



One-Year COVID-19 Pandemic Impacts on U.S. Caribbean Small-Scale Fisheries with a note on the Puerto Rican earthquake swarm of 2020 and 2021.

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Abstract

Small-scale fisheries around the world are facing significant hardships in the wake of the COVID-19 pandemic. This report provides an overview of a rapid socio-economic assessment of the impacts U.S. Caribbean small-scale fishers face and their responses one year into the pandemic. Drawing on 309 phone interviews with fishing captains around the Commonwealth of Puerto Rico and the Territory of the U.S. Virgin Islands, we examined how the pandemic affected fishing activity, revenues, and employment. In addition, we inquired about the main coping strategies used to withstand the impacts of the pandemic, and briefly touch on the impacts of the pandemic on the for-hire sector.

The survey found that the loss of seafood markets and/or reduced prices and, to lesser degree, governmental restrictions were the principal reasons fishers suspended their fishing activities for some time during 2020. Close to 60% of Puerto Rican respondents stopped fishing for more than 3 months compared to 39% of Crucian interviewees and 24% of St. Thomian and St. Johnian interviewees. Fishers from St. Thomas and St. John reported that their fishing activity fell by 59% in calendar year 2020 relative to the previous year, whereas the fishing activity of fishers from St. Croix and Puerto Rico dropped by 52%. On average, St. Thomian and St. Johnian fishers reported losing roughly \$48,000 in 2020, whereas Crucian and Puerto Rican fishers lost about \$23,650 and \$9,500, respectively.

Thirty-five percent of the respondents from St. Croix reduced their crew size compared to 27% from St. Thomas and St. John, and 15% from Puerto Rico. Of those fishers reporting downsizing their crew size, U.S. Virgin Islands fishers stated laying off, on average, 2 crewmembers and Puerto Rican fishers 1 crewmember. U.S. Caribbean fishers weathered the impacts of the pandemic thanks to the support of family and friends, personal savings, and social protection programs. Noteworthy is that Puerto Rican fishers tended to rely more on government assistance, whereas U.S. Virgin Islands fishers tended to depend more on personal savings. Finally, we inquired about the impacts of the Puerto Rican earthquake swarm of late 2020 and early 2021. Puerto Rican respondents stated that the swarm slowed down their fishing for several reasons, including emotional distress, cancelation of tourist reservations, closure of restaurants and bars, physical damage to fishing centers, changes in the ocean floor, and fish bite shutdown.

Key words: COVID-19, Caribbean, U.S. Virgin Islands, Puerto Rico, small-scale fishers, livelihoods, socio-economic, coping strategies, earthquake.

1. Introduction

The COVID-19 pandemic and the ensuing governmental containment policies (lockdowns, curfews, social distancing mandates) to contain its spread caused supply and demand shocks that affected the livelihoods and food security of millions of small-scale fishers around the world (FAO, 2020 and 2021a; Bennett et al., 2020; Stokes et al., 2020; Bassett et al., 2021; NMFS, 2021). In many places, the livelihoods of small-scale fishers were negatively affected by, among other things, the loss of demand, particularly from the leisure and hospitality sector and export markets (FAO, 2021a and 2021b; Glazier et al., 2021; NMFS, 2021; Campbell et al., 2021; Mangubhai et al., 2021; Love et al., 2021; Fernández-González et al., 2021; Ferrer et al., 2021); mobility restrictions (Aura et al., 2020; Sunny et al., 2021; Lopez-Ercilla et al., 2021; Mangubhai et al., 2021); reduced fish consumption (Fiorella et al., 2021; Bassett et al., 2021; Campbell et al., 2021); shifts in consumer preferences (Fiorella et al., 2021; Love et al., 2021); fishing input shortages (Aura et al., 2020; Sunny et al., 2021); reduced fishing times (Aura et al., 2020; Fiorella et al., 2021; Stokes et al., 2020; Bassett et al., 2021); loss of seasonal fishing opportunities (White et al., 2021); uncertainty about the duration of pandemic (FAO, 2021a and b); and health concerns (Bassett et al., 2021; Sunny et al., 2021; FAO, 2021a and b; NMFS, 2021). In addition, securing government support proved challenging because many small-scale fishers participate in the informal economy, and have limited (or no) representation (FAO, 2021a).

The aim of this work is to contribute to a growing literature concerned with the impacts of the COVID-19 pandemic on small-scale fisheries (e.g., Steenbergen et al., 2020, Vanuatu; Aura et al., 2020 and Fiorella et al., 2021, Kenya; Truchet et al., 2021, Argentina; Pedroza-Gutiérrez et al., 2021 and Lopez-Ercilla et al., 2021, Mexico; Sunny et al., 2021, Bangladesh; Grillo-Núñez et al., 2021, Peru; Agar et al., 2022, Puerto Rico; just to name a few). While most of these works focused on the immediate impacts of the pandemic, this research examines one-year impacts. This study focuses on the U.S. Caribbean region and considers 3 main questions. First, what were the main factors that disrupted small-scale fishing operations? Second, what were the medium-term impacts on fish production, employment, and

revenues? Last, how did fishers cope with the disruptions brought about the pandemic? The rest of this article is structured as follows: Sections 2 and 3 introduce the study site and methods employed, respectively; Section 4 summarizes and discusses the main results; and Section 5 offers the main conclusions of this study.

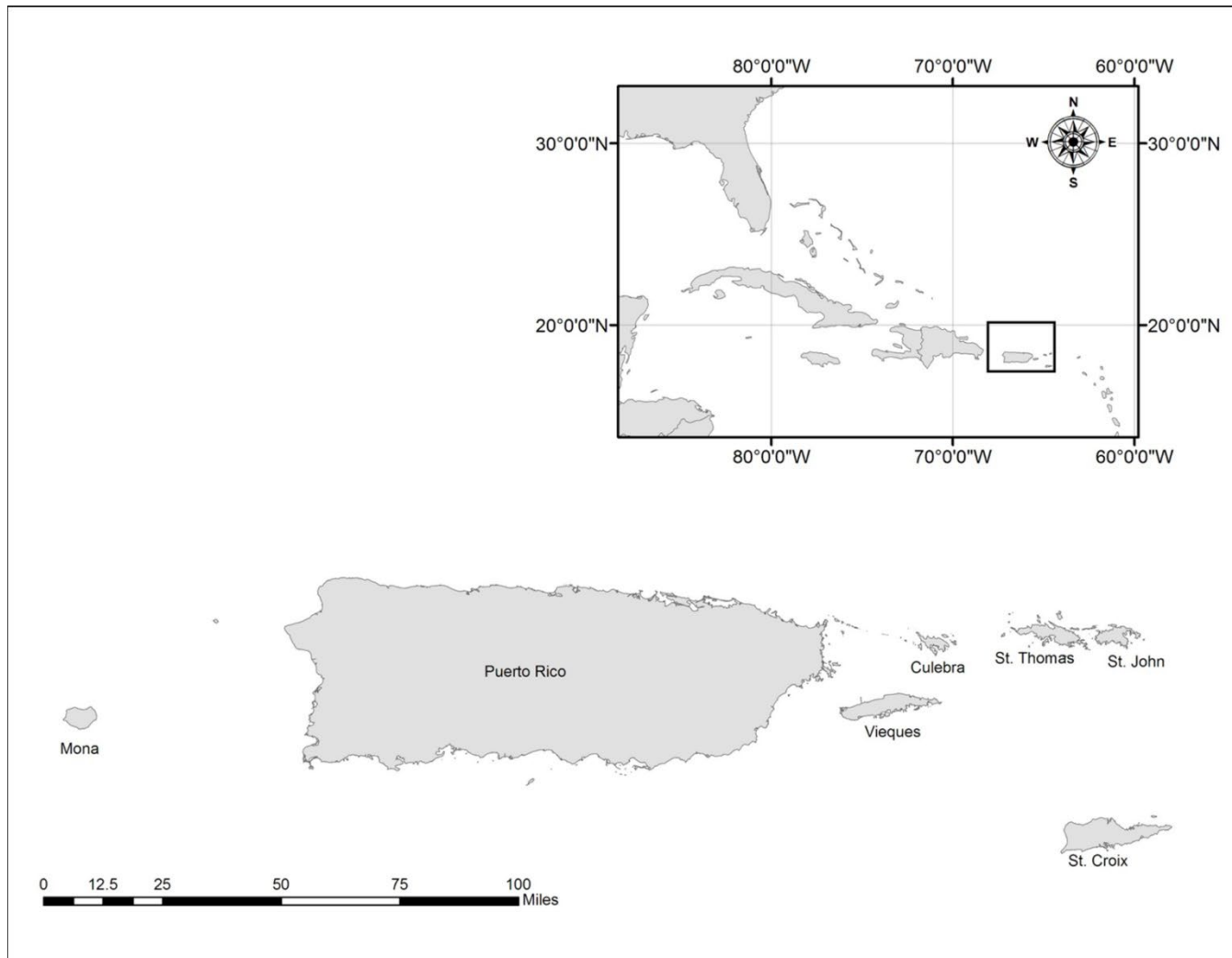
2. Fishery background

The U.S. Caribbean encompasses the Commonwealth of Puerto Rico and the Territory of the United States Virgin Islands (U.S. Virgin Islands), which lie in the northeast Caribbean (Figure 1). The Commonwealth of Puerto Rico is an archipelago consisting of the main island of Puerto Rico, several smaller islands (e.g., Mona, Culebra, and Vieques), and cays (Suarez-Caabro, 1979). The Territory of the U.S. Virgin Islands has three major islands, St. Thomas, St. John and St. Croix, and about 50 cays (Kojis et al., 2017). The U.S. Virgin Islands are administratively and politically divided into two districts: St. Thomas/St. John, and St. Croix (Kojis et al., 2017).¹

U.S. Caribbean fisheries are small-scale in nature but are an important source of income, food, employment, and cultural heritage to many coastal communities (Fiedler and Jarvis, 1932; Jarvis, 1932; Gutiérrez-Sánchez, 1982; Griffith et al., 2007; Stoffle et al., 2011; Matos-Caraballo and Agar, 2011; Valdés-Pizzini et al., 2010; Valdés-Pizzini, and Agar. 2012; Kojis et al., 2017). Stoffle et al. (2011) note that the U.S. Virgin Islands are unique in that most (if not all) of the local fish production is sold and consumed locally (i.e., there are no exports). There are around 1,200 Puerto Rican licensed fishers but fewer than 900 (including crew) appear in fishery statistics (NMFS, 2022). In the U.S. Virgin Islands, there are 119 licensed fishers in St. Thomas and St. John, and another 141 licensed fishers in St. Croix (Kojis et al., 2017).

¹ Puerto Rico and the U.S. Virgin Islands have an area of 9,104 km² (3,515 mi²) and 1,910 km² (737 mi²), respectively.

Figure 1: Map of the Commonwealth of Puerto Rico and the Territory of the U.S. Virgin Islands.



Fishers are highly dependent on local fisheries for food security and economic stability; nonetheless, many pursue other occupations to make ends meet. They supplement their fishing income with other income derived from formal and informal non-fishing, wage-earning opportunities. Fishers also work in construction, agriculture, tourism, and other industrial activities (e.g., oil refinery and rum production).

In 2019, Puerto Rican fishers landed 2.5 million pounds (mp) of seafood worth \$12.1 million and U.S. Virgin Island fishers landed 0.46 mp of seafood valued at \$1.9 million. Although, hurricanes Irma and Maria adversely impacted both jurisdictions (Stoffle et al., 2020; Seara et al., 2020; Agar et al., 2020), landings and revenues have been slow to recover in the U.S. Virgin Islands, especially in St. Croix. In 2017, fishers from the U.S. Virgin Islands landed about 0.75 mp of seafood valued at \$4.4 million. U.S. Caribbean fishers use various fishing gears such as scuba and skin diving (including spearfishing), manual and electric hook-and-line (vertical lines, handlines, longlines), traps or pots, and nets (trammel and gillnets) to catch spiny lobsters, queen conchs, reef fishes, and miscellaneous coastal pelagic species (Matos-Caraballo and Agar, 2011; Tonioli and Agar, 2011; Kojis et al., 2017). It is common for fishers to catch multiple species (and even use multiple gears) within a single trip. Fishers target different species depending on various variables such as seasonality, moon phases, and tides.

Most fishing revenues are concentrated on a few species. For example, in Puerto Rico between 2015 and 2019, 7 species accounted for 77% of the island's revenues: spiny lobster (28%), queen conch (17%), silk snapper (12%), queen snapper (7%), yellowtail snapper (5%), dolphinfish (4%), and lane snapper (3%; NMFS, 2022). Fishers from the U.S. Virgin Islands target similar species, including spiny lobster, queen conch, reef fishes (olewife/triggerfish, parrotfish, snapper, grouper, and grunt) and pelagic species (such as tuna, dolphinfish/mahi-mahi, wahoo, and kingfish). Most of the spiny lobster landed by fishers St. Thomas/St. John caught with traps whereas most of the spiny lobster landed by Crucian fishers is caught with SCUBA. Fishers from the U.S. Virgin Islands also target queen conch, a highly valued species for local and tourist consumption, with fishers from St. Croix landing more of this species than

their St. Thomian/St. Johnian counterparts do.

The U.S. Caribbean fishing fleet is made up of small-sized vessels that have moderate levels of propulsion and mechanization. In Puerto Rico, the average vessel length is 20 feet (ft), whereas in St. Thomas and St. John is 25 ft, and in St. Croix is 22 ft (Matos-Caraballo and Agar, 2011; Kojis et al., 2017). The average engine propulsion rate in Puerto Rico is 80 horsepower (hp), 110 hp in St. Thomas and St. John, and 90 hp in St. Croix (Matos-Caraballo and Agar, 2011; Kojis et al., 2017). A captain and a deckhand run most fishing operations with the exception of dive operations, which have larger crews because of safety concerns and productivity reasons (Agar and Shivlani, 2017; Kojis et al., 2017).

Puerto Rico's Department of Natural and Environmental Resources (DNER), U.S. Virgin Islands' Department of Planning and Natural Resources (DPNR), and the Caribbean Fishery Management Council (CFMC) are the main fishery management agencies. DNER manages out to 9 nautical miles (nm) from the shore, DPNR manages up to 3 nm from the coast, and the CFMC manages from 3 (or 9 in the case of Puerto Rico) to 200 nm. Puerto Rican fisheries are under a regulated open access regime with the exception of a limited entry program for the deep-water snapper-grouper fishery (i.e., queen and cardinal snappers). In contrast, fisheries in the U.S. Virgin Islands' are managed with a limited entry program that has been in place since 2001. Federal and commonwealth/territorial fishery managers use a variety of management measures, such as annual catch limits (or quotas), trip limits (for queen conch), gear restrictions, size limits, seasonal and area closures, and other miscellaneous restrictions (CFMC, 2021). There are also seasonal sales bans of regulated species during their spawning seasons; however, there is a short grace period at the onset of the seasonal closures so that fishers and dealers can exhaust their inventory (Agar et al., 2019).

3. Methods

3.1. Puerto Rico Data Collection

To understand the one-year socio-economic consequences of the COVID-19 pandemic, we

conducted a rapid assessment that targeted small-scale fishing captains and for-hire operators. However, because of the small sample of for-hire operators (n=8 for those that reported working exclusively on this sector (charters), and n=3 for those that worked on both the for-hire (charters) and commercial sectors), we focus our discussion (and tables) on those that exclusively worked on the small-scale (commercial) fishing sector. Nonetheless, we briefly touch on for-hire impacts in the document. The sampling frame was based on the population of fishing captains, who reported landings statistics in (2018 and/or 2019), or self-identified as a fishing captain in a recently conducted post-hurricane María fisher census. The sampling frame was the same used for the 6-month socio-economic assessment of the pandemic.

In total, we conducted 237 voluntary telephone interviews with Puerto Rican small-scale fishing captains. The unadjusted response rate was 74.3% which was estimated by dividing the total number of completed interviews by the total number of people contacted (N=319); however, if we ignore unreachable fishers (n=14), then the effective response rate rises to 77.7%. The main reasons for the non-responses were failure to reach fishers after three contacts (21.3%) and disconnected/wrong phone numbers (4.4%).

The sampling protocol had interviewers contact fishing captains over the telephone. To satisfy the requirements of the sampling protocol, trained interviewers drew a replacement fisher only if the randomly selected fisher a) declined to participate; b) was unavailable due to illness, travel, or death; or c) was unreachable after 3 separate attempts. Port agents from the DNER's Fisheries Research Laboratory and contracted field assistants, recent university graduates, conducted the telephone interviews.

We employed a national COVID-19 survey instrument developed by social scientists from the National Marine Fisheries Service (NMFS). We modified the survey slightly to ensure that closed-ended questions better aligned with the local context and translated it into Spanish. The data were entered into a Qualtrix platform. The survey instrument had both closed and opened-ended questions that inquired about a) demographic background; b) whether fishers were impacted by the pandemic and for how long; c) COVID-19 related factors that most affected fishing operations and its impacts on fishing activity,

employment, and revenues; and d) main sources of support to cope with COVID-19 related impacts. The survey instrument is available upon request from the authors. Canvassing began in March 1 and ended in April 26, 2021.

3.2. U.S. Virgin Islands Data Collection

Similar to the research effort undertaken in Puerto Rico, fishers from the U.S. Virgin Islands participated in a rapid socio-economic assessment focusing on a “one year later” examination of impacts of COVID-19 on the commercial and for-hire sectors. Because travel restrictions prevented face-to-face interviews, phone surveys were conducted. In total 84 folks were surveyed, of whom 72 were small-scale fishers, 8 were for-hire operators (charters), and another 4 fished commercially and ran for-hire operations. The tables in this report focus on the 72 small-scale fishers, but the report discusses for-hire impacts. In addition, 7 semi-structured key informant interviews provided greater insight into the impact of COVID-19 on the Islands, the residents, the tourism industry and the local fisheries. Surveys and interviews were conducted in either English or Spanish depending on interviewee preference.

4. Results and discussion

4.1. Sample characteristics

The average small-scale fishing captain was a middle-aged male with substantial fishing experience. (Table 1). On a jurisdiction basis, Puerto Rican fishers were slightly younger (56 yrs.) than their peers from the U.S. Virgin Islands (58 yrs.); however, they had a slightly larger cohort of 65 years and older fishers, which placed them at a greater risk of contracting COVID-19. Close to 29% of the Puerto Rican fishers polled fell in the 65 and older age bracket, while 26% of the Crucian and 21% of the St. Thomian and St. Johnian fishers did. Mueller et al. (2020) report that adults over 65 years of age represent 80% of hospitalizations and have a 23-fold greater risk of death than those under 65 years old. Fishers from St. Thomas and St. John and St. Croix were most seasoned fishers averaging 31 and 30 years of fishing experience, respectively. Puerto Rican fishers, on average, had 24 years of fishing experience.

Table 1: Sample characteristics by jurisdiction.

	St. Thomas & St. John	N	St. Croix	N	Puerto Rico	N
Number of fishers (count)	29	-	43	-	237	-
Age (yrs)	58.1 (11.0)	29	57.6 (14.3)	43	55.6 (13.9)	234
Fishing experience (yrs)	30.9 (13.4)	28	30.0 (12.9)	43	23.6 (15.9)	233
Completed High School (Yes, %)	76.9	26	47.1	34	69.6	227
Fishing main source of personal income (%)		29		43		237
Yes	58.6		65.1		73.8	
No	41.4		34.9		25.7	
Prefer not to answer	-		-		0.4	
Vessel length (ft)	26.6 (9.8)	16	22.9 (6.8)	32	20.9 (4.7)	224
Fishing areas (%)		29		43		237
Commonwealth/Territorial	24.1		44.2		62.9	
Federal	6.9		7.0		3.4	
Both	69.0		48.8		32.9	
Prefer not to answer			-		0.8	

Mean and standard deviation in parentheses, unless otherwise noted.

Respondents had significant levels of fishing dependence and moderate levels of formal education (Table 1). The proportion of respondents, who stated that fishing was their primary source of income, was highest in Puerto Rico (74%) and lowest in St. Thomas and St. John (59%). Sixty-five percent of Crucian fishers stated fishing was their main source of personal income. Fishers from St. Thomas and St. John and Puerto Rico reported higher levels of formal education than their St. Croix counterparts did. High school completion rates ranged from 47% in St. Croix to 77% in St. Thomas and St. John. About 70% of Puerto Rican respondents said they had completed high school (Table 1).

Most interviewees owned a single boat but some reported owning up to three. Fishers from St. Thomas and St. John, on average, had larger boats (27 ft) than Crucian (23 ft) and Puerto Rican (21 ft) fishers. Sixty-three percent of the Puerto Rican fishers fished in Commonwealth waters (≤ 9 nm) whereas 29% of St. Thomian and St. Johnian fishers and 49% of Crucian fishers fished in territorial (≤ 3 nm; Table 1).

For-hire operators in our sample (data not shown in tables) were slightly younger (50 and 55 years old in Puerto Rico and the U.S. Virgin Islands, respectively), had more formal education (88% completed high school in Puerto Rico and 100% in the U.S. Virgin Islands), and operated slightly larger vessels (31 ft in Puerto Rico and 35 ft in the U.S. Virgin Islands) than their commercial counterparts. About 2/3 of the for-hire operators from both Puerto Rico and the U.S. Virgin Islands reported that fishing was their main source of income.

4.2. COVID-19 disruptions and fisher responses

Disruptions

The majority of the U.S. Caribbean fishing operations were impacted by the COVID-19 pandemic (Table 2). The loss of markets and/or reduced markets, and, to a lesser degree, governmental restrictions were the 2 most COVID-19 related disruptive forces across all 3 jurisdictions. Seventy-three percent of St. Thomian and St. Johnian fishers ranked the loss of seafood markets and/or reduced prices as the most disruptive force compared to 68% of Crucian fishers and 47% of Puerto Rican fishers (Tables 3, 4 and 5). Noteworthy, is that relative to the first 6 months of the pandemic, governmental restrictions became

less burdensome. Glazier et al. (2022) report that in the first 6 months of the pandemic, 72% of the fishers reported that governmental restrictions were among the top 3 factors that had the largest impact on fishing businesses, whereas this study found that only 21% of Puerto Rican respondents and 15% of U.S. Virgin Islands respondents ranked governmental restrictions as the most disruptive force of the pandemic. For-hire operators from both Puerto Rico and the U.S. Virgin Islands also reported that governmental restrictions and the small number of clients (data not shown in tables) were the most important factors impacting their business. As a Puerto Rican for-hire operator explained:

“We had to reduce the number of passengers on board and equip the boat with materials to conform with the CDC [Center for Disease Control and Prevention] COVID-19 protocols. We had adapt our fishing equipment and the manner we fished to maintain social distancing”

Tables 3, 4 and 5 list other COVID-19 related factors that disrupted small-scale fishers’ normal fishing operations. With the exception of difficulties accessing marinas or port facilities, the list of COVID-19 related factors exhibited strong differences across jurisdictions. For instance, fishers from St. Croix stressed greater complications accessing bait and supplies (47%) than their peers from St. Thomas and St. John (12%) and Puerto Rico (2%) did. In addition, the impact of the increased costs related to safety protocols for COVID-19 were higher for St. Thomian and St. Johnian (27%) and Puerto Rican (27%) fishers than for Crucian fishers (4%). Noteworthy is that the impact of crew unavailability and dealer instructions not to fish were somewhat minor in St. Croix and Puerto Rico (6-8%) but non-existent in St. Thomas and St. John.

Table 2: COVID-19 related disruptions relative to the 1st semester of 2019 (Jan-Jun), even if temporary.

	St. Thomas & St. John	N	St. Croix	N	Puerto Rico	N
Was your fishing operation affected by COVID-19? (%)						
Yes	89.7	29	79.1	43	98.7	237
No	10.3		20.9		1.3	
Did you stop fishing for any period from Jan. to Dec. due to COVID-19? (%)						
Yes	65.4	26	82.4	34	86.8	234
No	34.6		17.7		12.4	
Prefer not to answer	-		-		0.9	
Duration of fishing inactivity (%)						
Less than 1 month	17.7	17	32.1	28	4.4	205
1-3 months	47.1		21.4		25.4	
More than 3 months	23.5		39.3		58.1	
Indefinitely with plans to resume fishing	11.8		7.1		10.7	
Prefer not to answer	-		-		1.5	
Went out of business	-		-		-	

Table 3: Disruptions to normal fishing operations in 2020 relative to 2019 in St. Thomas & St. John.

Disruptions to normal fishing operations in 2020 relative to 2019	St. Thomas & St. John (%)	Ranking of disruptions (%)			N
		1 st Ranked	2 nd Ranked	3 rd Ranked	
Reduced number of trips	80.8	7.7	57.7	7.7	26
Loss of seafood markets/reduced prices	92.3	73.1	11.5	7.7	26
Governmental restrictions	50.0	15.4	3.9	26.9	26
Added costs related to safety protocols for COVID-19	3.9	-	3.9	-	26
Developed new seafood markets	38.5	-	3.9	19.2	26
Other	11.5	-	-	-	26
Difficulties accessing marina or port facilities	11.5	-	3.9	3.9	26
Instructed not the fish by dealer	-	-	-	-	26
Crew unavailability or loss	-	-	-	-	26
Shifted fisheries	11.5	-	-	-	26
Difficulties obtaining bait and/or supplies	11.5	3.9	-	7.7	26
Prefer not to answer	-	-	-	-	26

Table 4: Disruptions to normal fishing operations in 2020 relative to 2019 in St. Croix.

Disruptions to normal fishing operations in 2020 relative to 2019	St. Croix (%)	Ranking of disruptions (%)			N
		1 st Ranked	2 nd Ranked	3 rd Ranked	
Reduced number of trips	88.2	11.8	50.0	23.5	34
Loss of seafood markets/reduced prices	91.2	67.7	14.7	5.9	34
Governmental restrictions	55.9	14.7	14.7	14.7	34
Added costs related to safety protocols for COVID-19	26.5	-	-	-	34
Developed new seafood markets	41.2	-	5.9	17.7	34
Other	32.4	2.9	-	2.9	34
Difficulties accessing marina or port facilities	11.8	-	-	-	34
Instructed not the fish by dealer	5.9	-	2.9	-	34
Crew unavailability or loss	5.9	-	-	-	34
Shifted fisheries	11.8	-	2.9	5.9	34
Difficulties obtaining bait and/or supplies	47.1	2.9	-	8.8	34
Prefer not to answer	-	-	-	-	34

Table 5: Disruptions to normal fishing operations in 2020 relative to 2019 in Puerto Rico.

Disruptions to normal fishing operations in 2020 relative to 2019	Puerto Rico (%)	Ranking of disruptions (%)			N
		1 st Ranked	2 nd Ranked	3 rd Ranked	
Reduced number of trips	83.8	17.0	47.7	14.5	235
Loss of seafood markets/reduced prices	80.0	47.2	24.3	7.2	235
Governmental restrictions	46.0	21.3	5.1	17.0	235
Added costs related to safety protocols for COVID-19	27.2	-	2.6	17.9	235
Developed new seafood markets	14.5	4.7	5.1	3.8	235
Other	12.8	4.3	1.7	0.9	235
Difficulties accessing marina or port facilities	8.9	0.9	2.1	3.8	235
Instructed not the fish by dealer	8.1	1.3	1.7	2.1	235
Crew unavailability or loss	6.4	0.4	0.4	1.7	235
Shifted fisheries	3.0	-	-	2.6	235
Difficulties obtaining bait and/or supplies	2.1	0.9	0.9	0.4	235
Prefer not to answer	1.7	-	-	-	235

Fisher Responses

Due to their “essential worker” status, U.S. Caribbean fishers were able to continue fishing and selling seafood. However, the loss of tourism from reduced cruise ship and air travel activity, the closure (either temporary or permanent) of hotels, restaurants and bars, and strict governmental restrictions forced many fishers to interrupt their fishing activities and/or alter their fishing strategies (e.g., targeting different species, and catching different amounts).

Puerto Rico reported the highest percentage of fishers (87%), who suspended their fishing, followed by fishers from St. Croix (82%) and St. Thomas and St. John (65%). Table 2 provides a breakdown of the length of time that fishers ceased to operate. Puerto Rican fishers tended to interrupt their activities for longer periods probably because of heightened contagion fears (particularly among older fishers), in addition to poor market conditions and strict governmental restrictions. Approximately 58% of the Puerto Rican fishers suspended their fishing for more than 3 months whereas only 39% of the Crucian fishers and 24% of the St. Thomian and St. Johnian fishers stopped fishing for that long.

When asked how their normal fishing operations were affected by the pandemic over the entire calendar year 2020 relative to 2019, even if only temporarily, respondents overwhelmingly reported that they reduced the number of fishing trips. On a jurisdictional basis, St. Croix had the highest percentage of fishers that reduced their fishing effort (88%), followed by Puerto Rico (84%), and St. Thomas and St. John (81%; Tables 3, 4, and 5). Although, the aggregate demand for local seafood dropped significantly, not all species were impacted equally. Fishers from the U.S. Virgin Islands were more aggressive (than their Puerto Rican peers were) developing alternative markets for their catches and shifting target species. Forty-one percent of Crucian fishers and 39% of St. Thomian and St. Johnian fishers reported developing new markets, relative to 15% of Puerto Rican fishers (Tables

3,4, and 5). About 12% of Crucian and St. Thomian and St. Johnian fishers said they shifted fisheries compared to only 3% of Puerto Rican fishers.

In the U.S. Virgin Islands, as the demand for tourist-favored species, such as spiny lobster and pelagics (e.g., tuna, wahoo, and dolphinfish/mahi-mahi) declined, fishers began catching more potfish species (e.g., parrotfish, olewive/triggerfish, grunt and snapper). Potfish consumption grew because these species were a staple in the diet of many residents and because these were competitively priced relative to other local seafood and store bought products. Smith et al. (2022) report that some pelagic fishers from the U.S. Virgin Islands purchased new fishing gear to target demersal species.

In Puerto Rico, the targeting behavior was tied to market conditions and the timing of the seasonal closures. For instance, Agar et al. (2022) report that Puerto Rican fishers switched from catching large snappers such as silk, yellowtail, and queen snappers (which were sold whole) to catching dolphinfishes, wahoos (which were sold as fillets) because the latter were practical and profitable choices for takeout. A small number of Puerto Rican fishers reported that they had begun catching more dolphinfish after the silk snapper seasonal closure began. One Puerto Rican respondent reported switching to lobster traps (from fish traps) because of the cost of wire and corrosion concerns with his fish traps, particularly during the hurricane season. Hanke et al. (2020) reported that Puerto Rican fishers lost \$1,900 in gear damages and losses, mainly from passive (or soaking) gears such as traps, gillnets, and trammel nets because governmental restrictions prevented their timely retrieval.

In addition to changing their fishing practices, many U.S. Caribbean fishers adopted novel marketing and delivery strategies, such as taking orders and, in many cases, delivering it directly to the consumer. One of the more interesting examples of this is highlighted in the newly formed product delivery relationship with the Limetree (oil refinery) workers in the U.S. Virgin

Islands. These employees would often pool money for end of the week parties, where they would gather on the Limetree residence compound having pre-ordered high-end species, such as tuna and mahi-mahi. Meeting this demand provided skilled fishers, who were known for targeting highly valued pelagics, an opportunity to supply the market and make some money fishing. Agar et al. (2022) discuss how Puerto Rican fishers worked with their fishing centers (villas pesqueras) to coordinate fishing activities (e.g., number of trips per week, catch composition) to align fish production with the existing demand.

The loss of tourism also impacted the for-hire sector. In Puerto Rico and the U.S. Virgin Islands, restrictions on cruise ship and air travel eliminated a steady stream of visitors that have historically been major suppliers of clients for their services. Some for-hire operators coped by taking trips to catch fish for their own consumption and others reduced their prices to encourage island based clients to charter trips (often reducing the cost by over 50% such as in the U.S. Virgin Islands). For-hire operators from the U.S. Virgin Islands noted that if a boat was not running, it was breaking down, and for that reason, many would find any reason to go out fishing. Others actually used the down time from fishing to pull the boats out of the water and make repairs or upgrades for when they were able to return to fishing. Under normal circumstances, a for-hire operator from the U.S. Virgin Islands might be booked for 4 to 6 trips a week, but during COVID-19 many reported that they would be lucky to get that many in a single month (some stating that they had lost all their charters due to cancelations). In addition to the revenue lost from tourist clientele, there was also the loss of revenue from canceled fishing tournaments, impacting not only the fishery but the local hotels and restaurants that catered to the competitors from both off and on Island.

4.3. Production, economic and employment losses

Despite the reopening of local economies, fishers' assessments about business conditions differed by jurisdiction. In general,

St. Thomian and St. Johnian fishers were more optimistic whereas Puerto Rican fishers were more pessimistic. Forty-two percent of the fishers from St. Thomas and St. John said that business conditions had improved in the 2nd semester of 2020 (relative the 1st semester of 2020) compared the 29% from St. Croix, and 22% from Puerto Rico. By contrast, 50% of the fishers from Puerto Rico said that business conditions had worsened during the same period compared to 21% of fishers from St. Croix and 15% of fishers from St. Thomas and St. John (Table 6).

When asked about the level of fishing activity in calendar year 2020 relative to the previous calendar year, respondents from St. Thomas and St. John stated that they were operating at a slightly lower level (41%) than interviewees from St. Croix and Puerto Rico (48%; Table 6). Predictably, most fishers reported revenue shortfalls because these are tied to the productivity of their fishing operations. On a jurisdictional basis, the percent of revenue loss in calendar year 2020 relative to the previous year was 53% for Crucian fishers, 55% for St. Thomian and St. Johnian fishers, and 62% for Puerto Rican fishers. When asked for a dollar estimate of the above losses, fishers from St. Thomas and St. John stated that they lost almost \$48,000 whereas Crucian and Puerto Rican fishers cited losses of about \$13,650 and \$9,500, respectively.

Most fishers reported that they did not lay off crew, with the exception of Crucian operations. Thirty-five percent of the fishers from St. Croix said they reduced their crew size compared to 27% from St. Thomas and St. John, and 15% from Puerto Rico. Of those fishers reporting downsizing their crew size, U.S. Virgin Islands fishers reported laying off, on average, 2 crew and Puerto Rican fishers 1 crewmember.

4.4. Coping strategies

One year into the pandemic, U.S. Caribbean fishing captains credited the support of family and friends, personal savings,

and government assistance as the most popular and helpful coping strategies to combat the disruptions caused by the pandemic (Table 8); however, their reliance differed across jurisdictions. For example, 47% of Puerto Rican fishers stated that government assistance was the most helpful coping strategy compared to 8% of St. Thomian and St. Johnian fishers and 6% of Crucian fishers (Table 8). By contrast, personal savings was ranked as the most helpful coping strategy by 39% of fishers from St. Thomas and St. John, 35% of fishers from St. Croix, and 19% of fishers from Puerto Rico. We are unclear why Puerto Rican fishers leaned more on government assistance and U.S. Virgin Islands fishers relied more on personal savings, but one contributing factor may be the higher poverty rate in Puerto Rico. The 2010 U.S. census found that 44.9% of the Puerto Rican population lives in poverty compared to 22% of the population in the Virgin Islands.²

Table 6: COVID-19 related changes in fishing activity and revenues.

Changes in fishing activity and revenues	St. Thomas & St. John	N	St. Croix	N	Puerto Rico	N
Fishing activity level in calendar year 2020 relative to 2019 (0-100%)	41.0 (22.2)	23	48.3 (25.5)	32	48.2 (26.4)	228
Changes in business conditions relative to the first half of 2020 (Jan-June, %)						
Gotten worse	15.4	26	20.6	34	50.4	234
Stayed the same	38.5		47.1		26.5	
Improved	42.3		29.4		21.8	

² The more recent 2020 US Census indicated that 43.4% of Puerto Rico's population lives in poverty but figures for the U.S. Virgin Islands were not available at the time of writing.

Prefer not to answer	3.9		2.9		1.3	
Revenue changes in 2020 due to COVID-19						
Decreased	96.2	26	94.1	34	85.5	234
Stayed the same	3.9		2.9		10.3	
Increased	-		2.9		2.6	
Prefer not to answer	-		-		1.7	
Share of revenue decrease relative to calendar year 2019 (%)	55.4 (24.0)	22	53.2 (21.7)	28	62.0 (21.1)	189
Forgone fishing income (\$)	47,980.0 (89,495.7)	10	23,650.0 (23,641.5)	16	9,427.5 (7,051.9)	160

Mean and standard deviation in parentheses, unless otherwise noted.

Table 7: COVID-19 related changes in fishing activity and employment.

Changes in fishing activity and employment	St. Thomas & St. John	N	St. Croix	N	Puerto Rico	N
Fishing activity level in 2020 relative to calendar year 2019 (%)	41.0 (22.2)	23	48.3 (25.5)	32	48.2 (26.4)	228
Crew employment changes in 2020 due to COVID-19 (%)						
No change	73.1	26	61.8	34	81.2	234
Decreased	26.9		35.3		15.4	
Prefer not to answer	-		-		2.6	

Increased	-		2.9		0.9	
Current employment levels on all vessels (excluding self)	1.3 (2.1)	22	1.7 (1.4)	33	1.3 (0.8)	223
Fewer employees	2.0 (1.5)	7	1.9 (1.5)	11	1.3 (1.0)	32

Mean and standard deviation in parentheses, unless otherwise noted.

During our fieldwork, one commercial fisher from the U.S. Virgin Islands commented on fishers' reluctance to seek small business loans and personal loans from banks. He explained his position in light of the cumulative impacts of hurricanes Irma and Maria of 2017 and then the prevalence of COVID-19 in 2020.

“The problem with using loans and borrowing money from banks is that you have to have collateral and go through a lot of time and search into your life; showing you have collateral and that you will be able to pay it back. We can't predict the future. We have just suffered massive losses and borrowing money to fix things only puts me in a bad spot. You see if we put up our trucks and our house as collateral what happens if we can't pay the loan back. It is better to just do it on our own. So you make sure you have some money put away for the boat. Then do your own repairs or have someone you know help you.

If you have to borrow money, do it from someone close who knows that you can pay them back but may need a little more time. Sometimes you can also do something for them to pay them back like help them fix something or go fishing and make sure that they have fish for their family.”

Table 8: Main coping strategies to withstand the effects of the COVID-19 pandemic.

Coping strategies	St. Thomas & St. John (%)	Most helpful (%)	St. Croix (%)	Most helpful (%)	Puerto Rico (%)	Most helpful (%)
Family and friends	57.7 (n=26)	38.5 (n=26)	61.8 (n=34)	44.1 (n=34)	47.9 (n=234)	27.9 (n=215)
Personal savings	61.5 (n=26)	38.5 (n=26)	67.7 (n=34)	35.3 (n=34)	35.0 (n=234)	18.6 (n=215)
Government assistance	7.7 (n=26)	7.7 (n=26)	50.0 (n=34)	5.9 (n=34)	50.9 (n=234)	46.5 (n=215)
Other	11.5 (n=26)	-	5.9 (n=34)	2.9 (n=34)	9.4 (n=234)	5.6 (n=215)
Prefer not to answer	-	-	-	-	8.1 (n=234)	-
Church, community groups, etc.	26.9 (n=26)	7.7 (n=26)	11.8 (n=34)	2.9 (n=34)	6.9 (n=234)	0.9 (n=215)
Crew and/or employees	-	-	-	-	0.4 (n=234)	-
Fishing associations	-	-	-	-	-	-
Worked different job	-	7.7 (n=26)	-	8.8 (n=34)	0.4 (n=234)	0.5 (n=215)

Table 9: Types of assistance received to withstand the effects of the COVID-19 pandemic.

Coping factors	St. Thomas & St. John (%)	N	St. Croix (%)	N	Puerto Rico (%)	N
Federal Stimulus Check	92.3	26	82.4	34	75.3	223
Unemployment benefits	-	26	8.8	34	50.7	223
Private bank loan/line of credit	-	26	-	34	0.5	223
Other	38.5	26	79.4	34	24.7	223
SBA loans	3.9	26	2.9	34	0.9	223
Paycheck Protection Program	3.9	26	-	34	0.9	223
Denied/not qualified for assistance	11.5	26	14.7	34	0.5	223
Did not request financial assistance	42.3	26	23.5	34	4.0	223
Prefer not to answer	-	26	-	34	1.8	223

Table 8 shows that support of family and friends ranked high in all three jurisdictions ranging from 28% in Puerto Rico to 44% in St. Croix, underscoring the importance of social connections to help navigate the profound challenges to everyday life brought about by the pandemic. Fishers also mentioned other less popular coping strategies such as support from churches and community groups, crewmembers, and fishing associations, working a different job, and other (catch all option). Of these less common coping strategies, support of churches and community groups was the most cited strategy, especially in the U.S. Virgin Islands. However, in terms of being the ‘most helpful’ strategy, working a different job equaled or surpassed the importance of receiving support from churches and communities groups in the U.S. Virgin Islands. Less than 1% of Puerto Rican fishers stated that working a different job was the most helpful coping strategy, perhaps because of health concerns and contagion fears. In addition, the extended benefits of the CARES Act may have discouraged many from searching for new employment opportunities, and because of their reluctance to disclose their income sources not to risk their access to public assistance as noted earlier.

Under the other (or catch all) option, most Puerto Rican fishers mentioned social security, pensions, working on construction and agriculture, helping out with boats repairs and fibreglassing, and taking on miscellaneous odd jobs (known as ‘chiripas’) such as working as a handyman building patios and painting homes, etc. Anecdotally, DNER officials mentioned that a small number of women active in the recreational sector became crew in small-scale operations to support their families. These women turned to crewing because of a combination of related factors, including a lower influx of domestic and international tourists, the extended closure of marinas and launching sites, and the cancellation (or postponement) of fishing tournaments. Noteworthy, is the minor role of fishing association and crewmembers as means to help withstand the adverse impacts of the pandemic.

Finally, the survey asked about financial assistance that fishers were able to access since January 2020. Overwhelmingly, the most popular source of financial assistance across all jurisdictions was the federal stimulus check ranging from 75% in Puerto Rico to 92% in St. Thomas and St. John.

Unemployment benefits were popular in Puerto Rico (51%) but not in St. Croix (9%) and St. Thomas and St. John (0%). Notably, 42% of St. Thomian and St. Johnian fishers and 24% of Crucian fishers did not request financial assistance compared to only 4% of Puerto Rican fishers. The Paycheck Protection Program and SBA loans were not widely used by U.S. Caribbean fishers (<4%).

4.5. A note on the earthquake swarm in Puerto Rico³

Before the COVID-19 pandemic began, the livelihoods of fishers living along the southwestern coast of Puerto Rico were under stress. Starting on December 28, 2019 the region suffered from a swarm of earthquakes, which included over 10 earthquakes with an intensity of 5 or higher on the Richter scale. Among the most devastating ones were 3 that occurred in early January 2020, which caused the collapse of the electrical system, heavy landslides, and substantial destruction in multiple areas, especially in the municipalities Guayanilla, Guánica, Utuado, Peñuelas, Ponce and Yauco. These earthquakes forced thousands to take refuge in shelters or to sleep in the open because of fear of their homes collapsing. A recent U.S. Geological Survey study acknowledges that the aftershocks will likely continue for years, if not decades (van der Elst et al., 2020).

This study also inquired about impacts of the recent seismic activity on the local fishing activity. Earthquakes and aftershocks affected 35% of the respondents, particularly those that lived on the south (74%) and west (47%) coasts. When we inquired about levels of home damage, 81 out of the 230 Puerto Rican fishers responded. Only 15% said that their homes had been completely destroyed (5%) or severely damaged (10%). Most respondents (60%) reported no damages.

When we parsed level of home damage by coastal area, we found that the percentage of fishers living on the north coast appeared to have been most impacted presumably, because they relocated. However, this finding was likely skewed by the low number of responses from the northern coast (i.e., 16 observations from the north coast vs. 32 and 28 observations from the south and west coasts, respectively).

³ Earthquakes do not appear to be an issue with the fishers from the U.S. Virgin Islands

When asked how the earthquakes had affected their livelihoods, most fishers reported that they interrupted or reduced their fishing because of 3 main reasons. One key reason was emotional distress. Earthquake survivors often experience temporary difficulty adjusting and coping because of post-traumatic stress disorder (PTSD; Pistoia et al., 2018; Orengo-Serra and Sánchez-Jauregui, 2021). Tang et al. (2017) report that PTSD rates in adults can range from 4% to 67% following an earthquake. Fishers explained that because earthquakes were unpredictable and ongoing, they were reluctant to go fishing not only out fear for their safety at sea, but also because they were anxious about leaving their families behind. Many fishers were also concerned that earthquakes could generate tsunamis; some divers were worried that their eardrums could burst if they went fishing. Another reason for the slowdown was the sharp drop in seafood demand because of the cancellation of tourist reservations and the damage and/or closure of many restaurants and bars. The swarm also damaged many fishing centers, where fishers land their catches and store their boat and fishing gear.

Additionally, many fishers stated that the earthquakes had caused changes in the ocean floor and shutdown the fish bite. Fishers explained that earthquakes destroyed reefs, caves, and crevices, where lobster hide making it harder to find them. One fisher said that after the tremors fish did not want to bite and hid (*“Los peces no quieren picar, se escondieron después de los temblores”*). Another fisher said that he had to increase the number of fish traps and let them soak longer to catch the same amount of fish.

5. Conclusions

One year into the COVID-19 pandemic, this study finds that many small-scale fishers continue to struggle. Although governmental restrictions eased throughout the U.S. Caribbean, the loss of seafood markets mostly in hospitality and leisure sectors, forced many to interrupt and/or lessen their fishing activities. Close to 60% of Puerto Rican fishers reported that they suspended their fishing for more than 3 months compared to 39% of Crucian fishers and 24% of St. Thomian and St. Johnian fishers. St. Croix had the highest percentage of fishers that reduced their fishing effort (88%), followed by Puerto Rico

(84%), and St. Thomas and St. John (81%).

On average, the fishing activity of fishers from St. Thomas and St. John fell by 59% in calendar year 2020 relative to the previous year whereas the fishing activity of fishers from St. Croix and Puerto Rico dropped by 52%. St. Thomian and St. Johnian fishers lost, on average, \$48,000 in 2020 whereas Crucian and Puerto Rican fishers lost about \$23,650 and \$9,500, respectively during the same period. The pandemic also affected employment. About 35% of the fishers from St. Croix reduced their crew size compared to 27% from St. Thomas and St. John, and 15% from Puerto Rico. Of those fishers downsizing their crew size, U.S. Virgin Islands fishers reported laying off, on average, 2 crew and Puerto Rican fishers 1 crew.

The study also found that fishers weathered the impacts of the pandemic thanks to the support of family and friends, personal savings, and social protection programs. The importance of the support of family and friends underscores the importance of social connections to deal with the daily challenges caused by the pandemic. The study also documented that the federal stimulus check was the most popular source of financial assistance. Finally, this study showed that rapid assessments could be useful tools to monitor ground conditions and to understand the far-reaching and differential impacts of public health and environmental crises.

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