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Early effects of COVID-19 on US fisheries and seafood consumption

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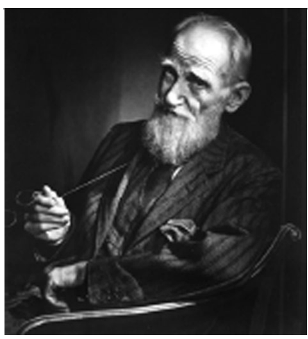
Abstract

The US seafood sector is susceptible to shocks, both because of the seasonal nature of many of its domestic fisheries and its global position as a top importer and exporter of seafood. However, many data sets that could inform science and policy during an emerging event do not exist or are only released months or years later. Here, we synthesize multiple data sources from across the seafood supply chain, including unconventional real-time data sets, to show the relative initial responses and indicators of recovery during the COVID-19 pandemic. We synthesized news articles from January to September 2020 that reported effects of COVID-19 on the US seafood sector, including processor closures, shortened fishing seasons and loss of revenue. Concerning production and distribution, we assessed past and present landings and trade data and found substantial declines in fresh seafood catches (−40%), imports (−37%) and exports (−43%) relative to the previous year, while frozen seafood products were generally less affected. Google search trends and seafood market foot traffic data suggest consumer demand for seafood from restaurants dropped by upwards of 70% during lockdowns, with recovery varying by state. However, these declines were partially offset by an increase (270%) in delivery and takeout service searches. Our synthesis of open-access data sets and media reports shows widespread, but heterogeneous, ramifications of COVID-19 across the seafood sector, implying that policymakers should focus support on states and sub-sectors most affected by the pandemic: fishery-dependent communities, processors, and fisheries and aquaculture that focus on fresh products.

KEYWORDS
aquaculture, COVID-19, fisheries, pulse disturbance, shocks



Ghoti papers

Ghoti aims to serve as a forum for stimulating and pertinent ideas. Ghoti publishes succinct commentary and opinion that addresses important areas in fish and fisheries science. Ghoti contributions will be innovative and have a perspective that may lead to fresh and productive insight of concepts, issues and research agendas. All Ghoti contributions will be selected by the editors and peer reviewed.

Etymology of Ghoti

George Bernard Shaw (1856-1950), polymath, playwright, Nobel prize winner, and the most prolific letter writer in history, was an advocate of English spelling reform. He was reportedly fond of pointing out its absurdities by proving that 'fish' could be spelt 'ghoti'. That is: 'gh' as in 'rough', 'o' as in 'women' and 'ti' as in palatial.

1 | INTRODUCTION

Shocks, or "black swan" events (Anderson et al., 2017), are a common feature of seafood systems and appear to be increasing in frequency (Cottrell et al., 2019; Gephart et al., 2016, 2017). Seafood shocks can be triggered by fish stock collapses, aquaculture diseases, natural disasters and oil spills, as well as broader, more disruptive anthropogenic conflicts or disasters, such as wars and state dissolution, where impacts may reach across multiple food sectors influencing the interdependencies among them (Cottrell et al., 2019; Gephart et al., 2017). There is often a mismatch between the short timescales in which policy decisions have to be made to respond to these sudden events and the longer term science and data collection that would ideally be available to inform such decisions. This is especially relevant for the seafood sector where data are not typically collected or released in "real time," but usually only available months or years later. The rate of availability of fisheries information stands in stark contrast to other fields, such as public health or meteorology, which are able to produce near real-time updates on developing or ongoing shocks (Menni et al., 2020; Zhang et al., 2019).

Despite some similarities to smaller shocks, the COVID-19 global pandemic has triggered larger, more unpredictable and synchronous impacts felt throughout entire food supply chains, across multiple sectors, and at local and global scales. The COVID-19 pandemic has forced many governments to shut down large segments of their economies, including businesses, restaurants and schools, at least temporarily, to promote social distancing and reduce infection rates (Althouse et al., 2020; Hale et al., 2020; White & Hébert-Dufresne, 2020). Both COVID-19 itself and responses to it have the potential to affect the seafood sector in multiple ways (Bennett et al., 2020; FAO, 2020; Love, Allison, et al., 2020). For example, during fishing and processing, seafood workers and observers often work long hours in tightly confined working conditions (Syron et al., 2018), which can facilitate the spread of the disease. Social distancing policies could also reduce seafood demand, given that 65% of United States spending ($69.6 billion in 2017) on seafood is in restaurants (Love, Asche, et al., 2020), and this could have the cascading effect of lowering overall seafood prices since restaurants pay premium values for seafood (Love, Asche, et al., 2020). Conversely, alternative seafood markets (e.g. community-based fisheries) may emerge (Stoll et al., 2020) or demand may increase for canned and frozen goods. Thus, COVID-19 has the potential to at least temporarily—and perhaps permanently—alter seafood supply chains. From fisheries and aquaculture production to distribution and purchasing patterns, various facets of COVID-19 present a broadscale natural experiment to examine how the different components of the seafood supply chain respond to and recover from a major system shock.

Although seafood sectors in countries around the world have likely been impacted by the COVID-19 shock, we focus here on the United States because of its importance to global fisheries, its geographic heterogeneity amongst states (which allows spatial comparisons) and data availability. The United States is the world's top importer and fourth largest exporter of seafood products (US Census Bureau, 2020). In addition, the US seafood sector is heterogeneous between states in terms of production, processing and demand, each with its own sub-sectors (NMFS, 2018). Seafood production includes aquaculture and commercial, recreational and subsistence fisheries, all of which vary by state. For instance, Alaska itself accounts for 58% of all US commercial fisheries landings, but other states like Massachusetts have higher value for seafood landed (NMFS, 2018). In addition, the seafood pipeline also includes processing, distribution and consumer demand. Indeed, domestic aquaculture production only accounts for <1% of annual production, but imported farmed species are among the most consumed (e.g. salmon and shrimp) (NMFS, 2018). Each of these sub-sectors will likely be affected differently by the fallout from COVID-19, especially given differences in responses to the pandemic across US states and at a federal level (Althouse et al., 2020; Hale et al., 2020; White & Hébert-Dufresne, 2020; Froehlich et al., 2020).

Here, we synthesize data from five distinct sources to assess early signals of the effects of COVID-19 on across US fisheries and seafood sectors. The data sets include two traditional types of fisheries data (fish landings data, and seafood imports and exports by product category) and three non-traditional real-time data sources: news articles, Google search trends (Bento et al., 2020) for seafood, and seafood market foot traffic. These data sources span multiple spatial and temporal scales as well as the entire seafood pipeline, from production to consumer demand. We highlight both the results of this data synthesis—which could help policymakers in the short term to focus efforts on those in the seafood sector with the greatest need, to inform plans to build more robust indicators for future shocks, and guide questions on what new modes of seafood supply may or should persist into the future—as well as on our general approach as a means of providing much-needed data to help inform evidence-based decisions during ongoing national and global shocks.

2 | METHODS

2.1 | Media reporting on COVID-19 and US seafood

We examined two sets of news article databases. First, we used GDELT, a searchable database that continuously compiles media from around the world (https://www.gdeltproject.org/). We used the search terms "(covid OR coronavirus) AND (seafood OR fishery OR fisheries OR aquaculture) AND [list of all state and territory names]" to compile all articles from 1 January 2020, to 1 September 2020 for the USA. We then removed duplicate titles and summarized the total number of articles. We also pulled individual state count data using the same search terms and a single state name. Second, we assembled a database of a partial collection of news articles focused on responses to the COVID-19 pandemic affecting various parts of the fisheries and seafood sectors (Gephart et al., 2020). We coded each article for geographic location, the supply chain sector involved, the type of production, and the specific impact and species groups involved. This resulted in a total of 196 news articles focused on the USA (Gephart et al., 2020).

2.2 | Fisheries landings

Landings data are often not publicly available for months or years. However, for highly regulated halibut (*Hippoglossus stenolepis*, Pleuronectidae) and sablefish (*Anoplopoma fimbria*, Anoplopomatidae) fisheries in Alaska (Hilborn et al., 2020), weekly landings data are reported weekly at https://www.fisheries.noaa.gov/alaska/commercial-fishing/fisheries-catch-and-landings-reports. We used data for these two fisheries for the first 40 weeks of each year from 2017 to 2020.

2.3 | Foreign trade

The US monthly seafood trade data (Customs Value, USD) come from the US Customs and Border Protection (US Census Bureau, 2020). We calculated year-over-year changes in imports and exports from July 2018 to August 2020, from trade data specific to fishery products destined for human consumption (data from all 6-digit codes within the 03 chapter of the Harmonized System Database https://www.usitc.gov). All frozen product forms were grouped together, as were all live, fresh or chilled products. Dried, salted, brined, prepared meals, fish meal and oils, and other miscellaneous preparations were excluded.

2.4 | Seafood market foot traffic

We use foot traffic data from SafeGraph (https://www.safegraph.com/), a data company that aggregates anonymized location data from numerous applications in order to provide insights about physical places. We examined data specific to fish and seafood markets (NAICS code 445220), which include some restaurants. We filtered out businesses that were mislabelled as seafood markets and those with less than 300 days of foot traffic data since the start of 2019. We followed SafeGraph's recommendations on normalizing data by dividing the number of daily visits by the number of devices present.

2.5 | Web searches

On 6 October 2020, US search trend data were extracted from Google Trends (https://trends.google.com) in the *Food and Drink* category for keyword *web search terms* of “seafood restaurant”, “seafood recipe”, “seafood delivery”, “sushi takeout” and, for comparative food system context, “bbq restaurant”. We compared daily search patterns of the past five years during the time frame of 1 January to 5 October, standardizing within each year.

3 | RESULTS AND DISCUSSION

3.1 | Media reporting on COVID-19 and US seafood

As early as January 2020, news articles focused on decreased international demand for some US seafood products (e.g. farmed geoduck (*Panopea generosa*, Hiatellidae), Maine lobster (*Homarus americanus*, Nephropidae)) caused by the lockdown in China during the initial COVID-19 outbreak, followed by increased domestic demand for frozen and shelf-stable products (e.g. canned tuna) as the outbreak spread in the USA and elsewhere (Figure 1c). Other commonly reported effects of COVID-19 on the US seafood industry include restrictions on travel of seasonal labourers, shifts in consumer demand, fishing seasons being cut short, aquatic farmers delaying outplanting, processing centres closing and seafood workers contracting COVID-19. There have also been several reports of industry adaptation on the commercial side, including direct-to-consumer marketing (e.g. https://finder.localcatch.org/, Stoll et al., 2020) and community-supported fisheries programmes, reducing the complexity of the supply chain. Media reporting on these effects have varied across the USA with the Northeast, Pacific Northwest and Alaska receiving the most coverage per capita (Figure 1d). In addition, news articles have tended to focus on fisheries production and fresh seafood (Figure 1g). Although most news articles were not species-specific, the species groups that were most commonly referenced were marine fishes, diadromous fishes (most notably salmon) and crustaceans (Figure 1h).

3.2 | Fisheries landings

Comparing two Alaskan fisheries, we found that prior to June, landings of halibut declined by 40%, whereas sablefish was in line with previous years (Figure S2). These differences likely reflect processing differences between these two fisheries since 60% of halibut is sold fresh (and for 30% higher prices than frozen product), while almost all sablefish catch is frozen (NMFS, 2018). Therefore, although sablefish is typically sold in the export market, sablefish demand should be more reliable for processors given increased demand for frozen goods generally during the pandemic. This is also in line with news articles on increased demand for frozen seafood products within the USA, including Alaskan pollock (*Gadus chalcogrammus*, Gadidae) (Gephart et al., 2020). Research in the Northeastern USA shows a similar complicated picture of commercial fisheries (Smith et al., 2020). Some stocks had landings in line with previous years, including those most familiar to US consumers, for example haddock (*Melanogrammus aeglefinus*, Gadidae). Conversely, stocks targeted

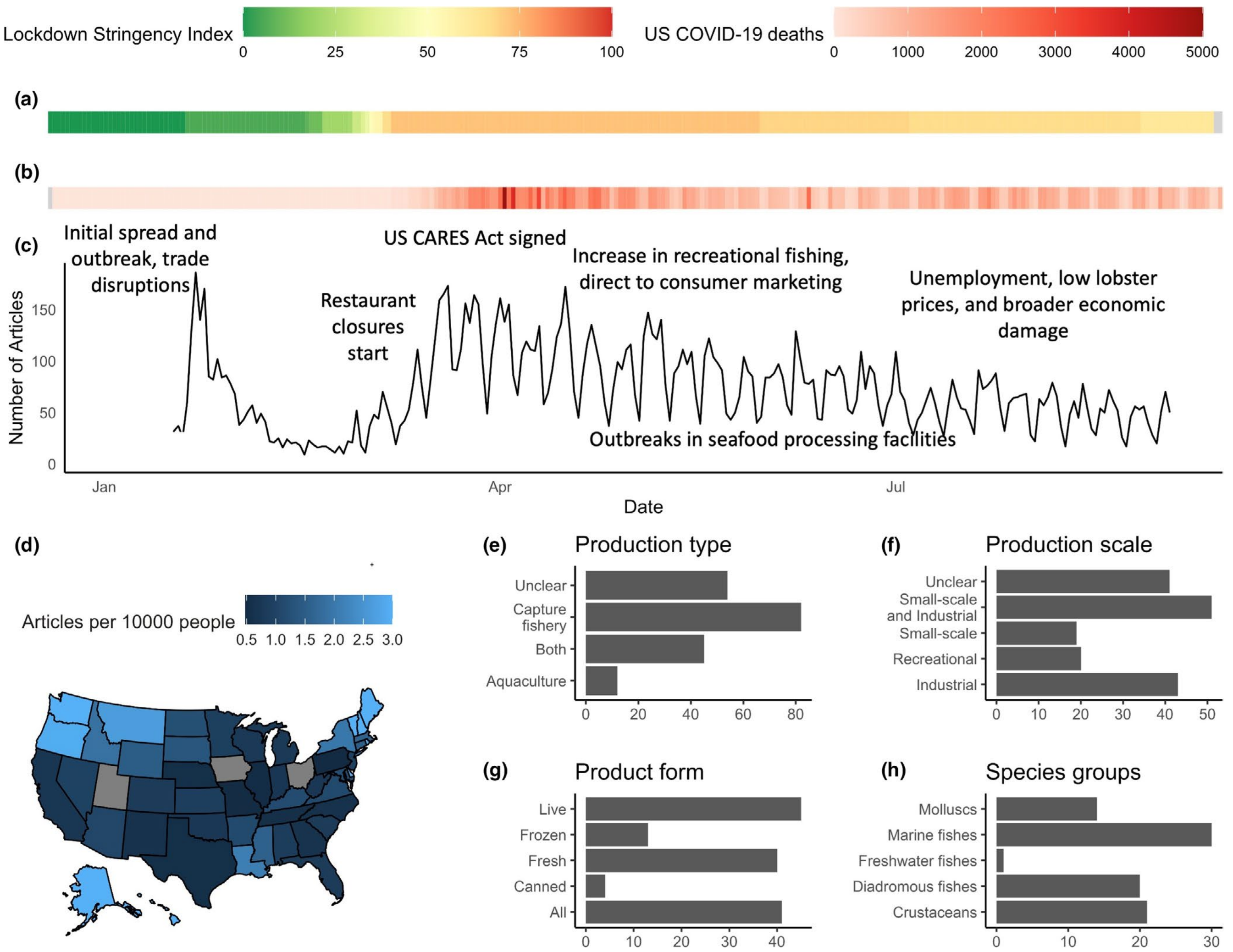


FIGURE 1 COVID-19 and associated media reports on seafood impacts in the USA. (a) Government lockdown stringency index ("17 indicators aggregated reporting a number between 1 and 100 to reflect the level of government action," Hale et al., 2020), (b) COVID-19-related deaths per day in the United States and (c) the total number of news articles published per day (from GDELT database) with particular search terms (see*Methods*). (d) Distribution of COVID-19 and seafood news articles per capita (from GDELT database) for each individual state since the start of the pandemic. (e–h) Distribution of impacts by production type, production scale, product form and species groups affected. An impact is defined as explicitly reported on in a news article for our smaller (n = 196) manually processed news database [Colour figure can be viewed at wileyonlinelibrary.com]

for exporting, for example monkfish (*Lophius americanus*, Lophiidae), experienced declines in both landings and price (Smith et al., 2020).

3.3 | Foreign trade

Given the importance of the United States in global seafood trade (Gephart & Pace, 2015), disruptions to trade were among the earliest COVID-19 impacts felt outside of China. Comparing year-over-year import and export value, we found that prior to January 2020, seafood imports had stayed within 5% of the previous year's value, but then increased by 7%–11% year over year in January and February 2020. This increase may be explained by shipments originally heading to China being redirected to the US market (Gephart et al., 2020). Live, fresh and chilled imports then fell to 37% below the previous year's value by April 2020, while frozen products were only 3.5% below 2019 levels. Imports of both frozen and fresh products increased into August 2020, with frozen imports reaching 2019 levels and fresh imports levelling off at around 14% below the previous year. Exports of frozen products declined from April to August to 39% below the previous level, while exports of fresh products increased to 14% above 2019 levels in July, before dipping to 35% below 2019 levels in August (Figure 2).

Possibly due to the trade war with China, exports of live, fresh and chilled products were generally lower than the previous year from April 2019 to September 2019 (−5% to −29% year over year). Coincident with the onset of COVID-19, exports sharply dropped to 29%–43% below the previous year's value in February–April 2020 (Figure 2). Exports of frozen fish were also generally below the previous year's values for most months of 2019 and at similar levels in

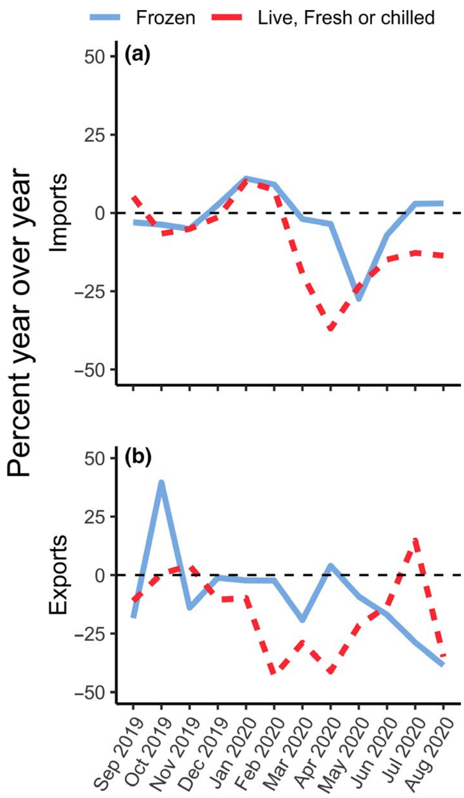


FIGURE 2 US Seafood Imports and Exports. Monthly US imports and exports of frozen or fresh (live, fresh or chilled) seafood as a per cent change since the previous year [Colour figure can be viewed at wileyonlinelibrary.com]

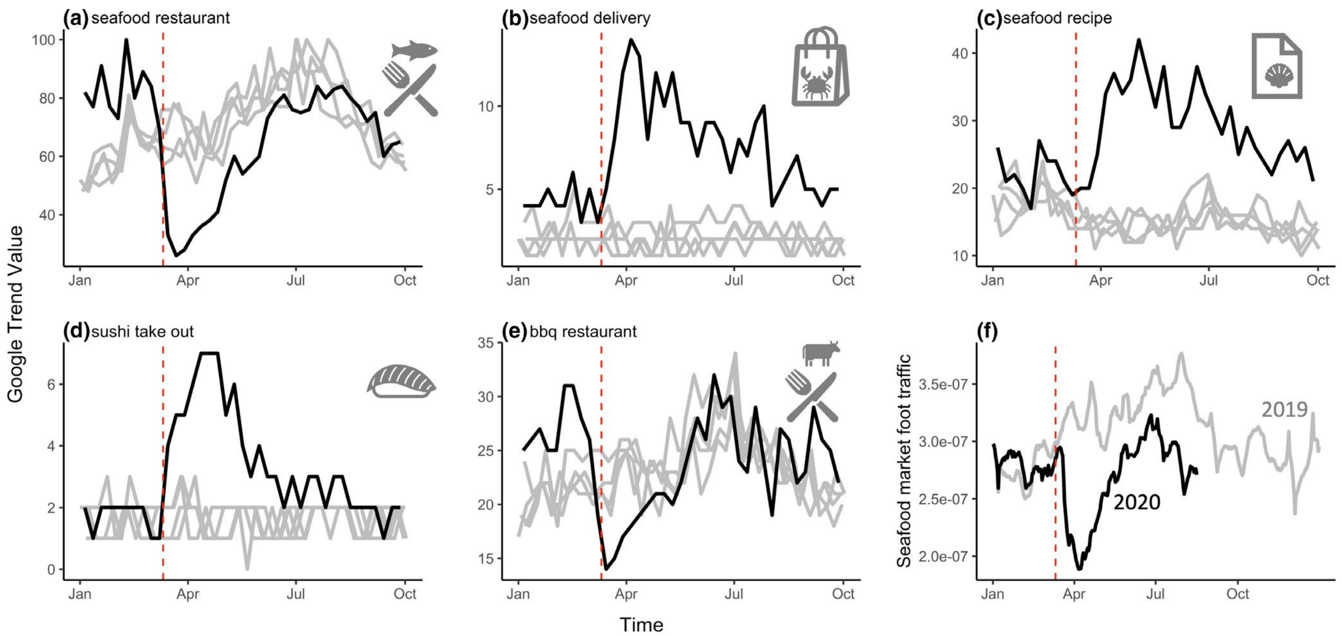


FIGURE 3 US seafood consumer demand. Previous and current relative Google trends for several search terms: (a) seafood restaurant, (b) seafood delivery, (c) seafood recipe, (d) sushi takeout and (e) bbq restaurant (as a control). Panel (f) is the rolling mean of normalized (see methods) foot traffic data for all US fish and seafood markets [Colour figure can be viewed at wileyonlinelibrary.com]

January and February 2020, before a sudden drop to 20% below the previous year in March 2020. Frozen exports, however, returned to 4% over the previous year's value in April 2020. In other words, domestic and foreign demand for frozen US seafood remained high in the first months of the pandemic.

3.4 | Seafood market foot traffic

The mean number of people visiting US fish and seafood markets (n = 3,391 with available data) decreased by 30% in 2020 as COVID-19 cases started increasing (Figure 3f, Figure S1). In total, 39 of the 41 states with sufficient data saw a decline in seafood market foot traffic from March 2019 to March 2020 (Figure S1). These widespread effects were most pronounced on both the east and west coasts. Some areas, particularly in the Southeast and Pacific Northwest have seen some recovery since June 2020 (Figure S1). This may be due to a combination of state-level differences in initial severity of COVID-19, social distancing restrictions and subsequent reopening strategies (Althouse et al., 2020; Hale et al., 2020; White & Hébert-Dufresne, 2020).

3.5 | Web searches

Google searches related to seafood in the USA increase on weekends and through the course of the year before peaking in mid-summer (Figure 3). In 2020, searches for "seafood restaurant" declined by approximately 70% starting mid-March, well before the health impacts of the virus started sweeping across the United States, but around the time the World Health Organization declared COVID-19 a global pandemic (March 11, 2020). This is not surprising given pre-emptive stay-at-home orders in some states, and the fact that 70%

of spending on seafood in the USA is in restaurants (Love, Asche, et al., 2020). However, searches started rebounding in late April as individual states started reopening (Figure 3a). During the same time period, searches for seafood delivery, takeout and recipes continued to increase (average 270%); although still at low relative magnitude (Figure 3b-d), this change may indicate a new move towards different forms of local demand. Indeed, seafood restaurant and sushi takeout searches have returned to comparable levels of previous years, while delivery and recipe searches are slightly higher.

4 | CONCLUSIONS

The COVID-19 pandemic and resulting economic crisis represent a global-scale disturbance that is being felt across all sectors, including seafood. In the USA, social distancing measures that have led to widespread restaurant closure and reduced seafood market foot traffic have driven greater public dependence on seafood deliveries and home cooking. Such changes in consumer demand have profoundly affected seafood production, with landings, as well as imports and exports, generally changing in favour of frozen products. While frozen products appeared less affected than live and fresh products early on, trade of both product groups was generally below 2019 levels from February through June 2020 and exports of frozen products reached the lowest year-over-year value in August 2020. Given the inherent heterogeneity between seafood sub-sectors and state-level differences in COVID-19, these changes have not been felt equally across the United States (Figure 1d, Figures S1 and S3). These immediate responses and distribution changes are important in highlighting weak spots in seafood supply chains (such as fresh products or products with long supply chains being more disruption-prone), but also hide other aspects of exposure or adaptive capacity in the face of seafood shocks for different communities. Some states, notably in the Southeast and Pacific Northwest have seen faster recoveries in terms of seafood market demand (Figure S1), possibly due to differences in social distancing guidelines. Fishery-dependent communities have been, and will likely continue to be, hit especially hard by the fallout from COVID-19.

With such varied responses, only time will tell the full extent of COVID-19 on US fishing and seafood industries. A combination of human responses, combined with species life history, will determine the timescale of these effects and whether or not they are temporary or cause longer term shifts in consumption, fishing patterns and fishery status. It is clear that we need better and more timely reporting of both fisheries landings and aquaculture data for rapid policy interventions (Gephart et al., 2019; Froehlich et al., 2020). Fisheries like those in Alaska point to examples where weekly updates of publicly available landings data can help inform science and policy. Although surveys of seafood workers were deployed during the pandemic (van Senten et al., 2020; Smith et al., 2020; Stoll et al., 2020), these were often unplanned and lacked pre-pandemic baselines. These types of surveys should be a more regular component of government agencies in order to capture the full social and economic effects of shocks. In the absence of these data, our work shows how using non-traditional indicators (e.g. seafood market foot traffic) can help inform science and policy.

The varied responses by seafood sub-sectors and states also suggest priorities for government interventions. Amid the COVID-19 pandemic, there were three significant actions by the federal government. First, in direct response to fallout from COVID-19, the CARES relief act directed $300 million to the seafood industry, though the distribution of these funds from the National Oceanic and Atmospheric Administration has reportedly been extremely slow, particularly for aquaculture (Gephart et al., 2020; van Senten et al., 2020). The federal government also purchased seafood directly, including 20 million pounds of shrimp (<1% total annual harvest) from Gulf of Mexico fishers (Gephart et al., 2020). While loans (e.g. Paycheck Protection Program) and heterogeneous state-level support were made available, aquatic farmers cited federal support as the most important relief to remain in business, highlighting a critical weak point in the current information and response structure for this sector (van Senten et al., 2020). Importantly, the stymied federal response to help the US seafood sector is not necessarily due to a lack of prioritization at the time. In fact, an expansive executive order was introduced to promote fisheries and aquaculture regulatory reform and increase production (Froehlich et al., 2020), occurring shortly after the time period (22–29 April) when seafood restaurant searches and foot traffic values were at their lowest point. Given the disruption and uncertainty, future interventions and funds for the US seafood sector should focus on fishery-dependent communities, improving processing infrastructure and safety, supporting systems that focus on fresh seafood products, and more broadly data collection and management to create a system which can more readily respond and distribute relief more quickly. The implementation of these various governmental policies, combined with the continued and possible future interventions to COVID-19, will ultimately determine the long-term effects on the US seafood industry.

By their very nature, shocks are unanticipated and therefore difficult to study. The COVID-19 pandemic has highlighted long-standing mismatches in the protracted nature of typical fisheries and seafood data availability and the shorter timescale required for effective policy actions. Although often collected on daily or weekly timescales, landings and production data need to be released publicly on shorter time scales in order to be helpful to both scientists and policymakers. Other data on consumer demand and the well-being of seafood workers should be collected more regularly and be more widely available to provide important information for policymakers and policy-relevant science before and during shocks. In addition, delays in publishing of scientific findings can also impede policy actions, highlighting the role in releasing preliminary results through venues such as preprint servers (Eisen et al., 2020). Further, the National Oceanic and Atmospheric Administration has cancelled many research cruises and has waived requirements for fisheries observers on all of its boats (with some redeployment of observers in the Northeast starting 14 August), which limits current and future assessments on the status of commercially fished species (Gephart et al., 2020).

Lastly, the COVID-19 pandemic has highlighted weaknesses along the seafood production pipeline. As a whole the US seafood industry relies heavily on imports and exports. Seafood processing centres have been a hotspot of COVID-19 cases and have consequently become a bottleneck for producers. Alternative seafood networks and distribution, including straight to consumer local sales, have shown some promise in providing resilience during the current pandemic (Stoll et al., 2020) and for adapting to future seafood shocks.

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AUTHOR CONTRIBUTIONS

E.R.W. and H.F. designed research; E.R.W, H.F, J.G. and R.A.B. collected data; E.R.W, H.F, J.G. and R.A.B. analysed data; and all authors wrote and edited the paper.

DATA AVAILABILITY STATEMENT

Except for the SafeGraph foot traffic data, all data and code used in this paper are available at https://github.com/eastonwhite/COVID19_US_Fisheries with the news article code at https://github.com/rahulAgrBej/seafoodGDELT.

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SUPPORTING INFORMATION

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

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