Received: 15 November 2021 | Revised: 23 April 2022 | Accepted: 6 May 2022

DOI: 10.1111/fme.12567

ARTICLE

Fisheries Management and Ecology WILEY

Review of adaptations of U.S. Commercial Fisheries in response to the COVID-19 pandemic using the *Resist-Accept-Direct* (RAD) framework

Sarah Lindley Smith[1] | Samantha Cook[2] | Abigail Golden[1] | Mia Aiko Iwane[3,4] | Danika Kleiber[4] | Kirsten M. Leong[4] | Anthony Mastitski[5] | Laurie Richmond[2] | Marysia Szymkowiak[6] | Sarah Wise[7]

[1]School of Environmental and Biological Sciences, Rutgers University, New Brunswick, New Jersey, USA

[2]Department of Environmental Science and Management, Humboldt State University, Arcata, California, USA

[3]Cooperative Institute for Marine and Atmospheric Research, Honolulu, Hawaii, USA

[4]NOAA Pacific Islands Fisheries Science Center, Honolulu, Hawaii, USA

[5]ECS Federal, LLC, Fairfax, Virginia, USA

[6]NOAA Alaska Fisheries Science Center, Juneau, Alaska, USA

[7]NOAA Alaska Fisheries Science Center, Seattle, Washington, USA

Correspondence
Sarah Lindley Smith, School of Environmental and Biological Sciences, Rutgers University, New Brunswick, New Jersey, USA.
Email: sarahlindleysmith@gmail.com

Present address
Abigail Golden, School of Aquatic and Fishery Science, University of Washington, Seattle, Washington, USA

Funding information
Climate Program Office, Grant/Award Number: 2019002753; California Sea Grant; California Ocean Protection Council; California Department of Fish and Wildlife

Abstract

The COVID-19 pandemic transformed social and economic systems globally, including fisheries systems. Decreases in seafood demand, supply chain disruptions, and public safety regulations required numerous adaptations to maintain the livelihoods and social resilience of fishing communities. Surveys, interviews, and focus groups were undertaken to assess impacts from and adaptive responses to the pandemic in commercial fisheries in five U.S. regions: the Northeast, California, Alaska, the U.S. Caribbean, and the Pacific Islands. Fishery adaptation strategies were categorized using the *Resist–Accept–Direct* (RAD) framework, a novel application to understand social transformation in a social-ecological system in response to a disturbance. A number of innovations emerged, or were facilitated, that could improve the fisheries' resilience to future disruptions. Fishers with diversified options and strategic flexibility generally fared better, i.e., had fewer disruptions to their livelihoods. Using the RAD framework to identify adaptation strategies from fishery system actors highlights opportunities for improving resilience of fisheries social-ecological systems to future stressors.

KEYWORDS
disturbance, RAD framework, resilience, social-ecological systems, transformation

1 | INTRODUCTION

1.1 | Social-ecological resilience and transformation

When faced with a disturbance, social-ecological systems (SESs) may respond by absorbing the disturbance and returning to a similar state or transforming into a new state (Holling, 1986). In an era when climate change, large-scale habitat disruptions, and other anthropogenic drivers lead to increasing uncertainty, nonlinearity, and fluctuations in system function (Chapin III et al., 2010; Perry et al., 2011), the potential for SES transformation in response to human or natural disturbance needs to be considered by system managers and participants. As SESs, fisheries are tightly linked systems that respond to disruptions across both social and ecological dimensions (Folke et al., 2005), making them susceptible to system-wide transformations (Salgueiro-Otero & Ojea, 2020).

The COVID-19 pandemic transformed social and economic systems throughout the world, including fisheries and coastal communities. As a large-scale shock with significant effects on fisheries, affecting nearly all fishery food systems across the globe, the pandemic has proved to be a natural experiment of sorts in looking at a range of fishery responses to social disruptions. Such a significant system shock provides pathways for transformation within a fishery SES, and requires actors to adapt to unknown future social conditions with no historical reference point. Because the pandemic has affected fisheries across many scales, from global to local-scale fisheries and supply chain dynamics, it provides an opportunity to understand and address the multiscale connectivity of fishery systems. Social transformations resulting from disturbances such as the COVID-19 pandemic can reshape fisheries activities, including effort and harvest, which can have implications for fish populations and communities (Figure 1).

The *Resist–Accept–Direct* (RAD) framework (Lynch et al., 2021; Schuurman et al., 2022; Thompson et al., 2021) provides a framework to understand management responses to ecosystem change and to guide responses under SES transformation. System transformation is defined here as a significant change in the composition, structure, and function of the system such that it leads to an entirely new SES (Thompson et al., 2021). As transformations become more common and more likely, including under climate change and other forms of anthropogenic-driven disturbances (Nolan et al., 2018), the need for such frameworks to guide managers' responses to press (long-term) and pulse (short-term) disturbances is increasing. The RAD framework allows managers to make three types of decisions for systems undergoing such transformations: *resisting* transformation by working to maintain or restore system structure, composition, or function based on historical or current conditions; *accepting* transformation by allowing the composition, structure, or function of the system to change unimpeded; or *directing* transformation by actively shaping change in system composition, function, or structure to achieve a desired future state (Lynch et al., 2021; Schuurman et al., 2022; Thompson et al., 2021).

Traditionally used in an ecological context, here this framework is expanded and applied to the social components of fisheries as SESs, encompassing the fishers, fisheries managers, and shoreside and other supply chain components of fishery systems. Because SESs are vulnerable to both ecological and social disturbances, it may be posited that transformation can happen across both ecological and social dimensions. In addition to guiding ecological transformation, the RAD framework can also be used to think about the role of managers and system actors in resisting, accepting, or directing *social* transformation within a SES. This study applies the RAD framework to a significant SES disturbance—the impacts to fisheries from the COVID-19 pandemic—to understand how various adaptive

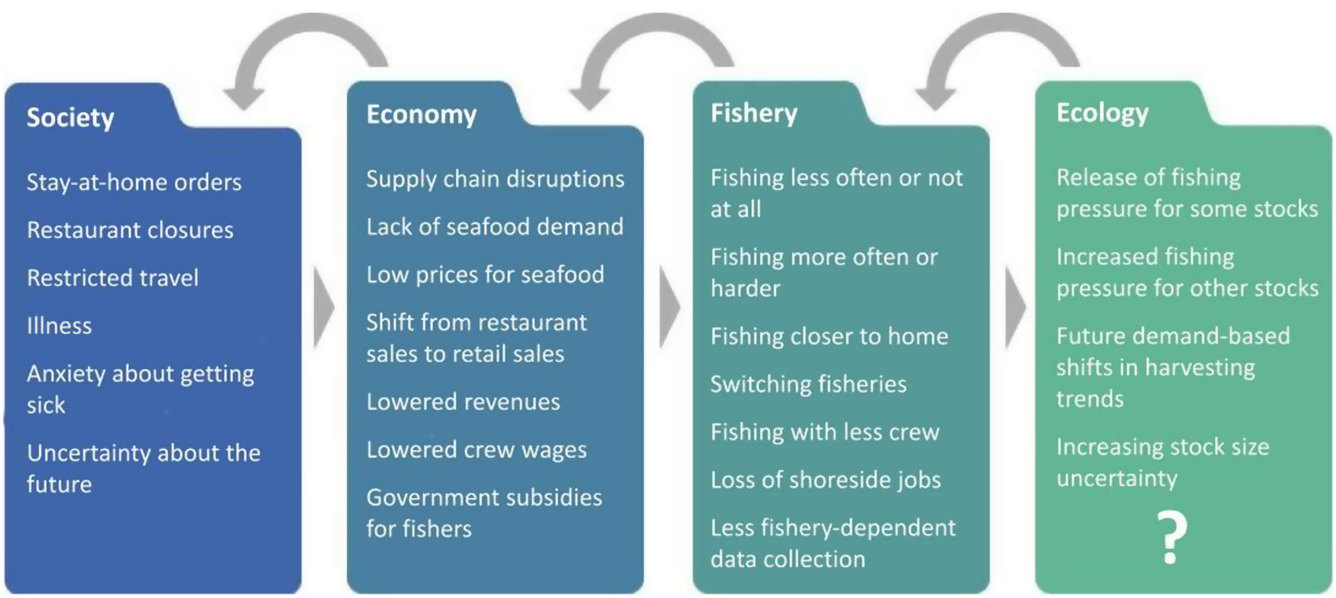

FIGURE 1 Linkages and feedbacks to fishery Social-Ecological Systems resulting from disruptions caused by the COVID-19 pandemic (adapted from Ojea et al., 2020)

strategies were employed by system actors to resist, accept, or direct system transformations resulting from a system shock.

This study analyzes the impacts of the pandemic on commercial fisheries and responses of commercial fishers and other fishery system actors to the pandemic across five regions of the United States (U.S.): (a) the Northeast (Maine through North Carolina), (b) California, (c) Alaska, (d) the U.S. Virgin Islands (USVI) and Puerto Rico, and (e) the Pacific Islands Region (PIR: Hawai'i, Guam, Commonwealth of the Northern Mariana Islands [CNMI], and American Samoa). These regions represent different fishery types and scales, and each region experienced and responded to the pandemic somewhat differently in terms of the timing and the severity of impacts. The following research questions are addressed through a comparison of impacts and adaptations of U.S. fisheries to the COVID-19 pandemic, and through analyzing fishery adaptive responses according to the RAD framework, in order to advance an understanding of resilience and transformation in fishery SESs:

- How have U.S. commercial fisheries responded to global disturbances in social dynamics caused by the pandemic?
- To what extent do these responses represent *resist*, *accept*, or *direct* strategies in the face of a system shock such as the COVID-19 pandemic?
- What RAD strategies could be useful for fisheries managers and fisheries actors in enhancing the resilience of fishery systems in the face of future and possibly compounding shocks?

1.2 | Extending the RAD framework to social-ecological transformations

The RAD framework has proved to be a useful tool for ecosystem managers to formalize their expectations of future system states and their options for addressing them (Lynch et al., 2022a, 2022b; Magness et al., 2022; Schuurman et al., 2022). However, the existing RAD literature is predominantly focused on ecosystem transformations and ecosystem management, when in fact many ecological systems are embedded within larger, complex SESs (Ostrom, 2009; Walker & Meyers, 2004). In these systems, both social and ecological transformations are possible, and social groups and actors (e.g., hunters, fishers, water users) have agency to *resist*, *accept*, or *direct* change alongside managers. The RAD framework is also somewhat hampered by its focus on known, or at least predicted, ecological "plausible futures," when in reality, it is difficult to predict what (1) potential future states of the social and ecological systems are possible or (2) whether a given disturbance will be transformative in the long term. Applying the framework is particularly difficult to do while it is still early enough to take meaningful action.

This study extends the RAD framework to SESs and social transformations. Originally designed to consider purely ecological systems, this represents a novel use of the RAD framework, and an extension of its application into the social components of SESs. Following Schuurman et al. (2022)'s definition of ecological transformation, one can define *social-ecological transformation* as "a dramatic and potentially irreversible shift in the ability of ecosystems to sustain the livelihoods and cultural benefits they have historically supported in human communities." The basis of these shifts can lie in ecological change, social or community-level change, and/or larger-scale externalities like changes in markets for ecosystem products. This definition highlights the links between the social and ecological subsystems of SES, and especially the ecosystem services that human communities receive from nature (Bennett et al., 2009), as a key nexus of transformation in a social-ecological context.

This study further develops definitions of actions that *resist*, *accept*, and *direct* social-ecological change from the social perspective (Table 1). In *resisting* change, managers of and actors within SESs seek to maintain the historical structure and composition of the social-ecological system and their links to it, for instance, by harvesting the same fish species and selling them in the same markets as before a disturbance. When *accepting* change, they allow the SES to change autonomously, without attempting to maintain historical social benefits or structure of the social-ecological system. This could include actions such as shifting to species that reflect new societal demands or leaving the marine economy entirely in response to economic hardship. By taking *direct* actions, communities and managers actively shape the ecosystem, social system, and the links between them to enable the provision of material, social, and cultural benefits under transformed conditions. For example, fishery managers or other actors may work to establish new markets for fish species that are moving into the region through climate-driven shifts.

The COVID-19 pandemic and its effects on U.S. commercial fisheries provide a case study of a social-ecological disturbance whose scope, duration, and potential to be truly transformative are still unknown. Fisheries are a valuable context in which to study SES interactions because they involve varied and complex links between human communities and ecosystems (Ojea et al., 2017; Partelow & Boda, 2015), their failure can have dire consequences for both ecosystems and human communities (Milich, 1999), and they are historically data rich in the United States (Basurto et al., 2013; Fuller et al., 2017). The COVID pandemic has had multivariate social impacts on fisheries, including the direct shutdown of fishing by public health measures and port closures and the indirect impacts of low seafood demand and supply chain disruptions. Fishing communities have had to adapt to immediate and dramatic changes to their livelihoods while working under conditions of extreme uncertainty about the length and trajectory of this ongoing pandemic. This study assembles examples of how fishers have adapted to these challenges throughout the United States and categorizes their responses in a novel application of the RAD framework to social transformations of SESs.

1.3 | COVID-19 pandemic and global fisheries

The COVID-19 pandemic is a large-scale shock to fisheries food systems, affecting the supply and demand of seafood worldwide

TABLE 1 Applying Schuurman et al. (2022)'s definitions of transformation, Resist, Accept, and Direct to a SES

	Definition from Schuurman et al. (2022)	Definition as applied to a social-ecological system	Example of SES definition
Transformation	The dramatic and effectively irreversible shift in multiple ecological characteristics of an ecosystem, the basis of which is a high degree of turnover in ecological communities	A dramatic and potentially irreversible shift in the ability of ecosystems to sustain the livelihoods and cultural benefits they have historically supported in human communities. The basis of this shift can lie in ecological change, social/community-level change, the broader governance structure, and/or larger-scale externalities like the availability of markets for ecosystem products	The loss of community structure and function in fisheries: fishing community shoreside infrastructure or function (function as a fishing community); the loss of markets to support fisheries; and loss of a critical mass of fishers and/or vessels to maintain a fishery
Resist	Work to maintain or restore ecosystem composition, structure, processes, or function on the basis of historical or acceptable current conditions	Work to maintain, restore, or subsidize the functions of a SES that historically provide livelihoods and/or cultural benefits	• Providing fuel subsidies to enable fishers to continue fishing even when it is unprofitable • Protecting spawning habitat of commercially valuable species to maintain the population
Accept	Allow ecosystem composition, structure, processes, or function to change autonomously	Allow the SES to change autonomously, without attempting to maintain historical social benefits or links between the social and ecological system	• Take no action to mitigate sea level rise that will submerge a barrier island with valuable tourist industries and commercial ports
Direct	Actively shape change in ecosystem composition, structure, processes, or function toward preferred new conditions	Actively shape the ecosystem and/or social system to enable the provision of new livelihoods and cultural benefits under transformed conditions	• Subsidize construction of ports and processing facilities in the expanded range of a climate-sensitive species and compensate owners for the decommission of infrastructure where the species no longer exists

(Belton, 2021) and the livelihoods of many of the more than 260 million people who work directly or indirectly in seafood supply chains (Teh & Sumaila, 2011). Seafood is an increasingly global product and one of the world's most substantially traded commodities (FAO, 2021). Seafood supply chains are also increasingly globalized and dependent on international trade, with fish often harvested in one country, processed in a second, and sold in a third (FAO, 2021). The highly globalized nature of fisheries has left them vulnerable to various types of shocks and perturbations, as longer supply chains have more opportunities for shock exposure at various nodes throughout the trade network (Gephart et al., 2017).

As one of the world's largest exporters of seafood products, fisheries production in the United States saw a steep decline at the start of the COVID-19 pandemic in March 2020 (White et al., 2020). When COVID-19 was declared a pandemic in March 2020, governments around the world, and state, territorial, and local governments in the United States, took a number of restrictive measures, affecting the movement of citizens and restricting many aspects of commerce to protect public health. These measures included lockdowns in the early weeks of the pandemic followed by extensive social distancing and quarantine requirements and guidelines; thereafter, including curfews and restrictions on travel, social gatherings, and restaurants and other businesses, all intended to prevent the spread of the virus.

These widespread restrictions, along with the accompanying uncertainty of the pandemic's trajectory caused significant disruptions in the seafood industry (Bennett et al., 2020) as they did across all aspects of global economies. The initial days of the pandemic generated significant and widespread uncertainty about markets, safety, and restrictions that left many fishing vessels tied to the dock (Smith et al., 2020). This had significant repercussions for the fishing industry given that 70% of U.S. seafood spending occurs in restaurants (NMFS, 2018), and demand for fresh seafood consequently slumped. Across the U.S. and its territories, fisheries of all scales suffered logistical and economic shocks throughout their supply chains. The U.S. federal government responded to the pandemic's effects on commercial fisheries and aquaculture by allocating $300 million for relief funds in the Coronavirus Aid, Relief, and Economic Security (CARES) Act in the spring of 2020 to seafood harvesters (NMFS, 2020).

One of the most obvious and immediate changes that some fishers faced was an abrupt change in access to fishing, where boat ramp closures, curfews, and other access restrictions mandated by local governments in response to COVID-19 led to the disruption of

TABLE 2 Overview of fisheries, markets, data collection, and analysis methods, and sample sizes for each region included in the study

Region	Sampling method	Data collection	Data analysis	Fishery types included	Markets
Pacific Island Region (Hawai'i, Guam, CNMI, American Samoa)	Snowball sampling beginning with key actors and Science Center contacts.	Apr 2020 to Feb 2021: Open ended phone interviews. ($n = 50$)	Transcribed interviews were inductively coded using MAXQDA.	Small scale: coral reef, bottomfish, and coastal pelagics Large scale: highly migratory pelagics	Local and tourist fresh fish market, fresh domestic export (Hawai'i), and canned domestic export (American Samoa)
U.S. Caribbean (United States Virgin Islands, Puerto Rico)	Fishers' contacts were collected through the respective territorial agency and local fishers association(s). Snowball sampling was also used from initial key actors.	Aug to Sep 2020: Semi-structured phone interviews ($n = 359$) Mar to Apr 2021: Follow-up semi-structured phone interviews ($n = 233$)	Transcribed semi-structured phone interviews and follow-up interviews. Quantitative analysis of Likert scale questions and response frequencies.	Small scale: lobster, coastal pelagics, reef fish	Local and Tourist fresh fish market
Alaska	Snowball sampling, beginning with key actors in commercial fisheries and management. Targeted interviews of agency personnel distributing Cares Act funds.	Aug 2020 to Jan 2021: Key actor interviews ($n = 21$), economic data, and policy analysis	Interviews, policy documents, and Regional Council public comment were transcribed and inductively coded using MAXQDA.	Large scale: Groundfish Trawl Small scale: salmon, halibut, and sablefish	Non-market subsistence, domestic markets, and international export
California	Participants were recruited through Project Team contacts, port liaisons, and a contact list of fishers provided by CDFW	Jul 2020 to Mar 2021: Virtual focus groups ($n = 85$)	Transcribed focus group recordings were thematically coded in Dedoose, where themes were linked to focus group question topics; frequencies of quantitative rating data were run in SPSS	Small scale: crab, salmon, rockfish, lobster, urchin, and coastal pelagics	International export, domestic fresh and frozen markets, restaurant, local, and direct
Northeast U.S. (Maine through North Carolina)	The survey was emailed through industry associations, state and federal agencies, regional fishery management councils, Cooperative Extension agents, and sometimes directly to commercial fishing license holders. Interview subjects were recruited from survey respondents and from snowball sampling.	May to Jun 2020: Semi-structured online surveys ($n = 258$) Dec 2020 to Jul 2021: Semi-structured follow-up phone interviews, ($n = 55$)	Quantitative analysis of Likert scale question data in R and inductive coding of semi-structured follow-up interviews.	Small scale: lobster, coastal pelagics, groundfish, shellfish, and crabs Large scale: groundfish, squid, scallops, herring, surf clams, and monkfish	International export (esp. lobster), domestic fresh (restaurants) and frozen markets, bait, and direct sales

fishing activities or ambiguity around access rights in some regions. While seafood harvesting was eventually allowed to continue in most of the world, as it was considered an essential service contributing to food supplies, initial and ongoing disruptions to trade had significant effects on fisheries (Aura et al., 2020).

The pandemic has significantly disrupted fisheries in the United States and throughout the world, yet the fisheries sector has implemented a number of adaptations in response to many pandemic-related economic and logistical challenges (FAO, 2021). Although pandemic restrictions differed on a statewide basis throughout the United States, states and territories each experienced a mandatory lockdown restricting the movement of residents beginning in mid-March of 2020 and lasting anywhere from 1 to 3 months. Numerous factors related to economics, markets, pandemic restrictions, demand, availability, management, and fishery characteristics have determined how individual fisheries have responded to the pandemic. Understanding what some of these responses were, and some of the factors driving these responses, is critical to managing system transformations related to future disturbances. These types of disruptions are likely to become more common, as climate change is projected to increase the probability of future extreme events including epidemics, and other ecological disruptions that have consequences for social systems (Ferguson et al., 2022; Marani et al., 2021).

2 | METHODS

This paper is a review and comparison of adaptation measures, analyzed through the RAD framework, deriving from several studies conducted independently by the authors in different regions of the United States to understand how fishing communities were impacted by and responded to the COVID-19 pandemic. In order to document immediate changes, the studies all began within a few months of the sudden emergence of the COVID-19 pandemic, which began in March 2020, and were all completed by Spring 2021. Some of this research was the product of rapid pivots of existing research projects interrupted by COVID-19. Other parts of this research represent entirely new projects conceived and initiated in response to the pandemic. Initial data collections were conducted separately for each region using a variety of methods including online surveys (Northeast, USVI, Puerto Rico), semi-structured interviews (Northeast, Pacific Islands Region), fisheries data and policy analysis (Alaska), and virtual focus groups (California). These states, regions, and territories support a large number of fisheries and fishery types, spanning from small-scale, inshore fisheries to industrial, offshore fisheries (Table 2). Small-scale fisheries are defined here as owner-operated vessels fishing short trips (1–2 days) relatively near shore, as compared with “large-scale” or industrial fisheries, which involve larger vessels fishing further offshore with a larger crew. Fishers who participated in the various data collection efforts described above are representative of this large diversity of fisheries. While interview protocols and survey instruments differed among these regions, all asked similar questions of respondents to assess how fishers' livelihoods have been affected by the COVID-19 pandemic, and in what ways they have adapted to the economic, logistical, and social distancing challenges posed by the pandemic. Analysis also differed between regions, and methods included quantitative analysis of Likert or other quantitative measures, or inductive coding of qualitative data including open ended questions, interviews, Regional Council public comments, policy documents, and focus group discussions.

2.1 | Analysis

The authors initially met when presenting preliminary findings at a virtual Society for Applied Anthropology conference in March of 2021 and noted similarities across regions. Datasets were examined collectively to explore commonalities and differences across regions. This process was cooperative and iterative. The authors met several times to discuss findings from their regional studies. To organize the information obtained by studies of each region, a set of questions was developed by the authors (Appendix S1). The authors from each region then answered the relevant questions based on the data from their regional study. Subsequent discussions of the responses led to the reorganization based on three major themes:

1. *Context and Impacts*: Important information about the regional fisheries and the changes that occurred directly because of COVID-19, including changes to fishing access, fisheries labor availability, the fisheries supply chain, and the value of fish products. This provides documentation of the drivers of adaptation.
2. *Adaptations*: Decisions made by fishers, fish marketers, and other shoreside labor in response to COVID-19-related changes, including adaptations to fishing effort, species caught, customer base, and sales strategies. This provides the details used in the RAD analysis.
3. *Adaptability*: Factors affecting the capacity of different actors in fishing and the supply chain to adapt to the changes brought about by COVID-19, including available capital, vessel size, ability to switch species, gear types, and catch volume, and ability to change market strategies. This provides additional context for why different parts of the fisheries may have different RAD responses.

Adaptation strategies were then categorized using the RAD framework adapted for social transformations (Table 3) to better understand responses of fishers, managers, and other system actors to the pandemic and potential for long-term social transformations. Categorizations were done collaboratively by the authors using an iterative process to collectively evaluate fishery system actor responses.

To date, the RAD framework has primarily been used to describe ecological outcomes, but here it has been adapted to categorize social outcomes (see also, Lynch et al., 2022a, 2022b). In the context of social outcomes, managers and fishers might *resist*, *accept*, or *direct*

TABLE 3 Examples of fisheries adaptation strategies identified, as characterized by the Resist-Accept-Direct framework

Social change/impacts	Scale of adaptation	Resist (work to maintain the structure and composition of the system)	Accept (allow the system to change)	Direct (working to actively shape the system in a new way)
Driver: Disruptions to fish harvesting and livelihoods				
Decrease in demand for fish and trade disruptions	Individual fishers	Fishers fishing harder (more/longer), increasing effort to make up for lost revenues Fishers fishing the same amount, making less money Compromising safety by fishing in poor weather just to make a paycheck	Fishers fishing less or tying up boats in response to a decrease in demand Fishers taking shorter trips or fishing closer to home to reduce costs	
Changes in demand for fish species (e.g., decreased demand from restaurants, export markets; increased demand for home cooking)	Individual fishers	Fishers shifting effort, fishing harder on traditionally caught species for which demand was stronger	Fishers switch to barter and subsistence fishing	Fishers shifting to target new species for which demand emerged or was sustained
Challenges resulting from physical distancing	Individual fishers		Captains limit crew to family/trusted people (i.e., form "pod")	
Changes in labor availability	Individual fishers		Captains fishing with fewer crew because of lack of available crew Sharing available crew Recruiting local crew where foreign crew were used previously	
Financially unable to support crew	Individual fishers	Fishing with fewer crew to limit expenses Coronavirus Aid, Relief, and Economic Security(CARES) Act funds to retain crew when they were unable to fish		
Traditional fishing practices no longer economically viable	Individual fishers	Paycheck Protection Plan (PPP) loans and CARES Act funds to allow fishing business to survive through the short-term hardship	Retirement	Leaving the fishery to pursue opportunities in other sectors, including shifting to aquaculture
Disruptions to traditional revenue streams	Fisheries managers and societal-scale institutions	CARES Act funds directed toward fishers who experienced a loss in revenue in effort to maintain pre-pandemic revenue and effort in the fishery Fisheries managers temporarily lifting constraints on harvesting restrictions to mitigate revenue losses		
Driver: Disruptions to markets and supply chains				
Loss of traditional markets (restaurants, export)	Individual fishers		Donating fish to community organizations feeding people struggling with hunger	Starting a retail business or community-supported fishery (CSF) Purchasing freezer truck to transport catch to farmers' markets Increasing direct sales at the dock, or through personal networks/social media

(Continues)

TABLE 3 (Continued)

Social change/impacts	Scale of adaptation	Resist (work to maintain the structure and composition of the system)	Accept (allow the system to change)	Direct (working to actively shape the system in a new way)
Low demand for products	Dealers and Processors		Dealers limit how much volume they will accept so as not to flood the market Fishing associations limit catch per fishing trip	Processors shifting from fresh to frozen product
Unreliable processing plants due to labor shortages and lack of demand	Dealers and Processors		Increased planning and communication between fishers and processors	
Increased need for local food security	Fisheries managers and societal-scale institutions		Fishing organizations set up fish donation programs to those in need Community organizations pay fishers to catch and deliver fish to food banks	Promoting alternative marketing strategies for fishers States revising process or permitting requirements for direct sales

social transformations in response to potentially permanent shifts in social systems. In fisheries, these systems include markets, supply chains, labor forces, and regulatory systems, and produce livelihood and cultural benefits for fishers and fishery actors. The following criteria were developed to characterize social adaptation within the RAD framework and applied to the adaptations made by fisheries actors in response to changes brought about by COVID-19:

Resist: *work to maintain, restore, or subsidize the pre-disturbance structure and functions of a SES that have historically provided livelihoods and/or cultural benefits.*

Resist actions include:

- Activities that maintained previous effort or income
- Large efforts to maintain traditional commercial fishing systems, including maintaining previous levels of income, existing livelihoods, and market structure

Accept: *allow the SES to change autonomously, without attempting to maintain historical social benefits or links between the social and ecological system.*

Accept actions include:

- Activities that change to match social realities transformed by COVID-19
- Making small and easily reversible changes to commercial fishing systems

Direct: *actively shaping the ecosystem and/or social system to enable the provision of new livelihoods and cultural benefits under transformed conditions.*

Direct actions include:

- Activities that work to create or anticipate new trajectories of demand that emerged due to COVID-19 societal constraints
- Seizing an opportunity for change
- Making large permanent changes to commercial fishing system

3 | RESULTS

3.1 | Categorizing adaptive strategies within the RAD framework

Across the various U.S. commercial fisheries included in this study, numerous similarities and differences in pandemic-related impacts to fishers and fisheries were documented by the authors. There were some universally shared outcomes of the pandemic, in particular the rapid drop in demand for fresh seafood and the resulting impacts on price. However, important variations across geographic boundaries, fishing sectors, and individuals were also noted by the authors.

In response to the pandemic-driven changes to the fishery, we identified a series of adaptation strategies adopted by actors within the fishery system. Each of these adaptation strategies is here analyzed using the RAD framework to understand its relationship to broader transformation of the fishery SES, summarized in Table 3. Mapping these adaptation strategies onto the RAD framework is helpful for fishery system participants, including managers, fishers, and other actors, to understand what types of options for adaptation exist within the fishery as they relate to the potential for system transformation. In this case, what is being *resisted*, *accepted*, or *directed* is a change in the composition or structure of the fishery SES resulting from this particular system shock (the pandemic). In describing these strategies, the actors involved in implementing a strategy may be fisheries managers, fishers, or supply chain actors (e.g., processing plant owners and fish dealers). We first summarize overall characteristics of the *resist*, *accept*, and *direct* strategies that were observed, and then review responses to specific impacts observed across regions, related to the RAD framework.

3.1.1 | Resist strategies

Resist strategies were characterized by actions that were intended to preserve the state of the fishery in its pre-pandemic form. Examples include maintaining the same size fishing fleet, shoreside support businesses available in fishing communities, or level of employment within the fishery. At the governance level, this took the shape of providing financial relief to fishers and fishery businesses to try to keep them afloat during this challenging time. It also included lifting restrictions of fish harvesting or other management measures designed to promote the financial stability of fisheries. These actions can be characterized as *resisting* transformation because they are an attempt to prevent the loss or attrition of components of the fishery system (infrastructure, vessels, and fishers) that can destabilize fishing communities or fishery supply chains and result in their loss.

Resist strategies undertaken by individual fishers and by fishery businesses also included strategies designed to keep their fishing operations financially solvent, intended to prevent attrition within the fishery. These strategies were often characterized by losses, fishing harder for less money, taking higher risks to ensure a paycheck, or relying on government compensation to make up for lost income. The *resist* strategy was more likely for fishers in large-scale fisheries, who tended to have greater capital assets and could remain in the fishery even if it meant significantly reduced revenues or a temporary cessation in fishing. Assets are one dimension of adaptive capacity in SESs, as Cinner and Barnes (2019) have described, that allowed many of this segment of the fishery to weather the pandemic.

3.1.2 | Accept strategies

Accept strategies were the most common type of response in the RAD characterization, and reflected an acceptance on the part of fishers, fisheries managers, and other system actors that the pandemic was creating a transformation of the fishery system. These strategies were characterized by system actors adapting to changes in the fishery SES while allowing for these changes to happen, including changes in markets, demand, fishing effort, and revenue. Importantly, most of the strategies that fall under *accept* are those that fishers were already set up to take advantage of through existing diversification of gear, fishery permits, and different types of market networks. Strategies that in pre-COVID times may have only been a small portion of their portfolio afforded the adaptive capacity to meet the changing circumstances of the pandemic, where they became more central. Some of these *accept* strategies may be adaptations to short-term change, while others are likely to be lasting.

3.1.3 | Direct strategies

Fewer *direct* strategies were documented in this study; however, many of those identified involved substantive changes to the fishery supply chain, such as adopting direct sales to consumers or participating in other types of alternative marketing strategies, or changing the types of fish being caught or processed to better meet consumer demand. These *direct* strategies represent an active shift on the part of fishers and others in the supply chain to change how fish are being marketed and sold, which could have long-term implications for the structure and function of the fishery SES. A common theme throughout each of the regions was an increase in fishers participating in direct sales to seafood consumers using social media, social networks, and informal selling venues such as from the dock or from the side of the road. Small-scale fishers in particular were able to successfully adapt to localized markets because they were in many cases already embedded in local communities and regularly participated in sharing networks and other alternative economies. They also operate on a lower-cost, lower-volume model that allows direct sales to make up a greater percentage of their revenue. However, fishers were somewhat constrained in their ability to further adopt *direct* strategies by regulations including permits, quota, and other barriers to entry in various fisheries, as well as by market limitations.

3.2 | Adaptive strategies to pandemic-related disruptions

Analysis and comparison of pandemic-related impacts to fisheries and the individual and system-level responses that followed illuminated a number of different types of adaptation strategies across the regions. Types of adaptive strategies are discussed below, as well as how they map onto the RAD framework, along with a description of the driver and impacts that led to this adaptive response. Examples from each of the regions are provided, along with sample quotes from survey and interview respondents to illustrate each point.

3.2.1 | Disruptions to fish harvesting and livelihoods

Change in commercial fishing effort

> We just catch small and sell small for the community, that's it
>
> (Saipan, PIR fisher).

Early in the COVID-19 pandemic, there was a swift drop in market demand for seafood across the regions as restaurants closed and supply chains were disrupted. This led to a subsequent drop in price along with considerable market uncertainty. Regions where tourism contributes significantly to the local economy, including Puerto Rico, USVI, and much of the PIR, were especially affected by the loss of demand for fresh seafood in restaurants. Exports also decreased substantially during the early pandemic because of supply chain disruptions, exacerbating market stagnation associated with ongoing tariff issues.

These factors initially led to a widespread reduction in commercial fishing effort to adapt to the new market realities. Many commercial fishers responded to these changes by fishing less often, adapting to the smaller volume of demand in local markets, or by pausing fishing activity altogether. For example, many fishers in Puerto Rico and USVI reported a complete cessation in fishing activity in the initial months of the pandemic. Other fishers (Northeast, PIR) reported taking shorter trips or fishing closer to shore to save on fuel costs and mitigate the risk of a longer trip. Some fishers reported retiring early in the pandemic because they were not making enough money and decided to leave fishing. Reducing or ceasing fishing are examples of *accept* strategies on the part of these fishers, who were adapting to a shift in demand and lower prices by reducing effort.

Some fishers reported leaving fishing to switch to a different industry, including both other marine resource industries such as aquaculture and offshore wind energy, or land-based industries, as a response to pandemic-related fishing challenges. This can be considered a *direct* response on the part of fishers, who seized the pandemic as an opportunity for change.

On the other hand, many other fishers reported maintaining the same level of effort while making less revenue, or in some cases fishing harder to try to make up for lost revenue. Other fishers reported fishing farther out to sea, taking longer trips, or fishing in bad weather, all in an effort to catch more fish and earn revenues that were on par with their pre-pandemic revenues, when fish prices were higher. These can each be considered *resist* strategies on the part of fishers because they are endeavoring to maintain or restore their overall level of fishing effort and income, which serves to resist transformation of both their livelihoods and of the fishery system overall, which will be altered by the attrition of both fishers and vessels.

At the fishery management level, state and federal governments provided considerable economic relief to fishers in the form of CARES Act funds, which were available to fishers who could demonstrate financial losses. This can be considered a *resist* strategy on the part of fisheries management, who infused money into the fishery SES to prevent a near-term transformation of the fishery system through the loss of fishery participants, and to maintain fisheries infrastructure such as processing and portside businesses, all of which require an active fishing fleet. Likewise, there were examples of fishery managers temporarily lifting harvesting restrictions in some fisheries, which can be viewed as an attempt to facilitate additional fishery income to resist system transformation.

Changes in fishing labor availability

> Everybody and their brother was getting big money for nothing through unemployment… but there's a few people right now who are looking for crew and they're not finding them… I don't know if they're going to find anybody or not, because like I said, they're getting free money
>
> (Maine, Northeast fisher).

Fishers identified numerous challenges related to labor needed to help run fishing operations. A fear of contracting COVID-19 while fishing led some fishers to operate with smaller or no crew, with many fishers reporting they chose to limit crew members to family or trusted individuals. Some fishers in both the Northeast and the PIR reported forming a pod or "bubble" with their crew, although others in the PIR stopped fishing altogether out of health concerns. In Alaska, family and Tribal operations turned to smaller, familiar social networks to continue fishing. In other cases, captains chose to fish with fewer crew to reduce costs.

At the same time, vessel owners across the regions also reported challenges in attracting and maintaining sufficient crew to staff their fishing operations during the pandemic. Fishers in both California and the Northeast reported that crew members who were newly eligible for unemployment assistance from pandemic relief funds chose to stop fishing because unemployment payments were more profitable than their jobs in the fishing industry. Where there was uncertainty around the demand for seafood in addition to lower market prices, crew members were likely to continue receiving unemployment funds rather than return to fishing. In the PIR, however, almost all of the crew is foreign labor, who did not qualify for funds for PPE or unemployment compensation. Vessel owners choosing to fish with fewer crew or changing the makeup of the crew in response to external factors can be considered an *accept* strategy that adjusts fishing practices to match the realities of the pandemic. Other fishers reported fishing with the same crew in order to financially support their crew members or to keep them employed for more profitable times, which can be considered a *resist* strategy.

Switching species

> We have nets that can catch bluefish [*Potatomus saltatrix*]… So when fluke [*Paralichthys dentatus*] in Rhode Island closed, I was like, I'm gonna try it, so we went and caught a bunch of bluefish… They were a buck-fifty during COVID… I never caught them before in my life. It was nuts - you can't make that up.
>
> (Rhode Island, Northeast fisher).

Fishers from all regions reported switching among species or targeting new species as an adaptation to the demand challenges brought about by the pandemic. In regions with significant tourism industries, small boat fisheries' adaptations in target species were a response to the shift from a tourism-based market to a local market. Not all small-scale fishers were so resilient; some lobster (*Homarus americanus*) fishers in the Northeast had greater difficulty finding buyers for their catch and were not easily able to shift their efforts to other species when demand for their high-value, luxury product declined. These fishers are typically not well diversified in their fishery participation and permits (Henry & Johnson, 2015). Similarly, in California, fishers chose not to target Dungeness crab (*Metacarcinus magister*) because of its lower price and consequently low value per effort.

Some large-scale fishing operations also engaged in species switching or stopped targeting certain species. For example, large-scale trawlers in the Northeast, which are multispecies vessels normally targeting squid and groundfish species, were often able to switch among these species, targeting whichever species had the highest price or greatest demand at the time. Many multispecies fishers reported shifting from species typically sold in the fresh food market, where sales are more likely to be directed to restaurants, toward species destined for the frozen market, as prices for frozen product markets held up somewhat better than for fresh products. Switching target species can be considered an *accept* strategy where fishers are targeting species within their existing fisheries portfolio (adjusting effort within a given group of species), in that fishers are making adjustments to meet market demands, or a *direct* strategy, where fishers are targeting entirely new species to meet an emerging species demand. In either case, shifting the species that are targeted can impact the SES through both fishing mortality and shifts in markets and infrastructure, which can have broad implications for the structure and composition of the fishery.

3.2.2 | Disruptions to supply chains and markets

Processing shifts

Instances of COVID-19 impacts on processing were noted in several regions. Northeast fishers reported processor closures due to the lack of buyers and oversupply of seafood. COVID-19 outbreaks occurred at several processing plants in the Northeast and Alaska (White et al., 2022), causing delays and even closures of processing activities, while travel restrictions in Alaska communities also reduced available labor. In some cases, processing plants reported that the labor shortage restricted the processing capacity, with some interviewees noting that processing capacity was down 35%–50%. The closure of processing plants meant that some catcher–processors were stuck at sea waiting to offload their fish for weeks at a time. California fishers described how these disruptions in processing meant they needed to plan and communicate their fishing activities with processors with much more advance warning.

In many cases, fishers were asked by dealers or fishing co-ops to bring in less catch so as not to flood the market with product that could not be sold. On O'ahu, Hawai'i, for example, by mid-March 2020, less than half the longline fleet was still fishing. A steep drop in price for fish meant fishing was no longer profitable. In response, the Hawai'i Longline Association set a maximum catch per fishing trip, while in tandem, the United Fishing Auction based in Honolulu restricted the weight of fish it would accept.

As described earlier, some processors and dealers that had the capacity to do so switched from fresh to frozen seafood products, in some cases purchasing additional equipment and storage. Frozen product is more likely to be sold in supermarkets and other retail settings for home consumption, where demand actually increased during the pandemic (Hagenbuch, 2021), and additionally can be stored for long periods while awaiting the return of higher prices. Processors and dealers limiting the amount of fish they would buy early in the pandemic is an example of an *accept* strategy, reducing the total amount of seafood in the supply chain in line with a shift in demand. On the other hand, a shift to frozen product can be viewed as a *direct* strategy, whereby these players in the supply chain are capitalizing on the opportunity to switch to a new product and strategy, in some cases investing in new equipment or freezer capacity to meet a shifting market.

Sales and marketing adaptation strategies

> This year because of the pandemic I started my own retail business… my wife and my sister actually set up a retail thing… We're actually buying a lot of fish from other boats that are local to the region
>
> (New Hampshire, Northeast fisher).

Although the direct sale of seafood products to consumers was already practiced in some regions, all regions saw a sizable increase in the number of fishers making direct sales and the overall volume of direct sales. Selling seafood directly to consumers by participating in a community-supported fishery or other alternative marketing strategy allowed many fishers to receive a higher price for their catch. *Direct* sales also allowed consumers to connect directly with fishers, bypassing supply chain disruptions and providing consumers with locally caught seafood. In the Northeast, many fishers reported getting assistance from family members or crew to help with direct sales through Facebook or at the farmers' market. Some California fishers recalled building or expanding online stores and turning to apps such as Instagram and Nextdoor to market their catch locally. Fishers reported earning higher prices for their catch with direct sales, and many planned to continue to participate in direct sales after many of the pandemic-driven social distancing requirements ended.

Dockside sales and other alternative marketing strategies adopted by fishers are all examples of *direct* strategies. In each case, fishers are changing the nature of supply chains, shortening them to provide better access to consumers and better prices for seafood. In many examples, fishers were making longer-term investments, such as purchasing freezer trucks or starting a retail business, to actively shape the seafood supply chain in a way that is more appropriate to shifts in demand and to circumvent pandemic-driven supply chain disruptions.

Although direct sales were a strategy undertaken primarily by individual fishers, some state and territorial governments responded in turn with measures designed to support the seafood industry, such as campaigns promoting local seafood or enabling direct sales of seafood where they had previously been restricted (Smith et al., 2020). These represent *direct* strategies at a higher level of governance. While it is unknown how many of these strategies persisted beyond the timeframe of data collection (Spring 2020 to Spring 2021), innovations such as direct sales have potential to seed longer-term transformations of fishery supply chains. Many fisher participants in each of the regions described plans to continue direct sales past the initial stages of the pandemic, and some considered expanding their operations.

Food security strategies

> We donated a lot of fish and still continue to donate a lot of fresh fish to, you know, nonprofits that serve food to our kūpuna [elders], to our neighbors, to those in need, to those who are facing hunger crises. And so, you know, maybe 2020 wasn't a profitable year in terms of the bottom line, but it's allowed us to really focus on what we can do, you know, as a food producing partner in the community
>
> (O'ahu, PIR fisher).

Some shifting economic strategies focused more explicitly on local food security. For example, some small-scale fishers in the PIR and Alaska exemplified maneuverability by shifting toward barter and subsistence fishing. In Alaska, some commercial fisheries associated with rural Community Development Quota programs (which allow rural Alaskan villages to invest in certain fisheries to support economic development) were closed; instead, fishers were paid to fish for subsistence for community sharing. Many fishers were directly or indirectly involved in food donation programs. In California, Santa Barbara fishers reported that their local fishing organization received a donation from a nonprofit that paid for them to catch and deliver fish to a local food bank, providing an alternative to the processor and restaurant markets that were not buying early in the pandemic. The Hawai'i seafood industry donated approximately 350,000 servings of fresh fish to those in need (NMFS, 2021). Some Alaskan fishing organizations set up fish donation programs, delivering fish boxes to local elders and those in need in response to local food shortages associated with supply chain disruptions.

These efforts represent *accept* strategies on the part of both community organizations and fishers. Community organizations were addressing a new reality that included increased food insecurity and hunger on the part of community members resulting from the pandemic, and a need to support local fishers. Fishers, accepting the changes in demand for their product, were often willing to donate their catch or sell it for a lower price to food aid organizations as a way to keep fishing and to provide a service to the local community.

3.3 | Adaptability

The ability to adapt to rapid shifts in market demand, both in volume and species, varied by fishery and individual fisher attributes. Adaptability of individual fishers was shaped by fishery specific, often interacting factors of available capital, vessel size, catch volume, availability of different species, ability to shift gear types, and ability to shift to different market strategies. Many of these factors were subject to external constraints related to management regulations, permit histories, and markets.

Flexibility, including permit and market diversification, proved to be particularly important in determining fishery- and individual-level responses. Fishers in multispecies fisheries were often more able to adapt to market changes by shifting their target species to species for which there was a stronger demand at a given point in time. Small-scale fishers, who often demonstrate higher permit diversity, were also more nimble in adjusting their target species. In the USVI, for example, tourism-focused lobster (*Panulirus argus*) fishers were able to quickly transition to the "potfish" fishery for home consumption, whereas pelagic fishers had to purchase new gear to better target demersal fish. Some smaller-scale fishers were able to adapt to some of the challenges of the pandemic through alternative marketing or direct sales. Their participation in a lower-volume fishery allowed them to effectively sell a sufficient percentage of their catch through direct sales to make up for some of their lost revenues.

By contrast, single species fisheries by their nature had less flexibility to adapt. This was the case for high-volume, single species fisheries like squid (*Doryteuthis pealeii* and *Illex illecebrosus*) or herring (*Clupea harengus*), where fishers' business model is to sell a high volume of catch to a single dealer. They could not as easily switch target species to make up for the lost revenue. Fishers participating in large-scale, high-volume fisheries were also not able to adapt through alternative marketing strategies. On the other hand, small-scale fishers participating solely in single-species fisheries (e.g., American lobster [*Homarus americanus*] in the Northeast) were similarly unlikely or unable to respond to changes in market demand by shifting species.

Conversely, many large-scale fisheries with greater capital weathered the early pandemic-related losses more easily, while small-scale fisheries, which tend to have much less capital to fall back on, suffered greater immediate losses (NMFS, 2020). For example, in Alaska, large catcher–processor vessels that could stay out at sea longer fared better than smaller vessels that required multiple port stops or crew turn over.

4 | DISCUSSION

4.1 | Fisheries transformations in the COVID-19 pandemic

Just as ecological transformations of SESs can have profound effects on livelihoods, human well-being, and food security, abrupt perturbations to established social conditions also have the potential to transform SES. We used the RAD framework to better understand the extent to which fishery adaptations to social changes stemming from COVID-19 might represent an opportunity to either prevent or guide system transformation following an unprecedented SES social disturbance. Facilitating such adaptations may become increasingly necessary if large-scale social disturbances become more common, as has been suggested is likely under current climate trajectories (Buma & Schultz, 2020; Ferguson et al., 2022).

Unlike previous applications of the RAD framework that focus on ecological transformations, where managers are the ones undertaking RAD strategies, our application of the framework to fishery SESs includes managers, fishers, and supply chain actors as participants with agency to *resist*, *accept*, or *direct* social ecosystem transformation. Managers can facilitate or constrain the number and type of options in any of the RAD strategies available to system participants via regulatory, policy, and management decisions (Clifford et al., 2022), yet how system participants act within that decision space determines the transformation's broader social outcomes. This expansion of the RAD framework better reflects the true nature of SESs, where humans are participants within the system, not just external managers of the system's ecological components. Expanding on the framework in this way is important to understanding the role all system actors can play in resisting, accepting, or directing system transformation, and how these actions shape the future of a SES.

Many of the adaptation strategies we observed were short-term coping mechanisms to address sudden changes in fishery markets and access, with the expectation or hope of a "return to normal." This was especially prevalent in research conducted early in the pandemic, when most people did not expect the pandemic to last more than a few months, let alone multiple years. This assumption is reflected in the stronger emphasis on *resist* strategies in our dataset, which attempted to maintain the pre-pandemic SES structure, and the scarcity of *direct* strategies, especially at the governance level. Furthermore, as previously noted, many of the *direct* strategies were undertaken by individual actors who were constrained by what was possible within the established regulatory structure.

As with ecological uncertainty, this brings into question how to identify periods of incremental versus transformational variation (Kates et al., 2012). As a "press"-type disturbance (one that is long term and continuous) (Piégay et al., 2020), it can be challenging for system actors to identify in the moment whether the system is experiencing a transformation or simply a temporary disruption. At what point is it necessary to forgo efforts to maintain system structures and enact transformational adaptation to prevent or reduce sizable risks inevitable in the face of climate uncertainty? What are the barriers to transformative actions, and how can these be remedied to initiate lasting change in otherwise vulnerable systems (Bierbaum et al., 2013; Woods et al., 2022)? These are questions for social and ecological systems alike on the cusp of transformation. Similarly, could an institutional emphasis on short-term societal resilience (Resist) prevent movement toward creative *accept* or *direct* strategies that might improve overall long-term societal resilience? Answering such questions will require system actors to openly acknowledge the possibility of irreversible ecosystem change and engage in thoughtful dialogue about the implications of various courses of action. Techniques such as scenario planning show promise in helping to identify options that will meet management goals across multiple possible sets of future ecosystem conditions (Frens & Morrison, 2020).

4.2 | Lessons in resilience

The significant social and economic consequences of the COVID-19 pandemic not only illuminated many limitations and weaknesses of fishery systems but also demonstrated mechanisms of resilience in the wake of such shocks (Smith et al., 2020; Stoll et al., 2021).

For instance, large-scale and small-scale fisheries displayed different strengths and vulnerabilities to the pandemic that illuminate weaknesses in our global food system while also highlighting opportunities for adaptive capacity. Although large-scale fisheries had the assets, such as financial capital (Cinner & Barnes, 2019), to weather short-term disruption, they were also heavily reliant on global markets. Their supply chains were lengthy and highly globalized, making them very susceptible to systemic shocks (Cottrell et al., 2019; Gephart et al., 2017; Love et al., 2021). Disruption of just one link in the supply chain limited the flow of seafood from harvesters to consumers and made it difficult for large-scale fisheries to adapt beyond the short term (FAO, 2021). Conversely, across regions, small-scale fisheries tended to be more diversified and have more opportunities for adaptation. Small-scale fisheries typically rely on fewer crew, so were less affected by social distancing requirements and crew shortages. In many cases, these fisheries historically employed multiple gear types and shifted between target species depending on market conditions and social obligations, positioning them well for adaptive responses to the pandemic. Small-scale fisheries are also typically low volume, with fewer crew and shorter trips leading to lower fishing costs overall and additional flexibility. Furthermore, small-scale fisheries frequently had more ties to community networks for sharing and direct sales. In this sense, small-scale fishers were already better positioned to adapt to the changing circumstances brought about by the pandemic due to their greater flexibility, a key social dimension of resilience (Cinner & Barnes, 2019).

These experiences illustrate a need to think about economic systems beyond commodity-focused economic models. While managing commercial fisheries as global commodities has resulted in efficient and lucrative commercial markets, there were few alternatives available because of the disruptions to the global supply chain caused by the COVID-19 pandemic. As one of these alternatives, a rapid increase in demand for local or direct-sourced seafood during the pandemic has been observed (Bassett et al., 2021; Stoll et al., 2021), which helped to support the fishing industry as other traditional markets struggled. A reliance on direct marketing as an adaptation strategy was widely noted throughout each of the regions in this study. Many fishers felt this shift to direct sales helped elevate the importance of commercial fishing in local foodways. In addition to contributing to local food security, fishers fulfilled important societal and cultural roles in caring for the community during a time when traditional economies were under threat.

This focus on caring for the community is a core component of other types of economic systems that are less focused on market outcomes and also include diversification in societal roles, as was prevalent in the more successful fishery adaptations. Some researchers have contrasted commodity economies with gift economies, where the exchange of fish as a gift is not only a transaction of food but also maintains social ties and fulfills cultural obligations (McCormack, 2015). Others refer to a social and solidarity economy, where the production and exchange of goods and services are outside of traditional state-run markets and priorities are social well-being, community building, cooperation, and solidarity (Utting et al., 2014). The role of fishers in feeding networks of friends and family, expanding into direct sales that ensured local seafood availability when traditional markets were unreliable, and donations to local food banks reflect characteristics of these alternate economies. Fewer of these types of adaptations were facilitated by fisheries managers and societal scale institutions, indicating a potential need to proactively plan for future social disruptions.

The few *direct* strategies observed at the fisher level reflect opportunities to rethink assessments of social change, including the potential role for activities that support a social and solidarity economy approach. Ecological transformations that result in regime shifts to a new system are typically assumed to be undesirable. Social transformations, on the other hand, could result in better outcomes for society, especially if they are guided to ensure equitable long-term benefits. For example, the shift toward direct and local sales observed in each of the five study regions and a consumer increase in demand for local seafood could provide increasing resilience to fisheries systems moving forward by providing alternative means of connecting fishers with consumers (Stoll et al., 2021). There were also a few examples of fisheries managers revising regulations to permit more dockside and direct sales (Smith et al., 2020). However, examples of fisheries managers restructuring fishing opportunities or directing supply chains to ensure the availability of seafood for domestic consumption were largely absent. This could be a missed opportunity to actively promote an emerging business model built on new technologies and forms of social engagement that strengthen social and solidarity networks. These additional economic models could provide redundancy in the system and provide local independence from global systems in the face of potential future disruptions to global markets, as has been observed in other studies (Ferguson et al., 2022).

4.3 | Directing future fisheries transformation

Our research identified a few ideas that represent fisheries- or system-level changes and could be considered *direct* strategies, but that have not been implemented, nor were they suggested at a broad scale. These include a shift away from reliance on tourism in the PIR, shifting the observer program to electronic monitoring rather than having human observers on board, shifting employment to offshore wind development and operation rather than commercial fishing, establishing online stores for direct marketing, and encouraging local domestic markets for U.S.-caught seafood. These speak to a recognition on the part of fishery actors that the pandemic represents an opportunity to guide transformation toward more stable and potentially more socially desirable outcomes, but also a lack of time, resources, or management support to make them happen.

Fisheries are increasingly experiencing multiple stressors with the potential for SES transformations. Climate-driven ecological transformations, such as species range shifts, habitat shifts, and new interactions between species, are already leading fishers to adopt new strategies, such as shifting fishing grounds, target species, or ports of landing, and the success of community adaptation is shaped by management and reorganization of social networks facilitating necessary adaptations (Barnes et al., 2020; Ojea et al., 2020; Papaioannou et al., 2021). The COVID-19 pandemic resulted in global transformations in the rules and norms governing social interaction to protect public health. While many have hoped for a "return to normal" following the pandemic, global changes in the interactions between people and biodiversity underpin disease emergence, and without preventative strategies, pandemics will emerge more often and have more devastating impacts (Daszak et al., 2020; WHO, 2020). Indeed, projections have estimated the probability of extreme epidemics increasing up to threefold in the coming decades, predominantly due to environmental change (Marani et al., 2021). Experts note that escaping the era of pandemics will require policy options that foster transformative change, beyond business as usual (Daszak et al., 2020; WHO, 2020), and many of their recommendations reflect a shift toward a social and solidarity economy approach.

As future system disturbances are not only likely but also inevitable, application of the RAD framework gives fisheries managers an opportunity to understand and direct future responses. Society is likely to experience further large-scale shocks like the COVID-19 pandemic, particularly as the effects of climate change increase in frequency and magnitude, and interact with other types of anthropogenic disturbances. The opportunity to learn from the COVID-19 pandemic to build resilient strategies that may lead SESs through future disturbances should not be ignored. The prevalence of *resist* strategies suggests that many fisheries SESs may not be well equipped to respond to forthcoming social disturbances and transformations. The *accept* and *direct* strategies identified in this study could be important options to improve long-term social resilience of fisheries SESs in the face of future stressors. These strategies would require larger-scale policy and management support but could better establish social and solidarity economies as part of the larger economic system. Just as fishers who were able to diversify were better able to adapt to the social transformations brought about by COVID-19, diversifying ways of thinking about economic transactions could improve resilience to future disasters that disrupt fishery SESs.

ACKNOWLEDGMENTS

California Department of Fish and Wildlife and the California Ocean Protection Council, with funding administered through California Sea Grant (California research); NOAA COCA Project 2019002753 (Northeast U.S. research).

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ORCID

Sarah Lindley Smith https://orcid.org/0000-0002-6905-2429
Abigail Golden https://orcid.org/0000-0001-9849-6291
Kirsten M. Leong https://orcid.org/0000-0002-5798-5977

REFERENCES

Aura, C.M., Nyamweya, C.S., Odoli, C.O., Owiti, H., Njiru, J.M., Otuo, P.W., Waithaka, E. & Malala, J. (2020) Consequences of calamities and their management: The case of COVID-19 pandemic and flooding on inland capture fisheries in Kenya. *Journal of Great Lakes Research*, *46*, 1767–1775. Available from https://doi.org/10.1016/j.jglr.2020.09.007

Barnes, M.L., Wang, P., Cinner, J.E., Graham, N.A.J., Guerrero, A.M., Jasny, L., Lau, J., Sutcliffe, S.R. & Zamborain-Mason, J. (2020) Social determinants of adaptive and transformative responses to climate change. *Nature Climate Change*, *10*, 823–828. Available from https://doi.org/10.1038/s41558-020-0871-4

Bassett, H.R., Lau, J., Giordano, C., Suri, S.K., Advani, S. & Sharan, S. (2021) Preliminary lessons from COVID-19 disruptions of small-scale fishery supply chains. *World Development*, *143*, 1–8. Available from https://doi.org/10.1016/j.worlddev.2021.105473

Basurto, X., Gelcich, S. & Ostrom, E. (2013) The social-ecological system framework as a knowledge classificatory system for benthic small-scale fisheries. *Global Environmental Change*, *23*(6), 1366–1380. https://doi.org/10.1016/j.gloenvcha.2013.08.001

Belton, B. (2021) FAO and Worldfish. 2021. Aquatic food systems under COVID-19. Rome. 12p. Available from: https://doi.org/10.4060/cb5398en

Bennett, E. M., Peterson, G. D., & Gordon, L. J. (2009) Understanding relationships among multiple ecosystem services. *Ecology Letters*, *12*(12), 1394–1404. Available from: https://doi.org/10.1111/j.1461-0248.2009.01387.x

Bennett, N.J., Finkbeiner, E.M., Ban, N.C., Belhabib, D., Jupiter, S.D., Kittinger, J.N., Mangubhai, S., Scholtens, J., Gill, D. & Christie, P. (2020) The COVID-19 pandemic, small-scale fisheries and coastal fishing communities. *Coastal Management*, *48*(4), 336–347. Available from: https://doi.org/10.1080/08920753.2020.1766937

Bierbaum, R., Smith, J.B., Lee, A., Blair, M., Carter, L., Chapin, F.S.III, Fleming, P., Ruffo, S., Stults, M., McNeeley, S., Wasley, E., & Verduzco, L. (2013) A comprehensive review of climate adaptation in the United States: more than before, less than needed. *Mitigation and Adaptation Strategies for Global Change*, *18*, 361–406. Available from: https://doi.org/10.1007/s11027-012-9423-1

Buma, B., & Schultz, C. (2020). Disturbances as opportunities: Learning from disturbance-response parallels in social and ecological systems to better adapt to climate change. *Journal of Applied Ecology*, *57*(6), 1113–1123. Available from: https://doi.org/10.1111/1365-2664.13606

Center for Disease Control (CDC). (2008) The next flu pandemic, what to expect. Available at: https://www.cdc.gov/flu/pandemic-resources/pdf/nextflupandemic.pdf [Accessed 05 November 2021].

Chapin, F.S. III, Carpenter, S., Kofinas, G., Folke, C., Abel, N., Clark, W., et al. (2010) Ecosystem stewardship: sustainability strategies for a rapidly changing planet. *Trends in Ecology & Evolution*, *25*, 241–249. Available from: https://doi.org/10.1016/j.tree.2009.10.008

Cinner, J.E., & Barnes, M.L. (2019) Social dimensions of resilience in social-ecological systems. *One Earth*, *1*(1): 51–56. Available from: https://doi.org/10.1016/j.oneear.2019.08.003

Clifford, K.R., Cravens, A.E., & Knapp, C.N. (2022). Responding to ecological transformation: mental models, external constraints, and manager decision-making. *Bioscience*, *72*(1), 57–70. Available from: https://doi.org/10.1093/biosci/biab086

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. Available from:. https://doi.org/10.1038/s41893-018-0210-1

Daszak, P., Amuasi, J., das Neves, C.G., Hayman, D., Kuiken, T., Roche, B., Zambrana-Torrelio, C., Buss, P., Dundarova, H., Feferholtz, Y., Földvári, G., Igbinosa, E., Junglen, S., Liu, Q., Suzan, G., Uhart, M., Wannous, C., Woolaston, K., Mosig Reidl, P., O'Brien, K., Pascual, U., Stoett, P., Li, H. & Ngo, H.T. (2020) *Workshop report on biodiversity and pandemics of the Intergovernmental Platform on Biodiversity and Ecosystem Services*. Bonn, Germany: Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), IPBES secretariat. Available from https://doi.org/10.5281/zenodo.4147317

FAO. (2021) The impact of COVID-19 on fisheries and aquaculture food systems, possible responses: Information paper, November 2020, Rome. Available from: https://doi.org/10.4060/cb2537en

Ferguson, C.E., Tuxson, T., Mangubhai, S., Jupiter, S., Govan, H., Bonito, V., Alefaio, S., Anjiga, M., Booth, J. Boslogo, T., Boso, D., Brenier, A., Caginitoba, A., Ciriyawa, A., Fahai'ono, J.B., Fox, M., George, A., Eriksson, H., Hughes, A., Joseph, E., Kadannged, S., Kubunavanua, E., Loni, S., Meo, S., Micheli, F., Nagombi, E., Omaro, R., Ride, A., Sapul, A., Singeo, A., Stone, K., Tabunakawai-Vakalalabure, M., Tuivuna, M., Vieux, C., Vitukawalu, V.B., & Waide, M. (2022). Local practices and production confer resilience to rural Pacific food systems during the COVID-19 pandemic. *Marine Policy*, *137*, 104954. Available from https://doi.org/10.1016/j.marpol.2022.104954

Folke, C., Hahn, T., Olsson, P. & Norberg, J. (2005) Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources*, *30*, 441–473. Available from https://doi.org/10.1146/annurev.energy.30.050504.144511

Frens, K.M., & Morrison, W.E. (2020). Scenario Planning: An Introduction for Fishery Managers. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OSF-9, 38 p. https://media.fisheries.noaa.gov/2020-09/OSF9%20_508_9.11.pdf

Fuller, E.C., Samhouri, J.F., Stoll, J.S., Levin, S.A. & Watson, J.R. (2017) Characterizing fisheries connectivity in marine social-ecological systems. *ICES Journal of Marine Science*, *74*(8), 2087–2096. https://doi.org/10.1093/icesjms/fsx128

Gephart, J.A., Deutsch, L., Pace, M.L., Troell, M. & Seekell, D.A. (2017) Shocks to fish production: Identification, trends, and consequences. *Global Environmental Change*, *42*, 24–32. Available from https://doi.org/10.1016/j.gloenvcha.2016.11.003

Hagenbuch, B. (2021) ASMI report finds COVID-19 pandemic boosted seafood consumption. SeafoodSource, 24 June 2021. Available at: https://www.seafoodsource.com/news/foodservice-retail/asmi-report-finds-covid-19-pandemic-boosted-seafood-consumption [Accessed 05 November 2021].

Henry, A.M. & Johnson, T.R. (2015) Understanding social resilience in the Maine lobster industry. *Marine and Coastal Fisheries*, *7*(1), 33–43. Available from https://doi.org/10.1080/19425120.2014.984086

Holling, C.S. (1986) The resilience of terrestrial ecosystems: local surprise and global change. In: Clark, W.C. & Munn, R.E. (Eds.) *Sustainable Development of the Biosphere*. Cambridge, UK: Cambridge University Press, pp. 292–317.

Kates, R.W., Travis, W.R., & Wilbanks, T.J. (2012) Transformational adaptation when incremental adaptations to climate change are insufficient. *PNAS*, *109*(19), 7157–7161. Available from: https://doi.org/10.1073/pnas.1115521109

Love, D.C., Allison, E.H., Asche, F., Belton, B., Cottrell, R.S., Froelich, H.E., Gephart, J.A., Hicks, C.C., Little, D.C., Nussbaumer, E.M., Pinto da Silva, P., Poulain, F., Rubio, A., Stoll, J.S., Tlusty, M.E., Thorne-Lyman, A.L., Troell, M., & Zhang, W. (2021) Emerging COVID-19 impacts, responses, and lessons for building resilience in the seafood system. *Global Food Security*, *28*, 100494. Available from https://doi.org/10.1016/j.gfs.2021.100494

Lynch, A.J., Thompson, L.M., Beever, E.A., Cole, D.N., Engman, A.C., Hoffman, C.H., Jackson, S.T., Krabbenhoft, T.J., Lawrence, D.J., Limpinsel, D., Magill, R.T., Melvin, T.A., Morton, J.M., Newman, R.A., Peterson, J.O., Porath, M.T., Rahel, F.J., Schuurman, G.W., Sethi, S.A. & Wilkening, J.L. (2021) Managing for RADical ecosystem change: applying the Resist-Accept-Direct (RAD) framework. *Frontiers in Ecology and the Environment*, *19*(8), 461–469. Available from https://doi.org/10.1002/fee.2377

Lynch, A.J., Thompson, L.M., Morton, J.M., Beever, E.A., Clifford, M., Limpinsel, D., Magill, R.T., Magness, D.R., Melvin, T.A., Newman, R.A., Porath, M.T., Rahel, F.J., Reynolds, J.H., Schuurman, G.W., Sethi, S.A., & Wilkening, J.L. (2022a) RAD adaptive management for transforming ecosystems. *Bioscience*, *72*(1), 45–56. Available from: https://doi.org/10.1093/biosci/biab091

Lynch, A.J., Rahel, F.J., Limpinsel, D., Sethi, S.A., Engman, A.C., Lawrence, D.J. et al. (2022b) Ecological and social strategies for managing fisheries using the Resist-Accept-Direct (RAD) framework. *Fisheries Management and Ecology*, *29*(4) 329–345. https://doi.org/10.1111/fme.12545

Magness, D.R., Hoang, L., Belote, R.T., Brennan, J., Carr, W., Chapin, F.S.III, Clifford, K., Morrison, W., Morton, J.M., & Sofaer, H.R. (2022) Management foundations for navigating ecological transformation by resisting, accepting, or directing social-ecological change. *Bioscience*, *72*(1), 30–44. Available from: https://doi.org/10.1093/biosci/biab083

Marani, M., Katul, G.G., Pan, W.K., & Parolari, A.J. (2021) Intensity and frequency of extreme novel epidemics. *Proceedings of the National Academy of Sciences*, *118*(35), 1–4. Available from https://doi.org/10.1073/pnas.2105482118

McCormack, F. (2015) Mauss, interestedness, and disinterest: Hawaiian and Maori fisheries. *Anthropological Forum*, *25*(4), 384–404. Available from: https://doi.org/10.1080/00664677.2015.1044941

Milich, L. (1999) Resource mismanagement versus sustainable livelihoods: the collapse of the Newfoundland cod fishery. *Society and Natural Resources*, *12*(7), 625–642. Available from: https://doi.org/10.1080/089419299279353

National Marine Fisheries Service (NMFS). (2018) Fisheries economics of the United States, 2016: Economics and sociocultural status and trends series. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-F/SPO-187, pp. 1–251. Available at: https://media.fisheries.noaa.gov/dam-migration/feus2016-report-webready4.pdf [Accessed 15 October 2021].

NMFS. (2020) *$300 million in assistance allocated by Secretary of Commerce in CARES Act*. Washington, DC: NOAA Fisheries. Available at: https://www.fisheries.noaa.gov/national/funding-and-financial-services/300-million-assistance-allocated-secretary-commerce-cares [Accessed 15 October 2021].

NMFS. (2021) NOAA Fisheries updated impact assessment of the COVID-19 crisis on the U.S. commercial seafood and recreational for-hire/charter industries. Available at: https://media.fisheries.noaa.gov/2021-02/Updated-COVID-19-Impact-Assessment-webready.pdf [Accessed 15 October 2021].

Nolan, C., Overpeck, J.T., Allen, J.R.M., Anderson, P.M., Betancourt, J.L., Binney, H.A., Brewer, S., Bush, M.B., Chase, B.M., Cheddadi, R., Djamali, M., Dodson, J., Edwards, M.E., Gosling, W.D., Haberle, S., Hotchkiss, S.C., Huntley, B., Ivory, S.J., Kershaw, A.P., Kim, S.H., Latorre, C., Leydet, M., Lezine, A.M., Liu, K.B., Liu, Y., Lozhkin, A.V., McGlone, M.S., Marchant, R.A., Momohara, A., Moreno, P.I., Muller, S., Otto-Bliesner, B.L., Shen, C., Stevenson, J., Takahara, H., Tarasov, P.E., Tipton, J., Vincens, A., Weng, C., Xu, Q., Zheng, Z., Jackson, S.T. (2018) Past and future global transformation of terrestrial ecosystems under climate change. *Science*, *361*, 920–923. Available from: https://doi.org/10.1126/science.aan5360

Ojea, E., Lester, S.E. & Salgueiro-Otero, D. (2020) Adaptation of fishing communities to climate-driven shifts in target species. *One Earth*, *2*, 544–556. Available from: https://doi.org/10.1016/j.oneear.2020.05.012

Ojea, E., Pearlman, I., Gaines, S. D., & Lester, S. E. (2017). Fisheries regulatory regimes and resilience to climate change. *Ambio*, *46*(4), 399–412. Available from: https://doi.org/10.1007/s13280-016-0850-1

Ostrom, E. (2009) A general framework for analyzing sustainability of social-ecological systems. *Science*, *325*(5939): 419–422. Available from: https://doi.org/10.1126/science.1172133

Papaioannou, E.A., Selden, R.L., Olson, J., McCay, B.J., Pinsky, M.L. & St. Martin, K. (2021) Not all those who wander are lost - responses of fishers' communities to shifts in the distribution and abundance of fish. *Frontiers in Marine Science*, *8*, 1–25. Available from: https://doi.org/10.3389/fmars.2021.669094

Partelow, S., & Boda, C. (2015). A modified diagnostic social-ecological system framework for lobster fisheries: case implementation and sustainability assessment in Southern California. *Ocean and Coastal Management*, *114*, 204–217. Available from: https://doi.org/10.1016/j.ocecoaman.2015.06.022

Perry, R.I., Ommer, R.E., Barange, M., Jentoft, S., Neis, B. & Sumaila, U.R. (2011) Marine social-ecological responses to environmental change and the impacts of globalization. *Fish and Fisheries*, *12*(4), 427–450. Available from: https://doi.org/10.1111/j.1467-2979.2010.00402.x

Piégay, H., Chabot, A., & Le Lay, Y-F. (2020) Some comments about resilience: from cyclicity to trajectory, a shift in living and non-living system theory. *Geomorphology*, *367*(15), 106527. Available from: https://doi.org/10.1016/j.geomorph.2018.09.018

Salgueiro-Otero, D., & Ojea, E. (2020) A better understanding of social-ecological systems is needed for adapting fisheries to climate change. *Marine Policy*, *122*, 104123. Available from: https://doi.org/10.1016/j.marpol.2020.104123

Schuurman, G.W., Cole, D.N., Cravens, A.E., Covington, S., Crausbay, S.D., Hawkins Hoffman, C., Lawrence, D.J., Magness, D.R., Morton, J.M., Nelson, E.A., & O'Malley, R. (2022) Navigating ecological transformation: resist-accept-direct as a path to a new resource management paradigm. *Bioscience*, *72*(1), 16–29. Available from: https://doi.org/10.1093/biosci/biab067

Smith, S.L., Golden, A.S., Ramenzoni, V., Zemeckis, D.R. & Jensen, O.P. (2020) Adaptation and resilience of commercial fishers in the Northeast United States during the early stages of the COVID-19 pandemic. *PLoS ONE*, *15*(12), pp. 1–31, Available from: https://doi.org/10.1371/journal.pone.0243886

Stoll, J.S., Harrison, H.L., De Sousa, E., Callaway, D., Collier, M., Harrell, K. et al. (2021) Alternative seafood networks during COVID-19: Implications for resilience and sustainability. *Frontiers in Sustainable Food Systems*, *5*, 1–12. https://doi.org/10.3389/fsufs.2021.614368

Teh, L.C.L. & Sumaila, U.R. (2011) Contribution of marine fisheries to worldwide employment. *Fish and Fisheries*, *14*(1), 77–88, Available from: https://doi.org/10.1111/j.1467-2979.2011.00450.x

Thompson, L.M., Lynch, A.J., Beever, E.A., Engman, A.C., Falke, J.A., Jackson, S.T., Krabbenhoft, T.J., Lawrence, D.J., Limpinsel, D., Magill, R.T., Melvin, T.A., Morton, J.M., Newman, R.A., Peterson,

J.O., Porath, M.T., Rahel, F.J., Sethi, S.A. & Wilkening, J.L. (2021) Responding to ecosystem transformation: Resist, accept, or direct? *Fisheries*, *46*(1), 8–21. Available from: https://doi.org/10.1002/fsh.10506
Utting, P., van Dijk, N., & Matheï, M.-A. (2014) Social and solidarity economy: Is there a new economy in the making? UNRISD Occasional Paper: Potential and Limits of Social and Solidarity Economy, No. 10. Geneva: United Nations Research Institute for Social Development (UNRISD), pp. 1-61. Available at: http://hdl.handle.net/10419/148793 [Accessed 15 October 2021].
Walker, B. & Meyers, J.A. (2004) Thresholds in ecological and social–ecological systems: a developing database. *Ecology and Society*, *9*(2), 3 Available from: http://www.ecologyandsociety.org/vol9/iss2/art3/
White, E.R., Froehlich, H.E., Gephart, J.A., Cottrell, R.S., Branch, T.A., Bejarano, R.A. & Baum, J.K. (2020) Early effects of COVID-19 on US fisheries and seafood consumption. *Fish and Fisheries*, *22*, 232–239. Available from: https://doi.org/10.1111/faf.12525
White, E.R., Levine, J., Moeser, A., & Sorensen, J. (2022) The direct and indirect effects of a global pandemic on US fishers and seafood workers. *PeerJ*, *10*:e13007. Available from: https://doi.org/10.7717/peerj.13007
Woods, P.J., Macdonald, J.I., Bárðarson, H., Bonanomi, S., Boonstra, W.J., Cornell, G., Cripps, G., Danielsen, R., Färber, L., Ferreira, A.S.A, Ferguson, K., Holma, M., Holt, R.E., Hunter, K.L., Kokkalis, A., Langbehn, T.J., Ljungström, G., Nieminen, E., Nordström, M.C., Oostdijk, M., Richter, A., Romagnoni, G., Sguotti, C., Simons, A., Shackell, N.L., Snickars, M., Whittington, J.D., Wootton, H., & Yletyinen, J. (2022) A review of adaptation options in fisheries management to support resilience and transition under socio-ecological change, *ICES Journal of Marine Science*, *79*(2), 463–479. Available from: https://doi.org/10.1093/icesjms/fsab146
World Health Organization (WHO). (2020) *WHO Manifesto for a healthy recovery from COVID-19*. Geneva, Switzerland: World Health Organization. Available at: https://www.who.int/news-room/feature-stories/detail/who-manifesto-for-a-healthy-recovery-from-covid-19 [Accessed 5 November 2021].

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

How to cite this article: Smith, S. L., Cook, S., Golden, A., Iwane, M. A., Kleiber, D., Leong, K. M., Mastitski, A., Richmond, L., Szymkowiak, M. & Wise, S. (2022). Review of adaptations of U.S. Commercial Fisheries in response to the COVID-19 pandemic using the *Resist-Accept-Direct* (RAD) framework. *Fisheries Management and Ecology*, *29*, 439–455. https://doi.org/10.1111/fme.12567