PREPRINT – ACCEPTED VERSION - Frontiers in Sustainable Food Systems
Published DOI: 10.3389/fsufs.2021.614368

Alternative seafood networks during COVID-19: Implications for resilience and sustainability

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Keywords: community supported fisheries, COVID-19, fisheries, resilience, seafood, systemic shock, trade

Abstract

Export-oriented seafood trade faltered during the early months of the COVID-19 pandemic. In contrast, alternative seafood networks (ASNs) that distribute seafood through local and direct marketing channels were identified as a "bright spot". In this paper, we draw on multiple lines of quantitative and qualitative evidence to show that ASNs experienced a temporary pandemic "bump" in both the United States and Canada in the wake of supply chain disruptions and government mandated social protections. We use a systemic resilience framework to analyze the factors that enabled ASNs to be resilient during the pandemic as well as challenges. The contrast between ASNs and the broader seafood system during COVID-19 raises important questions about the role that local and regional food systems may play during crises and highlights the need for functional diversity in supply chains.

1. Introduction

Seafood is among the most traded food commodities in the world. In 2018, 38% of the global fish supply was exported at a value of US$164 billion (FAO, 2020). By value, this represents an inflation adjusted increase of 168% in the last 40 years. Multiple factors are contributing to the continued growth and globalization of the seafood system, including neoliberal trade policies that incentivize export of seafood and advancements in technological capacity that enable wide distribution of highly perishable products (Anderson et al., 2010). The expansion of seafood trade has resulted in a range of socioeconomic benefits, including increased employment opportunity and food security (Asche et al., 2015). However, it also makes the seafood system more vulnerable to systemic shocks that disrupt the flow of product and the livelihoods that depend on it (Cottrell et al., 2019). The global financial crisis of 2007-2008, for example, resulted in an estimated 7% decline in seafood exports worldwide, including a 9% decline in the United States and Canada (US$632 million) (FAO, 2010). A decade later, the seafood system again faces a systemic shock, this time due to the COVID-19 pandemic (Love et al., 2021). Shocks like these are becoming an increasingly common feature of food systems, including those associated with seafood (Cottrell et al., 2019) – a trend that can be expected to continue, given the challenges presented by climate change (Rockstrom et al., 2020) and increased globalization in food systems (Kummu et al. 2020). Such disturbances will continue to have major implications for the well-being of the 60 million people worldwide who are directly employed by fisheries and aquaculture as well as those who are involved in processing, distribution, and sales and depend on seafood for nutrition (FAO, 2020). As such, systemic shocks like the COVID-19

pandemic provide an important opportunity to study food system resilience and learn from segments of it that exhibit shock-tolerance. By food system resilience we mean the "capacity over time of a food system and its units at multiple levels, to provide sufficient, appropriate and accessible food to all, in the face of various and even unforeseen disturbances" (Tendall et al. 2015: 19).

1.1. Alternative seafood networks contribute to systemic resilience

[Figure 1]

As seafood systems become increasingly globalized, evermore product flows out and away from the places where it is caught or farmed. However, during systemic shocks, food systems – including those associated with seafood – can experience "deadlock" where segments of the supply chain are unable to function because other segments of the supply chain are not operating and these segments cannot function because still other segments are not operating (Garnett et al., 2020). Such paralysis, even if temporary, can have serious socioeconomic implications. For example, an estimated 40 percent of survey participants in a study conducted in seven countries in Latin America and the Caribbean reported being without food during the COVID-19 lockdown (Hill and Narayan 2020 as reported in World Bank 2020). In the United States, US Census Bureau Household Pulse Survey shows that the percent of adults in the country that sometimes or often do not have enough to eat in the last seven days has increased from 8 percent before the pandemic to 11 percent by February 1, 2021 (US Census Bureau, 2021).

Local and regional seafood systems are not immune to shocks, including but not limited to those caused by extreme weather events (Marín et al., 2010) and anthropogenic catastrophes (Cockrell et al., 2019). Furthermore, these place-based systems are not fully decoupled from global seafood systems (Bronnmann et al., 2020; Farrell et al., 2020). Nevertheless, key distinctions between them exist in terms of their relationship and geographic orientation to consumers. In particular, what local and regional seafood systems lack in their overall geographic reach and total market potential, they make up in their direct connection and proximity to consumers (Stoll et al., 2020). This "relational" orientation between harvesters and consumers sets local and regional seafood systems apart from their global counterparts. Since these systems are not fully dependent on long or complex supply chains, the physical and social connectedness associated with them may also help to insulate local and regional seafood systems from the deadlock caused by systemic global shocks. We therefore

propose that there is likely an inverse, yet complementary, relationship between local and global seafood systems during periods of systemic shock. Specifically, we predict that during these episodes of systemic shock, we can expect to see a short-term re-localizing phenomenon unfold (Fig. 1) – one which contributes important systemic resilience to seafood systems at large.

To explore this dynamic, we draw on data from the United States and Canada during the early months of the COVID-19 pandemic. COVID-19 initially impacted seafood trade by altered consumer behavior in China, the largest importer of seafood worldwide (Love et al., 2021). The impacts of COVID-19 subsequently propagated worldwide. The first cases of COVID-19 were observed in the United States and Canada in early January of 2020. On March 11 the World Health Organization declared the spread of the COVID-19 virus a global pandemic and the United States and Canadian governments responded by temporarily closing businesses deemed non-essential and encouraged stay-at-home practices. Less than two weeks later, on March 21, the Canada-US and US-Mexico borders were closed to non-essential travel. Social distancing and other public health measures immediately altered consumer behavior, with the restaurant and food services sector particularly hard hit (White et al., 2021). In March 2020, for example, the US Farm Bureau reported a 27% increase in grocery store sales compared to the previous year and a 25% decrease in restaurant and other food establishments (U.S. Farm Bureau, 2020). Nearly all segments of the seafood system were impacted in some way by COVID-19 (Love et al., 2021; Sorensen et al., 2020; White et al., 2021). Examples include delayed fishing seasons, outbreaks in processing plants, and depressed prices due to reduced global demand.

The focus of this research is on a segment of the seafood system called alternative seafood networks (ASNs) (Fig. 2). ASNs refer to a range of "boat to fork" seafood distribution models that contribute to local and regional seafood systems (Witter, 2020; Witter and Stoll, 2016). Like alternative food networks in the agricultural sector (c.f. Whatmore et al. 2003; Goodman et al. 2012), which emerged in response to problems in terrestrial food systems, ASNs aim to address perceived economic, social, and environmental issues associated with the global seafood system – including but not limited to concerns about overfishing, industrialization, privatization, and the disappearance of small-scale and community-based fishing operations (Brinson et al., 2011; Campbell et al., 2014; McClenachan et al., 2014; Stoll et al., 2015). The literature also refers to ASNs as direct marketing arrangements (Stoll et al., 2015), community supported fisheries (Bolton et al., 2016), and relational seafood supply chains (Stoll et al., 2020). While further research is needed to define the parameters of ASN, we use the

term ASN broadly to describe individual and collective efforts by fishers and fishing families to use relational seafood supply chains to distribute their catch directly to consumers.

ASNs exist worldwide and were identified as a "bright spot" in both high- and low-income countries during the early months of the COVID-19 pandemic (Bennett et al., 2020; Gephart et al., 2020; Loring et al., 2020; O'Malley, 2020). For example, in the northeast, United States, Smith et al. (2020) found that 60% of the 258 fishers they surveyed reported adapting to local and direct seafood sales during the pandemic. Similarly, in a survey of small-scale fisheries across Europe from more than 105 fishing organizations from 12 countries, Pita et al. (2020) found that 48% of respondents had shifted to direct-to-consumer sales through ASNs. Even some multinational corporations pivoted towards local and direct models of seafood distribution (Cooke Aquaculture, 2020)[1].

In this paper, we present multiple lines of quantitative and qualitative evidence to show that ASNs experienced a short-term pandemic "bump" in both the United States and Canada in the wake of supply chain disruptions and government mandated social protections. We then analyze the factors that enabled ASNs to be resilient during the early months of the pandemic and discuss the implications for seafood systems. We frame our analysis of ASNs around the concept of systemic resilience, which describes the ability of actors in a complex system to effectively respond and recover from shock and surprise (Walker, 2012; Ungar, 2018). Generally, systemic resilience involves some sequence of actions through which agents (people, firms, or industries) adapt to new circumstances and secure the resources required for recovery (Ungar, 2018). Response diversity, flexibility, social capital, and learning are among the primary system properties known to confer systemic resilience (Carlisle, 2014; Leslie and McCabe, 2014). Systemic resilience also operates at multiple levels (Berkes and Ross, 2013); people may draw resilience from larger social networks or the state, and they may also, through their actions, contribute resilience to those higher levels. Here, we are particularly interested in the individual and structural circumstances that enabled or inhibited local agents' ability to adapt to the new societal and supply chain challenges created by COVID-19, effectively allowing the inverse pattern of response noted above. Our findings have important implications both for how we understand the role of heterogeneity in food systems, particularly with

[1] We note that our focus is on alternative seafood networks as opposed to efforts by multinational corporations to shift to e-commerce platforms and direct-to-consumer sales.

respect to the scale and organization of production and distribution of food, as well as for policy options for enhancing the systemic resilience of seafood systems moving forward.

[Figure 2]

2. Methods

This study uses mixed methods to examine changes experienced by ASNs during the early months of the COVID-19 pandemic. Specifically, we draw on multiple types of quantitative and qualitative data from different sources: Google search terms, website analytics, SafeGraph, and in-depth qualitative interviews. In gathering and analyzing data for this study, we also included a mixed authorship team, composed of academic and practitioner knowledge holders. This team was composed deliberately to be inclusive of gender, a wide range of geographies, and Indigenous and non-Indigenous participants. This team was recruited with intentions to conduct research with, instead of on, ASNs, and in recognition that knowledge emerges from society and the specific relationships we, as researchers, have to people and the environment. Adding non-traditional authors to our writing team represents a small way to acknowledge the important contributions that practitioners have had on our thinking, ability to collect critical data, and integral support to the research process. This decision also reflects our philosophy that shared authorship is also about distributing the privilege and legitimacy that comes with publishing.

2.1. Co-authorship

To acknowledge the different, but complementary ways in which researchers and practitioners create and disseminate knowledge, authorship on this manuscript was based on intellectual contribution rather than the particular tasks each author completed for the research (e.g., writing, revising, etc.) (see Castleden et al. (2010)). Our team included 14 individuals who are involved in ASNs in a professional capacity (including two with a dual role in academia) (hereafter referred to as "practitioners") and four researchers who do not have a financial interest in ASNs (hereafter referred to as "researchers"). The researcher sub-team was responsible for the initial conception of the paper, primary data collection, analysis, and drafting the manuscript. The practitioner sub-team provided website analytics data and feedback on the results and multiple drafts of the manuscript. By assembling this mixed authorship team, we acknowledge the important role practitioners often play

in enabling research and create space for those with grounded experiences to confirm that their lived experiences are represented appropriately.

2.2. Quantitative Analysis

We analyzed ASNs using three quantitative datasets: Google search terms, SafeGraph foot traffic, and website analytics.

2.2.1. Google search terms. Google search term data associated with seafood and food systems were analyzed for a 5-year period from June 2016 to July 2020. Search terms included in the search were "seafood," "direct seafood," "local fish", "home delivery seafood", "seafood box," "local seafood, "local food", and "community supported agriculture." We note that we did not include the search term "community supported fishery" because there was not enough data.

2.2.1. Foot traffic. SafeGraph is a data company that aggregates anonymized location data from numerous applications in order to provide insights about physical places. During the early months of the pandemic, SafeGraph made their foot traffic data publicly available. We used these data to compare foot traffic at fish and seafood markets to foot traffic associated with ASN (January – June, 2020). To do this, we used the North American Industry Classification System (NAICS) to identify fish and seafood markets (NAICS code 445220) and then used the Local Catch Network Seafood Finder, which lists ASN from across the United States and Canada, to identify the subset of businesses that are ASN. Following White et al. 2021, we filtered out businesses that were mislabeled as seafood markets and those with less than 300 days of foot traffic data since the start of 2019. Data were normalized by dividing the number of daily visits by the number of devices present per the recommendation of SafeGraph. The number of businesses fluctuated over time as well, so we normalized visits by the number of businesses included each day, resulting in an average number of visits per business per day.

2.2.3. Website analytics. Daily website analytics for eight ASNs in the United States (n = 6) and Canada (n = 2) was collected for the time period of January 1, 2019 to June 30, 2020. Businesses were selected purposefully to ensure geographic coverage across the United States and Canada (East and West Coasts) and to account for different types of ASN described by Bolton et al. (2016): (1) harvester focused; (2) consumer focused; and (3) species focused. Additional attention was given to

selecting different size ASN -- from those distributing to dozens of consumers to thousands. Because the website analytics data used in the analysis is from a non-random sample, results are intended to show a general trend. Data were downloaded from Google Analytics and Squarespace Analytics (n = 8) and analyzed in R (Version 3.6.1). Data were normalized to allow for business-to-business comparison using a z-score calculation ($z = (x-\mu)/\sigma$), where x represents the raw data, μ represents the population mean, and σ represents the population standard deviation. Change in consumer interest was calculated on a year-over-year basis for 2019 and 2020.

2.3. Qualitative Analysis

Thematic networks are used to organize salient themes and provide structure in the depiction of those themes and how they were derived (Attride-Stirling, 2001). Though similar to methods of qualitative analysis found in grounded theory (Corbin and Strauss, 2008), thematic networks are not intended to "discover the beginning of arguments or the end of rationalizations" (Attride-Stirling 2001, pg 388), but are rather a technique for organizing text and developing rationalizations and their significance (ibid). Thematic networks are constructed using three 'levels' of data organization: basic themes, organizing themes, and global themes.

In total, 48 semi-structured interviews were conducted with 16 people via telephone or online video conferencing between March and August of 2020. Interview participants were solicited via recruitment through the Local Catch Network and other similar outreach channels. All participants self-identified as being directly involved in an ASN. While there is not an established set of parameters or criteria for ASN, all participating operations reported selling at least a portion of their seafood through direct market channels(i.e., direct marketing, subscriptions, community supported fisheries, cooperative buying, fishermen's markets, or other alternatives). Interviews were recorded and transcribed, then analyzed using NVIVO qualitative analysis software.

To identify basic themes in the data, we followed the analytical steps laid out by Attride-Stirling (2001) and began by reducing the text via a presence/absence coding scheme. We focused the presence/absence on factors that supported or hindered resilience in ASNs. Once all transcripts were coded, codes were refined to consolidate any redundancy and clarify code definitions. Codes were organized around emerging themes, then refined to clarify discrete boundaries between ideas. The emergent themes were organized into coherent groupings, resulting in organizing themes of several

social and structural factors. We further consolidated those themes into key organizing themes of structural and response diversity, which fit best under a global theme of resilience. To connect empirical evidence from the interviews to the global theme, we linked exemplifying pieces of interview text to the thematic network at the basic coding level (Supplement 1). It is important to note that in the present approach to thematic coding, prevalence of occurrence of individual codes does not imply relative importance, and hence is not reported here.

To develop the policy recommendations table, we posed the following question to the practitioner authors: what social, political, economic, environmental, regulatory, and/or cultural changes are needed to institutionalize the short-term "pandemic bump" that CSFs have observed and lead to transformative change in the seafood system? We collected twenty-seven responses to this question and synthesized responses thematically.

3. Results

3.1. Alternative seafood networks during systemic shock

Our research suggests that in the early months of the COVID-19 pandemic there was a rapid increase in demand for local and directly sourced seafood in the United States and Canada, at a time when many other segments of the broader food system were disrupted (Garnett et al., 2020; Love et al., 2021). This finding is supported by multiple lines of quantitative and qualitative evidence. We find that Google searches for terms related to local and direct seafood distribution surged in the beginning of March. For example, from mid-March until the end of June, the searches for terms like "direct seafood" (not shown) (+88%), "seafood delivery" (+209%), and "local fish" (+4%) (not shown) all increased and then started to return to normal during the summer (Fig. 3). This pandemic "bump" is reflected in Google searches for terms related to the local food system more broadly such as "local food" (+47) and "community supported agriculture" (+124%) (not shown), but not general terms like "seafood" (-6%) (Fig. 3). These results are consistent with website analytics data across the United States and Canada. Across a geographically distributed but non-random subset of ASNs (n = 8), we find no year-over-year difference in ASN website traffic in January or February 2020 compared to the previous year. However, corresponding with the implementation of government ordered health measures related to COVID-19, there is a large mean year-over-year increase in March (+276%), April (+982%), May (+1,312%), and June (+339%) (Fig. 3). This pattern is observed in all eight of the ASN across geographic regions, scales, and types.

SafeGraph foot traffic data provides modest evidence that ASN did not decline as rapidly as conventional fish and seafood markets during the early months of the COVID-19 pandemic. The mean number of people visiting approximately 3,000 fish and seafood markets in the United States decreased by 30% in 2020 as COVID-19 cases started increasing (Fig. 4a), although this also varies by state (White et al. 2021). There was some recovery starting in mid-April, but foot traffic never reached levels seen in the previous year (Fig. 4a). Although a small sample size (n=16), ASNs listed on the Local Catch Network did not experience a sharp decline and followed a very similar pattern to 2019 (Fig. 4b).

Interview data with ASN operators further corroborate our findings. A total of 48 interviews were conducted with 16 ASN operators. In total, 15 of 16 ASNs (93%) reported a major increase in demand for their products through both in-person and online outlets. As one respondent observed:

> In the beginning I think a lot of us were nervous that we weren't going to be able to get rid of [our product] … And then the thing was for a couple of weeks, people started kind of panic buying in the beginning, and it was like 'Oh no, we actually can't keep up with what people are wanting'. But then once it started to level out we've been able to get rid of everything. (Participant 1, April 28, 2020).

Although ASN operators are optimistic that demand for local and directly sourced seafood will be sustained, some interviewees began reporting a decline in the initial "bump" in demand in June and July as retail locations reopened more broadly.

[Figure 3]

[Figure 4]

3.2. Resilience of ASNs during systemic shock

Research participants identified multiple drivers and determinants of their resilience and ability to adapt their business practices during the early months of the COVID-19 pandemic (Fig. 5 and Supplement 1). Generally, these fell into two categories: structural factors and response diversity. Structural factors describe the fixed or hard-to-change features of society, such as infrastructure and

policy, which create vulnerabilities to impacts and path dependence as people mount their responses to change and surprise (Loring et al., 2011). Response diversity, on the other hand, describes the breadth of existing and new strategies that people mount in response to some challenge (Leslie and McCabe, 2014), which as we discuss below and is influenced by a variety of factors at the individual- and societal-levels.

With respect to structural factors, study participants identified many circumstances that support or reduce resilience (Fig. 5), such as having access to diverse supply chain configurations (e.g., distribution methods, consumer-harvester interaction interfaces, consumer bases), and diversified fishing portfolios containing multiple species and fishing seasons. Participants also identified specific circumstances that inhibited or made more difficult their efforts to adapt to pandemic-induced challenges such as limited options to transport seafood products, closed or restricted fishing seasons, lack of processing infrastructure and freezer space, or lack of a well-established online retail system and brand.

One structural challenge to ASNs resilience was decline of restaurant sector due to the pandemic. Though ASNs reported a significant increase in demand from individual consumers, adapting to serve those markets came at a cost. To remain in business, ASNs were forced to pivot their consumer base away from restaurant-based markets and other retail outlets that had closed, such as farmers markets. These closures created an overall decline in demand and drop in price, resulting in the closure or delay of some fisheries (e.g., white fish fishery in the Great Lakes). In some places it also caused a loss of processing capacity when large processors temporarily closed due to a lack of product to process. As one ASN owner described:

> Having that really direct connection takes out a lot of variability or uncertainty. You know the more hands you put in the middle the more uncertainty there is. Right? The more, you know, you just don't know for example if this processor or that processor is going to shut down. Or if you're dealing with wholesalers or distributors in between you just don't know, you can't control those things. The direct relationship between the fishing family and the end consumer builds trust, builds flexibility on the part of the customer (Participant 9, April 22, 2020).

Other structural resilience challenges arose due to price uncertainty from large-scale processors, to whom many ASNs sold the excess of their catch, though the rising demand from new individual customers acted as a buffer for some ASN models. Processing capacity and availability, either within

the ASN or through a larger commercial processor, became tenuous as processing spaces closed their doors or limited their intake - a challenge for a small ASN with no privately-owned processing space. Similarly, accessing appropriate retail space such as docks or other physical locations that allowed for social distancing and sanitation measures was also critical for ASNs to maintain sales.

ASN operators also identified physical infrastructure and available workforce as critical to their ability to adapt to new buying and selling strategies, keep their workforce and customers safe, and rapidly scale their business model in response to increasing demand. ASN operators also noted the absence of physical infrastructures such as those described above as a hindrance to resilience. Difficulty in finding local employees (or the secondary barrier of processors not having enough employees, and thus closing) and working around COVID-19 distancing and health safety concerns (e.g., insufficient space, etc.) were significant challenges that limited ASN ability to adapt to new production and sales conditions. As one harvester described:

> I'm always a really big fan of selling whole fish. One of our infrastructure struggles is finding processors. We've had our favorite one shut down and he didn't reopen, so for us not knowing the market is one thing but getting it processed for high demand would actually be a challenge. At that point I would really encourage my customers to buy whole fish (Participant 3, May 5, 2020).

Some ASN operators identified the lack of access to fishing grounds, or feeling unsafe to travel to their fishing grounds, as a problem. Those who could access the fishing grounds identified geographic access to markets as a challenge in remote areas where fishers faced increased logistical barriers to getting their product to markets when transportation and travel became restricted. Secondary to challenges of access were challenges around maintaining a steady supply of product, particularly for those ASN harvesters who were unable to return to their harvesting grounds or missed important fishing seasons/openers. Here, ASNs often relied upon the aforementioned strong social networks between harvesters to maintain their seafood supply chains (e.g., access to harvested seafood through their co-op). As an ASN owner-harvester explained, "It's really been helpful that the co-op is providing me with basically it's like fish on tap, where I can go back and get more if I run out" (Participant 2, May 17, 2020).

Regarding response diversity, we found that factors at the individual and societal level influenced the range of options that ASN operators were able to mobilize in response to the pandemic. Participants

described drawing extensively upon social networks and their own personal psychological resilience to get through the early months of the pandemic. Inter-harvester relationships and relationships to higher-level organizations such as fisheries co-ops were cited by many participants as being essential to their ability to distribute their catch.

These relationships were also viewed by many as being important for facilitating new markets. For example, ASN harvesters who live away from the fishing grounds in the off-season were able to develop new markets in places that were otherwise not served by their fishery. Respondents also described the positive social and psychological impact of their relationships with consumers, and highlighted the opportunity for face-to-face interactions (e.g., during curb-side pickups or home deliveries), especially during COVID-19 where such interactions have been limited in daily life.

This emphasis on relationships is closely coupled with the underlying philosophies that shape ASNs and was key to informing how they operated during the pandemic. For example, ASNs often prioritize sustainable food systems, human and community health, and well-being alongside profitability (Witter and Stoll, 2016). These topics are often tightly coupled, but during the early months of the pandemic, ASNs grappled with the tradeoffs between the need to provide seafood and the risks associated with contracting or spreading the virus, particularly to rural and remote fishing communities. As one ASN operator explained, “I do feel like I have a right to get to our fishing boat and go catch fish. And as fishermen we are essential workers. But do I want to exercise that right? Do I want to put my kids on an airplane, fly myself and my partner and my kids up [to Alaska where we fish] and be a vector for this town that I love so much?" (Participant 2, April 27, 2020).

Setting appropriate price points and managing consumers’ fears and anxiety about committing to a subscription or share-based model during times of economic uncertainty was also a challenge. ASN owners reported being oriented around providing high quality seafood products for reasonable prices, but faced declining disposable income in their consumer bases as people struggle with financial security during the pandemic.

Respondents also identified relationships to place as being important in both developing new markets and selling place-based products. For example, ASN harvesters who live away from the fishing grounds in the off-season were able to develop new markets in places that were otherwise not served by their fishery. Their personal connection to their home area and their fishery was important to connecting consumers to the value and origin of their product. Harvesters also reported feelings of

satisfaction through connecting with their customers and sharing with them a nutritionally and emotionally valuable food product. This factor linked closely to ASNs having core underlying philosophies that inform their business decisions and offered flexibility in considering what an ASN should achieve and how a sustainable business model should look during the pandemic. For example, prioritizing sustainable food systems and human and community health and well-being alongside profitability.

Conversely, social and emotional tolls from the uncertainty of the COVID-19 pandemic's impact on their fisheries and markets hindered many ASNs with worries about risks and responsibilities of contracting or spreading the virus, particularly to rural and remote fishing communities. Setting appropriate price points and managing consumer fears/anxiety of commitment to a subscription or share-based model ASNs during times of economic turmoil has also been a challenge. As one harvester explained:

> We've actually dropped the prices on a lot of things. I know like tuna and opah went from being like $14.00, $15.00 to now everything is like $10.00/lbs and some of the whole fish is cheaper, whole or a couple dollars less fillet, just again people are I think wanting to move stuff but also make sure that people are able to buy because as much as we're struggling, so are the people that are supporting us (Participant 9, May 11, 2020).

Likewise, many discussed their own willingness to be flexible, e.g., moving their operations online, as well as having online marketing platforms and presences in the first place, as essential to accommodating social distancing requirements and accessing new consumers.
[Figure 5]

1. 3.3. Strengthening Alternative Seafood Networks

ASN operators identified several key barriers to ASN development and growth, notably a lack of appropriate infrastructure such as docks or other unloading areas, reliable postal services, or seafood processing locations. Others identified challenging regulatory environments that make it difficult to obtain appropriate permits, licenses, or other permissions required to direct-market seafood to local consumers or retailers. Underlying these challenges was also a reported lack of state/provincial or federal recognition of ASNs and small-scale fisheries and the role they provide to local food security.

Table 1 provides a synthesis of policy changes to address these challenges identified during interviews.

[Table 1]

4. Discussion

Our research provides evidence of a temporary re-localization in the seafood system during the early months of the COVID-19 pandemic, in which demand for local and directly sourced seafood spiked abruptly. This finding is consistent with recent studies that find evidence that fishers shifted to local and direct sales as a key adaptation strategy during the early months of the pandemic (Pita et al. 2020, Smith et al. 2021). To date, ASNs have been described as an important strategy for small- and mid-size seafood operations to build firm-level resilience (Kittinger et al., 2015; Stoll et al., 2020). However, the relative shock-tolerance that ASNs exhibited during the COVID-19 pandemic also suggests that they may contribute to the "systemic resilience" of the broader seafood economy. That is, ASN participants may be uniquely capable of mobilizing the necessary response diversity that allows producers and consumers to circumvent supply chain deadlocks during times of stress. Indeed, it is worth noting that the pattern of re-localization during shocks that we document in this paper is not a new phenomenon. For example, in 1917, during World War I, the Canadian Ministry of Agriculture encouraged citizens to establish "victory gardens" as part of the tactical strategy to increase food sovereignty and win the war. Woodrow Wilson, president of the United States between 1913 and 1921, launched a similar campaign. More contemporary examples also exist. For example, Gomez and Lien (2017) have previously observed that the global financial crisis of 2007-2008 played a critical role in catalyzing local food distribution in southern Europe. Similarly, during the 2007-2008 global financial crisis, the iconic lobster fishery in Maine, which had been becoming progressively more globalized (Stoll et al., 2018), pivoted their efforts towards local and domestic seafood distribution. Likewise, this pattern of food systems localization has also been reported to us anecdotally for multiple Latin American locales during the pandemic, including Puerto Rico (Marco Hanke, *pers. comm.* 17 August, 2020, Chile (Marah Hardt, *pers. comm.* 06 July 2020), Mexico (Ines Lopez, *pers. comm.* 31 August, 2020), and the Caribbean Islands (Felicity Burrows, *pers. comm.* 21 July 2020). Within Indigenous contexts, local pivots in fisheries may also open the door to Indigenous self-determination and food sovereignty through small-scale artisanal fisheries in North America (Lowitt et al. 2019).

Some of the drivers and determinants of resilience observed here match with findings of other research, including the importance of existing infrastructure, experience with alternative fisheries and marketing strategies, and a willingness to be flexible on the part of individual operators (Hamilton et al., 2003; Huntington et al., 2017). Particularly noteworthy, we believe, is the apparent role of psychological resilience and agency at the individual level, e.g., fishers' commitment to fishing and to core values for fishing, in supporting the continued function of the seafood system at higher levels. This is an important contribution to how we understand the role of individual coping and well-being in the resilience of fisheries and the larger social-ecological systems within which they are embedded (Adger, 2000). Resilience at the individual level has been discussed previously, but largely in terms of people's ability to cope and maintain their own well-being during crisis (Broch, 2013; Coulthard, 2012). Here, we have an example of individuals contributing positive resilience, that is, the ability to not just bounce back but bounce forward (Manyena et al., 2011), in a way that is transferring resilience to higher levels in regional food systems and the seafood sector at large.

Troell and colleagues previously hypothesized that the aquaculture sector could add resilience to the global seafood system by increasing the diversity of fished species and production locales (Troell et al., 2014). While we are unaware of studies that have tested their hypothesis for aquaculture or any other subsector of the seafood industry, here we present findings that suggest ASNs may contribute to the systemic resilience of the global seafood system. In part, they do by adding diversity to the production systems and supply chains and allow fishers to circumvent deadlocks in global supply chains by moving product through local markets. We also find that individual agency plays an important role, agency that is empowered by fishers' psychological resilience and commitment to the unique set values around fisheries that ASNs embody, values such as fair access and simple supply chains. This suggests that when considering how to improve global seafood systems moving forward, it is insufficient to look at diversification in production and supply chains without looking at the system of values that motivate the actors making and participating in those changes. Further research is needed to understand how ASN are able to persist over time in the face of ongoing and future crises.

ASN operators identified a number of structural and response factors that, depending on their local context, helped or hindered their resilience to impacts from the COVID-19 pandemic as well as possible policy options that could address some obstacles to resilience (Table 1). Those policy

opportunities were directed toward physical, social, socioeconomic, economic, and regulatory infrastructure. For example, operators identified that lack of physical infrastructure, such as working waterfronts or seafood processing capacity, posed a challenge to ASNs who need space to deliver their product and prepare it for sale. Prioritizing investment at multiple levels to develop and support existing local-level seafood infrastructure would provide appropriate locations and capacity for ASNs to scale their operations to meet demand and seasonal abundance (see Lowitt et al. 2020). Similarly, respondents identified that excessive regulatory 'red tape' was often challenging and expensive to navigate, creating disincentives for some seafood harvesters to seek out appropriate permissions to direct market their products. ASN operators identified that streamlining and simplifying direct-marketing permissions (e.g., permits, licenses, etc.) and the process by which they are obtained would make this process more accessible to a wider variety of seafood producers and bring direct-marketing of seafood in line with the more streamlined processes that exist for the direct sale of land-based agricultural products.

Finally, to more fully understand the role that ASNs play in the broader seafood system, better data on the sector are critically needed (O'Hara 2020). At present, there is no national-level data in either the United States nor Canada to describe the number of ASNs, their geographic distribution or their total socioeconomic contribution. However, sales associated with local and regional types of agricultural distribution in the United States alone are estimated to be US$9 billion, including US$2.8 billion direct to consumers (USDA, 2019). Addressing this data gap is not beyond the realm of possibility as parallel data for the agricultural sector have been collected since 1976 in the United States through the Farmer-to-Consumer Direct Marketing Act. Such data are critical to further understand the role of ASNs in shock-tolerance and the importance of functional diversity in supply chains, as demonstrated during the COVID-19 pandemic.

2. Conflict of Interest

JSS is the co-founder of Local Catch Network and owner of Georgetown Island Oyster Company. DC is a co-owner of the Walking Fish Cooperative. MC is a commercial fisherman and co- owner of West Coast Wild Scallops. KH is Chief Fisheries Officer with Sitka Salmon Shares. BJ is the marketing director for the Columbia River Inter-Tribal Fish Commission. JK is a commercial fisherman and co-manager for Tuna Harbor Dockside Market. EK is a commercial fisherman and the co-owner of Straight to the Plate. SK is co-founder and CEO of Wild for Salmon, Inc. AL is a co-founder and CEO of Real Good Fish. SS is the co-founder and CEO of Skipper Otto Community Supported Fishery. TS is a commercial fisherman fishmonger at Wooden Island Wild. AT is the general manager of New Hampshire Community Seafood. TY is the co-founder and director of Fishadelphia Community Seafood Program.

3. Author Contributions

JSS, HLH, EDS, and PAL conceived of the study. HLH, EDS, and PAL performed qualitative interviews. HLH and EDS analyzed qualitative data. JSS and ERW performed quantitative analysis. JSS, HLH, EDS, and PAL drafted the manuscript. DC, MC, KH, BJ, JK, EK, SK, AL, SS, TS, BT, AT, ERW, and TY contributed web analytics and interview data, and reviewed and commented on the manuscript.

4. Funding

JSS received partial funding from the Oak Foundation and the School of Marine Sciences at the University of Maine. HLH, EDS, and PAL received partial funding from the Social Sciences and Humanities Research Council of Canada. ERW was supported in part by the COVID-19 Rapid Research Fund from the Gund Institute for Environment at the University of Vermont.

5. Acknowledgments

We extend our appreciation to Mandy Marcum and Wen Xin Weng for help in accessing daily analytics data from two of the ASN. We also appreciate the helpful comments from two anonymous reviewers. Our deep gratitude to everyone who took part in this study and shared their experiences during the difficult and tumultuous times of the COVID-19 pandemic.

6. Data Availability Statement

Google search term data is downloadable at https://trends.google.com/trends/?geo=US. Aggregated Google Analytics data used in this study are available upon written request to the corresponding author. Data and code for the SafeGraph foot traffic data is available at: https://github.com/eastonwhite/COVID19_US_Fisheries. Ethnographic data and information on participants are confidential, protected by research ethics protocols and cannot be shared.

References

Adger, W. N. (2000). Social and ecological resilience: are they related? *Progress in Human Geography,* 24, 347–364. doi:10.1191/030913200701540465.

Anderson, J. J., Asche, F., and Tveteras, S. (2010). "World Fish Markets," in *Handbook of marine fisheries conservation and management*, eds. R. Q. Grafton, R. Hillborn, D. Squires, M. Tait, and M. Williams (Oxford University Press).

Asche, F., Bellemare, M. F., Roheim, C., Smith, M. D., and Tveteras, S. (2015). Fair enough? Food security and the international trade of seafood. *World Development,* 67, 151–160. doi:10.1016/j.worlddev.2014.10.013.

Attride-Stirling, J. (2001). Qualitative Research. *Qualitative Research* 1, 385–405.

Bennett, N., Finkbeiner, E., Ban, N., Dyhia, B., Jupiter, S., Kittinger, J., et al. (2020). The COVID-19 pandemic, small-scale fisheries and coastal fishing communities. *Coastal Management,* 48, 336–347. doi:10.1080/08920753.2020.1766937.

Berkes, F., and Ross, H. (2013). Community resilience: toward an integrated approach. *Society and Natural Resources,* 26, 5–20. doi:10.1080/08941920.2012.736605.

Bolton, A. E., Dubik, B. A., Stoll, J. S., and Basurto, X. (2016). Describing the diversity of community supported fishery programs in North America. *Marine Policy,* 66, 21–29. doi:10.1016/j.marpol.2016.01.007.

Brinson, A., Lee, M.-Y., and Rountree, B. P. (2011). Direct marketing strategies: the rise of community supported fishery programs. *Marine Policy* 35, 542–548. doi:10.1016/j.marpol.2011.01.014.

Broch, H. B. (2013). Social resilience - local responses to changes in social and natural environments. *Maritime Studies,* 12, 1–17.

Bronnmann, J., Smith, M. D., Abbott, J., Hay, C. J., and Næsje, T. F. (2020). Integration of a local fish market in Namibia with the global seafood trade: Implications for fish traders and sustainability. *World Development,* 135, 105048. doi:10.1016/j.worlddev.2020.105048.

Campbell, L. M., Boucquey, N., Stoll, J., Coppola, H., and Smith, M. D. (2014). From vegetable box to seafood cooler: applying the community-supported agriculture model to fisheries. *Society and Natural Resources,* 27, 88–106. doi:10.1080/08941920.2013.842276.

Carlisle, L. (2014). Diversity, flexibility, and the resilience effect: lessons from a social-ecological case study of diversified farming in the northern Great Plains, USA. *Ecology & Society,* 19, 45–45. doi:10.5751/ES-06736-190345.

Castleden, H., Morgan, V. S., and Neimanis, A. (2010). Researchers' perspectives on collective/community co-authorship in community-based participatory indigenous research. *Journal of Empirical Research on Human Research Ethics,* 5, 23–32. doi:10.1525/jer.2010.5.4.23.

Cockrell, M. L., O'Farrell, S., Sanchirico, J., Murawski, S. A., Perruso, L., and Strelcheck, A. (2019). Resilience of a commercial fishing fleet following emergency closures in the Gulf of Mexico. *Fisheries Research* 218, 69–82. doi:10.1016/j.fishres.2019.04.017.

Cooke Aquaculture (2020). Cooke reeling-in customers online by delivering unique seafood boxes. Available at: https://www.cookeseafood.com/2020/05/25/cooke-reeling-in-customers-online-by-delivering-unique-seafood-boxes/.

Corbin, J., and Strauss, A. (2008). *Basics of qualitative research*. 3rd ed. Thousand Oaks, California: Sage.

Cottrell, R. S., Nash, K. L., Halpern, B. S., Remenyi, T. A., Corney, S. P., Fleming, A., et al. (2019). Food production shocks across land and sea. *Nature Sustainability,* 2, 130–137. doi:10.1038/s41893-018-0210-1.

Coulthard, S. (2012). Can we be both resilient and well, and what choices do people have? Incorporating agency into the resilience debate from a fisheries perspective. *Ecology & Society,* 17. doi:10.5751/ES-04483-170104.

Farrell, P., Thow, A. M., Wate, J. T., Nonga, N., Vatucawaqa, P., Brewer, T., et al. (2020). COVID-19 and Pacific food system resilience: opportunities to build a robust response. 1–9. doi:10.1007/s12571-020-01087-y.

Food Agricultural Organization of the United Nations (2010). The State of World Fisheries and Aquaculture 2010. Rome.

Food Agricultural Organization of the United Nations (2020). The State of World Fisheries and Aquaculture 2020. Rome. doi:10.4060/ca9229en.

Garnett, P., Doherty, B., and Heron, T. (2020). Vulnerability of the United Kingdom's food supply chains exposed by COVID-19. *Nature Food*, 1–4. doi:10.1038/s43016-020-0097-7.

Gephart, J., Cottrell, R. S., Froehlich, H. E., Nussbaumer, E., Stoll, J. S., and White, E. (2020). Covid-19 seafood impacts (Version 1.0). 1st ed. doi.org/10.5281/ZENODO.3866189.

Goodman, D., DuPuis, E, Goodman, M. (2012). Alternative food networks: Knowledge, practice, and politics.

Gómez, S., and Lien, M. E. (2017). Recovering food commons in post industrial Europe: cooperation networks in organic food provisioning in Catalonia and Norway. *Journal of Agricultural and Environmental Ethics,* 30, 625–643. doi:10.1007/s10806-017-9691-6.

Hamilton, L., Brown, B., and Rasmussen, R. O. (2003). West Greenland's cod-to-shrimp transition: local dimensions of climatic change. *Arctic,* 56, 271–282.

Huntington, H., Begossi, A., Gearheard, S. F., Kersey, B., Loring, P., Mustonen, T., et al. (2017). How small communities respond to environmental change: patterns from tropical to polar ecosystems. *Ecology & Society,* 22, 1–13.

Kittinger, J. N., Teneva, L. T., Koike, H., Stamoulis, K. A., Kittinger, D. S., Oleson, K. L. L., et al. (2015). From Reef to Table: Social and Ecological Factors Affecting Coral Reef Fisheries, Artisanal Seafood Supply Chains, and Seafood Security *PLoS ONE*, 10, e0123856–24. doi:10.1371/journal.pone.0123856.

Kummu, M., Kinnunen, P., Lehikoinen, E., Porkka, M., Queiroz, C., Roos, E., Troell, M. Weil, C. (2020). Interplay of trade and food system resilience: Gains on supply diversity over time at the cost of trade independency. Global food security, 24, 100360.

Leslie, P., and McCabe, T. (2014). Response Diversity and Resilience in Social-Ecological Systems. *Current Anthropology*, 2, 114–143.

Loring, P., De Sousa, E., Harrison, H., and Stoll, J. (2020). As coronavirus threatens seafood economy, community fisheries find ways to stay afloat. *The Conversation,* 1–7.

Loring, P., Fazzino, D., Agapito, M., Chuenpagdee, R., Gannon, G., and Isaacs, M. (2011). "Fish and food security in small-scale fisheries," in *Transdisciplinarity for Small-Scale Fisheries Governance*, eds. R. Chuenpagdee and S. Jentoft, 55–73.

Love, D., Allison, E., Asche, F., Ben Belton, Cottrell, R. S., Froehlich, H., Gephart, J., Hicks, C., Little, D., Nussbaumer, L., Pinto da Silva, P., Poulain, F., Rubio, A., Stoll, J., Tlusty, M., Thorne-Lymann, A., Troell, M., Zhang, W. (2021). Emerging COVID-19 impacts, responses, and lessons for building resilience in the seafood system. Global Food Security, 28, 1-12.

Lowitt, K., Levkoe, C. Z., Lauzon, R., Ryan, K., & Sayers, C. D. (2019). Indigenous self-determination and food sovereignty through fisheries governance in the Great Lakes region. In Civil Society and Social Movements in Food System Governance. Routledge.

Lowitt, K., Levkoe, C. Z., Spring, A., Turlo, C., Williams, P. L., Bird, S., Sayers, C. D., & Simba, M. (2020). Empowering small-scale, community-based fisheries through a food systems framework. Marine Policy, 120, 104150. https://doi.org/10.1016/j.marpol.2020.104150

Manyena, B., OBrien, G., OKeefe, P., and Joanne, R. (2011). Disaster resilience: a bounce back or bounce forward ability? *The International Journal of Justice and Sustainability,* 16, 417–424. doi:10.1080/13549839.2011.583049.

Marín, A., Gelcich, S., Araya, G., Olea, G., Espíndola, M., and Castilla, J. C. (2010). The 2010 tsunami in Chile Devastation and survival of coastal small-scale fishing communities. *Marine Policy,* 34, 1381–1384. doi:10.1016/j.marpol.2010.06.010.

McClenachan, L., Neal, B. P., Al-Abdulrazzak, D., Witkin, T., Fisher, K., and Kittinger, J. N. (2014). Do community supported fisheries (CSFs) improve sustainability? *Fisheries Research,* 157, 62–69. doi:10.1016/j.fishres.2014.03.016.

O'Malley, J. (2020). How COVID-19 is threatening Alaska's wild salmon fishing season. *New York Times*. Available at: https://www.nytimes.com/2020/06/23/dining/alaska-salmon-coronavirus.html?smid=tw-share.

O'Hara. J. K. (2020). Farmers Markets and Seafood: Where is it feasible? Marine Resource Economics 35, 35, 411-426.

Pita, C. (2020). People, COVID-19 and beyond: impacts, adaptation, and innovation among small-scale fisheries. Small is Bountiful Conference. Online Available at: http://toobigtoignore.net/opportunity/join-us-for-world-ocean-day-2020/.

Rockstrom, J., Edenhofer, O., Gaertner, J., and DeClerck, F. (2020). Planet-proofing the global food system. *Nature Food*, 1–3. doi:10.1038/s43016-019-0010-4.

Rotz, S., and Fraser, E. D. G. (2015). Resilience and the industrial food system: analyzing the impacts of agricultural industrialization on food system vulnerability. *Journal of Environmental Studies and Science,* 5, 459–473. doi:10.1007/s13412-015-0277-1.

Smith, S., Golden, A., Ramezoni, V., Zemeckis, D., and Jenson, O. (2021). Adaptation and resilience of commercial fishers in the Northeastern United States during the early stages of the COVID-19 pandemic. Plos One, 1-31. doi:10.31235/osf.io/z3v2h.

Sorensen, J., Echard, J., and Weil, R. (2020). From bad to worse: the impact of COVID-19 on commercial fisheries workers. *Journal of Agromedicine,* 00, 1–4. doi:10.1080/1059924X.2020.1815617.

Stoll, J. S., Bailey, M., and Jonell, M. (2020). Alternative pathways to sustainable seafood. *Conservation Letters,* 13, 1–7. doi:10.1111/conl.12683.

Stoll, J. S., Crona, B. I., Fabinyi, M., and Farr, E. R. (2018). Seafood trade routes for lobster obscure teleconnected vulnerabilities. *Frontiers in Marine Science,* 5, 587–8. doi:10.3389/fmars.2018.00239.

Stoll, J. S., Dubik, B. A., and Campbell, L. M. (2015). Local seafood: rethinking the direct marketing paradigm. *Ecology & Society,* 20, 1–14. doi:10.5751/ES-07686-200240.

Tendall, D.M., Joerin, J., Kopainsky, B., Edwards, P., Shreck, A., Le, Q.B., Krütli, P., Grant, M. and Six, J., (2015). Food system resilience: defining the concept. Global Food Security, 6, pp.17-23.

Troell, M., Naylor, R. L., Metian, M., Beveridge, M., Tyedmers, P. H., Folke, C., Arrow, K., Barrett, S., Crepin, A., Ehrlich, P., Gren, A., Kautsky, N., Levin, S., Nyborg, K., Osterblom, H., Polasky, S., Scheffer, M., Walker, B. H., Xepapadeas, T., Zeeuw, A. (2014). Does aquaculture add resilience to the global food system? *Proceedings of the National Academy of Sciences of the United States of America,* 111, 13257–13263. doi:10.1073/pnas.1404067111.

Ungar, M. (2018). Systemic resilience: principles and processes for a science of change in contexts of adversity. *Ecology & Society,* 23, 34–17. doi:10.5751/ES-10385-230434.

United Nations (2020). UN Comtrade Database. Available at: https://comtrade.un.org/data/.

USDA (2019). 2017 Census of Agriculture. Available at: https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_US/usv1.pdf.

Whatmore, S., Stassart, P., Renting, H. (2003). What's alternative about alternative food networks?.

White, E. R., Froehlich, H. E., Gephart, J. A., Cottrell, R. S., Branch, T. A., Bejarano, R. A., & Baum, J. K. (2021). Early effects of COVID-19 interventions on US fisheries and seafood. *Fish and Fisheries*, 22, 232:239.

World Bank (2020). Poverty and Shared Prosperity 2020: Reversals of Fortune. Washington, DC: World Bank. Doi: 10.1596/978-1-4648-1602-4.

Witter, A. (2020). Boat to fork: seafood value chains and alternative food networks. 1–207. https://doi.org/10.14288/1.0390311.

Witter, A., and Stoll, J. (2016). Participation and resistance_ Alternative seafood marketing in a neoliberal era. *Marine Policy*, 80, 130–140. doi:10.1016/j.marpol.2016.09.023.

Figures

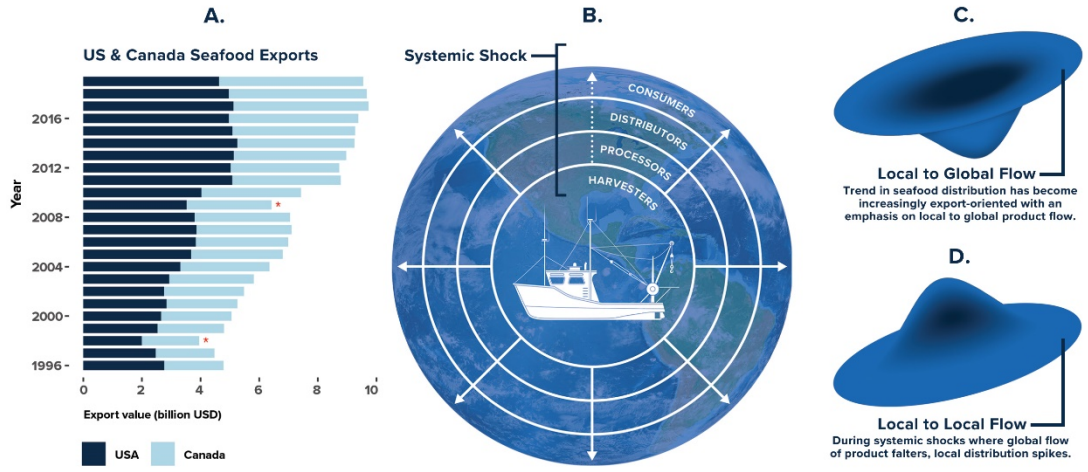

Figure 1. (A) Fisheries in the United States and Canada have become increasingly trade-oriented, but in the last 25 years, multiple systemic shocks have caused global trade to drop sharply, including during the ongoing COVID-19 pandemic (United Nations, 2020). Asterisks correspond to global recessions. (B) Systemic shocks impact all levels of the food system, from producers to consumers, and can lead to "deadlock" in the system. (C) Globalization in the seafood system leads to a local-to-global pattern where product is distributed out and away from the places where it is caught, creating a void of seafood. (D) During the early months of COVID-19 pandemic, however, global seafood supply chains faltered, leading to greater dependence on local food systems and a surge or “bump” in local and direct distribution.

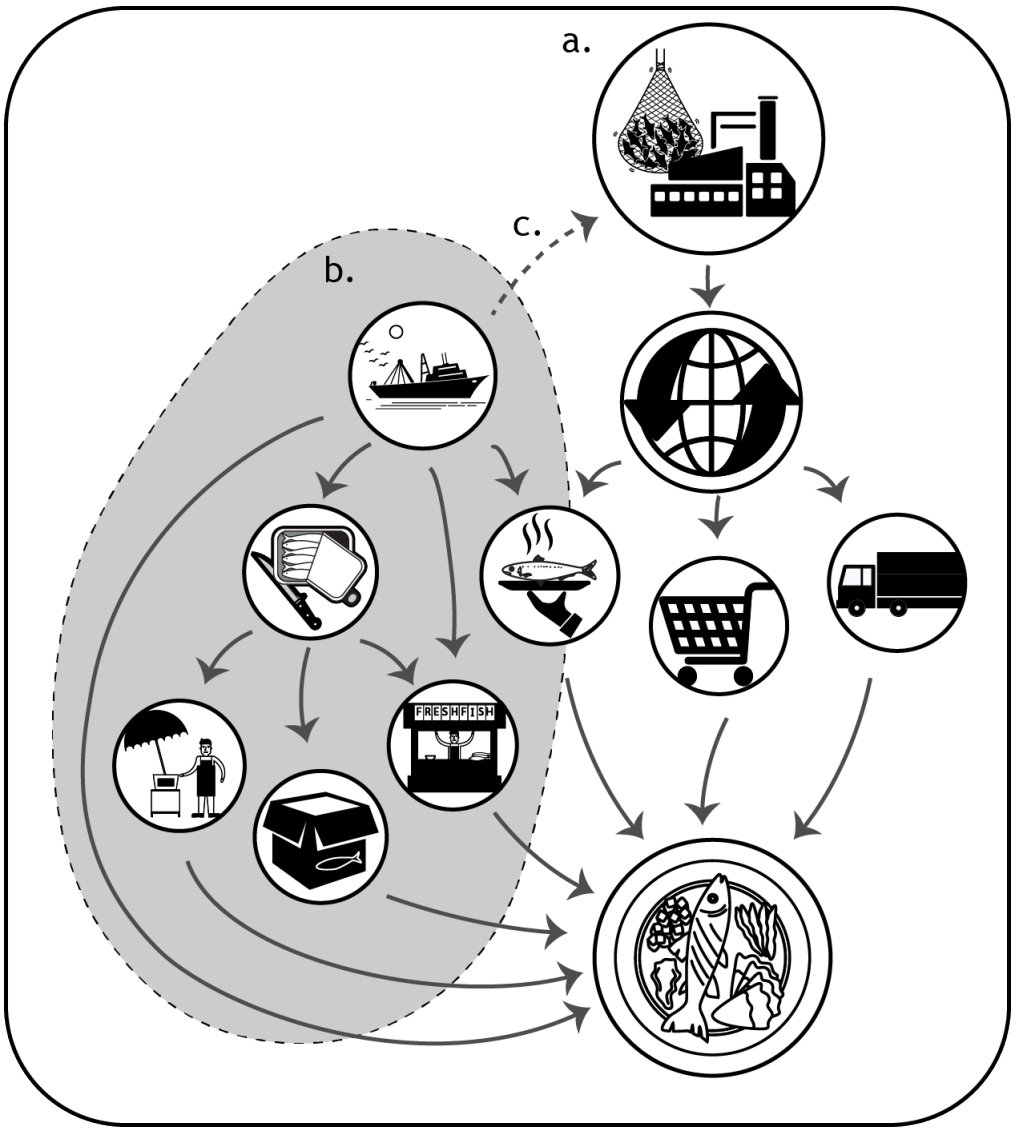

Figure 2. A simplified depiction of Alternative Seafood Networks and their orientation to the global seafood supply chain. (a) The predominant system is based on transactional relationships and moves seafood into the global marketplace. (b) ASNs diverse distribution channels provide ways for small-scale operators to directly connect with consumers through local and direct-to-consumers sales. Note the redundancy of linkages. (c) Small-scale operators that sell through ASNs also often depend on the predominant seafood system for selling a portion of their catch.

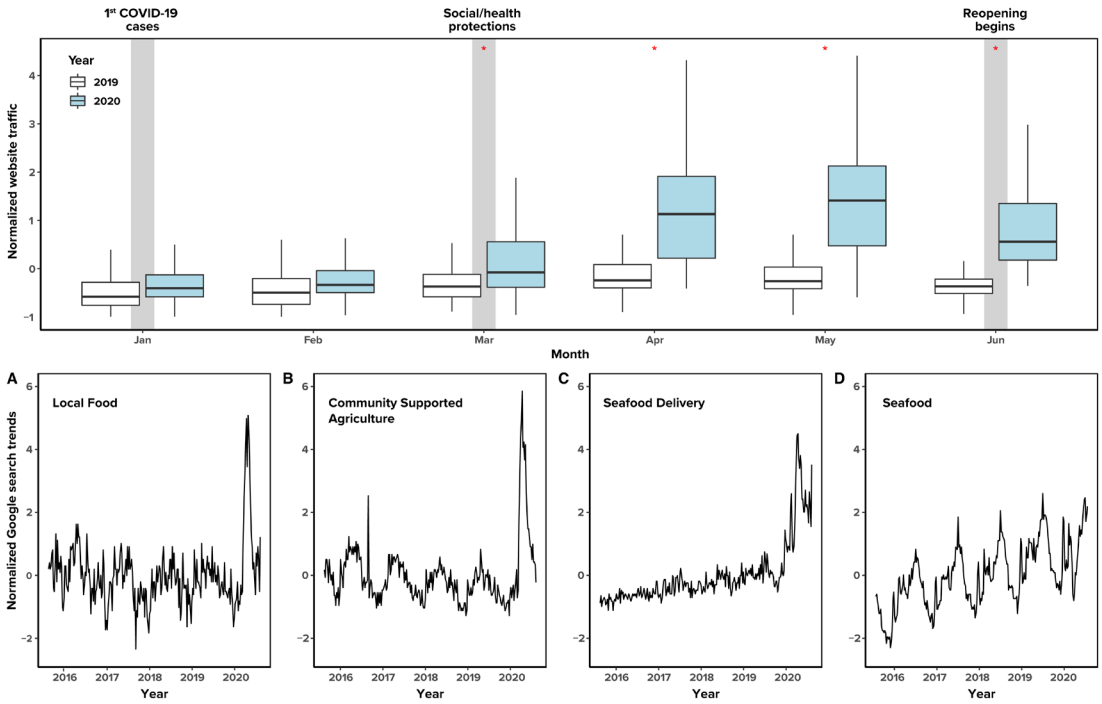

Figure 3. (Top) Google Analytics web traffic data for select alternative seafood networks (n=8). (Bottom) Google search trends for example phrases related to local food systems and direct producer-to-consumer sales White et al. (2020) similarly describe an increase in web searches for the term "seafood recipes" (A-C). Note that a similar pattern does not exist for the more general term "seafood" (D).

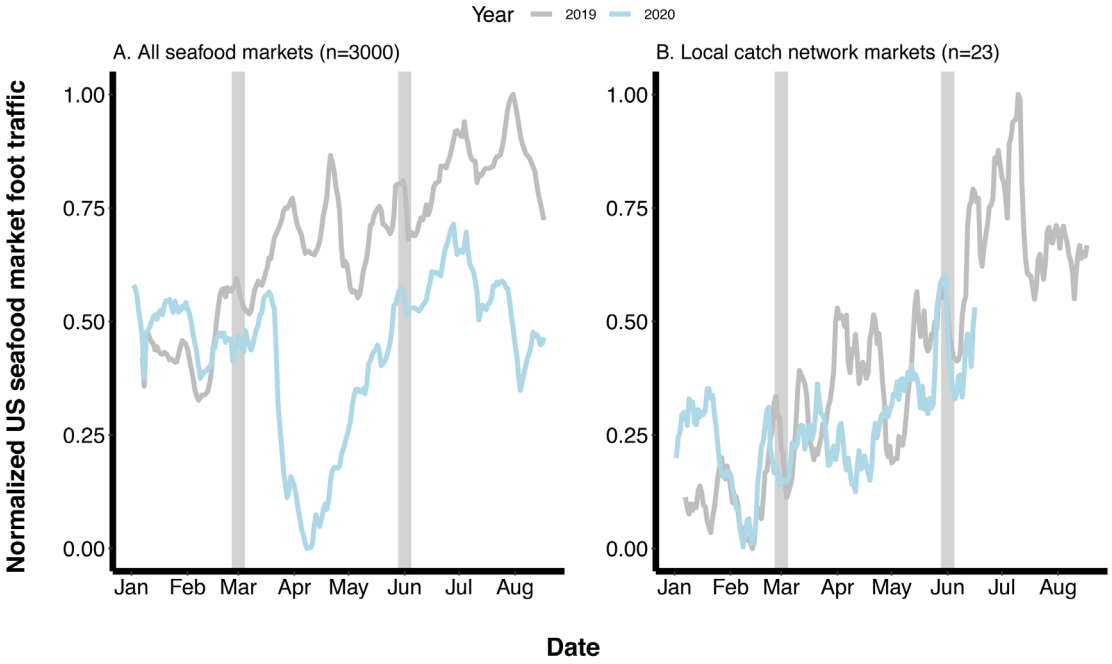

Figure 4. Rolling mean of normalized seafood market foot traffic for (A) all seafood markets in the US and (B) only those seafood markets found in the Local Catch Network (https://finder.localcatch.org/). The vertical grey bars designate the initial introduction of social-distancing guidelines and subsequent reopening efforts.

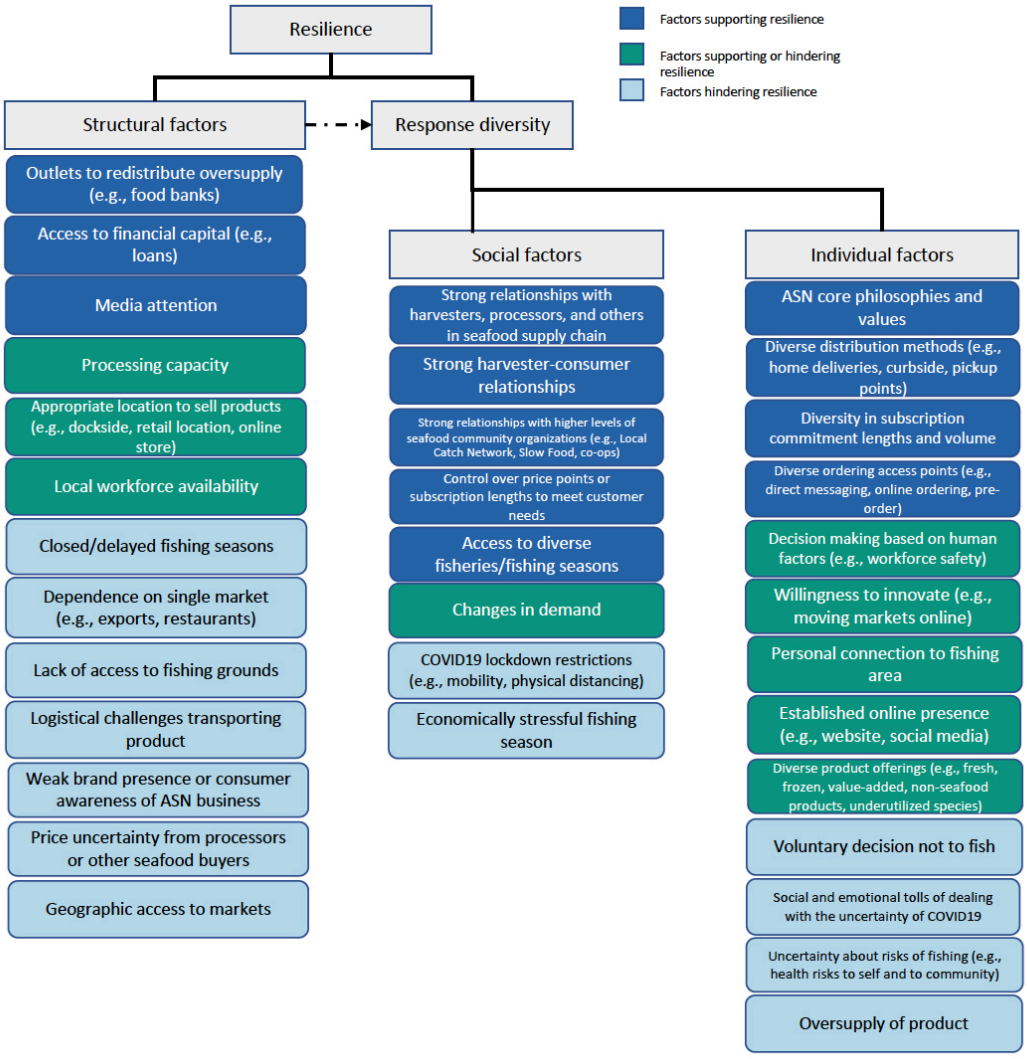

Figure 5. Structural and response factors that supported or hindered ASN resilience during the COVID-19 pandemic. Factors in dark blue were identified as being important to supporting ASN resilience across research participant contexts. Factors in green were either supportive or hindering ASN resilience depending on the context of individual ASNs. Factors in light blue were identified as hindering ASN resilience across research participant contexts.

List of Tables

Table 1. Policy opportunities to strengthen alternative seafood networks.

Type of infrastructure	Action / Investment
Physical	Make local and state/provincial investments in scale-appropriate infrastructure (e.g., working waterfronts, postal service, food hubs, etc.) that is conducive for direct-sale of seafood products through multiple channels and locations.
Social	Provide affordable, accessible health care for essential food production workers in the seafood industry that reflect the seasonality of fishing.
Social / Economic	Develop fair and affordable financial tools to help young and new fishermen enter highly competitive and costly fisheries.
Economic	Establish financial incentives for domestic seafood purchasing and consumption, with priority on sustainability of stocks and fair labor practices.
Regulatory	Streamline and simplify regulatory requirements for fishermen to sell their catch directly to consumers or local retail outlets. These policies exist for land-based farmers, but are much more arduous for seafood producers.
Regulatory / Marketing	Acknowledge the diversity of domestic seafood markets (ASNs, large-scale), and expand the definition of what “local” means in terms of labeling so as to include products harvested elsewhere by local residents.
Marketing	Provide leadership at the state/provincial and federal level to highlight and promote the value of North America’s commercial fishing fleets and emphasize local, U.S./Canadian caught/raised seafoods (i.e., national seafood council) and consumption of local, sustainably-harvested, underutilized species.