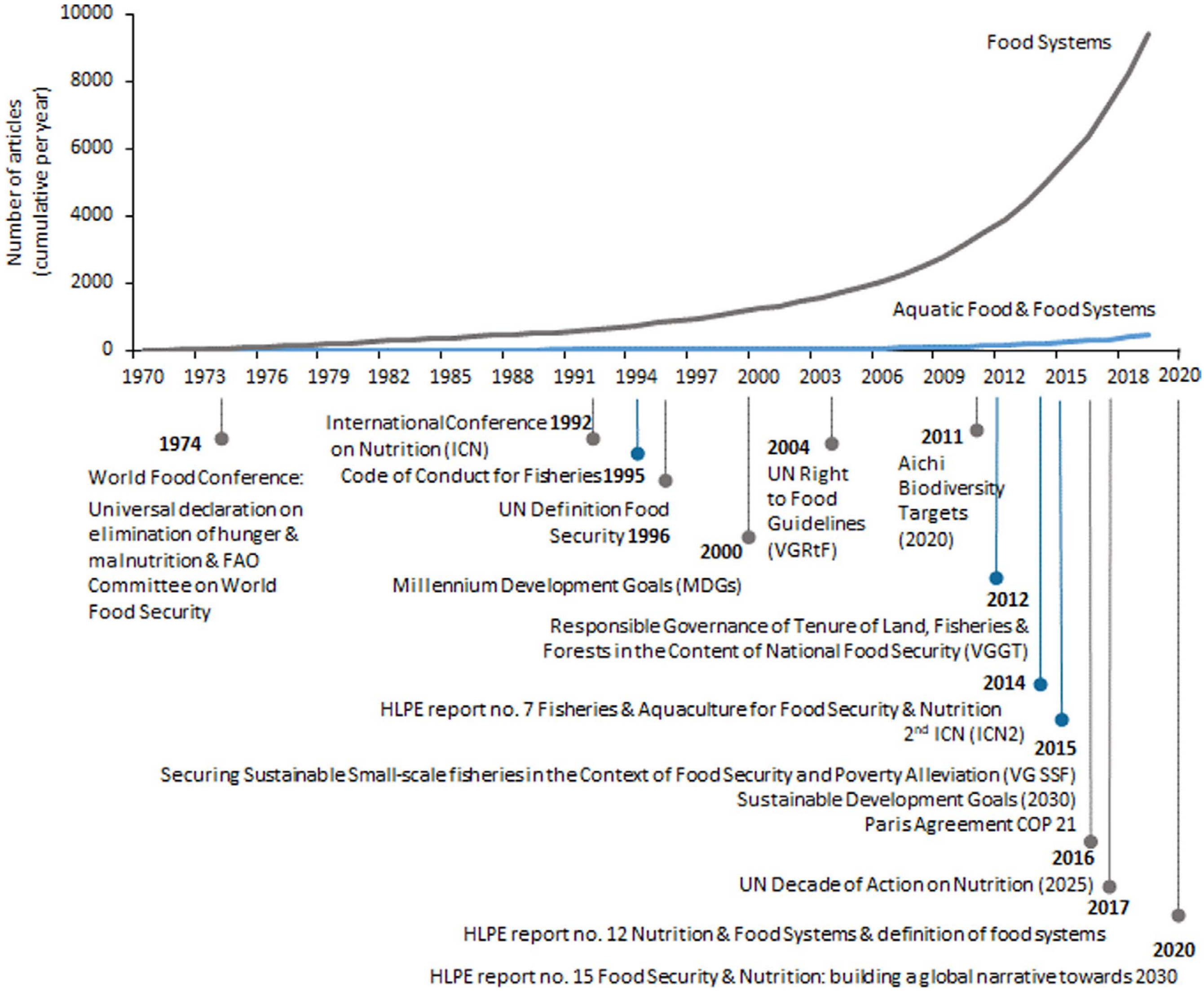

FIGURE 4 The recent history of food systems and food and nutrition security research and events. Upper shows all articles referring to food systems, and all articles referring to food systems with fisheries, aquaculture and aquatic foods published between (and inclusive of) 1970 and 2019. Lower depicts the timeline of select events and developments influencing understandings of food and nutrition security and food systems (those specifically relating to fisheries, aquaculture and aquatic foods are highlighted in blue)

was a book or a chapter of a book that was not freely available; (3) the article focussed on biochemistry and demonstrated no clear connection to human food (e.g. referring to "food system" in terms of oil–water emulsions only); (4) the term "aquatic" was only used to refer to aquatic ecosystems and not aquatic foods.

The full text of the 129 retained articles was scanned for eligibility for inclusion in the analysis. We excluded another 40 articles due to one or more of the following reasons: (1) the article described technological or methodological advances but did not apply them to human food; (2) the article suggested implications for human food or nutrition in the discussion or conclusion only (i.e. human food had not been examined or analysed elsewhere in the article); and/or (3) the article mentioned an aquatic food once, in passing or as listed alongside other commodities—but it did not appear as a component of the analysis, results or perspective. Eighty eight articles were included in the final stage analyses with the resultant inclusion criteria being articles that consider aquatic foods in relation to human food and nutrition.

The search strategy did not capture unpublished/grey literature, articles not written in English, and articles that considered fisheries, aquaculture or aquatic foods in the main text but not within the title, abstract and/or keywords. To ensure our review was well-rounded, we selectively brought in other food systems literature to illustrate research benchmarks and gaps. Our choice to categorize research against the HLPE framework allowed us to describe the distribution of research attention, but it was not our intention to analyse conformance or non-conformance with this particular framework. We found that some important research approaches and findings relating to sustainability, rights, equity and gender were difficult to categorize using our coding structure aligned to the HLPE (2017) framework. Whilst this illustrates limitations of our analysis, it also highlights that food systems approaches may be at risk of overlooking these social aspects of sustainability and may be complemented by (or necessitate complementarity with) other framings such as human wellbeing and environmental justice.

3.2 | Analysis

We conducted content analysis on this final subset of articles (*n* = 88) by coding text in NVivo 12 Plus (QSR International). First, we coded the characteristics of research according to the *type of research*, including scale (i.e. local case study or global) and geography. Second, we coded to *food systems engagement* where codes aligned to the components of food systems that papers focussed on, and included a four point scale describing the level of engagement with food systems (Figure 3). The four points on the scale were as follows: (1) research structuring—the article and/or analysis was designed around the framework with many mentions of food systems throughout; (2) analytical framing—the food systems framework was used explicitly to discuss the results; (3) discussion of findings—mentions food systems mainly in abstract/ introduction and discussion/conclusion; (4) mention food systems only once or twice. The number and type of components and relationships examined in articles were evaluated. Twelve components of food systems, as described in HLPE (2017), were considered as follows: food supply chains, food environments, consumer behaviour, diets, and nutrition and health and impact outcomes, as well as environmental, technological, political and economic, socio-cultural, demographic and institutional drivers. We coded to relationships when articles examined the relationships of at least two components. Our coding structure aligned to the framework did not present sufficient resolution on sustainability and gender, so we constructed two text search queries that we applied to articles. To locate references to sustainability, we searched for [sustainable*]. To locate treatment of gender we searched for gender OR man OR men OR woman OR women OR boy* OR girl* OR sex OR male* OR female* OR empowerment OR equity OR equality. A matrix coding query was created to export data from NVivo into Excel.

To check inter-coder reliability, two researchers coded three articles independently, and then compared results, reviewed inconsistencies and refined coding definitions to allow for continued use by a single coder. To refine and verify coding interpretation, and minimize bias induced by subjective coding, code definitions were developed as per descriptions on the components of the food systems framework provided by the HLPE (2017), representing the most widely adopted framework during the period examined.

4 | RESULTS AND DISCUSSION

Since 1970, the use of the term "food system" has increased with a notable uptick in the past 10 years (Figure 4). However, fisheries, aquaculture and aquatic foods have rarely been considered in the literature since 1970, featuring in only 5% of articles (i.e. fisheries, aquaculture, aquatic food AND food system*, *n* = 456; food system*, *n* = 9,414). The past 10 years has seen more attention to food systems research that considers fisheries, aquaculture and aquatic foods, increasing by approximately four-fold over the past 10 years, perhaps associated with the publication of the landmark report (HLPE, 2014) that recognized that fish and fisheries are fundamental to achieving food and nutrition security.

4.1 | Key features of research that applies a food systems concept

Scholars argue that food systems research should increasingly aim to span multiple food or commodity types (Ingram, 2011), increase interdisciplinarity (Veldhuizen et al., 2020), examine diverse contexts and cultures (Béné et al., 2019), and with a focus on people who are most vulnerable to food and nutrition insecurity (Thilsted et al., 2016). Our review illustrates if, how, and to what degree fisheries, aquaculture and aquatic food research examines different types of aquatic foods and production systems, fisheries amongst other agricultural productions systems and foods, geographies and demographics.

Aquatic foods include diverse animals, plants and microorganisms from marine, brackish and fresh water bodies. We found that finfish (or "fish" unspecified) was the most frequently mentioned aquatic food type (*n* = 84 of 88 articles), 23 articles mentioned molluscs (e.g. mussels, squid), crustaceans (e.g. crab, shrimp) and/or invertebrates, in general. We identified 17 articles that mentioned aquatic plants and seaweeds (Figure 5b) (Amparo et al., 2017; Marushka et al., 2019; Schubel & Thompson, 2019). Marine mammals were mentioned in four articles; all related to traditional diets of indigenous peoples in North America (Bersamin et al., 2019; Rapinski et al., 2018). One third of articles (26 of 88) examined multiple types of aquatic food. Marushka et al. (2019) discussed the substantial contribution of diverse finfish species, as well as clams, prawns, shrimps and crabs make to the nutrient intake of indigenous populations in Canada. Rapinski et al. (2018) highlighted that the role of non-finfish is often overlooked in Inuit diets, with crustaceans and kelp harvested through gleaning, for example, providing a nutritious, accessible and resilient year-round food for Arctic communities. The dominant focus on finfish, despite the well-documented nutritional and cultural role of other aquatic foods, is representative of broader trends in fisheries and food and nutrition security literature, from local dietary assessments to global meta-analysis (e.g. Hicks et al., 2019). Whilst not applying the food systems concept, other scientists have also highlighted the importance of a diversity of aquatic foods to local food and nutrition security; for example, in rice fields of the Lower Mekong Basin (Freed, Barman, et al., 2020), coastal reef flats of Timor-Leste (Tilley et al., 2020), and the river floodplains of Tanzania, where many aquatic foods are more accessible than terrestrial animal-source foods, particularly during times of seasonal hunger (Moreau & Garaway, 2018). Nutritional value can also vary between and within species, due to nutritional differences, dietary preferences and consumption behaviour (e.g. Hicks et al., 2019).

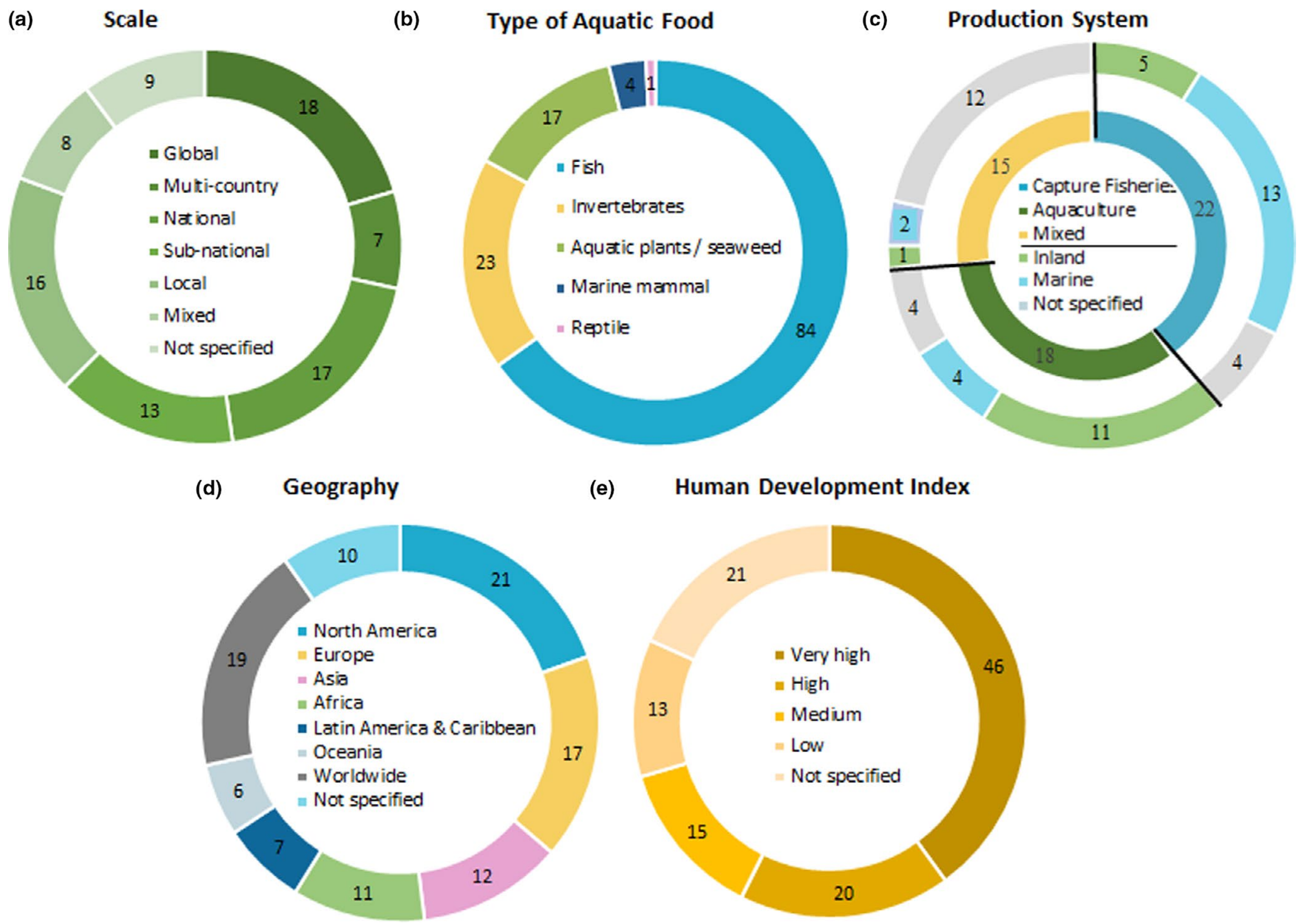

FIGURE 5 Summary of food systems research being conducted in aquatic foods according to the results from 88 articles: (a) scale, (b) type of aquatic food, (c) production system, (d) geography and (e) Human Development Index 2018 ranking

Included in our review, Tlusty et al. (2019) argued that there is a need to ensure more research captures, accounts for, and "embraces the diversity" of aquatic foods, by going beyond single species, to examine multiple aquatic food groups (e.g. fish, invertebrates and aquatic plants), as well as the diversity of species within them.

The type of production system was specified by 55 (or 63%) articles including: capture fisheries ($n = 22$), aquaculture ($n = 18$), and mixed fisheries and aquaculture systems ($n = 15$) (Figure 5c). Capture fisheries research focussed predominantly on marine environments ($n = 13$) rather than inland or freshwater systems ($n = 5$). These findings resonate with previously reported biases in fisheries literature, where inland fisheries are considered as the most underreported and undervalued aquatic production sector (Fluet-Chouinard et al., 2018; Halpern et al., 2019). By contrast, aquaculture predominantly focussed on inland or freshwater systems ($n = 11$) with only four articles examining production in marine environments. The attention on freshwater environments for aquaculture reflects current aquaculture production patterns for finfish (FAO, 2020), which are likely to continue into the future (Belton et al., 2020).

Only four articles explored trade-offs and connections between capture and culture production systems, a gap previously noted in a global review (Bennet et al., 2018), although this lack of discussion on trade-offs is not confined to aquatic research only (Béné et al., 2019). Interactions examined were on relative water use (also in comparison to agriculture) (Gephart et al., 2017) and inclusion of fisheries and aquaculture in the sustainable diets literature—where aquatic food (or seafood) consumption is often presented as a "dilemma" because of the "perceived trade-offs" between health benefits and concerns for sustainability of fisheries (Farmery et al., 2017). Articles also examined the complementary (rather than replacement) value of aquaculture relative to capture fisheries (Longo et al., 2019), and the opportunities for increasing abundance and sustainability through diverting more small pelagic fish towards human consumption as opposed to use as aquaculture and livestock feed, and related market failures, policy and other constraints, such as related to food safety (Pihlajamäki et al., 2019). These articles build on previous research on the complementarity of both production systems in their ability to increase food availability and access (Belton et al., 2018; Thilsted et al., 2016) of nutritious foods (Bogard et al., 2017; Thilsted et al., 2016).

Aquatic foods are produced, and obviously consumed, alongside other foods critical to diets and nutrition. Understanding food systems requires that nutrition outcomes, and production or sustainability trade-offs, are understood amongst agricultural and other food sectors (Béné et al., 2019; Veldhuizen et al., 2020), as opposed to a narrow focus on a single food source (Haddad et al., 2016). In many instances, food systems research still maintains a single-sector perspective (van Bers et al., 2019; Tezzo et al., 2020; Veldhuizen et al., 2020). However, we found that nearly half of the examined articles (*n* = 43 of 88) investigated aquatic foods alongside other food production sectors or examined the whole diet, with the other half of articles focussing on aquatic foods. This suggests there is reasonable progress in research on food systems that moves beyond a single-sector or product focus. Cottrell et al. (2018) examined the sustainability of fish production alongside agriculture, and identified linkages in terms of ecosystem connectivity and climate change feedback, and also trade-offs, calling for cross-sector management and policies. For example, whilst not identified in our review, Dubois et al. (2019) noted the increased investment in water control infrastructure presents opportunities to incorporate fisheries and aquaculture as a way to make further, complementary nutrition gains from multiple water use. Nonetheless, Seto and Fiorella (2017) argue that current approaches or visions for food systems transformations remain "disjointed" and that aquatic foods are barely considered in the context of diverse and sustainable diets.

Malnutrition occurs globally but manifests differently between geographies and across socio-economic contexts. At the broadest level, there are correlations between rates of over-nutrition in nations of higher economic development and undernutrition in nations with lower economic development (Development Initiatives, 2018). Where articles in our review reported a geographic focus, research was predominantly (84%) focussed on North American, European or Asian countries with medium to very high HDI (Figure 5d and e, Supplementary Information S1, Table S1). Only 13 studies focussed on countries with a low HDI (19% of reported, *n* = 13 of 67, and 15% of total articles). This trend echoes the broader failure of food systems research and recommendation to address contexts and concerns of low-income countries and the most vulnerable regions (van Bers et al., 2019; Hirvonen et al., 2019), which has been reported for fisheries (Béné et al., 2016; Bennett et al., 2018; Thilsted et al., 2016). Articles focussing on countries with low HDI (*n* = 13) and high food and nutrition insecurity tended to focus just on finfish as opposed to a diversity of aquatic foods (*n* = 9 out of 13), but over half examined aquatic foods (mainly finfish) alongside other food commodities (*n* = 8) (Fisher et al., 2017; Gelli et al., 2019; Limuwa et al., 2018). In addition, attention on components of nutrition outcomes (*n* = 4), socio-cultural drivers (*n* = 3), demographic drivers (*n* = 4) and food safety (*n* = 1) is negligible, relative to the urgency and persistence of these challenges in countries with low HDI. It is worth noting that more research on these components exists outside of peer reviewed journal articles but does not make explicit reference to food systems as a guiding concept (Marinda et al., 2018; van Vliet et al., 2018; Wahyuni et al., 2018).

Research across geographic and jurisdictional levels, or research that at least acknowledges cross-level complexity, is integral to understanding food systems (Ericksen et al., 2010). Of the articles reviewed that specified the geographic level of analysis, over half were conducted at national and global levels (*n* = 42 of 79) (Figure 5a). We identified only eight studies spanning multiple spatial levels. This sparsity is consistent with the broader trend of food systems research to focus on a single level (Delaney et al., 2018), lacking attention to the integration of research across levels (Veldhuizen et al., 2020), and arguably reflecting a failure to meet the ambitions of what a food systems concept might bring to research (HLPE, 2017). National and regional framings have the ability to account for external drivers of change and stakeholder priorities (Ingram, 2011), and can be highly effective for understanding where vulnerabilities exist within food systems (Ericksen et al., 2010). Conversely, a limitation of research focussed on the national-level only is that it can potentially mask important differences between sub-national regions and parts of society (e.g. by gender, ethnic group, rurality and social or economic standing). Thus, as fisheries and food and nutrition security are highly context-specific, food systems (van Bers et al., 2019) and fisheries (Béné et al., 2016) scholars have called for more local level assessments that disaggregate outcomes with markers of social identity.

4.2 | Systemicity of fisheries, aquaculture and aquatic food research

Research that seeks to understand food systems requires moving beyond traditional single-node or value-chain approaches to examine multiple drivers (structural social and gender, political, economic, cultural, and environmental), outcomes (nutrition, sustainability), interactions and feedback from consumption to production, across scales and levels, and with diverse stakeholders (HLPE, 2014a; Ingram, 2011; Tezzo et al., 2020). This demand for greater systemicity of research might be achieved through a broadening of research design, or through interpretation of (relatively narrow) findings as they are situated within the system. The analysis that we conducted illustrates the extent to which, and the ways in which, fisheries, aquaculture and aquatic foods research has tackled this ambition.

The complete assemblage of system components, as described in HLPE (2017), was covered by the aggregated 88 articles we reviewed, with numerous relationships between components receiving analytical attention (Figure 6). No article examined all components (a goal that might be considered more aspirational than feasible); however, the articles explored a median of four components (Supplementary Information S1, Table S2).

In examining more deeply which food system components were addressed, we found articles predominately investigated supply chains (*n* = 65, 74%) (Figure 6) that encompass production, distribution and storage, processing and packaging, retail and markets. Of these 65 articles, 60% focussed exclusively on production; a trend noted to be common in food security literature (van Bers et al., 2019). Those that considered components of supply chains often focussed on trade (Clark & Longo, 2019; Golden et al., 2017; Wegren & Elvestad, 2018).

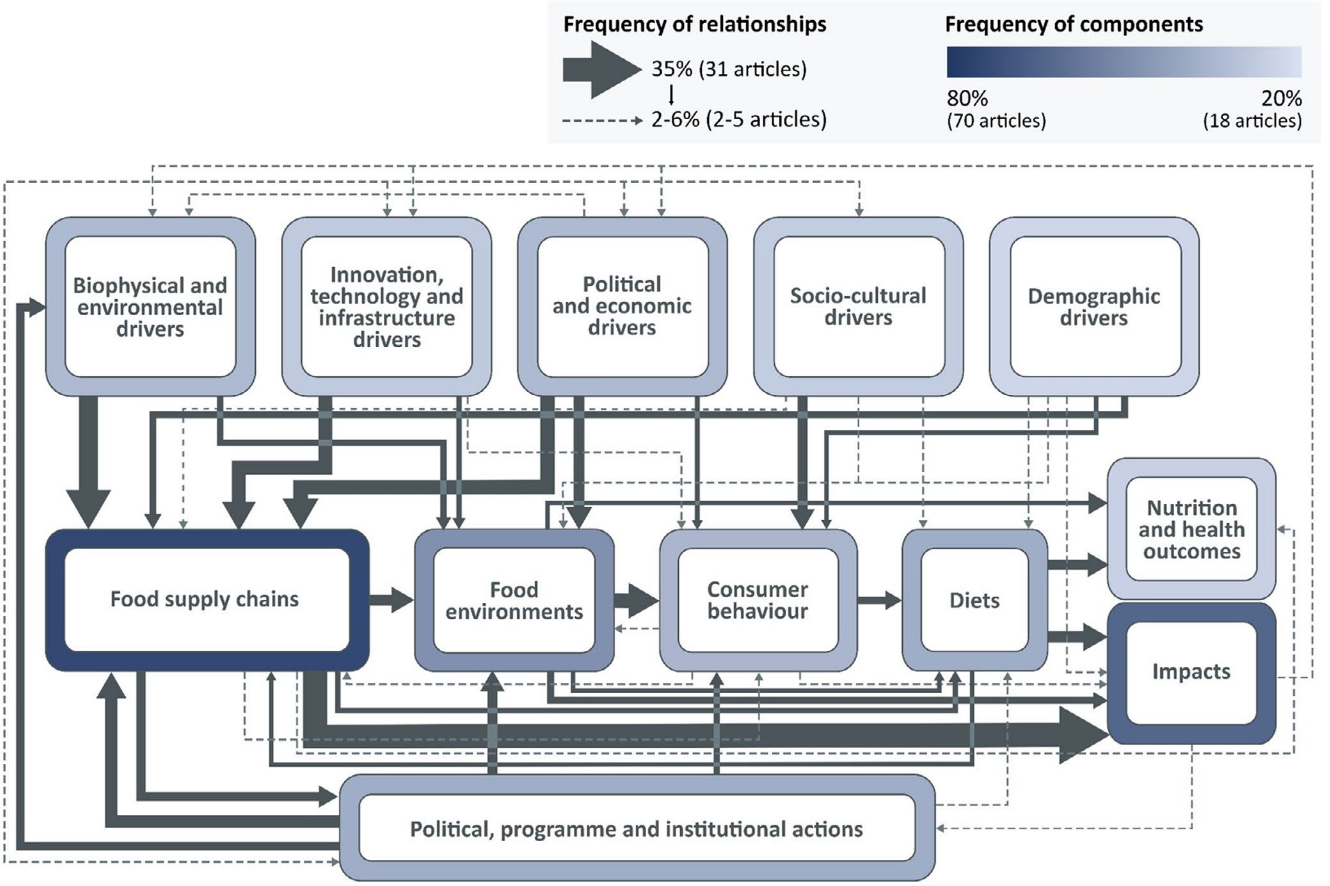

FIGURE 6 The frequency of 2017–2019 (n = 88) articles looking at the different sections of the food systems framework: for components, frequency is represented as a gradient of blues, and for the relationships between components, the frequency is represented as the thickness of the arrow

Little research addressed processing, distribution, retail and markets (Boatemaa et al., 2019). The few articles that adopted a production to consumption, or "hook-to-plate" approach, highlighted challenges in the availability of data on food provision and food environments (Bogard et al., 2019; Teneva et al., 2018). In addition, supply chain research that examined countries with low-to-medium HDI (n = 12) focussed more on production part of supply (n = 10), rather than value chains (n = 2). The lack of attention on value chains in countries with low HDI has been noted previously (Jose & Shanmugam, 2019; Tlusty et al., 2019). Veldhuizen et al. (2020) and Tezzo et al. (2020) similarly found a "missing middle" in fisheries, aquaculture and aquatic food research in that there was little attention given to factors mediating food provision and acquisition, which largely sit within "food environment" (HLPE, 2017). Whilst the introduction of the concept of food systems is, in part, intended to drive holistic research and system-wide knowledge, this ambition for greater systemicity is not yet being met. To meet the aspiration and intent of food systems, research and investment to broaden from the narrow focus on production (Rosegrant et al., 2014), towards identifying solutions and entry points across distribution, markets and in food environments, including understanding and tackling food spoilage and waste (FAO et al., 2020).

Approximately half of articles gave attention to food environments (n = 43, 49% of articles) (Figure 6), within which the focus tended to be on access to food (n = 30) which is the second pillar of food and nutrition security (Fanzo & Davis, 2019; Ingram, 2011). About 18% (n = 16) of articles examined food quality and safety and the influence these have on access to, and acceptability of, food and subsequent nutrition and health outcomes. A few articles (n = 8) also investigated marketing strategies and information dissemination as a part of food environments and provided some insights on how product acceptability and consumer choice are influenced. For example, as part of a project in the Baltic region, Haapasaari et al. (2019) examined food safety concerns of fish, and Pihlajamäki et al. (2019) found that consumer perceptions around food safety were the biggest barrier to increasing consumption of Baltic herring because it is predominantly (97%) used as feed for livestock as opposed to human consumption. Food safety is an increasing concern given the global publish health costs of foodborne diseases (Faour-Klingbeil & Todd, 2019), which lead to one in 10 people falling ill annually (WHO, 2015). Women are active, but underrecognized production, supply and risk managers for livestock and aquatic food production and supply. Future food systems research addressing the influence of gender on risk exposure is critical for improving food safety in informal markets in developing countries (Grace et al., 2015), as well as understanding the food safety of aquatic foods.

Over one-third of the articles examined consumer behaviour (*n* = 31) or diets (*n* = 34), of which half examined both (*n* = 17). Fewer articles followed through to examine nutrition outcomes (*n* = 23). We found two articles that measured the contribution of fish to recommended nutrient intake (Bogard et al., 2018; Smith et al., 2019), and three that examined the nutrient attributes and nutritional contribution of a broader suite of aquatic foods (Baye et al., 2019; Marushka et al., 2019; Rapinski et al., 2018). We found one study that linked a driver (climate change) to the production and nutrient contribution of a range of aquatic foods appearing in diets; in this instance for an indigenous population in Canada (Marushka et al., 2019). More research attention is warranted on nutrient qualities of food relative to diets given that diets are considered an essential point from which to transform food systems through "nutrition-sensitive food consumption" (Caron et al., 2018) and that improved nutrition outcomes are the target of food systems transformations (Fanzo, 2019).

Over half of the articles noted other system outcomes (*n* = 56), predominantly environmental sustainability (*n* = 32), with some incorporating wider sustainability dimensions (social equity and economic) (*n* = 25), such as livelihoods (Fisher et al., 2017; Limuwa et al., 2018; Savo et al., 2017), food sovereignty and justice (Heeringa et al., 2019; Levkoe et al., 2017; Mills, 2018). The majority of articles investigating sustainability outcomes focussed on production (*n* = 47), with only a small number looking at aspects across value chains (*n* = 10), such as investigating waste and loss (Blas et al., 2018) and energy use (Song et al., 2019). The focus on environmental sustainability corroborates Béné et al. (2019), who found that food systems research largely has a narrow focus on environmental sustainability, with poor definition and interpretation of social equity and economic sustainability.

Food system transformation will be driven or curtailed by macro-level environmental, economic, and institutional drivers, but to date scholars argue these have received insufficient attention relative to their influence over food systems (Béné et al., 2019; van Bers et al., 2019) and fisheries (Bennett et al., 2018). Published outside of our search period, institutional drivers have been examined by van Bers et al. (2019) examination of collective action for improving fisheries management, and by Friel et al. (2020) in assessing (non-aquatic food) international trade agreements and climate change impacts on nutrition. Our review identified most articles 73% (*n* = 64) gave some attention to at least one food system driver. Articles primarily gave attention to biophysical and environmental (*n* = 30) (focussing on climate change), politics and economics (*n* = 30), innovation and technology (*n* = 25), socio-cultural (*n* = 24) and demographic (*n* = 21) drivers.

4.2.1 | Relationships between food systems components researched

Relationships, feedbacks and flows between components are considered critical to understanding food systems (van Bers et al., 2019). Articles in our review explored relationships within the food systems framework (median = 3 relationships), again focussing on supply chains, with drivers and impacts (Figure 6). Seven articles stand-out as more thorough explorations of relationships. These examined activities from production to consumption, diverse relationships, drivers of change and outcomes (nutrition, and/or impacts) (Bogard et al., 2019; Love et al., 2017), examined multiple food sectors, multiple levels (Bogard et al., 2018; Vittuari et al., 2019) and/or focussed their research on countries with low HDI or vulnerable populations (*n* = 3) (Gelli et al., 2019; Heeringa et al., 2019; Marushka et al., 2019). Love et al. (2017) drew upon multiple case studies from the United States and Peru, to identify leading examples of integrated fisheries and health policies, across levels and entry points in food systems, to promote nutrition (e.g. fish to school programmes). Marushka et al. (2019) and Gelli et al. (2019) explored the impacts of multiple drivers on aquatic food production and cross-sector value chains, respectively, in vulnerable contexts, identifying solutions with multiple and equitable benefits. Vittuari et al. (2019) explored drivers of food loss and waste from production to consumption, impacts on environmental sustainability and policies across levels, with feedback loops. These articles reveal how a food systems framing adds value in understanding nutrition, social equity and environmental sustainability through impacts of multiple drivers, and identification of entry points for interventions.

In addition to the components and relationships assessed, we also examined the research design and analytical structure that articles used. Over half of articles (55%) only superficially engaged, using the term occasionally or only within discussions (*n* = 48). We considered only about 23% (*n* = 20) of articles to integrate food systems framing throughout the article, going beyond use as a discursive tool. For example, Amparo et al. (2017) applied the food systems framework throughout their study of fish consumption in coastal communities in the Philippines. In doing so, they examined from production, diets, and socio-cultural and biophysical drivers that ultimately influenced consumption. However, there were a few articles that embedded the food systems framing but examined few relationships or components, such as Pulker et al. (2018) who conducted a focussed study on food environments examining the power and sustainability commitments of supermarkets. Conversely, there were also a few articles that only mentioned food systems superficially but had a breadth of research in terms of number of components and relationships. For example, Wu et al.'s (2019) study on sustainable seafood and vegetable production evaluated innovations through aquaponics, environmental and economic sustainability impacts, demographic (urban) drivers, and implications for diets, food safety, and human health, but food systems was only mentioned once. Whilst our review deliberately focussed on those studies that invoked the term food systems, we don't argue that is a necessary attribute of good, useful or impactful research on food systems. The opportunity for research to benefit from the food systems framework is to explicitly design research and data collection to span multiple components and relationships between them, and/or to situate study findings and limitations amidst the broader food system components and relationships, and interpret findings against sustainability, equity and food and nutrition security outcomes.

4.3 | Emerging challenges for food systems

Access to safe and nutritious food, effective governance, and the well-being and agency of food system actors (particularly those experiencing social and economic marginalization) are critical to overcoming current global challenges of malnutrition, structural inequality, environmental sustainability and climate change (Béné et al., 2019; van Bers et al., 2019; FAO et al., 2020; HLPE, 2020). In this section, we look at where fisheries, aquaculture and aquatic foods research that adopts a food systems concept has been positioned and framed in relation to these particular global challenges, and some of the insights they have generated.

The HLPE food systems framework is oriented towards food security and nutrition outcomes. Combatting malnutrition amongst vulnerable populations was a core principle behind its development (HLPE, 2017). However, we found that less than one-third of food systems and aquatic foods articles actually examined nutrition outcomes (Bogard et al., 2019; Love et al., 2017), and less than 10% examined nutrition outcomes in geographies with high rates of malnutrition, or vulnerable populations (Heeringa et al., 2019; Marushka et al., 2019). The link between aquatic foods and nutrition outcomes in vulnerable populations is well-established in fisheries literature (HLPE, 2014; Thilsted et al., 2016). However, the potential of aquatic foods for nutrition has not yet permeated to the broader food and nutrition security research (Bennett et al., 2018; Caron et al., 2018; Thilsted et al., 2016), and the flows of nutrition potential from aquatic foods through foods systems is yet to be well-considered in research that is nominally attempting to inform food systems transformation.

Food environments are a central component in food system and shape access to nutritious and safe food. Interventions targeted at improving food environments (i.e. natural and built environments, information and political contexts) have significant promise for improving access to safe and nutritious food, and addressing inequitable distribution of access to food, particularly for the most nutritionally vulnerable and food insecure (Downs et al., 2020; FAO et al., 2020; HLPE, 2017). The literature that we reviewed suggested that policies and programmes that shape food environments could be used to improve access to food, as well as social outcomes, for example, through the introduction of local (rather than imported) fish in school feeding programmes (Bonanomi et al., 2019), and through tackling food loss and safety challenges that might ultimately allow for greater supplies of affordable fish (Pihlajamäki et al., 2019). Relative to the importance given to food environments as a critical entry point, food environment appears to be relatively under-investigated within aquatic foods research (Downs et al., 2020).

Addressing increasing inequalities in the distribution of benefits of food systems and empowering marginalized populations in governing processes are critical for achieving equitable food systems for nutrition and sustainability (social, economic and environmental). Research on this subject includes that on identifying integrated livelihood solutions for improved food security (Fisher et al., 2017; Limuwa et al., 2018; Savo et al., 2017), highlighting inequalities in income and access to food (Croft et al., 2019; Love et al., 2017; Vittersø et al., 2019), and promoting rights and food sovereignty to address the imbalance of power and marginalization of small-scale fishers (Heeringa et al., 2019; Levkoe et al., 2017; Mills, 2018).

Food systems research is intended to shed new light on sustainability and planetary health impacts (HLPE, 2017; WWF, 2020). We found 32 of the 56 articles that identified broader food system outcomes examined environmental sustainability, most of which focussed on the environmental impacts of production (n = 27). Springmann et al. (2018) projected a 50%–90% increase in the environmental impacts of food production and consumption by 2050 (driven by increasing populations and incomes), and identified that shifts in diets towards plants, with reductions of red meat and modest consumption of other animal-source foods, such as fish, could reduce the environmental impact of food systems compared to current dietary patterns. The few studies in our review (n = 5) that went beyond environmental impacts of the production system, looked at consumer-driven trends in food (inclusive of aquatic foods) with respect to energy use in production and processing (Song et al., 2019), greenhouse gas emissions from production and processing (Hitaj et al., 2019), the impacts of waste and loss on water use (Blas et al., 2018), and sustainability issues in supply chains (Jose & Shanmugam, 2019). Tlusty et al. (2019) also argued that there is a "productionist bias" and a burden placed on producers in low-income countries to improve sustainability. Food systems research identified key solutions, such as cross-sector ecosystem management (Cottrell et al., 2018; Delevaux et al., 2018), integrated livelihoods for resilience (Fisher et al., 2017), value chain innovations for reductions in food waste and loss (Springmann et al., 2018), and a shift in diets towards more diverse, sustainable and healthy foods (Cottrell et al., 2018), through mechanisms such as policies targeting food environments (Springmann et al., 2018).

The presence of and connections to macro-level or systematic drivers is a more prominent feature of the food systems framework than in conventional food and nutrition security conceptual frameworks. Climate change was a relatively common focus, including research on feedback with climate change across terrestrial–aquatic food production sectors (Cottrell et al., 2018), and coastal development and climate change as interacting drivers on reef resilience and local (fisheries-associated) food security (Delevaux et al., 2018). In the face of climate change impacts, aquatic foods have been framed as a resilient source of livelihoods (Fisher et al., 2017) and nutrition, particularly, in traditional food systems where incomes and access to markets are insecure (Marushka et al., 2019; Smith et al., 2019). The effects of COVID-19 on food systems, and the producers and consumers of aquatic foods (Béné, 2020; Belton et al., 2020; FAO et al., 2020; Ferrer et al., 2021), are a particularly stark example of the importance of increasing understanding of, and planning for, external shocks on food systems, including efforts to understand and build resilience of food systems in ways that reduce future vulnerabilities.

Socio-cultural factors, such as social norms, culture and religion are important drivers of food environments, consumer behaviour and diets (HLPE, 2017). They are also key drivers in agricultural innovation, which underpins supply, as well as in livelihoods (Aregu et al., 2019; Lawless et al., 2019; Locke et al., 2017). Agency and distribution of power experienced by different food system actors, including individuals, households and communities, are affected by socio-cultural contexts and are critical determinants of food systems outcomes and broader well-being (van Bers et al., 2019; HLPE, 2020). In particular, agency can be constrained by gendered social norms, relations and practices, which often affect women's vulnerability to food insecurity (FAO et al., 2020; Kawarazuka & Béné, 2010). Agency and gender are embedded within the food systems framework, particularly in socio-cultural drivers and consumer behaviour (HLPE, 2017), with agency explicitly recognized as a pillar of food security in the new framing (HLPE, 2020). Half of the articles in our review ($n = 42$) referred to gender, but upon closer examination, most in fact were found to only be referring to collecting (Amparo et al., 2017; Limuwa et al., 2018; Zheng et al., 2018) or reporting (Brewer et al., 2017; Savo et al., 2017) sex-disaggregated data, without interpreting the influence of gender (or agency) on food systems processes and outcomes. Similarly, seven articles engaged with women (but not gender), in the form of analysis of consumption of fish by women, or both women and men, particularly its importance for nutrition, pregnancy and child development (Love et al., 2017; Marushka et al., 2019; Smith et al., 2019; Watts et al., 2017), women's perceptions of food (Sato et al., 2019; Traoré et al., 2018), or specific food-related issues like meal interventions in schools (Bersamin et al., 2019). We found no articles that examined gender norms and relations, or women's control over income or care burdens—both of which directly shape food access, and/or consumption and nutritional outcomes. This reflects the critical lag in effective gender integration in the sector: repeated calls to understand socially-differentiated vulnerabilities or access to food system benefits (FAO et al., 2020; Kawarazuka & Béné, 2010) may still be unmet by fisheries, aquaculture and aquatic foods research. Gender scholars note that this sectors, amongst others, demonstrate underlying resistance or inertia in integrating gender into research and practice (Kruijssen et al., 2018; Lawless et al., 2019; Locke et al., 2017), despite the high level commitments (e.g. Sustainable Development Goal 5; Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries (VG-SSF)) and practical guidance (e.g. Gender in VG-SSF). From a food systems perspective, the lack of engagement with gender from production to consumption contributes to the persistence of underlying gender barriers (especially constraining gender norms and data gaps), unequal gender dynamics and limited women's empowerment, resulting likely in loss of food supply, household resilience and nutritional outcomes.

Political reform, governance improvements, and institutional strengthening have been called for, across sectors, to improve food systems for nutrition and sustainability outcomes, and achieve related international development goals (Béné et al., 2019; HLPE, 2017). Five articles in our review examined how policies enabled or hindered nutrition and sustainability outcomes (Brewer et al., 2017; Delevaux et al., 2018; Fisher et al., 2017; Love et al., 2017). For example, Love et al. (2017) illustrated synergies between fisheries and health policies for increasing the role that aquatic foods play in nutrition, through "fish to school" programmes. In Peru, for example, this included changes to policies, value chains and consumer behaviour that would increase human consumption of high turn-over species (Peruvian anchoveta) that were not being used for human consumption (Love et al., 2017). These studies go some way in meeting the call for more research to examine food systems and fisheries governance of trade-offs between revenue generation (through export for example) and nutrition outcomes (Béné et al., 2019; Bennett et al., 2018). Along these lines, three articles in our review (Levkoe et al., 2017; Love et al., 2017; Marushka et al., 2019) called for greater attention to food sovereignty, localized food systems (i.e. close physical proximity and short value chains between producers and consumers), integrated fisheries and health policies, and programmes such as home grown to school to resilience of the sector and nutrition for vulnerable populations.

4.4 | Nudging towards the concept of food systems

The food systems concept and its frameworks (HLPE, 2017, 2020) are offered to the research and development community as a way to gain explanatory power and enhance outcomes. Whilst there has been a sharp increase in the usage of the term over the last decade, our review shows that engagement with the concept and framework is relatively light, and rarely extends beyond production and value chains. Our findings suggest that on this trajectory research will not reach the ambition to identify key barriers and opportunities for advancing nutrition and sustainability goals. At worst, food systems may be reduced to an over-used buzzword and an under-engaged concept. One of the challenges faced by research is the complexity of the framework, and the practicalities of conducting robust research that examines multiple components and relationships. There are no guidelines or principles on how, and to what degree, research should engage to rightly claim a food systems approach has been taken. Scholars argue (Ericksen, 2008; Ingram, 2011) that a food systems framing can be used to identify and describe the determinants of nutrition and sustainability outcomes as food flows from production to consumption; which leaves substantial freedom for researchers to interpret what this means in terms of research design and interpretation. Our findings from this review lead us to three broad areas to nudge fisheries, aquaculture and aquatic foods research towards the concept and challenges of food systems. In sum, we argue that research should examine a broader set of aquatic food types (i.e. beyond finfish) and their role in diets, examine system-wide flows (and losses) of nutrients and trade-offs amongst objectives, and focus on opportunities and innovations to address nutritional needs of vulnerable and marginalized social groups.

4.4.1 | Consider a broader set of aquatic food types amidst diverse diets

Current global assessments of food production and diets under-represent the diversity of aquatic foods contributing to nutrition outcomes. This is in part perpetuated by a focus on a few species considered of greatest economic importance, a focus on quantifying and reporting "men's fishing" and the underreported nature of many multi-species and subsistence fisheries (FAO et al., 2021; Halpern et al., 2019; Kleiber et al., 2015; Tlusty et al., 2019). For example, fish and other aquatic foods sourced from inland waters are consistency overlooked and undervalued (FAO, 2020; Fluet-Chouinard et al., 2018). Crustacea, molluscs, amphibia, snakes, macrophytes and algae are largely overlooked despite contributions to diets and livelihoods of food system actors (Freed, Barman, et al., 2020; Marushka et al., 2019; Moreau & Garaway, 2018; Rapinski et al., 2018). For example, "other aquatic animals" contribute some 30% of the total annual catch of 2.3 million tonnes from the Lower Mekong Basin (Nam et al., 2015). As a result of the mainstream narrow view of aquatic foods, national and global policies are too commonly built on information about a few key, high value aquatic species. To build more just and distributive food systems, more attention must be paid to the diverse aquatic foods that are produced and consumed in every corner of the globe. Multiple initiatives are underway (e.g. Illuminating Hidden Harvests initiative, the Blue Food Assessment, EAF-Nansen programme on nutrition and food safety) to improve mainstream knowledge of the full suite of aquatic foods and their role in potential pathways to maintain and meet sustainability and nutrition goals. There is also a need to change academic institutions to induce a new wave of aquatic food systems research that breaks down sector and disciplinary silos (Jennings et al., 2016). This includes teaching a broader view of fisheries, aquaculture, food security, food systems governance and agricultural advancement, and connecting multiple knowledge systems, in addition to government managers, commercial fisheries and private sector or industry experts. Examining a greater diversity of aquatic foods brings new knowledge and leverage points for improvements through food systems that would otherwise have been ignored or marginalized in food systems policies and investments (Rapinski et al., 2018; Tlusty et al., 2019). Improving the coverage and availability of data, particularly, through national reporting and international public repositories like the FAO INFOODS database (Rittenschober et al., 2016), including diverse aquatic foods (Byrd et al., 2020; Farmery et al., 2017; Tlusty et al., 2019), and underreported sectors to "put all food on the same table" will widen the view of pathways available to decision makers (Halpern et al., 2019).

4.4.2 | Examine system-wide flows of nutrients and trade-offs amongst objectives

Understanding and engaging with the flows and losses of nutrition potential, social equity and environmental impacts across all components and relationships of the food system is critical to understand how nutrition and sustainability outcomes can be improved (van Bers et al., 2019; Fanzo et al., 2020). Research that has taken this opportunity has illuminated innovations in value chains and governance processes that improve equity (Levkoe et al., 2017; Mills, 2018), enhance environmental sustainability, reduce food loss and waste (Springmann et al., 2018), and tackle underlying social barriers with concurrent investment in locally designed technology (Cole et al., 2018). Advances will be made with greater attention to the "missing middle" (Tezzo et al., 2020; Veldhuizen et al., 2020), or the drivers and patterns of processing and distribution that mediate food acquisition and consumption. A review of the food environments that impact fish acquisition and consumption in the Great Lakes Region of Africa provides a useful illustration of the range of socio-cultural, economic, physical and behavioural mediating factors (de Bruyn et al., 2021). These patterns and mediating factors in food environments (HLPE, 2017) harbour entry points for change that are overlooked relative to investments and interest in production, but that may be equally important in driving food system transformations towards healthier and more sustainable configurations (Downs et al., 2020).

Increased research attention is needed to understand the social, economic and environmental dimensions of sustainability (Béné et al., 2019) of food systems, coupled with trade-offs between meeting sustainability goals and nutrition needs (Hallström et al., 2019; Seconda et al., 2018). Our review suggests that this need also extends to local manifestations trade-offs but also to how external drivers of change are influential, and the relative balance between social, economic and environmental gains and losses particularly in the provision of diverse and adequate diets (Caron et al., 2018; Downs et al., 2020). Research can identify the avenues and contexts in which governance structures (e.g. trade agreements, subsidies, taxes) can be adjusted to better support nutrition and equity, alongside environmental and economic goals (FAO et al., 2020; Hicks et al., 2019). COVID-19 has brought global attention to the interacting nature of external drivers, and where those interactions compound experiences of limited access to food and ultimately nutrition insecurity. A challenge to future research is to account for (and even anticipate) multiple interacting drivers, and the dynamic nature of food systems.

4.4.3 | Focus on vulnerable and marginalized social groups

The attention of fisheries, aquaculture and aquatic foods research is presently focussed on countries with high HDI, risking the propagation of dietary, sustainability or equity solutions that are inappropriate for malnutrition profiles of many countries (Golden et al., 2017; Love et al., 2017; Vittersø et al., 2019). The nationally and locally divergent needs within countries with low HDI include combating high rates of poverty, the individual and societal costs of malnutrition and high vulnerability relative to capacity to cope with shocks that affect primary production (van Bers et al., 2019; FAO et al., 2020; Hirvonen et al., 2019). Countries with low HDI might also experience outflows of nutritional potential to nations with high HDI (Hicks et al., 2019) as well as inflows of environmental costs. Tlusty et al. (2019) pointed to measures, such as certification schemes and improved value chain traceability, implemented in high HDI countries that can be inaccessible or pose barriers for small-scale producers and value chain actors, particularly prevalent in countries with low HDI. Place-based and rights-based approaches are critical for food systems transformations to meet goals of equity and inclusion; as stipulated by the Sustainable Development Goals and other policy frameworks (FAO, 2015, 2016). This corroborates calls to understand food systems in a broader range of contexts and cultures (Béné et al., 2019), including the multiple and interacting food systems (e.g. traditional, mixed and modern) that exist and may be in transition in many nations (Caron et al., 2018; Downs et al., 2020; Fanzo et al., 2020).

An opportunity for research is to build greater understanding to sub-national variation, and diets and nutrition needs that differ between people within any community (FAO, 2020; Funge-Smith, 2018; Myers et al., 2017). Even more critical, perhaps, is understanding the drivers of inequality and injustice, including knowledge, economic policies, social norms and power dynamics as they play out across levels (HLPE, 2020). Of particular value is research that guide interventions where food systems are not serving the needs of vulnerable populations, especially rural communities (Caron et al., 2018), indigenous peoples (Marushka et al., 2019), marginalized people in urban centres, and the most nutritionally vulnerable, particularly women and children (Thilsted et al., 2016). Factors that limit peoples access to a variety of foods (rather than volumes of food) have been tackled by school feeding programmes (Bersamin et al., 2019; Love et al., 2017) and by sustainable livelihoods approaches that improve physical and economic access to food (Fisher et al., 2017; Limuwa et al., 2018; Savo et al., 2017). These include poverty drivers, incipient impacts of environmental degradation and climate change, corruption, and ethnic and gender marginalization. New research beyond our review across diverse regions; the African Great Lakes (Kakwasha et al., 2020; O'Meara et al., 2021), continental South and Southeast Asia (Freed, Barman, et al., 2020; Freed, Kura, et al., 2020) and the Pacific (Albert et al., 2020; Farrell et al., 2020), are employing the food systems concept to understand the opportunities and limitations of aquatic foods for addressing the multiple forms of malnutrition and food insecurity. Addressing the needs of the vulnerable (FAO et al., 2020) across different contexts and cultures (Hirvonen et al., 2019) is critical to ensure sustainable food systems and achieve the ambitions of sustainability, equity and food and nutrition security.

5 | CONCLUSION

Although food systems are extraordinarily complex, research has started to build an improved understanding of how food systems function, and their influence on human, societal and environmental well-being. The historical changes in the way in which nutrition and health outcomes are understood—arriving most recently at food systems frameworks such as developed by the HLPE (2017, updated 2020)—reflects this maturing in both research and policy. Addressing the environmental sustainability, social equity, economic and health challenges of the 21st Century will require transformation of the global food system (Springmann et al., 2018; Willett et al., 2019). Given the research trends we observed, we argue that transformation is also needed to the policy, institutional and funding arrangements that perpetuate siloed research, a focus on single or few species, and the predominance of knowledge systems and innovation from and for the Global North. We argue persistence in these trends will mean research, as a whole, remains unfit for the complexity and urgency of global food system challenges. Employing the food systems concept more consistently and comprehensively (i.e. greater systemicity) in research on fisheries, aquaculture and aquatic foods has the potential to shed light on nutritional and environmental, social and economic, and sustainability gains or losses as they are experienced by different people, in different contexts. The food systems concept presents an aspirational framing for research design and data interpretation. To meet this aspiration, we have outlined the ways in which research may be better positioned to contribute to the ambition of food systems transformation (FAO, 2020; Halpern et al., 2019; Independent Group of Scientists appointed by the Secretary-General, 2019). This would likely help realize the potential of fisheries, aquaculture and aquatic foods amidst, and as a driver of, food system transformations towards improved environmental and human well-being.

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DATA AVAILABILITY STATEMENT

The full data that we extracted from the reviewed studies are available in.csv (Supplementary file S2).

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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