



Existing foundations, emerging discourses, and unexplored potential for a maricultural geography

Elizabeth O. Ruff^{*}, Tyler McCreary, Sarah E. Lester

Department of Geography, Florida State University, 113 Collegiate Loop, PO Box 3062190, Tallahassee, FL 32306-2190, USA

ARTICLE INFO

Keywords:

Mariculture
Aquaculture
Seafood
Food geographies
Critical ocean studies

ABSTRACT

The field of geography has long contributed crucial insights to our understanding of food systems; however, this scholarship has focused predominantly on terrestrial food production, even though over a third of the global population relies on seafood to meet their dietary needs. While geographers have identified aquaculture (the farming of aquatic species) as a fruitful field of study, there has been little consideration for how the varied environments in which aquaculture is produced, from freshwater ponds to open ocean net pens, can and should shape specific research questions and disciplinary pursuits within the broader aquacultural geography discourse. As such, we present the case for a ‘maricultural geography’ that engages with the distinct dynamics and tensions of farming in the sea. We evaluate geographers’ existing contributions to the mariculture literature and identify emerging discourses within political economy, political ecology, and science and technology studies. We then outline three pathways for further disciplinary engagement focused on food geographies, feminist geographies, and social studies of science. Geographers can offer valuable analyses of mariculture’s position within existing sociocultural food structures, present alternative pathways for postcapitalist production, and explore the mechanization of a fluid world through technoscientific systems. In return, the ocean context provides novel opportunities for thinking geographically about our food systems and reimagining terrestrial ontologies of governance and regulation, development and urbanization, and sustainability and innovation.

1. Introduction

Aquaculture (i.e., the farming of fish and other aquatic species) is one of the fastest growing sectors of our global food system and makes up an increasing proportion of global seafood production (Duarte et al., 2009; FAO, 2020). In 2018, total aquaculture production amounted to ~113.6 million metric tons (MT), valued at ~263 billion USD (Chopin & Tacon, 2021; FAO, 2020). In comparison, global capture fisheries (inland and marine waters) produced ~97.3 million MT, valued at ~151 billion USD (Chopin & Tacon, 2021; FAO, 2020). With the global demand for seafood increasing as a result of population and economic growth, and the relatively limited potential to sustainably expand yields from wild-capture fisheries to meet this demand, most of the projected growth in seafood production is expected to come from aquaculture (FAO, 2020). Aquaculture’s increasing prominence within the seafood sector has spawned research agendas across the physical sciences, from understanding the environmental impacts of production on surrounding ecosystems (e.g., Black, 2001; Holmer et al., 2007) to producing more efficient feeds for carnivorous species (e.g., Drew et al., 2007; Soler-Vila

et al., 2009), but the social sciences have devoted comparatively less attention to aquaculture as a subject of inquiry. Geography’s limited participation in the arena of aquaculture research is particularly notable given its strong tradition of engaging with agro-food systems (e.g., McMichael, 1994; Watts et al., 2005; Whatmore, 1993).

Both Barton and Stanford (1998) and Belton and Bush (2014) have presented research agendas for geographic engagement with aquaculture, and the latter note an “improvement in the volume and scope of aquacultural geography” since the former’s publication, though critical ‘net deficits’ persist (Belton & Bush, 2014). While these agendas have presented broad pathways for further disciplinary exploration, they neglect to consider the varied environments, from land-based tanks to open ocean net pens, in which aquaculture is produced and how those distinct contexts can and should shape specific research questions and disciplinary pursuits within the aquaculture arena. Marine aquaculture, also referred to as mariculture, is the farming of marine species in marine spaces and has increasingly attracted scholarly attention, both within and outside geography, due to the sector’s marked expansion over the last 60 years (Costa-Pierce, 2002; Naylor et al., 2021).

^{*} Corresponding author.

E-mail addresses: eoruff@fsu.edu (E.O. Ruff), tmccreary@fsu.edu (T. McCreary), slester@fsu.edu (S.E. Lester).

However, mariculture and the unique dynamics of producing nature in ocean spaces have yet to be treated as a fruitful subfield of geography distinct from the broader aquacultural geography scholarship (Belton & Bush, 2014; Friedman et al., 2002). The ocean's fluid medium challenges how geographers' have conceptualized comparatively static terrestrial spaces, and thus requires new ways of thinking about farming in a liquid and ever-changing environment. Social scientists have increasingly turned their attention to the sea, proclaiming an 'oceanic turn' in scholarship (or the rise of 'critical ocean studies') (DeLoughrey, 2017, 2019; Ingersoll, 2016); however, there is still a need and opportunity for targeted geographic inquiry on seafood farming in marine spaces.

While other disciplines have participated more substantially in the mariculture discourse, much of this engagement generally focuses on economic markets or biophysical production potential in isolation. Geography is well-positioned to holistically examine how mariculture disrupts and changes socioeconomic, sociopolitical, and socioecological assemblages, providing the 'doing words' (Lambert, 2004) to explain connections and relationships between people, spaces, and places. Moreover, much of the mariculture literature lacks an "in-depth relational spatial focus" that geography could provide (Albrecht & Lukkarinen, 2020, 2). As coastal economies increasingly pursue mariculture as a form of economic growth and food security, geography as an integrative and cross-pollinating discipline is well-suited to examine the multifaceted realities of the industry at various scales. Geography employs scale as an anchor point for analysis (i.e., conducting studies from local, national, regional, and global perspectives), while also leveraging the ability to zoom in and out, revealing multiscale networks where local actions influence global outcomes and vice versa (Jackson, 2006). This multifocal lens is especially valuable given the scalar complexities of mariculture production and trade. For example, while some high-value mariculture species, such as salmon, are part of a highly commodified and globalized industry (Asche et al., 2015), lower-value species largely remain in local and domestic markets (Belton et al., 2018).

In this paper, we present the case for a 'maricultural geography' that accounts for the physical, political, social, and economic liquidity of the sea. We review the existing English-language maricultural geography literature, tracing the progression of geographic engagement within the field of marine farming over the last three decades. Within this broader review, we also follow the evolution of specific themes in the mariculture discourse, including the growing contributions from critical geographies. We then discuss the unexplored potential for geographic contributions to the mariculture discourse, outlining specific pathways for future disciplinary reckoning. In outlining a mariculture research agenda for geographers, we attempt to "bring geographic theory to the sea, and bring the sea to geographic theory" (Steinberg & Peters, 2015, 261).

2. The case for a maricultural geography

As a sub-category under the broader 'aquaculture' umbrella, mariculture presents distinct differences from land-based and freshwater aquaculture that warrant a separate 'maricultural geography'. For one, the ocean does not conform to our perceptions of the terrestrial environment as an "idealized inert and homogenous space" (Herrera-Racionero et al., 2020, 126). The application of the terrestrial definition of 'space' implies boundaries, which are difficult to see and define in the ocean context. This is not to say that boundaries are not imposed in the marine environment, as Exclusive Economic Zones (EEZs; the 200-nautical mile boundary surrounding coastal countries within which a nation has sovereign rights) and marine protected areas (a section of the ocean that restricts human activity for conservation purposes) are prevalent forms of delineating ocean spaces. However, given that the sea is a fluid medium, these boundaries are much fuzzier and more porous than their terrestrial counterparts. These fluid boundaries are reflected

in the general absence of widespread property rights and enclosure in the oceans up until the mid-twentieth century, with the sea and its resources still broadly viewed as public property or a commons in many contexts and regions (Skladany et al., 2007; Steinberg, 2018). Yet, mariculture operations generally involve the exclusion of people and other activities, and thus the acquisition of property rights and the explicit demarcation of 'boundaries' around an ocean 'space'. This enclosure of the ocean can recast marine governance networks and the sociopolitical hierarchies nested within them (Boucquoy et al., 2016; Fairbanks et al., 2018).

Mariculture also faces conflicting protectionist and productivist narratives that necessitate a distinct discourse separate from the broader aquacultural geography. There is an 'overuse' narrative that the ocean and its resources are already exceedingly taxed by human activities (Steinberg, 2008), with mariculture representing an additional 'use' of the marine world. Simultaneously, mariculture advocates across governments, NGOs, and the industry itself tout marine farming as a means of relieving fishing pressure, conserving wild-capture fish stocks, and/or producing more food (Stotz, 2000). These contrasting perspectives are further convoluted by the conflation of small-scale, commercial production with industrialized mariculture development, overlooking how the latter can displace and undermine the former. Artisanal and small-scale, commercial mariculture is and has been a central part of the livelihoods and cultures of many coastal communities, particularly in East Asia (Msuya & Hurtado, 2017; Subasinghe et al., 2009). But mariculture has also rapidly industrialized over the past 60 years in some regions (Costa-Pierce, 2002; Naylor et al., 2021), most notably in Norway and Chile where farmed salmon production has exploded (Phyne, 2010). Researchers have highlighted the environmental concerns (e.g., disease outbreaks, escapees, and habitat destruction) associated with these industrialized operations, most prominently in the context of intensive finfish production; however, conservationists, popular media, and the general public often ascribe these impacts to mariculture more broadly, regardless of the scale of production or the farmed species (Knapp & Rubino, 2016). These dueling commentaries complicate political, scientific, and public perceptions of mariculture not found in other food production settings (Froehlich et al., 2017).

There are also important environmental and logistical differences between farming in the ocean versus other aquatic settings that warrant specific exploration by geographers. The ocean offers substantial expanses of potentially suitable mariculture production area as well as key production inputs such as food (for filter-feeders like molluscs), nutrients (for primary producers like algae), and oxygenation (Roels et al., 1979; Tang et al., 2011). On the other hand, the marine environment is a far more hostile one to operate in compared to terrestrial or freshwater environments. Farm operators must navigate volatile changes in weather and ocean conditions as well as invest in equipment and technology that can withstand this harsh environment. While land-based aquaculture operates in a much more forgiving environment and there are also large expanses of land available, this form of production must grapple with its own limitations, including water shortages, pollution, and price increases for production inputs (Costa-Pierce et al., 2021; Newton et al., 2021). Given these differences, it is important to understand the geographic factors that shape the distinct industrial development pathways for mariculture. Technological advances and the adaptation of organizational elements from other established marine industries (e.g., offshore petroleum extraction) are opening up the ocean frontier and tackling some of the physical obstacles to production, particularly in offshore environments (Fløysand & Jakobsen, 2017). In doing so, these advances are recasting the knowledge processes of land-based and freshwater aquaculture production and constructing new networks of technological and organizational innovation.

Our argument for a specific 'maricultural geography' does not extend singularly from a dearth of geography-centric literature on marine farming. We also contend that the context of the ocean opens new possibilities of thinking geographically, as the marine world "creates the

need for new understandings of mapping and representing; living and knowing; governing and resisting” (Steinberg & Peters, 2015, 260). Just as geographers can advance mariculture scholarship, the mariculture context offers an opportunity to expand disciplinary ontologies and paradigms. For example, Ascuí et al. (2018) explore the burgeoning agency of environmental Big Data in the context of salmon mariculture management in Tasmania, diverging from previous geographic perspectives on data as a passive intermediary. And through a case study of tidal flat fisheries in South Korea, Choi (2019) extends critiques of neoliberal logics beyond variegation to consider the “drivers and potentiality of the making of neoliberal assemblages” (21). These challenges to established theory reveal mariculture’s potential as a proving ground and honing mechanism for the geographic discipline. Mariculture specifically, rather than the marine environment and other marine activities broadly, presents fertile territory for geographic engagement as an extension of the existing agro-food geographies corpus. The focus of this paper is thus not simply on how the marine environment presents a different context for considering geographic theory and practice but how mariculture specifically challenges existing considerations around the production of nature.

3. Maricultural geography in review

We review geographers’ contributions to mariculture scholarship following a similar approach to Belton and Bush’s (2014) survey of aquacultural geography. We narrowed our literature search to 2019’s top 50 geography journals ranked by Clarivate Analytics (formerly the Institute for Scientific Information) (see Supporting Information, Table SI1) and used the Web of Science database to search for mariculture papers published in these journals from 1990 to 2020. We acknowledge that limiting our search to the top 50 geography journals excludes mariculture research by geographers published in non-geography journals. However, we contend that by querying the leading geography journals, we can more explicitly assess how geographers have situated mariculture within the discipline, understand how mariculture has been employed as a context for geographic theory, and gauge to what extent geography journals are contributing to and disseminating mariculture scholarship. Given the dominance of English-language journals in academia, we note that our review provides a limited account of non-Anglophone scholarship.

The term ‘mariculture’ has been applied to a variety of production systems, including those taking place in brackish water and in land-based saltwater tanks. However, for the purposes of this paper, we utilize the definition from the Food and Agriculture Organization (FAO) of the United Nations that ‘mariculture’ is “conducted in the sea, in a marine water environment” (FAO, 2020, 25). As such, we did not include literature focused on aquaculture in brackish pond and coastal lagoon settings or marine species grown in land-based tanks. However, we did include production of rainbow trout in the Baltic Sea, despite its classification as a brackish water environment by the FAO, given it is connected to the Atlantic Ocean and its hydrography (including tidal currents) mirrors that of oceans.

We queried 30 different terms that could be used to refer to aquaculture operations in marine environments (see Supporting Information, Table SI2), including species-specific terms for marine farming. We applied each of these terms under ‘topic’ in the Web of Science advanced search in conjunction with the journal title under ‘publication name’. This search produced 90 papers. Given the expanse of our search terms, we then conducted a thorough review of each article to verify their application to mariculture, including removing papers on coastal pond and lagoon aquaculture and papers where mariculture was conflated with aquaculture broadly with no specific focus on marine production. We also differentiated between papers that situated geographical concepts within the mariculture arena, and those that only included a passing reference to mariculture; we excluded publications that simply mentioned mariculture (e.g., in a list of marine activities) or did not

focus on mariculture in a way that was imperative to meeting the stated objectives of the paper (e.g., Karp et al., 2015). We retained articles where mariculture was not the central focus but provided perspective for the broader discussion and objectives of the paper, including papers that discussed aquaculture broadly but had mariculture-specific commentary as one component. This approach resulted in 45 papers for our evaluation of the current state of ‘maricultural geography’ (see Supporting Information, Table SI3).

For each of the 45 publications, we recorded information on key geographic themes and theories, case study locations, and species. Approximately 69% of the articles were published after 2009, indicating a growing engagement with mariculture by geographers in the last decade (Fig. 1). Of the 50 journals we queried, only 18 included mariculture articles, and 7 of those have published only one mariculture piece as of 2020. Further, three journals (*Global Environmental Change*, *Journal of Rural Studies*, and *Geoforum*) were responsible for almost half (~47%) of the total number of publications.

Although 14 countries were represented in the literature, Chile and Norway accounted for 46% of the case study papers. Given this trend, it is not surprising that salmon production featured in 60% of species-specific studies; shellfish was a distant second with 20% of articles. The focus on Norway and Chile is indicative of a broad bias in geography and other disciplines towards countries farming high-value, globally traded species to the neglect of countries whose production, in some cases, dwarfs that of Chile and Norway but who produce species that have lower market value and are sold in domestic markets (Fig. 2a) (Belton & Bush, 2014). For example, China and Indonesia are the top two mariculture-producing countries and made up ~80% of global mariculture production by volume in 2018 (Fig. 2b) (FAO, 2020). Not one article in our review focused exclusively on either country, and China’s only notable inclusion was as part of Coull’s (1993) global review of mariculture production trends. For comparison, Norway and Chile contribute less than 5% to global mariculture production volume (FAO, 2020).

The geographic composition of the papers we identified is at least partially attributable to the preponderance of English language journals located in the Global North in Web of Science’s top 50 rankings which, in turn, is a reflection of academia’s larger bias towards publishing in English (Belcher, 2007; Hyland, 2016). We acknowledge that our sampling method limits the scope of our review and excludes maricultural geography contributions made in languages other than English. While this limitation is indicative of a broader need to develop transnational and translingual dialogues within geography, addressing these gaps in representation can foster compelling opportunities for maricultural geography scholarship moving forward.

4. Existing foundations and emerging discourses

Based on our detailed review of geographic engagement with mariculture over time, we identified existing and emerging research areas within this discourse. The following section provides an overview of the existing English-language maricultural geography corpus, divided into subsections based on three broad themes: political economy, political ecology, and science and technology studies. Within this broader review, we also explore how geographic perspectives have progressed over time within these themes and subthemes. This approach allows us to assess deficits in the broader literature as well as identify specific areas where geographic perspective is lacking. We recognize that papers often grapple with multiple themes or subthemes, but we grouped articles based on their primary research questions and objectives. For publications where mariculture was not the central focus, we categorized them based on the context in which mariculture was addressed. Because the current maricultural geography literature is limited, we are intentional in our inclusion of all 45 publications in the following review as we seek to understand the extent to which geographers have situated themselves within the maricultural scholarship.

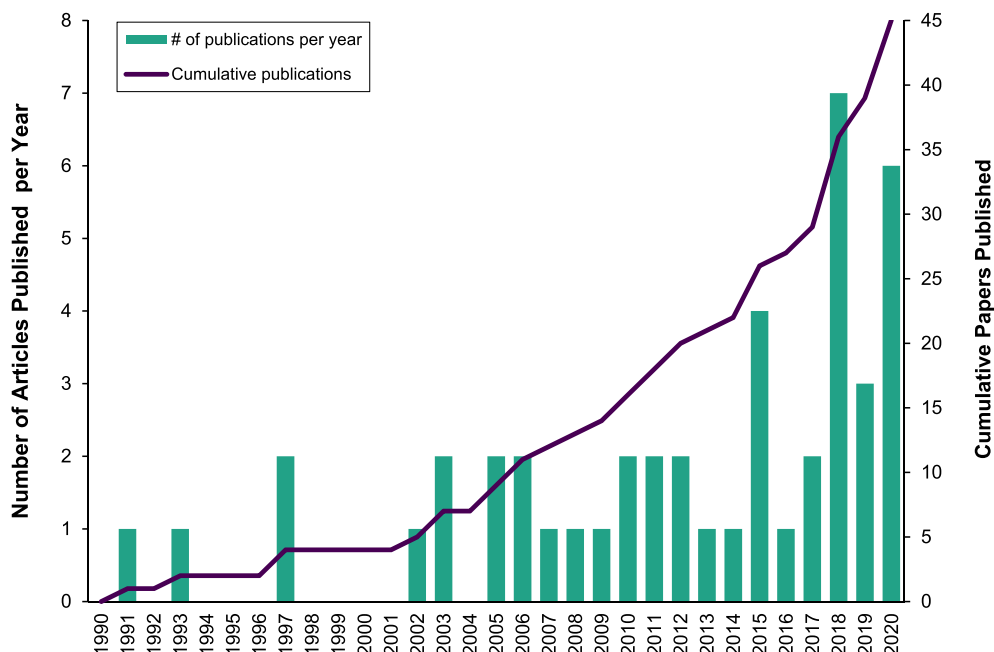


Fig. 1. Thirty years of maricultural geography. Mariculture papers published in geography journals per year (left axis, green bars) and cumulative publications over the 30-year review period, 1990–2020 (right axis, purple line). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

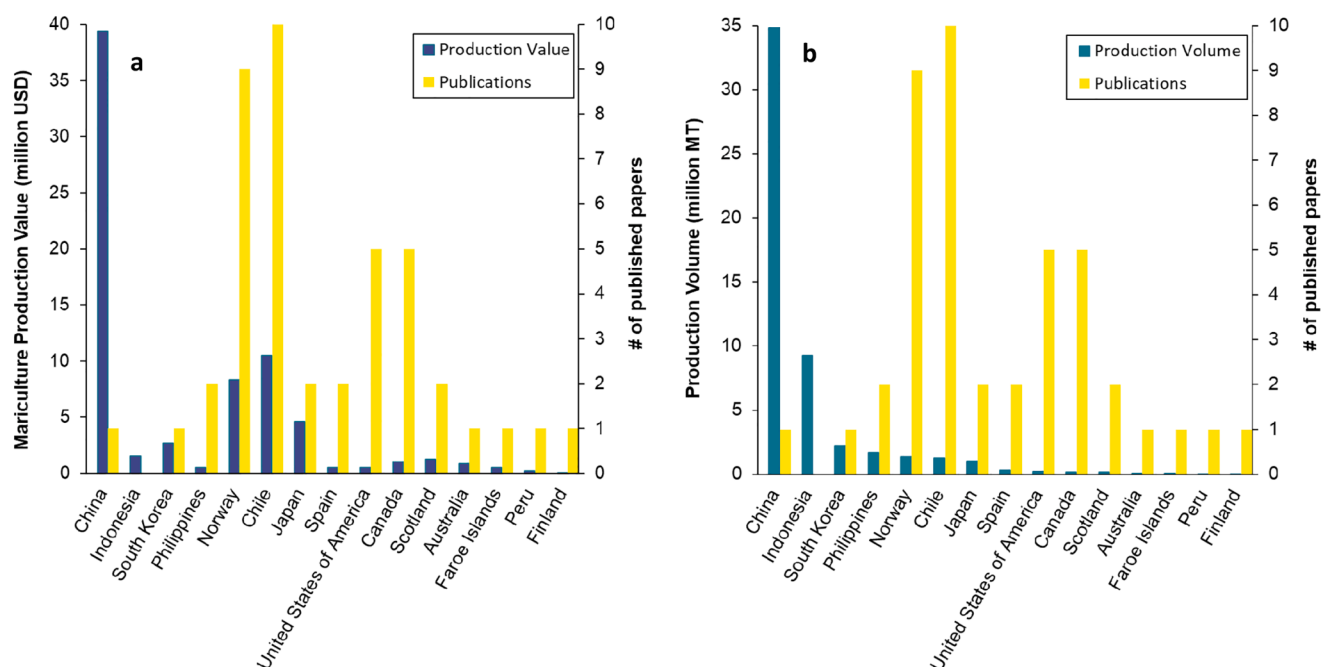


Fig. 2. Number of paper references compared to country-level mariculture value and production. A) Countries total mariculture production value (USD '000) (left axis, blue bars) and the number of mariculture papers in the top-50 geography journals referencing them (right axis, yellow bars) are shown to the left. B) Countries' total mariculture production volume (MT) (left axis, green bars) and the number of mariculture papers in the top-50 geography journals referencing them (right axis, yellow bars) are shown to the right. Sources: [FAO, 2020](#); [Marine Scotland, 2020](#). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

4.1. Political economy

Political economy perspectives can delve into the systems, processes, and actors that operationalize governance, investment, commodification, and labor within the mariculture industry. Geographic engagement with mariculture has been skewed heavily towards this discourse, with

governance perspectives predominating. Geographers have also grappled with the potentiality of knowledge spillovers across mariculture sectors, the industry's role in the global seafood market, and how mariculture can change labor dynamics within rural communities. Mariculture's burgeoning role in our global food system necessitates the evaluation of the sociopolitical and economic structures that are shaping

the industry as it evolves. Geographers have pursued analogous lines of inquiry within the context of terrestrial food systems from which they can draw on and adapt for mariculture.

4.1.1. Regulatory frameworks for an emerging bioeconomic sector

Lloyd and Livingstone's (1991) initial foray into the institutional mechanisms that control and operationalize the mariculture industry in Scotland was followed by similar case study assessments of regulatory regimes by McDaniels et al. (2005) in Canada and Peel and Lloyd (2008) also in Scotland. These studies offer insights into the need for public consultation in mariculture planning frameworks (Lloyd & Livingstone, 1991), the importance of multi-scale considerations in regulatory decisions (McDaniels et al., 2005), and the rise of regulatory regimes as a response to perceived operational problems within the mariculture industry (Peel & Lloyd, 2008). The growth of geographic governance scholarship corresponded with greater focus on critical perspectives in later years (starting in 2013), offering commentary on neoliberal governance practices within the mariculture industry (Choi, 2019; Fabinyi, 2018; Silver, 2013), indigenous interactions with mariculture governance regimes (Silver, 2014), mariculture policy mobilities in the United States (Fairbanks, 2018), blue bioeconomy governance (Albrecht & Lukkarinen, 2020), and the assertion of regulatory authority through mapping (Movik & Stokke, 2020).

These later publications are more intentional in their employment of geographical perspectives and theory and directly engage with dynamics distinct to mariculture such as privatization of public ocean space and governance within the blue economy. For example, Silver (2013) challenges the disciplining of the coastal space and its subjects through government-led and government-funded interventions under the guise of economic modernization and sustainability. In the context of shellfish aquaculture initiatives in British Columbia, they highlight the capitalist transformation of ocean spaces via enclosure and privatization, which are "prioritized and reproduced through discourse and government activity" (Silver, 2013, 436). Additionally, Albrecht and Lukkarinen (2020) grapple with the disconnect between national blue economy policy frameworks and localized implementations of those policies, highlighting four key arenas of 'reconnection': blue resource values, technology and innovations, blue markets and products, and water governance arrangements. These reconnections are not simply "counter-discourses for the hegemonic blue-growth policies" but emergent pathways "to engage with localized blue (bio)economy developments" through strong local and regional networks (Albrecht & Lukkarinen, 2020, 14).

4.1.2. Flows of investment, commodity chains, and labor relations

In the early years of our review timeline, economic perspectives were absent from the maricultural geography literature outside of Coull's (1993) review of global trends in aquaculture development. Industry development perspectives are still quite limited, though insightful. Employing co-evolution and path-dependence theories, Aarset and Jakobsen (2015) explore the institutional arrangements within the highly profitable salmon mariculture industry in Norway, finding these frameworks have not diffused to other mariculture sectors, which have struggled to find similar development and growth success. This phenomenon indicates there are potential barriers to co-evolution across seemingly analogous industry paths in Norwegian mariculture and suggests knowledge transfers within the mariculture industry are not a given. Fløysand et al. (2017) utilize a similar theoretical basis to explore the dynamic interplay between foreign direct investment, multinational companies, and industry renewal in western Norway's salmon farming industry.

The early 2000s mark an increased engagement by geographers with seafood market dynamics. Commodity chains are a popular focus for these papers, with geographers investigating 'buyer-driven' markets within the mariculture industry itself (Phyne et al., 2006; Phyne & Mansilla, 2003) and analyzing mariculture's growth and position within

the global seafood value chain (Wilkinson, 2006). Through an integrated livelihood and value-chain analysis approach, Andriess (2018) expands on this research in the context of poverty reduction and rural development in the Philippines, contrasting downstream export successes (e.g., the increasing value of seaweed exports) with the precarious social and economic conditions faced by upstream actors (e.g., rural producers' dependence on costly intermediaries to connect to urban markets). Parallel literature explores the rise of mariculture as a global industry and the resulting international trade flows associated with feed inputs (Deutsch et al., 2007), the impact of agglomeration on profits in the Norwegian salmon farming sector (Asche et al., 2016), and the evolution of the market structure for the Spanish turbot industry (Fernández-González et al., 2020).

Mariculture is often promoted by national governments and development initiatives as a form of economic enhancement, including job creation (Engle, 2009). As such, labor geographies can provide critical insights into the sociospatial processes and patterns of employment within the mariculture industry. However, our literature search uncovered only a few studies of labor processes within the mariculture industry. While focusing on several potential drivers of land use change in Southern Chile, Díaz et al. (2011) find that proximity to salmon farming production centers increased the probability of land abandonment, possibly indicating that mariculture operations offer rural job opportunities that encourage labor migration from the agricultural sector. Oseland et al. (2012) explore labor organization within the Chilean salmon mariculture industry and challenge traditional applications of labor geography, particularly regarding the scale at which labor dynamics are evaluated. Employing the term 'glocalcentrism', i.e., "the tendency in labor geography to overemphasize local-to-global connections", they argue that nationally-scaled structures and processes (which have been influenced by the Pinochet regime's lingering legacy of labor repression) are integral considerations in discussions of labor agency (Oseland et al., 2012, 95). Kluger et al. (2020) offer perspectives on labor mobility and migration due to an abrupt environmental disturbance, in this case the El Niño Southern Oscillation that occurred off coastal Peru in 2017. In exploring how small-scale resource users (i.e., fishers and scallop farmers) cope with climatic events through mobilization, they find a gender bias whereby men are the main actors of labor migration despite women's major contributions to fisheries and mariculture activities (Kluger et al., 2020).

4.2. Political ecology

Political ecology provides a useful lens for untangling the relationship between the natural environment and socioeconomic processes, including the sociocultural dynamics among users and consumers of nature. The maricultural geography scholarship that engages with themes in the political ecology arena has a fairly limited scope, focusing largely on ecological sustainability (with a handful of critical perspectives on sustainability metrics) and conflicts among users of the ocean space. Geography is well-situated to contribute to and direct these discourses within mariculture scholarship as the discipline can grapple with evolving expectations of ecological, social, and economic sustainability as a collective set of objectives as well as harness ideologies of environmental conservation and social justice, focusing them through a lens of place and space.

4.2.1. Environmental impacts and the operationalization of sustainability

Geography's initial engagement with environmental issues related to mariculture centered on the impacts of fish disease and issues of contamination from feed and chemical treatments (Barton, 1997), paralleling early discourse in other disciplines (e.g., Silvert & Sowles, 1996; Sindermann, 1984; Tovar et al., 2000). Barton and Fløysand (2010) further assess the rise of the Chilean salmon industry under weak environmental regulations, its collapse due to disease outbreaks in the late 2000s, and its attempt to emerge from this crisis via new

sustainability-oriented ‘neo-structural’ governance regimes. Geographers have also given attention to sustainability through a climate lens, focusing on the feasibility of meeting current and increased per capita fish consumption through wild-capture fisheries and aquaculture broadly (with the salmon farming industry highlighted) (Merino et al., 2010) and the potential impact of predicted climatic conditions on the global fishmeal value chain (which mariculture is heavily dependent upon) (Merino et al., 2012).

More recent discourses explore the ways in which sustainability can be operationalized within the mariculture industry. Swanson (2015) describes ‘shadow ecologies’ (Dauvergne, 1997) that Japan’s high demand for farmed salmon has created in Chile, specifically how the former country’s patterns of resource consumption affect the natural environment of the latter. In transferring the environmental liabilities associated with large-scale production of salmon to Chile, Japan has been able to decentralize and restructure its own salmon industry towards sustainability through eco-friendly management schemes that acknowledge indigenous rights as well as citizen-led conservation projects (Swanson, 2015). Geographers have also offered critiques of sustainability certification schemes that seek to operationalize sustainability through quantitative assessments of mariculture operations. The development and implementation processes of certification paths and the global and local actors that contribute to their construction invite manifold biases (e.g., the design of standards by retailers and NGOs in the global North for application to operations in the global South), and geographers have challenged the political and social legitimacy of these proposedly impartial systems (Cid Aguayo & Barriga, 2016). Another arena for geographic critique is the predominant focus of certification schemes on environmental and governance standards, to the exclusion of social, cultural, and economic issues. Through a global review of aquaculture certification schemes and standards (several of which are specific to mariculture), Osmundsen et al. (2020) find that even when cultural and economic indicators are considered, they are primarily focused on issues of industry investment in technology/innovation and employee interests and well-being, not the equitable distribution of economic benefits or the creation of local social capital.

4.2.2. Human resource conflicts and socationatural transformations

Engagement with issues of user and property rights in mariculture have been notably sparse. This absence is particularly significant given perceptions of the sea as a public space and the fluidity of the ocean complicate the application of terrestrial forms of user and property rights to mariculture. Earlier literature focuses on conceptualizing the costs and benefits of mariculture to coastal users (Ridler, 1997), the property institutions employed to operationalize commercial mariculture (Suryanata & Umemoto, 2003), and collective choice rights in resource use decisions (Suryanata & Umemoto, 2005). Coastal and environmental planning processes feature prominently in these papers, both as a means of negotiating and resolving human and resource conflicts (Ridler, 1997; Suryanata & Umemoto, 2003) and as a form of representative politics that requires special attention to social processes during formal public deliberations (Suryanata & Umemoto, 2005).

Consultative processes carry over into later publications as well, with a greater inclination towards understanding the geographies of stakeholder dynamics. Through a rural postproductive transition lens, Hanes (2018) explores the dynamics between coastal landowners and seafood farmers at lease hearings in three of Maine’s mariculture regions, finding that varying physical and cultural geographies in these areas create differing levels and forms of user conflict. Hanes pursues an explanation as to why certain conflicts arise among groups by observing stakeholder dialogues at town hall meetings. Alternatively, Plieninger et al. (2018) and Herrera-Racionero et al. (2020) consult with stakeholders directly to identify potential conflicts. The former leverages participatory mapping and narrative analysis techniques to assess local opinions of fish farming and processing (as well as tourism and renewable energy) in the Faroe Islands, revealing mixed levels of acceptance and concern

regarding the mariculture industry. Herrera-Racionero et al. (2020) take a more qualitative approach to explore the competitive relationships between mariculture farmers and local fishermen and identify potential obstacles to future management collaborations. These relationships are reflected in how each stakeholder group perceives and interacts with the sea and its inhabitants, creating two conflicting groups that are “immersed in a process of mutual misunderstanding, leading them to adopt positions which are irreconcilable” (Herrera-Racionero et al., 2020, 129).

Despite prominent depictions of mariculture as a means of economic development for rural communities (by governments, NGOs, and academics), geographers’ attention to this arena has been limited. However, it is possible that the bias of our review methodology towards English-language publications focused on the Global North has obfuscated the extent to which geographers have contributed to this discourse in other languages and world regions. Several of the papers outlined in this review are case studies of rural countries and regions; however, their attention is directed towards economic markets, governance, and technology that just so happen to occur within these areas rather than the mechanisms by which mariculture transforms socioeconomic and ecological communities themselves. Blanco et al. (2015) pursues this latter objective through an ethnographic assessment of Patagonia’s regional transformation resulting from the territorialization of salmon. They posit that salmon farming introduces new forms of biopower that are operationalized through neoliberal markets, prompting regional transformation by producing “new relations between life, agency and nature” (179).

4.3. Science and Technology Studies

Science and Technology Studies (STS) (sometimes referred to as Science, Technology and Society) grapples with the ways in which science, society, and political processes shape systems of knowledge and innovation and, in turn, how the latter impact socioeconomic and cultural institutions. As a relatively nascent commercialized industry that operates within the challenging ocean environment, the intellectual, material, and social facets of mariculture production have received limited scholarly attention, and geographic contributions to the STS discourse focused on mariculture have been sparse in comparison to the political economy and political ecology literature. However, six of the eight STS papers presented below were published within the final four years of our review timeline, indicating an increasing engagement with this corpus.

4.3.1. Industry evolution and sociotechnical systems

In exploring the institutional-spatial dynamics that characterize modernization, technology, and knowledge processes in mariculture, Doloreux et al. (2009) start to unravel the role of policy and innovation support organizations in stimulating development of the mariculture industry in Norway and suggest that the absence of such institutions as an explanation for Quebec’s less successful industry growth. Fløysand and Jakobsen (2017) employ an evolutionary economic perspective to better understand industrial ‘renewal’ – understood as industry rejuvenation and innovation – through the development trajectories of green technologies for salmon mariculture in Norway. They find that the Norwegian salmon farming industry illustrates lock-in tendencies, whereby industry actors and institutions seek to preserve the existing industrial structures and slow the process of renewal (Fløysand & Jakobsen, 2017). These dynamics have limited the expansion of green technology within the industry and offer a critical foundation for understanding the evolution of and barriers to more sustainable operating practices within the mariculture industry.

Barton et al. (2019) turn a critical eye to the processes by which innovation is pursued. They contrast the ‘traditional science-firm nexus’ of neostructural productivism, where innovation objectives center solely on expanding or improving production, with responsible research and

innovation that balances production objectives with sustainable regional development goals such as improving local livelihoods and welfare. This nascent focus on development objectives has called attention to the regional transformations of peripheral economies as a result of the techno-industrial complex of commercial salmon aquaculture. This has been particularly apparent in southern Chile, where “techno-scientific production of the Atlantic salmon as an industrial commodity” has forced the local socioecological communities into large global markets (Miller, 2018, 128). This commodification has created a cash and credit economy that has enabled the expansion of other socio-technical systems, such as the Mall Paseo Chiloé retail space, in a previously rural region (Miller, 2018).

4.3.2. Social construction of knowledge and space

The few publications exploring the people, places, and procedures that shape and promulgate information proffer valuable context for how knowledge creation processes operate around the mariculture industry and suggest the immense potential for geographers to participate further in this corpus. Both Peuhkuri (2002) and Freitag (2018) assess how interest groups wield knowledge to influence mariculture policy and management decisions. The former does so through a case study of rainbow trout farming in Finland and the regulatory struggle between fish farmers and other stakeholders that was driven by competing definitions of ‘eutrophication’, focusing on “the role of knowledge as a resource in the struggle over the definition” (Peuhkuri, 2002, 157). In this example, interest groups selectively applied research results to prop up their pre-established views while simultaneously using scientific uncertainty as a justification to oppose environmental restrictions on fish farming effluent. Freitag (2018) similarly deals with the problematization of definition, this time in the application of the term ‘wilderness’ as outlined in the United States Wilderness Act of 1964. Through an ethnographic study of communities located in the North Bay of California, they find that stakeholder-driven discussion can facilitate integrated definitions and values and construct new forms of knowledge (Freitag, 2018). Mansfield (2011) moves beyond stakeholder knowledge processes and technological infrastructure to explore how aquaculture and salmon mariculture specifically have led to the reconstruction of knowledge in the context of human health narratives surrounding seafood consumption and the production of a “materially different fish” that can contain larger concentrations of pollutants than wild capture fish (423). By integrating human health with geographic considerations of nature-society relations, Mansfield reconceptualizes the recursive relationship between production (of fish bodies) and consumption (by human bodies) as both unhealthy and healthful.

With the emergence of new technologies and expanding data collection capabilities, there is growing geographic attention given to the evolving role of information in shaping governance systems for mariculture. Ascuí et al. (2018) grapple with the ‘new and unpredictable agency’ of environmental Big Data in the management of salmon mariculture in Tasmania, exploring how data are central actors in debates regarding how the salmon farming industry is managed. In this way, their work diverges from traditional critical perspectives, which have evaluated the tools and methods of data collection but have largely neglected to critically evaluate the data themselves, instead treating data as mere byproducts of knowledge production.

5. Unexplored potential

Despite the growth in contributions to a maricultural geography in recent years, there remains substantial scope and depth left unattended. The liquid volume of the ocean and its distinct processes of ecological, political, economic, and cultural circulation provide opportunities to examine both the potential for and limitations to expanding existing geographic frameworks to new spaces. As Lehman (2020) argues, the ocean has challenged geographers’ traditionally terrestrial-centered epistemologies and ontologies, showcasing limits to our existing

paradigms and requiring new pathways for thinking geographically. Relatedly, alongside the continued development of marine farming, there are exciting opportunities to highlight the distinct contributions that geographic scholarship can add to the larger field of mariculture studies, and, in turn, to demonstrate how thinking through mariculture can contribute to expanding and reconfiguring the canon of geographic thought. In this section we outline three possible pathways for geographic engagement in the mariculture discourse: food geographies, feminist geographies, and geographies of science and data. These are not intended as an exhaustive list of themes or questions but represent promising avenues where geographers publishing in English-language journals have been conspicuously absent despite analogous discourses within the discipline.

5.1. Food geographies

Geographic examinations of food have asked basic questions involving ‘who gets what, where, and how’ (Smith, 1974). To date, food geographies have been expansive, connecting food deserts to the perpetuation of health disparities in low-income communities (e.g., Shannon, 2014), elucidating how foodways link to people’s sense of place and identity (e.g., Dudley, 2011; Yeh & Lama, 2013), and investigating questions of justice and sovereignty in urban food systems (e.g., Gattrell et al., 2011). And yet, many of these foundational questions that inform research in food geographies have yet to be applied to mariculture. Existing literature (Costello et al., 2020; Gentry, Froehlich, et al., 2017) estimates that mariculture could contribute substantially to increased supplies of seafood as wild-capture fisheries production stagnates. However, these estimates are aggregated at global and national scales and have not considered the spatial distribution of and access to this potential increased food supply (Brugere et al., 2021; Krause et al., 2015). Mariculture presents geographers with the distinct opportunity to delve into these questions of equity in the context of a multiscale food system that participates in both global commodity chains and domestic markets.

The promotion of mariculture development for the purpose of economic growth and food security is often targeted at countries in the Global South, and discussions of mariculture’s economic potential in these countries largely center on being able to participate in global markets (Asche et al., 2015; Bostock et al., 2010), which necessitates the industrialized production of high-value, capital-intensive species, such as salmon and cobia. While geographers have started to examine the impacts of capital injection and building infrastructure on rural economies, their focus has been exclusively in the context of salmon production in Chile. Expanding these perspectives to other regions of the Global South can highlight the varying ways in which industrialized mariculture is subsumed under and projected through economic growth and food security narratives. In this regard, geographers can turn their attention to impacts of industrialized mariculture on traditional forms of food provision, including the displacement of artisanal fishing communities and small-scale, commercial marine farming practices; shifts in community structure as a result of in-migrating labor; and political struggles over who decides the course of industry development and what knowledge they employ in decision-making. Additional discourses can give attention to the sociocultural geographies that link people to the sea, consider the individual and collective identities that are attached to traditional marine resource use, and attend to the ways in which mariculture conforms to and contends with the sociocultural connections and values of coastal communities. Extending the oceanic reach of food geographies research in this way will facilitate rethinking some of the normative underpinnings of mariculture as solely an economic and nutritional tool.

5.2. Feminist geographies

As mariculture has continued to expand, there has been recent

movement toward reconfiguring economic development objectives and shifting political and industrial focus from blue economies to blue communities (Campbell et al., 2020). The ‘blue communities’ concept eschews maximizing economic growth and argues for “multidimensional wellbeing”, whereby social, cultural, and environmental equity are prominent objectives of mariculture development (Campbell et al., 2020, 3). Feminist geographies, in particular, are poised to grapple with these issues of economic, environmental, and social equity associated with maricultural development trajectories.

Although mariculture in some contexts has more gender-equitable employment than wild-capture fisheries (e.g., Brugere & Williams, 2017; Burbridge et al., 2001), there are substantial open questions regarding its gender impacts. Broadening the conceptualization of work to encompass a range of activities—commodified and non-commodified, paid and unpaid—has been a longstanding project of feminist political economy (Battacharya, 2017; Federici, 2004; Meehan & Strauss, 2015; Oberhauser, 2000). Thus, alongside charting gendered rates of access to formal employment in mariculture, it is necessary to critically engage with the impacts of commercial mariculture development on other strategies of social provisioning in coastal communities—for instance, subsistence fishing—as well as on reproductive care work within the household. Even where industry increases employment, it has the potential to exacerbate inequities in regions as new industrial work intersects, overlaps, and offsets older forms of household production. Simultaneously, if mariculture development displaces other subsistence economies, particularly those operating in the nearshore area, it will increasingly render families and communities dependent on the recirculation of wages from the mariculture industry, creating new tertiary economies and labor hierarchies.

Feminist perspectives should also look beyond industrialized production and attend to the social and economic agency of women participating in the small-scale, commercial production of low-value mariculture products. For example, seaweed farming, particularly in the Global South, is conducted mostly by women (Msuya & Hurtado, 2017). While this production is unlikely to drastically change the economic trajectory of their respective countries, it has enabled these women to not only generate a sustainable livelihood for themselves but also to improve the health and educational outcomes of their families and communities (Msuya & Hurtado, 2017). In engaging with these largely overlooked forms of small-scale production, feminist geographers can uncouple community well-being from economic growth and recalibrate mariculture development objectives to the local level rather than at national or global scales.

There are also intriguing age dynamics across the various scales of mariculture production that present distinctive opportunities for geographic engagement through a feminist lens. In some regions of the world, elderly women and men play a key role in the small-scale, commercial industry; however, older workers are starting to experience displacement as businesses seek to increase processing speeds by bringing in younger workers (Soejima, 2014). As industrialized mariculture expands, the current social structures of these latter communities will likely be subverted as traditional opportunities within the sector are reallocated to younger populations. Geographers can reflect how these agrarian transitions can marginalize established livelihood strategies for particular subpopulations and substantially change the current social structure of these coastal communities.

5.3. Social studies of science and big data

As our capacity to collect, study, and synthesize high-volume and high-dimensional datasets has expanded, geographers have pursued dialogues regarding the use of Big Data in geography as well as how geography can inform Big Data scholarship (e.g., Graham & Shelton, 2013; Kitchin, 2013). These discussions largely center on social datasets used in human geography (e.g., Graham & Shelton, 2013) and geospatial datasets utilized by GIS and spatial scientists (e.g., Chun et al., 2019).

While the sea remains largely underexplored, especially in comparison to land, new technologies have enhanced real-time, high-resolution visualization of ocean dynamics and have brought the ocean environment into the realm of modern Big Data (Lehman, 2018).

Feminists writing at the interface of geography and STS have elucidated how gender and patriarchal power structures are imbricated within and projected forward through technological systems (e.g., Haraway, 1988; Holloway et al., 2000; Lohan & Faulkner, 2004). From data collection technologies that inform the management of established mariculture farms to technologies of governance that delineate the spaces in which mariculture can operate, technoscientific tools for decision making abound within the industry. For example, marine spatial planning (MSP), akin to land-use planning, has been presented as a means of encouraging mariculture development by identifying ocean areas with suitable growing conditions as well as reducing conflicts with other industries and ocean stakeholders (Gentry, Lester, et al., 2017; Lester et al., 2018). MSP is based on an iterative process of scientific data collection and stakeholder participation and generally entails developing maps (through spatial software like GIS) that designate usage of the ocean space. MSP and similar processes of technoscientific mariculture governance can create inequitable power structures, bias perceptions of scientific ‘knowledge’, and alter relational ontologies depending on the proprietors of the mapping technology and the stakeholders included in consultative processes (Garland et al., 2019). Lehman (2018) suggests that moving ocean science from traditional ship-based studies to data centers or even home offices may enable women to overcome some of the traditional exclusionary geographies of ocean science. Thinking carefully through these changes, and the potentials and pitfalls they present, feminist geographers are situated to define questions of power and participation in marine spatial planning processes and untangle the sociopolitical knots that are embedded in mariculture’s technoscientific systems.

In addition to these knowledge enshrining processes, geographers should also consider how data and analytics are circumscribing the ocean into spheres of legal and economic authority. Although Ascuí et al. (2018) grapple with the role of Big Data in salmon mariculture governance in Tasmania, there are more and broader considerations for geographers. For example, Shapiro (2020) demonstrates how ‘smart cities’ are cultivated by data flows and information merging with capital in urban settings, creating systems of ‘logistical governance’. Change the urban setting to the ocean, and we are presented with questions about the architecture of a developing marine industry and how legal and institutional infrastructure is built in a fluid environment. Additionally, physical geographers can leverage predictive technologies and Big Data to explore how climate change and ocean acidification will impact the siting and management of mariculture operations and the type of species suitable to changing oceanic conditions.

6. Conclusion

Mariculture is a growing sector in our global food system, and geographers are uniquely positioned to reflect the realities of the industry as it expands, contributing valuable critiques and commentary to topics that have been largely overlooked by the broader mariculture scholarship. Situating geography within the context of ocean farming addresses the ‘net deficits’ in mariculture knowledge as well as challenges and broadens the discipline’s current discourses surrounding agro-food systems, sionatural networks, and technoscientific agency. Geography’s pluralism lends itself to untangling the human and more-than-human communities that are embedded in and intertwined through mariculture’s production of nature. By harnessing this intradisciplinary diversity, geographers can set forth a mariculture research agenda that not only engages their fellow practitioners but also encourages non-geographers in the mariculture arena to think more geographically.

CRediT authorship contribution statement

Elizabeth O. Ruff: Conceptualization, Methodology, Investigation, Writing – original draft. **Tyler McCreary:** Resources, Writing – original draft. **Sarah E. Lester:** Funding acquisition, Conceptualization, Methodology, Writing – original draft.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors would like to acknowledge financial support from the Waitt Foundation and the National Science Foundation (NSF Grant No. 1759559). The statements, findings, conclusions, and recommendations are those of the authors and do not necessarily reflect the views of our funders.

Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.geoforum.2022.02.006>.

References

- Aarset, B., Jakobsen, S.-E., 2015. Path dependency, institutionalization and co-evolution: The missing diffusion of the blue revolution in Norwegian aquaculture. *J. Rural Stud.* 41, 37–46. <https://doi.org/10.1016/j.jrurstud.2015.07.001>.
- Albrecht, M., Lukkarinen, J., 2020. Blue bioeconomy localities at the margins: Reconnecting Norwegian seaweed farming and Finnish small-scale lake fisheries with blue policies. *Environ. Plann. C: Polit. Space* 38 (7–8), 1465–1483. <https://doi.org/10.1177/2399654420932572>.
- Andriess, E., 2018. Primary Sector Value Chains, Poverty Reduction, And Rural Development Challenges In The Philippines. *Geogr. Rev.* 108 (3), 345–366. <https://doi.org/10.1111/gere.12287>.
- Asche, F., Bellemare, M.F., Roheim, C., Smith, M.D., Tveteras, S., 2015. Fair Enough? Food Security and the International Trade of Seafood. *World Dev.* 67, 151–160. <https://doi.org/10.1016/j.worlddev.2014.10.013>.
- Asche, F., Roll, K.H., Tveteras, R., 2016. Profiting from Agglomeration? Evidence from the Salmon Aquaculture Industry. *Regional Stud.* 50 (10), 1742–1754. <https://doi.org/10.1080/00343404.2015.1055460>.
- Asci, F., Haward, M., Lovell, H., 2018. Salmon, sensors, and translation: The agency of Big Data in environmental governance. *Environ. Plann. D* 36 (5), 905–925. <https://doi.org/10.1177/0263775818766892>.
- Barton, J.R., 1997. Environment, sustainability and regulation in commercial aquaculture: The case of Chilean salmonid production. *Geoforum* 28 (3–4), 313–328. [https://doi.org/10.1016/S0016-7185\(97\)00013-4](https://doi.org/10.1016/S0016-7185(97)00013-4).
- Barton, J.R., Fløysand, A., 2010. The political ecology of Chilean salmon aquaculture, 1982–2010: A trajectory from economic development to global sustainability. *Global Environ. Change* 20 (4), 739–752. <https://doi.org/10.1016/j.gloenvcha.2010.04.001>.
- Barton, J.R., Román, Á., Rehner, J., 2019. Responsible research and innovation (RRI) in Chile: From a neostructural productivist imperative to sustainable regional development? *Europ. Plann. Stud.* 27 (12), 2510–2532. <https://doi.org/10.1080/09654313.2019.1658719>.
- Battacharya, T. (Ed.), 2017. *Social Reproduction Theory*. Pluto Press.
- Barton, J., Stanford, D., 1998. Net deficits and the case for aquacultural geography. *Area* 30 (2), 144–155. <https://doi.org/10.1111/j.1475-4762.1998.tb00058.x>.
- Belcher, D.D., 2007. Seeking acceptance in an English-only research world. *J. Second Language Writing* 16 (1), 1–22. <https://doi.org/10.1016/j.jslw.2006.12.001>.
- Belton, B., Bush, S.R., 2014. Beyond net deficits: New priorities for an aquacultural geography. *Geogr. J.* 180 (1), 3–14. <https://doi.org/10.1111/geoj.12035>.
- Belton, B., Bush, S.R., Little, D.C., 2018. Not just for the wealthy: Rethinking farmed fish consumption in the Global South. *Global Food Security* 16, 85–92. <https://doi.org/10.1016/j.gfs.2017.10.005>.
- Black, K.D. (Ed.), 2001. *Environmental impacts of aquaculture* (Vol. 5). Taylor & Francis.
- Blanco, G., Arce, A., Fisher, E., 2015. Becoming a region, becoming global, becoming imperceptible: Territorialising salmon in Chilean Patagonia. *J. Rural Stud.* 42, 179–190. <https://doi.org/10.1016/j.jrurstud.2015.10.007>.
- Bostock, J., McAndrew, B., Richards, R., Jauncey, K., Telfer, T., Lorenzen, K., Little, D., Ross, L., Handiside, N., Gatward, I., Corner, R., 2010. Aquaculture: Global status and trends. *Philos. Trans. Roy. Soc. B: Biol. Sci.* 365 (1554), 2897–2912. <https://doi.org/10.1098/rstb.2010.0170>.
- Boucquey, N., Fairbanks, L., St. Martin, K., Campbell, L.M., McCay, B., 2016. The ontological politics of marine spatial planning: Assembling the ocean and shaping the capacities of ‘Community’ and ‘Environment’. *Geoforum* 75, 1–11. <https://doi.org/10.1016/j.geoforum.2016.06.014>.
- Brugere, C., Troell, M., Eriksson, H., 2021. More than fish: Policy coherence and benefit sharing as necessary conditions for equitable aquaculture development. *Marine Policy* 123, 104271. <https://doi.org/10.1016/j.marpol.2020.104271>.
- Brugere, C., Williams, M., 2017. *Profile: Women in Aquaculture*. <https://genderaquafish.org/portfolio/women-in-aquaculture/>.
- Burbridge, Hendrick, Roth, Rosenthal, 2001. Social and economic policy issues relevant to marine aquaculture. *J. Appl. Ichthyol.* 17 (4), 194–206. <https://doi.org/10.1046/j.1439-0426.2001.00316.x>.
- Campbell, L.M., Fairbanks, L., Murray, G., Stoll, J.S., D’Anna, L., Bingham, J., 2020. From Blue Economy to Blue Communities: Reorienting aquaculture expansion for community wellbeing. *Marine Policy* 124, 104361. <https://doi.org/10.1016/j.marpol.2020.104361>.
- Choi, Y.R., 2019. Profitable tidal flats, governable fishing communities: Assembling tidal flat fisheries in post-crisis South Korea. *Polit. Geogr.* 72, 20–30. <https://doi.org/10.1016/j.polgeo.2019.03.006>.
- Chopin, T., Tacon, A.G.J., 2021. Importance of Seaweeds and Extractive Species in Global Aquaculture Production. *Rev. Fish. Sci. Aquacult.* 29 (2), 139–148. <https://doi.org/10.1080/23308249.2020.1810626>.
- Chun, Y., Kwan, M.-P., Griffith, D.A., 2019. Uncertainty and context in GIScience and geography: Challenges in the era of geospatial big data. *Int. J. Geogr. Inform. Sci.* 33 (6), 1131–1134. <https://doi.org/10.1080/13658816.2019.1566552>.
- Cid Aguayo, B.E., Barriga, J., 2016. Behind certification and regulatory processes: Contributions to a political history of the Chilean salmon farming. *Global Environ. Change* 39, 81–90. <https://doi.org/10.1016/j.gloenvcha.2016.04.005>.
- Costa-Pierce, B.A., 2002. *Ecological Aquaculture: The Evolution of the Blue Revolution*. John Wiley & Sons.
- Costa-Pierce, B.A., Bockus, A.B., Buck, B.H., van den Burg, S.W.K., Chopin, T., Ferreira, J. G., Goseberg, N., Heasman, K.G., Johansen, J., Shumway, S.E., Sims, N.A., Tacon, A. G.J., 2021. A Fishy Story Promoting a False Dichotomy to Policy-Makers: It Is Not Freshwater vs. Marine Aquaculture. *Rev. Fisheries Sci. Aquaculture* 1–18. <https://doi.org/10.1080/23308249.2021.2014175>.
- Costello, C., Cao, L., Gelcich, S., Cisneros-Mata, M.Á., Free, C.M., Froehlich, H.E., Golden, C.D., Ishimura, G., Maier, J., Macadam-Somer, I., Mangin, T., Melnychuk, M.C., Miyahara, M., de Moor, C.L., Naylor, R., Nøstbakken, L., Ojea, E., O’Reilly, E., Parma, A.M., Plantinga, A.J., Thilsted, S.H., Lubchenco, J., 2020. The future of food from the sea. *Nature* 588 (7836), 95–100. <https://doi.org/10.1038/s41586-020-2616-y>.
- Coull, J.R., 1993. Will a Blue Revolution Follow the Green Revolution? The Modern Upsurge of Aquaculture. *Area* 25 (4), 350–357.
- Dauvergne, P., 1997. *Shadows in the forest: Japan and the politics of timber in Southeast Asia*. MIT press.
- DeLoughrey, E., 2017. Submarine Futures of the Anthropocene. *Comparat. Literature* 69 (1), 32–44. <https://doi.org/10.1215/00104124-3794589>.
- DeLoughrey, E., 2019. Toward a Critical Ocean Studies for the Anthropocene. *English Language Notes* 57 (1), 21–36. <https://doi.org/10.1215/00138282-7309655>.
- Deutsch, L., Gräslund, S., Folke, C., Troell, M., Huitric, M., Kautsky, N., Lebel, L., 2007. Feeding aquaculture growth through globalization: Exploitation of marine ecosystems for fishmeal. *Global Environ. Change* 17 (2), 238–249. <https://doi.org/10.1016/j.gloenvcha.2006.08.004>.
- Díaz, G.I., Nahuelhual, L., Echeverría, C., Marín, S., 2011. Drivers of land abandonment in Southern Chile and implications for landscape planning. *Landscape Urban Plann.* 99 (3–4), 207–217. <https://doi.org/10.1016/j.landurbplan.2010.11.005>.
- Doloreux, D., Isaksen, A., Aslesen, H.W., Melançon, Y., 2009. A Comparative Study of the Aquaculture Innovation Systems in Quebec’s Coastal Region and Norway. *Europ. Plann. Stud.* 17 (7), 963–981. <https://doi.org/10.1080/09654310902949240>.
- Drew, M.D., Borgeson, T.L., Thiessen, D.L., 2007. A review of processing of feed ingredients to enhance diet digestibility in finfish. *Anim. Feed Sci. Technol.* 138 (2), 118–136. <https://doi.org/10.1016/j.anifeeds.2007.06.019>.
- Duarte, C.M., Holmer, M., Olsen, Y., Soto, D., Marbà, N., Guiu, J., Black, K., Karakassis, I., 2009. Will the Oceans Help Feed Humanity? *Bioscience* 59 (11), 967–976. <https://doi.org/10.1525/bio.2009.59.11.8>.
- Dudley, S., 2011. Feeling at home: Producing and consuming things in Karenni refugee camps on the Thai-Burma border. *Population, Space Place* 17 (6), 742–755. <https://doi.org/10.1002/psp.639>.
- Engle, C.R., 2009. *Mariculture: Economic and social impacts*. In: *Encyclopedia of ocean sciences*, 2nd ed. Elsevier, pp. 545–551.
- Fabinyi, M., 2018. Environmental fixes and historical trajectories of marine resource use in Southeast Asia. *Geoforum* 91, 87–96. <https://doi.org/10.1016/j.geoforum.2018.02.033>.
- Fairbanks, L., 2018. Policy mobilities and the sociomateriality of U.S. offshore aquaculture governance. *Environ. Plann. C: Polit. Space* 37 (5), 849–867. <https://doi.org/10.1177/0263774X18809708>.
- Fairbanks, L., Campbell, L.M., Boucquey, N., St. Martin, K., 2018. Assembling Enclosure: Reading Marine Spatial Planning for Alternatives. *Ann. Am. Assoc. Geogr.* 108 (1), 144–161. <https://doi.org/10.1080/24694452.2017.1345611>.
- FAO, 2020. *The State of World Fisheries and Aquaculture 2020. Sustainability in Action*. Food and Agriculture Organization of the United Nations. <https://doi.org/10.4060/ca9229en>.
- Federici, S., 2004. *Caliban and the Witch: Women, the Body, and Primitive Accumulation*. Autonomedia.

- Fernández-González, R., Pérez-Pérez, M.I., Garza Gil, M.D., 2020. Market concentration in the Spanish turbot aquaculture sector: A regional analysis. *Pap Reg Sci* 100 (3), 777–794. <https://doi.org/10.1111/pirs.12589>.
- Floydsand, A., Jakobsen, S.-E., 2017. Industrial renewal: Narratives in play in the development of green technologies in the Norwegian salmon farming industry. *Geogr. J.* 183 (2), 140–151. <https://doi.org/10.1111/geoj.12194>.
- Floydsand, A., Njos, R., Nilsen, T., Nygaard, V., 2017. Foreign direct investment and renewal of industries: Framing the reciprocity between materiality and discourse. *Europ. Plann. Stud.* 25 (3), 462–480. <https://doi.org/10.1080/09654313.2016.1226785>.
- Freitag, A., 2018. Visions of wilderness in the North Bay communities of California. *Area* 50 (1), 101–108. <https://doi.org/10.1111/area.12356>.
- Friedman, A., Brown, N.R., McGaffey, A.P., 2002. A basis for bias in geographical judgments. *Psychon. Bull. Rev.* 9 (1), 151–159. <https://doi.org/10.3758/BF03196272>.
- Froehlich, H.E., Gentry, R.R., Rust, M.B., Grimm, D., Halpern, B.S., Somers, C.M., 2017. Public Perceptions of Aquaculture: Evaluating Spatiotemporal Patterns of Sentiment around the World. *PLoS ONE* 12 (1), e0169281. <https://doi.org/10.1371/journal.pone.0169281>.
- Garland, M., Axon, S., Graziano, M., Morrissey, J., Heidkamp, C.P., 2019. The blue economy: Identifying geographic concepts and sensitivities. *Geogr. Compass.* <https://doi.org/10.1111/gec3.12445>.
- Gatrell, J.D., Reid, N., Ross, P., 2011. Local food systems, deserts, and maps: The spatial dynamics and policy implications of food geography. *Appl. Geogr.* 31 (4), 1195–1196. <https://doi.org/10.1016/j.apgeog.2011.01.013>.
- Gentry, R.R., Froehlich, H.E., Grimm, D., Kareiva, P., Parke, M., Rust, M., Gaines, S.D., Halpern, B.S., 2017a. Mapping the global potential for marine aquaculture. *Nat. Ecol. Evol.* 1 (9), 1317–1324. <https://doi.org/10.1038/s41559-017-0257-9>.
- Gentry, R.R., Lester, S.E., Kappel, C.V., White, C., Bell, T.W., Stevens, J., Gaines, S.D., 2017b. Offshore aquaculture: Spatial planning principles for sustainable development. *Ecol. Evol.* 7 (2), 733–743. <https://doi.org/10.1002/ece3.2637>.
- Graham, M., Shelton, T., 2013. Geography and the future of big data, big data and the future of geography. *Dialogues Human Geogr.* 3 (3), 255–261. <https://doi.org/10.1177/2043820613513121>.
- Hanes, S.P., 2018. Aquaculture and the Postproductive Transition on the Maine Coast. *Geogr. Rev.* 108 (2), 185–202. <https://doi.org/10.1111/gere.12247>.
- Haraway, D., 1988. *Situated Knowledge: The Science Question in Feminism and the Privilege of Partial Perspective*. *Feminist Stud.* 14 (3), 575–599.
- Herrera-Racionero, P., Martínez-Novo, R., Lizcano, E., Miret-Pastor, L., 2020. Sea-based aquafarming and traditional fishery: Oceans apart? *J. Rural Stud.* 78, 123–130. <https://doi.org/10.1016/j.jrurstud.2020.06.016>.
- Holloway, S.L., Valentine, G., Bingham, N., 2000. Institutionalising Technologies: Masculinities, Femininities, and the Heterosexual Economy of the IT Classroom. *Environ. Plann. A: Econ. Space* 32 (4), 617–633. <https://doi.org/10.1068/a3238>.
- Holmer, M., Black, K., Duarte, C.M., Marba, N., Karakassis, I. (Eds.), 2007. *Aquaculture in the Ecosystem*. Springer Science & Business Media.
- Hyland, K., 2016. Academic publishing and the myth of linguistic injustice. *J. Second Language Writing* 31, 58–69. <https://doi.org/10.1016/j.sjsw.2016.01.005>.
- Ingersoll, K.A., 2016. *Waves of Knowing*. Duke University Press.
- Jackson, P., 2006. Thinking Geographically. *Geography* 91 (3), 199–204. <https://doi.org/10.1080/00167487.2006.12094167>.
- Karp, D.S., Tallis, H., Sachse, R., Halpern, B., Thonicke, K., Cramer, W., Mooney, H., Polasky, S., Tietjen, B., Waha, K., Walz, A., Wolny, S., 2015. National indicators for observing ecosystem service change. *Global Environ. Change* 35, 12–21. <https://doi.org/10.1016/j.gloenvcha.2015.07.014>.
- Kitchin, R., 2013. Big data and human geography: Opportunities, challenges and risks. *Dialogues Human Geogr.* 3 (3), 262–267. <https://doi.org/10.1177/2043820613513388>.
- Kluger, L.C., Alff, H., Alfaro-Córdova, E., Alfaro-Shigueto, J., 2020. On the move: The role of mobility and migration as a coping strategy for resource users after abrupt environmental disturbance – the empirical example of the Coastal El Niño 2017. *Global Environ. Change* 63, 102095. <https://doi.org/10.1016/j.gloenvcha.2020.102095>.
- Knapp, G., Rubino, M.C., 2016. The Political Economics of Marine Aquaculture in the United States. *Rev. Fish. Sci. Aquacult.* 24 (3), 213–229. <https://doi.org/10.1080/23308249.2015.1121202>.
- Krause, G., Brugere, C., Diedrich, A., Ebeling, M.W., Ferse, S.C.A., Mikkelsen, E., Pérez Agúndez, J.A., Stead, S.M., Stybel, N., Troell, M., 2015. A revolution without people? Closing the people-policy gap in aquaculture development. *Aquaculture* 447, 44–55. <https://doi.org/10.1016/j.aquaculture.2015.02.009>.
- Lambert, D., 2004. *The power of geography*. <https://www.geography.org.uk/write/MediaUploads/Advocacy%20Files/NPOGPower.doc>.
- Lehman, J., 2018. From ships to robots: The social relations of sensing the world ocean. *Soc. Stud. Sci.* 48 (1), 57–79. <https://doi.org/10.1177/0306312717743579>.
- Lehman, J., 2020. Sea Change: The World Ocean Circulation Experiment and the Productive Limits of Ocean Variability. *Sci. Technol. Human Values* 46 (4), 839–862. <https://doi.org/10.1177/0162243920949932>.
- Lester, S.E., Stevens, J.M., Gentry, R.R., Kappel, C.V., Bell, T.W., Costello, C.J., Gaines, S.D., Kiefer, D.A., Maue, C.C., Rensel, J.E., Simons, R.D., Washburn, L., White, C., 2018. Marine spatial planning makes room for offshore aquaculture in crowded coastal waters. *Nat. Commun.* 9 (1), 945. <https://doi.org/10.1038/s41467-018-03249-1>.
- Lloyd, M.G., Livingstone, L.H., 1991. Marine fish farming in Scotland: Proprietary behaviour and the public interest. *J. Rural Stud.* 7 (3), 253–263. [https://doi.org/10.1016/0743-0167\(91\)90088-A](https://doi.org/10.1016/0743-0167(91)90088-A).
- Lohan, M., Faulkner, W., 2004. Masculinities and Technologies: Some Introductory Remarks. *Men Masculinities* 6 (4), 319–329. <https://doi.org/10.1177/1097184X03260956>.
- Mansfield, B., 2011. Is Fish Health Food or Poison? Farmed Fish and the Material Production of Un/Healthy Nature*. *Antipode* 43 (2), 413–434. <https://doi.org/10.1111/j.1467-8330.2010.00743.x>.
- Marine Scotland, 2020. *Scottish Fish Farm Production Survey Data*. <https://www.gov.scot/publications/scottish-fish-farm-production-survey-2020/>.
- McDaniels, T.L., Dowlatabadi, H., Stevens, S., 2005. Multiple scales and regulatory gaps in environmental change: The case of salmon aquaculture. *Global Environ. Change* 15 (1), 9–21. <https://doi.org/10.1016/j.gloenvcha.2004.12.007>.
- McMichael, P. (Ed.), 1994. *The Global Restructuring of Agro-food Systems*. Cornell University Press.
- Meehan, K., Strauss, K. (Eds.), 2015. *Precarious Worlds: Contested Geographies of Social Reproduction*. University of Georgia Press.
- Merino, G., Barange, M., Blanchard, J.L., Harle, J., Holmes, R., Allen, I., Allison, E.H., Badjeck, M.C., Dulvy, N.K., Holt, J., Jennings, S., Mullon, C., Rodwell, L.D., 2012. Can marine fisheries and aquaculture meet fish demand from a growing human population in a changing climate? *Global Environ. Change* 22 (4), 795–806. <https://doi.org/10.1016/j.gloenvcha.2012.03.003>.
- Merino, G., Barange, M., Mullon, C., Rodwell, L., 2010. Impacts of global environmental change and aquaculture expansion on marine ecosystems. *Global Environ. Change* 20 (4), 586–596. <https://doi.org/10.1016/j.gloenvcha.2010.07.008>.
- Miller, J.C., 2018. No fish, no mall. Industrial fish produce new subjectivities in Southern Chile. *Geoforum* 92, 125–133. <https://doi.org/10.1016/j.geoforum.2018.04.005>.
- Movik, S., Stokke, K.B., 2020. Asserting authority through mapping: The politics of re-scaling coastal planning in western Norway. *Landscape Res.* 46 (2), 197–210. <https://doi.org/10.1080/01426397.2020.1778659>.
- Mtuya, F.E., Hurtado, A.Q., 2017. The role of women in seaweed aquaculture in the Western Indian Ocean and South-East Asia. *Eur. J. Phycol.* 52 (4), 482–494. <https://doi.org/10.1080/09670262.2017.1357084>.
- Naylor, R.L., Hardy, R.W., Buschmann, A.H., Bush, S.R., Cao, L., Klinger, D.H., Little, D.C., Lubchenco, J., Shumway, S.E., Troell, M., 2021. A 20-year retrospective review of global aquaculture. *Nature* 591 (7851), 551–563. <https://doi.org/10.1038/s41586-021-03308-6>.
- Newton, R., Zhang, W., Xian, Z., McAdam, B., Little, D.C., 2021. Intensification, regulation and diversification: The changing face of inland aquaculture in China. *Ambio* 50 (9), 1739–1756. <https://doi.org/10.1007/s13280-021-01503-3>.
- Oberhauser, A.M., 2000. Feminism and economic geography: Gendering work and working gender. In: Sheppard, E., Barnes, T.J. (Eds.), *A Companion to Economic Geography*. Blackwell Publishing, pp. 60–76. <https://doi.org/10.1111/b.9780631235798.2002.x>.
- Osland, S.E., Haarstad, H., Floydsand, A., 2012. Labor agency and the importance of the national scale: Emergent aquaculture unionism in Chile. *Polit. Geogr.* 31 (2), 94–103. <https://doi.org/10.1016/j.polgeo.2011.11.001>.
- Osmundsen, T.C., Amundsen, V.S., Alexander, K.A., Asche, F., Bailey, J., Finstad, B., Olsen, M.S., Hernández, K., Salgado, H., 2020. The operationalisation of sustainability: Sustainable aquaculture production as defined by certification schemes. *Global Environ. Change* 60, 102025. <https://doi.org/10.1016/j.gloenvcha.2019.102025>.
- Peel, D., Lloyd, M.G., 2008. Governance and planning policy in the marine environment: Regulating aquaculture in Scotland. *Geogr. J.* 174 (4), 13. <https://doi.org/10.1111/j.1475-4959.2008.00304.x>.
- Peuhkuri, T., 2002. Knowledge and interpretation in environmental conflict. *Landscape Urban Plann.* 61 (2–4), 157–168. [https://doi.org/10.1016/S0169-2046\(02\)00110-X](https://doi.org/10.1016/S0169-2046(02)00110-X).
- Phyne, J., 2010. A Comparative Political Economy of Rural Capitalism: Salmon Aquaculture in Norway, Chile and Ireland. *Acta Sociol.* 53 (2), 160–180. <https://doi.org/10.1177/0001699310365632>.
- Phyne, J., Hovgaard, G., Hansen, G., 2006. Norwegian salmon goes to market: The case of the Austevoll seafood cluster. *J. Rural Stud.* 22 (2), 190–204. <https://doi.org/10.1016/j.jrurstud.2005.08.011>.
- Phyne, J., Mansilla, J., 2003. Forging Linkages in the Commodity Chain: The Case of the Chilean Salmon Farming Industry, 1987–2001. *Sociol. Ruralis* 43 (2), 108–127. <https://doi.org/10.1111/1467-9523.00234>.
- Plieninger, T., av Rana, H.A., Fagerholm, N., Ellingsgaard, G.F., Magnussen, E., Raymond, C.M., Olafsson, A.S., Verbrugge, L.N., 2018. Identifying and assessing the potential for conflict between landscape values and development preferences on the Faroe Islands. *Global Environ. Change* 52, 162–180. <https://doi.org/10.1016/j.gloenvcha.2018.07.006>.
- Ridder, N.B., 1997. Rural development in the context of conflictual resource usage. *J. Rural Stud.* 13 (1), 65–73. [https://doi.org/10.1016/S0743-0167\(96\)00052-6](https://doi.org/10.1016/S0743-0167(96)00052-6).
- Roels, O.A., Laurence, S., Van Hemelryck, L., 1979. The utilization of cold, nutrient-rich deep ocean water for energy and mariculture. *Ocean Manage.* 5 (3), 199–210. [https://doi.org/10.1016/0302-184X\(79\)90001-5](https://doi.org/10.1016/0302-184X(79)90001-5).
- Shannon, J., 2014. Food deserts: Governing obesity in the neoliberal city. *Prog. Hum. Geogr.* 38 (2), 248–266. <https://doi.org/10.1177/0309132513484378>.
- Shapiro, A., 2020. *Design, Control, Predict: Logistical Governance in the Smart City*. University of Minnesota Press.
- Silver, J.J., 2013. Neoliberalizing coastal space and subjects: On shellfish aquaculture projections, interventions and outcomes in British Columbia, Canada. *J. Rural Stud.* 32, 430–438. <https://doi.org/10.1016/j.jrurstud.2013.10.003>.
- Silver, J.J., 2014. From fishing to farming: Shellfish aquaculture expansion and the complexities of ocean space on Canada's west coast. *Appl. Geogr.* 54, 110–117. <https://doi.org/10.1016/j.apgeog.2014.07.013>.

- Silvert, W., Sowles, J.W., 1996. Modelling environmental impacts of marine finfish aquaculture. *J. Appl. Ichthyol.* 12 (2), 75–81. <https://doi.org/10.1111/j.1439-0426.1996.tb00066.x>.
- Sindermann, C.J., 1984. Disease in marine aquaculture. *Helgoländer Meeresuntersuchungen* 37 (1-4), 505–530. <https://doi.org/10.1007/BF01989327>.
- Skladany, M., Clausen, R., Belton, B., 2007. Offshore Aquaculture: The Frontier of Redefining Oceanic Property. *Soc. Nat. Resourc.* 20 (2), 169–176. <https://doi.org/10.1080/08941920601052453>.
- Smith, D., 1974. Who gets what, where, and how: A welfare focus for human geography. *Geography* 59 (4), 289–297.
- Soejima, K., 2014. Changes in the Roles of Women and Elderly Persons within Oyster Aquaculture in Japan. *Asian Fisheries Sci.* 27, 59–66.
- Soler-Vila, A., Coughlan, S., Guiry, M.D., Kraan, S., 2009. The red alga *Porphyra dioica* as a fish-feed ingredient for rainbow trout (*Oncorhynchus mykiss*): Effects on growth, feed efficiency, and carcass composition. *J. Appl. Phycol.* 21 (5), 617–624. <https://doi.org/10.1007/s10811-009-9423-z>.
- Steinberg, P.E., 2008. It's so Easy Being Green: Overuse, Underexposure, and the Marine Environmentalist Consensus: It's so easy being green. *Geogr. Compass* 2 (6), 2080–2096. <https://doi.org/10.1111/j.1749-8198.2008.00173.x>.
- Steinberg, P.E., 2018. The ocean as frontier. *Int. Soc. Sci. J.* 68 (229-230), 237–240. <https://doi.org/10.1111/issj.12152>.
- Steinberg, P., Peters, K., 2015. Wet Ontologies, Fluid Spaces: Giving Depth to Volume through Oceanic Thinking. *Environ. Plann. D: Soc. Space* 33 (2), 247–264. <https://doi.org/10.1068/d14148p>.
- Stotz, W., 2000. When aquaculture restores and replaces an overfished stock: Is the conservation of the Species assured? The case of the scallop *Argopecten purpuratus* in Northern Chile. *Aquacult. Int.* 8, 237–247.
- Subasinghe, R., Soto, D., Jia, J., 2009. Global aquaculture and its role in sustainable development. *Rev. Aquaculture* 1 (1), 2–9. <https://doi.org/10.1111/j.1753-5131.2008.01002.x>.
- Suryanata, K., Umemoto, K., 2005. Beyond environmental impact: Articulating the “intangibles” in a resource conflict. *Geoforum* 36 (6), 750–760. <https://doi.org/10.1016/j.geoforum.2004.11.007>.
- Suryanata, K., Umemoto, K.N., 2003. Tension at the Nexus of the Global and Local: Culture, Property, and Marine Aquaculture in Hawai'i. *Environ. Plann. A: Econ. Space* 35 (2), 199–213. <https://doi.org/10.1068/a35116>.
- Swanson, H.A., 2015. Shadow ecologies of conservation: Co-production of salmon landscapes in Hokkaido, Japan, and southern Chile. *Geoforum* 61, 101–110. <https://doi.org/10.1016/j.geoforum.2015.02.018>.
- Tang, Q., Zhang, J., Fang, J., 2011. Shellfish and seaweed mariculture increase atmospheric CO₂ absorption by coastal ecosystems. *Mar. Ecol. Prog. Ser.* 424, 97–104. <https://doi.org/10.3354/meps08979>.
- Tovar, A., Moreno, C., Manuel-Vez, M.P., García-Vargas, M., 2000. Environmental impacts of intensive aquaculture in marine waters. *Water Res.* 34 (1), 334–342. [https://doi.org/10.1016/S0043-1354\(99\)00102-5](https://doi.org/10.1016/S0043-1354(99)00102-5).
- Watts, D.C.H., Ilbery, B., Maye, D., 2005. Making reconstructions in agro-food geography: alternative systems of food provision. *Prog. Hum. Geogr.* 29 (1), 22–40. <https://doi.org/10.1177/030913259301700106>.
- Whatmore, S., 1993. Agricultural geography. *Prog. Hum. Geogr.* 17 (1), 84–91. <https://doi.org/10.1177/030913259301700106>.
- Wilkinson, J., 2006. Fish: A Global Value Chain Driven onto the Rocks. *Sociol. Ruralis* 46 (2), 139–153. <https://doi.org/10.1111/j.1467-9523.2006.00408.x>.
- Yeh, E.T., Lama, K.T., 2013. Following the caterpillar fungus: Nature, commodity chains, and the place of Tibet in China's uneven geographies. *Soc. Cult. Geogr.* 14 (3), 318–340. <https://doi.org/10.1080/14649365.2013.765025>.