

COVID-19 Impacts on Puerto Rican Small-Scale Fisheries in the First 6 Months

JUAN J. AGAR, MANOJ SHIVLANI, and DANIEL MATOS-CARABALLO

Introduction

The COVID-19 pandemic had a dramatic impact on food supply chains around the world, causing ripple effects from production to processing, marketing and distribution (FAO, 2020; NMFS, 2021). Early reports and studies relying on secondary information suggested that fisheries and aquaculture, particularly small-scale fisheries, were among the most heavily disrupted productive sectors (FAO, 2020; FAO and ECLAC, 2020; Bennett et al., 2020; Stokes et al., 2020; Bassett et al., 2021; Love et al., 2021). In Latin America and the Caribbean, 85% of the seafood consumed comes from

small-scale fishing operations (FAO and ECLAC, 2020).

Because the duration and scale of demand and supply disruptions vary widely within and across fisheries and regions, the design of mitigation measures requires a timely understanding of ground conditions. In many places, the pandemic worsened pre-existing vulnerabilities to socioeconomic and environmental stressors (Bennett et al., 2020; Steenbergen et al., 2020; Campbell et al., 2021; Sunny et al., 2021). In the Commonwealth of Puerto Rico, the pandemic arrived on the heels of two major tropical storms (Hurricanes Irma and María) and an earthquake swarm, which in turn came after severe political and public debt crises. These events interacted with each other compounding the challenges faced by fishermen. The COVID-19 pandemic also threatened Puerto Rico's food security because 82% of its agricultural needs are imported; only 18% is produced locally (Ramos Segarra, 2020). Moreover, Ostolaza et al. (2021) report that food insecurity in Puerto Rico rose from 38% to 40% within the first 3 months of the pandemic.

The objective of this study was to investigate the immediate social and economic consequences of the pandemic on Puerto Rican small-scale fisheries, focusing on its impacts on fishing practices, income, and employment. The study covered the first 6 months of 2020 (January through June) because the early disruptions to seafood markets can be traced to January 2020, when the Chinese government imposed a lockdown in the city of Wuhan (White et al., 2021; Love et al., 2021; NMFS, 2021).

To understand the impacts of the pandemic, we conducted a rapid assessment between July and September 2020. Rapid assessments refer to a suite of evaluation methods and techniques used to gain information about local conditions in an expeditious and economical manner. Rapid assessments can be useful tools to document and monitor evolving ground conditions, and to inform and guide funding relief decisions. In addition, they can serve as a baseline to evaluate the impact of mitigation measures and coping strategies (Chambers, 1981; Garces et al., 2010; van Holt et

Juan J. Agar is with the Social Science Research Group, Southeast Fisheries Science Center, National Marine Fisheries Service, NOAA, Miami, FL 33149 (email: Juan.Agar@noaa.gov); Manoj Shivlani is with the Department of Environmental Science and Policy, University of Miami (RSMAS), Miami, FL 33149 (email: MShivlani@rsmas.miami.edu); and Daniel Matos-Caraballo is with the Fisheries Research Laboratory, Department of Natural and Environmental Resources, P.O. Box 3665, Mayagüez, Puerto Rico 00681 (email: matos_daniel@hotmail.com).

doi: <https://doi.org/10.7755/MFR.83.1-2.3>

ABSTRACT—The COVID-19 pandemic and governmental actions to contain its spread threatened the livelihoods of millions of small-scale fishermen around the world. Because the duration and scale of the impacts can vary widely within and across fisheries and regions, it is important to monitor ground conditions. This study reports on the early socioeconomic effects of COVID-19 on Puerto Rican small-scale fishermen. The study focuses on the first 6 months of 2020 since COVID-19 began to disrupt seafood markets in January 2020.

Drawing on 317 telephone interviews with fishing captains conducted between July and September 2020, we find that the pandemic severely disrupted fishing operations owing to three main factors: loss of

seafood markets mainly in the leisure and hospitality sector, strict commonwealth and local governmental restrictions (lockdowns and curfews), and the adoption of sanitary control and prevention measures (face covering and social distancing requirements). These interrelated factors forced most fishermen to pause their fishing activities. Forty-three percent of the fishermen polled stopped their fishing between 1–3 months, and another 33% suspended their fishing for more than 3 months.

Preliminary self-reported fishery statistics show that landings and dockside revenues fell by 40% and 51%, respectively, in the first semester of 2020 (January–June) relative to the same period in 2019. However, the fishermen surveyed specified that

their fishing revenues had declined by 65% during the same period. Fishing income shortfalls, layoffs, and the loss of non-fishing opportunities adversely impacted fishermen's livelihoods. Captains reported losing, on average, almost \$6,900 relative to the first semester of 2019. One in four captains reported laying off, on average, 1 crewmember. The study also found that fishermen withstood the initial impacts of the pandemic thanks to the support of family and friends, personal savings, and social protection programs (unemployment benefits, federal stimulus checks, food stamps, etc.). Entrepreneurial fishermen were able to make ends meet by turning to online retailing and delivery and by continuing to sell roadside and house-to-house.

al., 2016; Smith et al., 2019; Smith et al., 2020).

Fishery Background

Small-scale fishermen operate around the entire archipelago, which consists of the main island of Puerto Rico and several smaller islands and cays, including Vieques, Culebra, and the fishing banks near the islands of Mona and Desecheo (Fig. 1). In 2019, Puerto Rican fishermen landed about 2.5 million pounds of finfish and shellfish worth \$12.1 million in dockside revenues (NMFS¹). Between 2015 and 2019, the west and east coasts accounted for the majority of the commonwealth's landings and dockside revenues. On average, the west coast generated 35% of landings and 36% of the revenues and the east coast generated 30% of the landings and 32% of revenues. The south coast accounted for 21% of the landings and 19% of revenues and the north accounted for the remaining 13% of the landings and revenues. The west coast is the most productive area partly because it has a relatively shallow and extended shelf. The east coast also has a large shelf area, which includes the nearby islands of Vieques and Culebra; by contrast, the north coast is the least pro-

¹NMFS. 2022. Accumulated landings system (Avail. at <https://www.fisheries.noaa.gov/inport/item/1905>). Accessed 3 March 2022.

ductive coast because it has a narrow insular shelf and an exposed coast that provides little protection against rough seas which partly discourages the use of use of certain gears such as traps (Suarez-Caabro, 1979; Tonioli and Agar, 2011).

There are around 1,200 licensed fishermen but fewer than 900 (including crew) show up in fishery statistics (NMFS, 2021). Most fishing vessels are small (20 ft in length) with moderate levels of propulsion (80 hp) and mechanization (Matos-Caraballo and Agar, 2011). Fishermen mainly target spiny lobster, *Panulirus argus*; queen conch, *Strombus gigas*; reef-fish (Lutjanidae, Serranidae, Scaridae, Labridae); and other miscellaneous coastal pelagic species (Scombridae, Coryphaenidae). Between 2015 and 2019, seven species accounted for 77% of the commonwealth's dockside revenues. Spiny lobster, queen conch, silk snapper, *Lutjanus vivanus*; queen snapper, *Etelis oculatus*; yellowtail snapper, *Ocyurus chrysurus*; dolphinfish, *Coryphaena hippurus*; and lane snapper, *Lutjanus synagris*, accounted for 28%, 17%, 12%, 7%, 5%, 4%, and 3% of the revenues, respectively.

On a regional basis, the west coast derived 77% of its revenues from five species (spiny lobster, 24%; silk snapper, 18%; queen snapper, 17%; queen conch, 14%; and dolphinfish, 4%), and

the east coast obtained 79% of its revenues from four species (spiny lobster, 36%; queen conch, 31%; yellowtail snapper, 7%; and silk snapper, 5%). The south coast derived 69% of its revenues from seven species (spiny lobster, 35%; queen conch, 9%; lane snapper, 8%; yellowtail snapper, 6%; silk snapper, 4%; queen snapper, 4%; and dolphinfish, 3%) and the north derived 68% of its revenues from seven species (silk snapper, 24%; dolphinfish, 13%; spiny lobster, 12%; yellowtail snapper, 10%; other snappers, 4%; queen snapper, 3%; and lane snapper, 2%).

The most common gears around the island are scuba and skin diving (including spearfishing), hook and line, fish and lobster traps, and nets (Matos-Caraballo and Agar, 2011; Tonioli and Agar, 2011; Agar et al., 2017). Between 2015 and 2019, scuba and skin diving, hook and line, and fish and lobster traps accounted for 39%, 37% and 16% of the revenues, respectively. Regionally, most of the west coast revenues originate from hook and line (49%) and scuba and skin diving (37%), whereas east coast revenues are mainly derived from scuba and skin diving (55%) and fish and lobster traps (24%). South coast revenues are mainly sourced from scuba and skin diving (32%) and fish and lobster traps (30%), while on the north coast they

RESUMEN—La pandemia del COVID-19 y las medidas gubernamentales para contener su propagación amenazaron el sustento de millones de pescadores de pequeña escala en todo el mundo. Dado que la duración y escala de los impactos pueden variar considerablemente dentro y entre pesquerías y regiones, es importante hacer un seguimiento de las condiciones de campo. Este estudio describe los impactos socioeconómicos iniciales de la pandemia sobre los pescadores de pequeña escala de Puerto Rico. El estudio se enfoca en los primeros 6 meses del 2020, debido a que la pandemia comenzó a afectar los mercados de pescado y mariscos en enero del 2020.

Basándonos en 317 entrevistas telefónicas con capitanes de pesca, realizadas entre julio y septiembre del 2020, hallamos que la pandemia interrumpió severamente las operaciones de pesca debido a tres factores

principales: pérdida de mercados de pescado y mariscos (principalmente en el sector de la hostelería), restricciones estrictas impuestas por los gobiernos nacionales y locales (confinamiento y toques de queda), y la adopción de medidas sanitarias de control y prevención (ordenes de cobertura facial y distanciamiento social). Estos factores interrelacionados obligaron a la mayoría de los pescadores a detener sus actividades de pesca. Cuarenta y tres por ciento de los pescadores encuestados dejaron de pescar entre 1 y 3 meses, y otro 33% suspendió su pesca por más de 3 meses.

Las estadísticas pesqueras preliminares indican que los desembarques e ingresos cayeron un 40% y un 51%, respectivamente, en el primer semestre de 2020 (enero-junio) en relación con el mismo periodo de 2019. Sin embargo, los pescadores encuestados especificaron que sus ingresos provenientes de

la pesca habían disminuido en un 65% durante el mismo periodo. La disminución de los ingresos de la pesca, los despidos, y la pérdida de oportunidades laborales no relacionadas con la pesca afectaron negativamente el sustento de los pescadores. Los capitanes indicaron haber perdido, en promedio, casi \$6,900 en relación con el primer semestre del 2019. Uno de cada cuatro capitanes informó haber despedido, en promedio, un miembro de la tripulación. El estudio también halló que los pescadores sobrellevaron los impactos iniciales de la pandemia gracias al apoyo de familiares y amigos, ahorros personales y programas de protección social (beneficios por desempleo, cheques de estímulo federal, cupones de alimentos, etc.). Pescadores con espíritu emprendedor lograron sobreponerse recurriendo a la venta minorista en línea con entrega, y vendiendo en la carretera y de casa en casa.

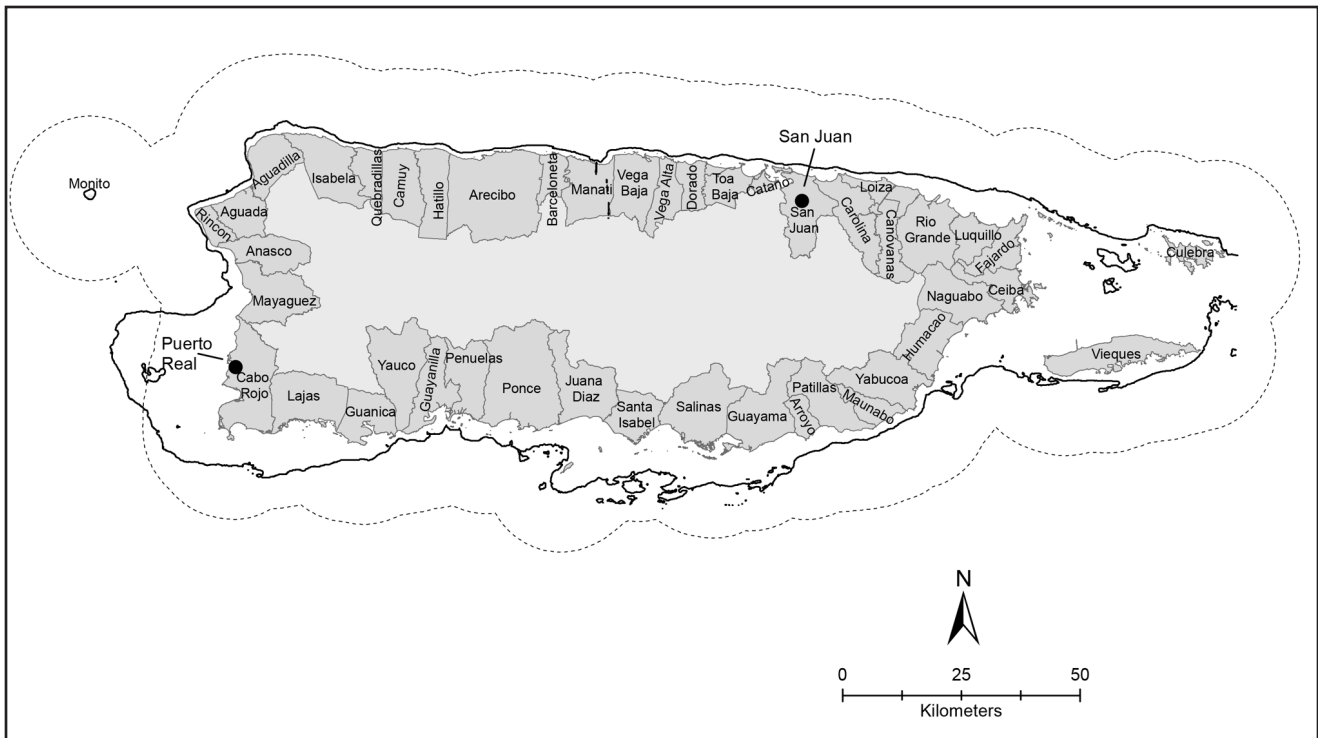


Figure 1.—Coastal municipalities in the Commonwealth Puerto Rico.

are primarily derived from hook and line (65%) and skin and scuba diving (19%)

A captain and a single deckhand (known as a “proel”) run most fishing operations with the exception of dive operations, which have larger crews (Agar and Shivlani, 2016). Many fishermen have diverse livelihood portfolios that may include local work in construction and agriculture as well as temporary migrations to the United States mainland (Gutiérrez-Sánchez, 1982; Pérez, 2005; Griffith et al., 2007; Agar et al., 2020). Many also supplement their income with government transfer (welfare) payments (Griffith and Valdés-Pizzini, 2002; Pérez, 2005).

Fishing centers (known as “vil-las pesqueras”) are places where fishermen land, process, and market fish. They may also repair and store fishing gear and equipment and socialize and exchange information with their peers (Gutiérrez-Sánchez, 1982; Valdés-Pizzini, 1990). Fishermen also sell

directly to dealers, fish stores, restaurants, and hotels; a few fishermen retail their catches from their homes or peddle them to nearby communities (Valdés-Pizzini, 2011; Matos-Caraballo and Agar, 2011).

Puerto Rico’s Department of Natural and Environmental Resources (DNER) and the Caribbean Fishery Management Council (CFMC) are the main fishery management agencies. DNER manages fisheries out to 9 nmi from the coast, and the CFMC manages those in federal waters, which extend from 9 to 200 nmi (Agar et al., 2019). With the exception of the deepwater snapper fishery limited entry program (i.e., cardinal, *Pristipomoides macrophthalmus*, and queen snappers), fisheries operate under a regulated open-access regime. Federal and commonwealth fishery managers use a variety of management measures, including annual catch limits (or quotas), trip limits (for queen conch), gear restrictions, seasonal and area closures, size

limits, and other miscellaneous restrictions (CFMC²).

Methods

We conducted a rapid assessment to examine the initial socioeconomic consequences of the pandemic on small-scale fisheries between July and September 2020. The study focused on the first 6 months of 2020 (January through June) because seafood markets began to be disrupted in January 2020 when the Chinese government imposed a lockdown in the city of Wuhan. The assessment targeted seafood dealers and processors, for-hire operators, and small-scale fishermen; however, for the sake of brevity, we only discuss the results of the last group.

The sampling frame was based on the population of fishing captains who either reported landings statistics in

²CFMC (Caribbean Fishery Management Council), 2021. Regulations (Avail. at <https://www.caribbeanfmc.com/regulations>).

2018 and/or 2019 or self-identified as a fishing captain in a recently conducted post-hurricane María fishermen census. We chose this frame over one that solely relied on fishermen who reported fishery statistics because of the difficulty of identifying the population of active participants. This population is hard to sample because of post-hurricane María fishermen turnover and the diversity of livelihood strategies. These strategies may combine year-round or seasonal fishing with other wage labor opportunities, including work in the United States mainland (Griffith and Valdés-Pizzini, 2002; García-Quijano et al., 2015; Agar et al., 2020). Additionally, many fishermen continued fishing with expired licenses.

The sampling protocol required interviewers to reach out to captains by telephone, drawing from a stratified, random sample. We stratified the sample by coastal region (i.e., east, north, south, and west) to capture the impact of the pandemic on a wide range of fisheries (Fig. 1). To satisfy the requirements of the sampling protocol, interviewers were instructed to draw a replacement fisherman only if the randomly selected fisherman a) refused to participate; b) was unavailable due to illness, travel, or death; or c) could not be contacted after three separate attempts. Before starting the survey, interviewers read a script indicating that responses were voluntary and that they would be kept confidential. The script also stated that survey participants could decline to answer any questions, and that there were no direct benefits, risks, or compensation for participating in the survey. Port agents from the DNER's Fisheries Research Laboratory and contracted field assistants, mainly recent university graduates, conducted the telephone interviews.

Consistent with other regional COVID-19 impact assessments, we employed the survey instrument designed by NMFS social scientists (Benaka and Thunburg, 2021; Glazier et al., 2021); however, we slightly modified its content to ensure that some of the closed-ended questions better aligned

with the local context. The survey was translated into Spanish and the data were entered into a Qualtrics³ platform.

The survey instrument inquired about a) demographic background; b) whether fishermen 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.

In total, 317 fishing captains participated in the voluntary survey. Despite the absence of compensation, only 10 respondents declined taking the survey showing a high degree of avidity. The actual response rate was 45%; however, if we ignore unreachable fishermen, then the effective response rate rises to 68%. The main reasons for the non-responses were failure to reach the fisherman after three contacts (35%), disconnected/wrong phone numbers (22%), duplicate names (21%), and missing phone numbers (19%). Approximately 28% of the respondents were from the north coast, 27% from the west coast, 26% from the east coast, and the remaining 18% from the south coast.

The study also benefited from governmental fishery statistics, print media stories, CFMC records, and interviews with key informants, who are individuals who have first-hand knowledge about the fishing industry such as fishery and fishing center managers. We used this information to gain additional insight about the impacts of the pandemic and to contextualize our findings. DNER runs the fishery statistics program which collects trip-level information on landings by species (or species groups), landing site, fishing gear used, effort expended, and dockside prices. The data collected is self-reported by the fishermen.

³Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Statistical Analysis Software (SAS) was used to develop commonwealth and regional (north, east, south, and west coasts) descriptive and inferential statistics.⁴ We used one-way ANOVA, Kruskal-Wallis, Chi square, and Fisher tests to examine for differences among coastal regions. One-way ANOVA tests were used to examine whether there are statistically significant differences between the means of three or more independent (unrelated) groups. One-way ANOVA tests are an omnibus test in that they cannot tell which specific groups were statistically significantly different from each other, but rather that at least two of the groups were. The Kruskal-Wallis test is a non-parametric test that was used when the normality assumption of the one-way ANOVA did not hold. The Chi-squared tests were used to examine whether there was a relationship between categorical variables. The Fisher exact test is a more powerful, computationally intensive test that was used to examine relationships between variables when there were few observations or highly unequal cell distributions. To counter the effects of multiple testing we used the Bonferroni correction. Tables report p-values, but only those bolded p-values are statistically significant at the 5% level after the Bonferroni correction.

Results and Discussion

Sample Characteristics

Most of the fishing captains interviewed were males with extensive fishing experience (Table 1). Ages ranged from 19 to 96 years, averaging 54 years. Around 5% of the survey participants were 30 years old or younger, and 27% were 65 years old or older. On average, east coast fishermen were older (56 years old) and west coast fishermen younger (51

⁴The northern region extends from the municipalities of Isabella to Luquillo (Fig. 1). The eastern region runs from the municipalities of Fajardo to Maunabo, including the islands of Vieques and Culebra, and the southern region stretches from the municipalities of Patillas to Lajas. The western region extends from the municipalities of Cabo Rojo to Aguadilla.

years old). Respondents had been fishing between 1 and 76 years, averaging 27 years. Regionally, fishermen from the west coast were the most experienced (31 years) whereas those from the north coast were the least experienced (23 years).

Households were highly dependent on commercial fishing (Table 1). Seventy-three percent of the captains reported that fishing was their primary source of personal income. The proportion of respondents who stated that fishing was their primary source of income was highest on the west coast (84%) and lowest on the north coast (53%). Puerto Rican fishermen often participate in formal and informal non-fishing, wage-earning occupations such as construction, mechanical work, landscaping, and farming to supplement their fishing income.

About 60% of the captains fished mainly in commonwealth waters and another 39% fished in both commonwealth and federal waters (Table 1). Eighty-two percent of the east coast captains primarily fished in commonwealth waters whereas the majority of west coast captains (72%) fished in both federal and commonwealth waters.

Main COVID-19 Disruptions

On 15 March 2020, Governor Wanda Vázquez-Garced issued Executive Order 2020-23, mandating an island-wide lockdown, a nighttime curfew, and the closure of hotels, restaurants, and other food service establishments, except for those using takeout, delivery, and drive-through.^{5,6} The order also closed public and private schools and universities, all non-essential businesses and public agencies, and implemented travel restrictions. Due to the uncertainty about the designation of fishermen as essential workers, fishing ceased briefly. After the government confirmed their essential worker designation, fishing resumed to take advantage of the rest of the Lenten season,

⁵Executive Order 2020-23 (<https://www.fmcsa.dot.gov/sites/fmcsa.dot.gov/files/2020-03/PR%20DeclarationofEmergency.pdf>).

⁶The island-wide lockdown lasted 88 days.

Table 1.—Sample characteristics by coastal region.¹

Item	Region				Puerto Rico total	No.
	East coast	North coast	South coast	West coast		
Number of respondents	83	89	58	87	317	317
Age (yr)	55.8 (13.2)	55.5 (14.3)	55.2 (15.2)	50.5 (13.7)	54.2 (14.1)	312
Fishing experience (yr)	26.2 (16.4)	22.8 (18.9)	26.1 (18.0)	31.3 (16.3)	26.6 (17.6)	313
Fishing main source of income (%)						
Yes	77.1	52.8	79.3	83.9	72.6	317
No	20.5	46.1	20.7	14.9	26.2	
Prefer not to answer	2.4	1.1		1.2	1.3	
Main fishing areas (%)						
Commonwealth (0- 9 nm)	91.6	60.7	62.1	26.4	59.6	317
Federal (9-200 nm)		1.1	1.7		0.6	
Both	8.4	38.2	36.2	72.4	39.4	
Prefer not to answer				1.2	0.3	

¹Mean and standard deviation (in parentheses), unless otherwise noted.

Table 2.—Early COVID-19 related impacts on fishing operation.

Item	Region				Puerto Rico total	No.
	East coast	North coast	South coast	West coast		
Was your fishing operation affected by COVID-19? (%)						
Yes	97.6	94.4	98.3	94.3	95.9	317
No	2.4	5.6	1.7	5.8	4.1	
Did you stop fishing for any period of time due to COVID-19? (%)						
Yes	95.1	98.8	87.7	91.4	93.7	303
No	4.9	1.2	12.3	6.2	5.6	
Prefer not to answer				2.5	0.7	
Duration of fishing inactivity (%)						
Less than 1 month	23.4	8.4	12.0	7.9	12.9	286
1-3 months	48.1	31.3	52.0	46.1	43.4	
More than 3 months	18.2	55.4	34.0	22.4	32.9	
Indefinitely with plans to resume fishing	9.1	4.8	2.0	19.7	9.4	
Went out of business	1.3			1.3	0.7	
Prefer not to answer				2.6	0.7	

when seafood sales increase because many Christians give up meat and eat fish on Fridays. In 2020, Lent started on 26 February and ended on 9 April.

Our survey found that the majority of the fishing operations were affected by the pandemic, forcing many to interrupt their fishing activities for extended periods of time (Table 2). When we inquired about the top three COVID-19 related factors that had the largest impact on fishing operations, respondents cited the loss of seafood markets (79%), commonwealth and local government restrictions (71%), and the adoption of sanitary control and prevention measures (48%; Table 3).

In addition to the losses already suf-

fered from the closure of restaurants and hotels following the lockdown, fishermen explained that seafood sales weakened after Lent because many of the remaining food establishments limited their menu options to “value propositions” which mainly used chicken, pork, and beef to stay in business.⁷ As one fisherman from the municipality of Rincón explained, “no one is going to buy an expensive fish from a restaurant (e.g., queen snapper

⁷In April alone, 30,000 jobs were lost in the Puerto Rican leisure and hospitality sector. BLS (U.S. Bureau of Labor Statistics). 2021. Puerto Rico. (Avail. at https://www.bls.gov/regions/new-york-new-jersey/puerto_rico.htm#eag_pr.f.1, accessed 16 April 2021).

Table 3. — Top 3 COVID-19 related factors that had largest impact on fishing operation.¹

Largest impacting factor (%)	Region				Puerto Rico total	No.	p-value
	East coast	North coast	South coast	West coast			
No seafood markets	71.1	76.4	81.0	87.4	78.9	317	0.0639
Restrictions by commonwealth and local governments	80.7	69.7	72.4	63.2	71.3	317	0.0885
Implementation of sanitary measures	80.7	38.2	58.6	20.7	48.3	317	<0.0001²
Low seafood prices	28.9	12.4	8.6	33.3	21.8	317	0.0002
Other	3.6	34.8	37.9	13.8	21.5	317	<0.0001
Instructed to stop fishing by dealer, fish receiver, processor	7.2	6.7	8.6	50.6	19.2	317	<0.0001
Lack of charter clients	3.6	38.2	20.7	1.2	15.8	317	<0.0001
Loss of crew	4.8	4.5	5.2	1.2	3.8	317	0.0069 ³
No available crew	4.8	2.3	1.7	1.2	2.5	317	0.5090 ³
Prefer not to answer	2.4			2.3	1.3	317	10.3436 ³

¹χ² tests were used to test for differences among coastal regions, unless otherwise noted.

²Statistically significant differences after the Bonferroni correction (p<0.05) are shown in bold.

³Fisher tests were used to test for differences among coastal regions.

which retails for \$40–50 a dish) to eat it out of a foam container. They want to be served in a restaurant.” A DNER study, which surveyed fishermen and fish dealers between 15 March and 31 April 2020, reported additional reasons for the drop in seafood demand, including fewer consumers heading to fish stores because of COVID-19 exposure worries, time constraints, and/or travel restrictions due to the curfew and lockdown, and an uneasiness about fish retailers’ adherence to COVID-19 food safety protocols.⁸ This DNER study also reported that many of fish houses closed after Lent because of the slow demand and that few fishermen went out fishing because of poor weather conditions.

Table 3 shows that restrictive commonwealth and local mandates were the second most cited COVID-19 related factor impacting fishing activities. In contrast to the sluggish response of the local government following hurricanes Irma and María, the government acted swiftly to control the spread of the virus. Commonwealth and local governments implemented timely and strict lockdowns and curfews to safeguard the fragile health care system (Cruz-Correa et al., 2020). Perreira et al.⁹ reported that the mass outmigra-

tion of health care professionals in the past decade left few physicians to care for Puerto Rico’s aging and poor population, particularly in San Juan’s metropolitan area and nearby municipalities. Perreira et al.⁹ also reported that the U.S. Health Resources and Services Administration (HRSA) considered 72 of 78 commonwealth municipalities to be medically underserved.

Our study also documented that poorly enforced governmental orders caused significant angst among fishermen because they were routinely stopped by local enforcement agencies and told to return home. Fishermen would be stopped for either driving to go fishing during curfew hours or for having expired boat registrations and/or fishing licenses, which could not be renewed because government offices were closed. Hanke et al.¹⁰ reported that many fishermen shunned nighttime fishing so they would not be stopped during curfew hours. To address these problems, DNER reached out to enforcement to remind them that fishermen were designated essential workers and also issued (fishing license and/or boat registration) waivers

to allow fishermen to return to their fishing routines. Hanke et al.¹⁰ also noted that small-scale fishermen were burdened by recreational boating and fishing restrictions because these restricted their access to public ramps and docks.

The implementation of sanitary control and prevention measures was the third most cited COVID-19 related factor that impacted fishing operations the most (Table 3). Survey participants raised the same concerns as those previously reported by the DNER study⁸, namely that sales fell because of social distancing mandates that resulted in the closure of restaurants and hotels, and reduced foot traffic to seafood markets due to exposure worries, time and travel restrictions, and concerns about the quality of food safety protocols regarding COVID-19 (Fig. 2).⁸ Fishermen also told us that infection concerns for oneself and loved ones sidelined many older fishermen. Port agents observed (personal communications) that few active fishermen followed face covering and social distancing guidelines because these were impracticable in small fishing vessels where fishermen spend extended periods of time in close proximity.

Noteworthy is that of the three main COVID-19 related factors reported to have had the largest impact on fishing operations, only the adoption of sanitary measures exhibited significant regional differences, suggesting that the impact of COVID-19 on seafood mar-

infrastructure assessment: site visit report. Urban Inst., Wash., D.C., 30 p. (Avail. at <https://www.urban.org/research/publication/puerto-rico-health-care-infrastructure-assessment-site-visit-report>).

¹⁰Hanke, M., P. M. Sotomayor, K. M. Torres-Figueroa, E. M. Collazo Montañez, and G. Hernández. 2020. Cambios en la actividad pesquera de Puerto Rico a raíz de la pandemia de COVID-19: Un cuestionario de pescadores comerciales. Unpubl. manusc., Univ. Puerto Rico, Recinto de Humacao.

⁸Santiago-Soler, W. G. 2020. COVID-19 impact in Puerto Rican commercial fishers [PowerPoint slides]. Reunión del Panel Asesor de Distrito de Puerto Rico, Carib. Fish. Manage. Council, 3-4 June.

⁹Perreira K., R. Peters, N. C. Lallemand, and S. Zuckerman. 2017. Puerto Rico’s health care in-

kets and on governmental actions were universally felt throughout Puerto Rico (Table 3). We are unclear why the adoption of sanitary measures showed marked regional disparities, especially between fishermen from the east and west coasts. Although west coast fishermen are on average younger than those from other regions it is unlikely that health concerns were sole factor driving these regional differences.

Other less cited factors that impacted their fishing operations included low seafood prices (22%), miscellaneous reasons (22%), dealer instructions to limit their catches (19%), and lack of charter clients (16%; Table 3). The relatively modest ranking of low seafood prices was somewhat unforeseen (or perhaps conflated with the loss of markets answer), but it is consistent with the findings of the DNER and Hanke et al. studies.^{8, 10} In line with these studies, a CFMC member reported that villas pesqueras in Puerto Rico did not lower the prices paid to the fishermen but rather “played with retail prices” (i.e., markups) to ensure that fish was accessible to the public, re-sellers (e.g., wholesalers, peddlers, and individuals tied to fish delivery), and to a small number of villas pesqueras, which had no or little fishing activity.¹¹ The impact of low seafood prices had a marked regional component probably because of the strong competition for customers, especially on the west and east coasts, which are the two most productive regions. Another reason that may explain why the impact of low prices differed across regions, is that dealer instructions to slow down fishing (“aguantar la pesca”) ranked considerably higher on the west coast, which may have encouraged local fishermen to be more aggressive finding additional markets for their catches (Table 3).

The “other” category was meant to be a “catch all” option for answers not available as choices; however, fisher-

¹¹Caribbean Fishery Management Council. 2020. Reunión del Panel Asesor de Distrito de Puerto Rico. June 10, 2020. [Video on YouTube. <https://www.youtube.com/watch?v=MWrZ5GhyC5w>].



Figure 2.—COVID-19 sanitary protocol sign in villa pesquera “Jarealito” in the municipality of Arecibo. Credit: Daniel Matos-Caraballo.

men mostly reiterated concerns voiced earlier. On the south coast, fishermen emphasized infection and curfew concerns, followed by worries about expired fishing licenses, soft markets, poor weather, and earthquakes. On the north coast, fishermen expressed concerns about protecting themselves and their family members, particularly those who were sick, and, to a lesser extent, issues related to the difficulties of renewing fishing license and market weakness. On the west coast, fishermen stressed contagion fears, fishing license renewal difficulties, and concerns about gear theft, whereas those on the east coast raised the problems associated with fishing license renewals and access to closed public ramps and docks. Table 3 shows that the loss of charter clients was more noticeable on the north coast probably because the many fishermen in our sample either ran or mostly likely worked as crew in charter operations. The northwest coast is an important hub for offshore and inshore fishing. The loss or unavailability of crew had minor impact on most fishing operations (Table 3).

Operational Responses and Obstacles

When we inquired how the pandemic had affected fishermen’s normal

fishing operations, even if temporary, compared to the first 6 months of the previous year (January–June 2019), the single, most common answer was that they took fewer fishing trips (83%; Table 4). Similar results were reported by the DNER and Hanke et al. studies^{8,10}; however, the impact on catch volumes (per trip) was mixed. Hanke et al.¹⁰ reported reductions of up to 50%, while the DNER study⁸ stated that catch volumes were comparable to those of earlier years. A CFMC member reported that villas pesqueras in Puerto Rico did not impose explicit catch limits on their members but did require them to limit the number of trips to four per week (weekdays only) so that they could move the inventory over the weekend (wholesale, house to house, delivery and/or takeout).^{11,12} She also noted that the villas pesqueras would inform their members which species were popular with consumers and how much inventory they could sell, which proved useful aligning supply and demand. Fishermen from the

¹²The only exception to this rule was for boats that targeted queen snapper and large silk snappers, which were primarily sold to restaurants. These boats were only allowed to take 1 trip per week; however, there were no limits on the duration of the trip and how much could be landed because these species are caught in deeper waters.



Figure 3.—Seafood marketing using social media. Credit: Carlos Joel Velázquez (Pescadería Kadmiel, Naguabo).

Table 4.—Early COVID-19 related operational responses and obstacles, even if temporary.¹

Operational responses, even if temporary (%)	Region				Puerto Rico total	No.	p-value
	East coast	North coast	South coast	West coast			
Reduced number of trips	92.8	74.2	77.6	87.4	83.3	317	0.0045²
Other	28.9	37.1	63.8	17.2	34.4	317	<0.0001
Developed new markets (dealers, buyers, clients)	20.5	18.0	13.8	62.1	30.0	317	<0.0001
Difficulties obtaining other supplies	38.6	20.2	19.0	5.8	20.8	317	<0.0001
Difficulties obtaining bait	34.9	15.7	10.3	10.3	18.3	317	<0.0001
Shifted to other fisheries	12.1	3.4	1.7	4.6	5.7	317	0.0458 ³
Prefer not to answer	1.2	2.3		2.3	1.6	317	0.8154 ³

¹ χ^2 tests were used to test for differences among coastal regions, unless otherwise noted.

²Statistically significant differences after the Bonferroni correction ($p < 0.05$) are shown in bold.

³Fisher tests were used to test for differences among coastal regions.

east and west coasts reported the highest reductions in fishing effort most likely because they are the most productive regions in Puerto Rico.

The pandemic not only affected governmental policies but also the food purchasing and consumption behavior of consumers. Consumers increased their use of delivery services, prepared more home cooked meals, and sought healthier food choices as result of shelter in place orders and also to reduce their chances of contracting COVID-19. Our survey found

that 30% of the fishermen polled revamped their marketing strategies to cater to these emerging opportunities. One fisherman from the municipality of Rincón explained that the pandemic forced them to reinvent ourselves (“la pandemia nos obligo a reinventarnos”). Villas pesqueras, fish stores, and entrepreneurial fishermen became more active on social media using Facebook and Instagram to post information on species availability, prices, health benefits, and delivery and pick-up options, including contactless alter-

natives (Fig. 3). Many processed their catches (e.g., scaling, filleting, and “steaking”) to add value and incorporated additional offerings such as seafood and land crab turnovers (“empañillas de mariscos y jueyes”) to make their products consumer friendly.¹³

Only 6% of the survey participants shifted to other fisheries (Table 4). We heard of a small number of fish-

¹³Notiséis 360. 2020. Pescadores se reinventan para mantener la industria activa. 16 April 2020. [Video on YouTube. https://www.youtube.com/watch?v=1FnuM6_w91I].

ermen who switched gears (e.g., from hook and line to nets) to catch low value nearshore species (e.g., sardines, scads, and jacks) for human consumption, and of others that kept the same gear (e.g., hook and line) but targeted more economical species (e.g., from silk snapper to little tunny, *Euthynnus alletteratus*). A chef from Arecibo observed that the pandemic had forced him to switch from selling 2–3 lb. whole fish (e.g., silk, queen, and yellowtail snappers) to fish fillets (e.g., dolphinfish and wahoo, *Acanthocybium solandri*) because the latter species were more practical and profitable alternatives for takeout (Hanke et al.¹⁰). The Hanke et al. study¹⁰ also found that most fishermen did not alter the composition of their catches, with the exception of those who fished at night (e.g., yellowtail snapper and king mackerel, *Scomberomorus cavalla*) because of curfew hassles.

In addition to overhauling their marketing practices, fishermen had to deal with a number of logistical obstacles that hampered their fishing operations. Among the top hurdles were “other” (34%) and difficulties procuring supplies (21%) and bait (18%; Table 4). In the “other” or catch-all category, fishermen from the south coast reported that production had fallen because of weak markets, earthquakes, fishing license renewal difficulties, and fishing supply shortages (e.g., rope and wire for traps, compressed air for scuba tanks). On the north coast, fishermen stated that they took fewer trips because of contagion concerns, weak demand, and complications in renewing their fishing licenses. A handful reported difficulties securing fishing supplies. East coast fishermen underscored the loss of markets and, to a lesser extent, difficulties renewing their fishing licenses, while west coast fishermen mainly stressed the loss of markets.

Supplies and bait procurement hurdles ranked high on the east coast (39% and 35%, respectively) relative to the other regions probably because a higher percentage of east coast fishermen launch from marinas (e.g., Puer-

to Del Rey) and public ramps (e.g., Las Croabas). The island-wide closure of marinas and public ramps to recreational boating and fishing (but not to commercial fishing) resulted in fewer fishing supply stores remaining open. Marinas could only sell fuel to government and commercial fishing vessels. Hanke et al.¹⁰ also found that the closure of fishery-support businesses (e.g., mechanics), fishing supply and equipment shortages (e.g., spare parts, bait, etc.), and the loss of cold storage options forced many to stop fishing. In addition, most, if not all, surf and dive shops were closed, limiting air supply options to scuba diving operations (Hanke et al.¹⁴). Many fish stores were uncertain how to implement sanitary protocols which further slowed down the fishing activity.

Production, Economic, and Employment Losses

With COVID-19 impacting both the demand and supply of seafood, the local fishing activity fell dramatically. Ninety-four percent of the respondents were forced to interrupt their fishing activities (Table 2). One third of the fishermen polled said that they paused for more than 3 months and another 9% said that they stopped indefinitely but planned to resume fishing. Less than 1% reported that they went out of business (Table 2).

Fishermen reported that their fishing activity was 36%, relative to June 2019 levels. Regionally, the west coast was the hardest hit (26%), followed by the south (39%), east (40%), and north (42%) coasts (results not in tables). The marked regional differences are probably tied to declining catches of species that were largely sold to restaurants and hotels (e.g., queen and silk snappers) and to the tremors and aftershocks (December 2019–January 2020) that caused extensive structural damage along the southwest coast.

Fishermen’s earnings also declined because these are tied to the success of the fishing operation. Rather than be-

ing paid a wage, fishermen receive a share of the net returns. Share (or lay) arrangements are widely used around the world to spread the risk of fishing and to foster and reward productivity and teamwork (Acheson, 1981; Gutiérrez-Sánchez, 1982; Agar et al., 2017). Many fishermen also lost non-fishing, wage labor opportunities because of the lockdown and social distancing mandates. Eighty-seven percent of respondents said that their fishing revenue fell since January 2020 (Table 5).

Fishermen reported that, on average, their revenues fell by 65% relative to the first 6 months (January–June) of 2019, which translates to \$6,900 (\$5,000 median; Table 5). The severity of the losses varied regionally, ranging from \$5,700 on the south coast to \$8,600 on the west coast. Hanke et al.¹⁰ estimated that Puerto Rican fishermen lost \$8,300 in fishing revenues during the first 6 months of the pandemic (Table 5). Additionally, Hanke et al.¹⁰ note that fishermen lost an extra \$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.

Fishermen also mentioned that their income suffered because of poaching. A fisherman from the municipality of Rincón reported that large numbers of poachers in this area were having a “field day” (“Los furtivos se hicieron su Agosto”¹⁵), many selling their illegal catches unfazed in social media. Stokes et al. (2020) also reported an increase in illegal fishing in nature reserves around San Juan.

Due to uncertain recovery prospects, 25% of the respondents said they laid off crew. On average, they reduced the size of their crew by one worker (Table 5). However, the impact of COVID-19 on the livelihoods of the crew was probably more pronounced because many crew members, who preferred to work full time, ended up

¹⁴Hanke, M. Caribbean Fishery Management Council, San Juan, Puerto Rico, personal commun., 7 April 2021.

¹⁵This Spanish expression refers to the benefits of a bountiful harvest which take place during summer months.

Table 5.—Early COVID-19 related impacts on revenues and employment.¹

Item	Region				Puerto Rico total	No.	p-value
	East coast	North coast	South coast	West coast			
Revenue changes since January 2020 (%)							
Increased		1.2			0.3	303	<0.0001 ²
Decreased	95.1	78.6	79.0	95.1	87.5		
Stayed the same	4.9	20.2	21.1	2.5	11.6		
Prefer not to answer				2.5	0.7		
Revenue decrease relative to January-June of 2019 (\$)	6,440.6 (5,657.3)	6,312.5 (7,427.6)	5,706.7 (4,048.8)	8,595.5 (9,543.7)	6,909.4 (7,155.7)	222	0.7482 ³
Current crew size on all vessels (excluding self)	1.7	1.2 (0.9)	1.1 (0.8)	1.0 (0.7)	1.2 (0.6)	297 (0.8)	<0.0001³
Fewer employees	1.4 (0.6)	0.8 (0.8)	0.7 (0.6)	1.0 (0)	1.0 (0.7)	75	0.0105³

¹Mean and standard deviation (in parentheses), unless otherwise noted.

²Fisher tests were used to test for differences among coastal regions.

³Kruskal-Wallis tests were used to test for differences among coastal regions. Statistically significant differences are shown in bold.

Table 6.—Main coping strategies that helped to deal with the early impacts of COVID-19.¹

Factors (%)	Region				Puerto Rico total	Most Important	No.	p-value
	East coast	North coast	South coast	West coast				
Family and/or friends	49.4	53.9	46.6	69.0	55.5	90	317	0.0222
Personal savings	71.1	21.4	32.8	64.4	48.3	84	317	<0.0001
Government assistance	37.4	25.8	41.4	57.5	40.4	74	317	0.0003
Other	1.2	28.1	19.0	3.5	12.6	28	317	<0.0001
Church, community groups, etc.	25.3	2.3	5.2	6.9	10.1	10	317	<0.0001
Fishing associations, cooperatives	1.2	3.4	6.9	4.6	3.8	5	317	0.3344 ²
Prefer not to answer	1.2	3.4	1.7	3.5	2.5	4	317	0.8338 ²
Crew and/or employees	3.6				1.0		317	0.0233 ²

¹χ² tests were used to test for differences among coastal regions, unless otherwise noted.

²Fisher tests were used to test for differences among coastal regions.

Statistically significant differences after the Bonferroni correction (p<0.05) are shown in bold.

working on a part-time basis. Also, as noted earlier, many might have missed out on non-fishing employment opportunities due to the lockdown. Key informants noted that Coronavirus Aid, Relief, and Economic Security (CARES) Act funds, which began to be dispersed in May 2020, provided much needed relief to the sector; however, some wondered if the unemployment benefits discouraged many from returning to work.¹⁶

The CARES Act created a federal package to provide economic relief to workers, families, businesses, and communities to protect them from the health and economic impacts of the pandemic. Among other things, it established the Pandemic Unemployment Assistance (PUA) pro-

gram, which provided comparable unemployment benefits to unemployed workers who would not normally be eligible, such as self-employed workers and independent contractors. It also added a \$600 supplement to state-paid unemployment compensation for those who already qualified for up to 4 months, which increased the current weekly unemployment compensation of \$190 to a maximum of \$790 weekly. To place these figures in context, Puerto Rico’s minimum wage is \$7.25 per hour, which translates to \$290 per week. In addition, the Act extended unemployment compensation by 13 weeks beyond the eligibility time provided under current law, which was 26 weeks, until 31 December 2020. The Act also provided direct payments (stimulus checks) based on income and household size. Individuals who earned \$75,000 in adjusted gross in-

come or less received direct payments of \$1,200 each, whereas married couples who earned up to \$150,000 received \$2,400, with an additional \$500 for each child.

Coping Strategies

Finally, we asked fishermen which were the main coping strategies that they relied on to weather the impacts of the pandemic. Among the most popular ones were the support of family and friends (56%), personal savings (48%), and access to public assistance (40%; Table 6). Other less frequently used coping strategies listed in Table 6 include “other” (13%), support from churches and community groups (10%), and assistance from fishing associations (4%). Less than 1% said that their crew or employees had helped them cope with the effects of COVID-19. In the “other” (or catch-

¹⁶Coronavirus Aid, Relief, and Economic Security (CARES) Act. Public Law 116-136. 2020.

Table 7.—Main sources of financial assistance during the early days of the COVID-19 pandemic.¹

Sources (%)	Region				Puerto Rico total	No.	p-value
	East coast	North coast	South coast	West coast			
Federal stimulus check	69.9	78.7	74.1	78.2	75.4	317	0.5167
Unemployment benefits	34.9	44.9	41.4	56.3	44.8	317	0.0419
Other	25.3	31.5	27.6	6.9	22.4	317	0.0005
No assistance requested	7.2	2.3	5.2	8.1	5.7	317	0.3093 ²
Prefer not to answer	2.4	3.4	1.7	2.3	2.5	317	1.0000 ²
Private bank loans/personal line of credit	2.4	3.4			1.6	317	0.1825 ²
Paycheck Protection Program			5.2		1.0	317	0.0059²
SBA loans		1.1			0.3	317	1.000 ²

¹ χ^2 tests were used to test for differences among coastal regions, unless otherwise noted.

²Fisher tests were used to test for differences among coastal regions.

Statistically significant differences after the Bonferroni correction ($p < 0.05$) are shown in bold.

all) category, fishermen identified social security and/or pension benefits, accessing food stamps, and non-fishing employment.

When asked to rank the most helpful coping strategy, 28% mentioned the support of family and friends, 26% stated personal finances, and another 23% said government assistance. Like in earlier crises, fishermen turned to family and friends for emotional and financial support underscoring the importance of social capital during times of need.

Social capital is a broad concept that describes the strength of social ties, the degree of trust, and norms of reciprocity that facilitate collaboration among individuals and groups of individuals (Grafton, 2005). A growing literature indicates that communities with high levels of social capital better handled recent outbreaks (SARS, Ebola, Zika, and early COVID) (Makridis and Wu, 2021).

A fisherman from the municipality of Rincón recounted the various ways that fishermen helped each other during the pandemic. He mentioned that some would loan money to be paid later or deducted from future fish sales (e.g., instead of getting paid say \$8/lb, the borrower would receive \$7/lb until the loan was repaid), while others would lend bait and supplies to be returned later. We also learned of individuals who would help out fishermen by purchasing their catches, and then they would re-sell them. This helped fishermen because it provided them with another outlet for their catches.

In addition to the support of fam-

ily and friends, fishermen stressed the importance of government assistance because many lived day-to-day and could not find non-fishing work because of social distancing mandates. Moreover, many had informal contractual arrangements and were uncertain about a rapid recovery. Among the most popular government programs that fishermen could access since January 2020 were federal stimulus checks (75%), unemployment benefits (45%), and “other” (22%; Table 7). Under the “other” category, many identified federal stimulus checks and pandemic unemployment benefits and added social security and pension benefits, municipal assistance, small business incentives, and occasional odd jobs. Less than 1% received help from the Paycheck Protection Program, which helped small businesses keep employees on their payrolls and/or bring back furloughed or laid off employees. Six percent of the respondents stated that they did not seek assistance.

It is noteworthy that many of the coping strategies used were similar to those employed to recover from the havoc of hurricanes María and Irma, with the exception of migrating to the continental United States. Agar et al. (2020) report that the support of family and friends (53%), personal finances and labor (45%), and government assistance (i.e., 33% for food stamps and 14% for disaster unemployment assistance) were the main coping strategies used by fishermen to rebuild their livelihoods following the hurricanes. Also, it is impor-

tant to mention that social distancing measures and mobility restrictions disrupted the normal flow of support from formal networks and employees. Relative to the pre-pandemic times, the standing of religious, community, and non-governmental organizations fell (e.g., churches, 15%; community groups, 13%; and NGOs, 7%, post-María vs. 10% during the pandemic) and employees (5% post-María vs. 1% during the pandemic), underscoring the importance of having universal social safety nets during crises, particularly health crises.

Conclusions

This rapid appraisal of the immediate socioeconomic impacts of COVID-19 found that the loss of seafood markets mostly in hospitality and leisure sectors, strict commonwealth and local governmental restrictions (lockdowns, curfews), and the adoption of sanitary control and prevention measures (face covering and social distancing requirements) were the main factors that disrupted the livelihoods of Puerto Rican fishermen. These factors drove most fishermen to interrupt their fishing activities.

Preliminary fishery statistics show that reported landings and dockside revenues fell by 40% and 51%, respectively, relative to the first 6 months of 2019; however, fishermen told us that their fishing revenues had declined by an average of 65% during the same period. Fishermen also reported losing, on average, \$6,900 relative to the first 6 months of 2019. One in four fishing captains laid off one crewmember.

The study also documented that the support of family and friends, personal savings, and social protection programs (unemployment benefits, federal stimulus checks) were main factors that helped fishermen withstand the early impacts of the pandemic. Seventy-six percent of the respondents benefited from the federal stimulus checks, 45% received unemployment benefits, and less than 1% participated in the Paycheck Protection Program suggesting that the latter program was the least helpful providing timely, short-term relief. An encouraging aspect of the pandemic was that many fishermen were able to find innovative ways to market their catches. To eke out a living some turned to increasing their use of social media while others returned to selling from roadside stands and house to house.

As of March 2021, preliminary fishery statistics show landings and dockside revenues increasing after this initial socioeconomic appraisal; however, it is too early to tell the course, duration, and full consequences of the pandemic, especially among vulnerable fishermen. Periodic rapid socioeconomic assessments such as this one can be useful tools to monitor unfolding ground conditions, to understand the far-reaching impacts of the pandemic, and to provide insights into how to better respond to future crises.

Acknowledgments

We would like to express our gratitude to the fishermen who kindly shared their time and knowledge about the impacts of COVID-19. Also, we would like to acknowledge the hard work of our interviewers Mariangelina Leon, Jesus Leon, Martha Ricaurte, Lucia Vargas, Juan Lugo, and Wilson Santiago. The views and opinions provided or implied in this manuscript are those of the authors and do not necessarily reflect the positions or policies of NOAA and Puerto Rico's DNER. This work was supported by the NMFS Office of Science and Technology.

Literature Cited

- Acheson, J. M. 1981. Anthropology of fishing. *Annu. Rev. Anthropol.* 10:275–316.
- Agar, J., and M. Shivilani. 2016. Socio-economic profile of the small-scale dive fishery in the Commonwealth of Puerto Rico. *Mar. Fish. Rev.* 78(3–4):12–21 (doi: <https://doi.org/10.7755/MFR.78.3–4.2>).
- _____, _____, and D. Solis. 2017. The commercial trap fishery in the Commonwealth of Puerto Rico: an economic, social and technological profile. *N. Am. J. Fish. Manag.* 37(4):778–788 (doi: <https://doi.org/10.1080/02755947.2017.1317678>).
- _____, _____, C. Fleming, and D. Solis. 2019. Small-scale fishers' perceptions about the performance of seasonal closures in the Commonwealth of Puerto Rico. *Ocean Coast. Manag.* 175:33–42 (doi: <https://doi.org/10.1016/j.ocecoaman.2019.03.025>).
- _____, _____, and D. Matos-Caraballo. 2020. The aftermath of Hurricane Maria on Puerto Rican small-scale fisheries. *Coast. Manage.* 48(5):378–39 (doi: <https://doi.org/10.1080/08920753.2020.1795967>).
- Bassett, H. R., J. Lau, C. Giordano, S. K. Suri, S. Advani, and S. Sharan. 2021. Preliminary lessons from COVID-19 disruptions of small-scale fishery supply chains. *World Develop.* 143(105473) (doi: <https://doi.org/10.1016/j.worlddev.2021.105473>).
- Benaka, I., and E. Thunberg. 2021. Analysis of COVID-19 impacts on surveyed west coast and Alaskan commercial fishing operations during the first six months of the pandemic. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-226, 13 p.
- Bennett, N. J., E. M. Finkbeiner, N. C. Ban, D. Belhabib, S. D. Jupiter, J. N. Kittinger, S. Mangubhai, J. Scholtens, D. Gill, and P. Christie. 2020. The COVID-19 pandemic, small-scale fisheries and coastal fishing communities. *Coast. Manage.* 48(4):336–347 (doi: <https://doi.org/10.1080/08920753.2020.1766937>).
- Campbell, S. J., R. Jakub, A. Valdivia, H. Setiawan, A. Setiawan, C. Cox, A. Kiyu, D. Lely, F. Djafar, E. de la Rosa, W. Suherfian, A. Yuliani, H. Kushardanto, U. Muawanah, A. Rukma, T. Alimi, and S. Box. 2021. Immediate impact of COVID-19 across tropical small-scale fishing communities. *Ocean Coast. Manag.* 200:105485 (doi: <https://doi.org/10.1016/j.ocecoaman.2020.105485>).
- Chambers, R. 1981. Rapid rural appraisal: rationale and repertoire. *Public Admin. Develop.* 1(2):95–106 (doi: <https://doi.org/10.1002/pad.4230010202>).
- Cruz-Correa, M., E. C. Díaz-Toro, J. L. Falcón, E. J. García-Rivera, H. M. Guiot, W. T. Maldonado-Dávila, K. G. Martínez, W. Méndez-Latalladi, C. M. Pérez, M. L. Quiñones-Feliciano, J. C. Reyes, P. Rodríguez, J. Santana-Bagur, L. C. Torrellas, D. Vázquez, G. J. Vázquez, and S. Rodríguez-Quilichini. 2020. Public Health Academic Alliance for COVID-19 response: the role of a National Medical Task Force in Puerto Rico. *Int. J. Environ. Res. Public Health* 17(13):4,839 (doi: <https://doi.org/10.3390/ijerph17134839>).
- FAO. 2020. The impact of COVID-19 on fisheries and aquaculture—a global assessment from the perspective of regional fishery bodies: initial assessment. *Food Agric. Organ. U.N.*, No. 1, 38 p., Rome (doi: <https://doi.org/10.4060/ca9279en>).
- _____, and ECLAC. 2020. Food systems and COVID-19 in Latin America and the Caribbean: towards inclusive, responsible and sustainable fisheries and aquaculture. *Food Agric. Organ. U.N.*, Bull. 15, 21 p., Santiago (<http://www.fao.org/3/cb1197en/CB1197EN.pdf>).
- Garces, L. R., M. D. Pido, R. S. Pomeroy, S. Koeshendrajana, B. I. Prisantoso, N. A. Fatan, and M. Dey. 2010. Rapid assessment of community needs and fisheries status in tsunami-affected communities in Aceh Province, Indonesia. *Ocean Coast. Manag.* 53(2):69–79 (doi: <https://doi.org/10.1016/j.ocecoaman.2009.12.004>).
- García-Quijano, C., J. Poggie, A. Pitchon, and M. Del Pozo. 2015. Coastal resource foraging, life satisfaction, and wellbeing in south-eastern Puerto Rico. *J. Anthropol. Res.* 71(2): 145–167.
- Glazier, E., M. Jepson, M. McPherson, E. Thunberg, L. Colburn, M. Shivilani, J. Agar, B. Stoffle, A. Mastitski, and F. Martin. 2021. Marine fisheries and the COVID-19 pandemic: interim survey data and analysis. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-220, 31 p.
- Grafton, R. Q. 2005. Social capital and fisheries governance. *Ocean Coast. Manage.* 48:753–766 (doi: <https://doi.org/10.1016/j.ocecoaman.2005.08.003>).
- Griffith, D. C., and M. Valdés-Pizzini. 2002. Fishers at work, workers at sea: a Puerto Rican journey through labor and refuge. Temple Univ. Press, Phila., Pa., 256 p. (doi: <https://doi.org/10.2307/1556555>).
- _____, _____, C. García-Quijano, J. J. Agar, and B. Stoffle (Editors). 2007. Entangled communities: socioeconomic profiles of fishers, their communities, and their responses to marine protected measures in Puerto Rico: Overview. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFSC-556, 524 p.
- Gutiérrez-Sánchez, J. 1982. Características personales y de trabajo de los pescadores en Puerto Rico. Programa Sea Grant UPR-SG-85-02, 38 p. Univ. Puerto Rico, Mayagüez.
- Love, D. C., E. H. Allison, F. Asche, B. Belton, R.S. Cottrell, H. E. Froehlich, J. A. Gephart, C. C. Hicks, D. C. Little, E. M. Nussbaumer, P. Pinto da Silva, F. Poulain, A. Rubio, J. S. Stoll, M. F. Thlusty, A. L. Thorne-Lyman, M. Troell, and W. Zhang. 2021. Emerging COVID-19 impacts, responses, and lessons for building resilience in the seafood system. *Global Food Sec.* 28:100494 (doi: <https://doi.org/10.1016/j.gfs.2021.100494>).
- Makridis, C. A., and C. Wu. 2021. How social capital helps communities weather the COVID-19 pandemic. *PLOS ONE* 16(1):e0245135 (doi: <https://doi.org/10.1371/journal.pone.0245135>).
- Matos-Caraballo, D., and J. Agar. 2011. Census of active fishers in Puerto Rico: 2008. *Mar. Fish. Rev.* 73(1):13–27.
- NMFS. 2021. U.S. seafood industry and for-hire sector impacts from COVID-19: 2020 in perspective. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SPO-221, 88 p.
- Ostolaza, C., C. Rosas, A. M. García-Blanco, J. Gittelsohn, and U. Colón-Ramos. 2021. Impact of the COVID-19 pandemic on food insecurity in Puerto Rico. *J. Hunger Environ.*

- Nutr. (doi: <https://doi.org/10.1080/19320248.2021.1997857>).
- Pérez, R. 2005. The state and small-scale fisheries in Puerto Rico. Univ. Press Fla., Gainesville, 218 p.
- Ramos Segarra, C. G. 2020. Food autonomy is impossible in Puerto Rico. Sept. 9, Updated Sep. 15. *The Weekly J.* (Avail. at https://www.theweeklyjournal.com/business/food-autonomy-is-impossible-in-puerto-rico/article_2622ff42-f22d-11ea-a158-d71aa4411364.html).
- Smith, S. L., R. Karasik, A. Stavrinaky, H. Uchida, and M. Burden. 2019. Fishery socioeconomic outcomes tool: a rapid assessment tool for evaluating socioeconomic performance of fisheries management. *Mar. Policy* 105:20–29 (doi: <https://doi.org/10.1016/j.marpol.2019.03.009>).
- _____, A. S. Golden, V. Ramenzoni, D. R. Zemeckis, and P. O. Jensen. 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):e0243886 (doi: <https://doi.org/10.1371/journal.pone.0243886>).
- Steenbergen, D. J., P. T. Neihapi, D. Koran, A. Sami, V. Malverus, R. Ephraim, and N. Andrew. 2020. COVID-19 restrictions amidst cyclones and volcanoes: a rapid assessment of early impacts on livelihoods and food security in coastal communities in Vanuatu. *Mar. Policy* 121:104199 (doi: <https://doi.org/10.1016/j.marpol.2020.104199>).
- Stokes, G. L., A. J. Lynch, B. S. Lowe, S. Funge-Smith, J. Valbo-Jørgensen, and S. J. Smidt. 2020. COVID-19 pandemic impacts on global inland fisheries. *Proc. Natl. Acad. Sci.* 117(47):29419–29421 (doi: <https://doi.org/10.1073/pnas.2014016117>).
- Suárez-Caabro, J. A. 1979. *El Mar de Puerto Rico: una introducción a las pesquerías de la Isla*. Editorial Univ., Univ. de Puerto Rico, Río Piedras, 259 p.
- Sunny, A. R., S. A. Sazzad, S. H. Prodhan, Md. Ashrafuzzaman, G. C. Datta, A. K. Sarker, M. Rahman, and M. H. Mithun. 2021. Assessing impacts of COVID-19 on aquatic food system and small-scale fisheries in Bangladesh. *Mar. Policy* 126:104422 (doi: <https://doi.org/10.1016/j.marpol.2021.104422>).
- Tonioli, F. C., and J. J. Agar. 2011. Synopsis of Puerto Rican commercial fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFSC-622, 69 p.
- Valdés-Pizzini, M. 1990. Fishermen associations in Puerto Rico: praxis and discourse in the politics of fishing. *Human Organ.* 49:164–172 (doi: <https://doi.org/10.17730/humo.49.2.bl24551243635627>).
- _____. 2011. Una mirada al mundo de los pescadores en Puerto Rico: Una perspectiva global. Sea Grant, Centro Interdisciplinario de Estudios del Litoral. UPRSG-G-209, 68 p., Mayaguez, P.R.
- van Holt, T., W. Weisman, J. C. Johnson, S. Käll, J. Whalen, B. Spear, and P. Sousa. 2016. A social wellbeing in fisheries tool (SWIFT) to help improve fisheries performance. *Sustainability* 8(8):667 (doi: <https://doi.org/10.3390/su8080667>).
- White, E. R., H. E. Froehlich, J. A. Gephart, R. S. Cottrell, T. A. Branch, R. A. Bejarano, and J. K. Baum. 2021. Early effects of COVID-19 on U.S. fisheries and seafood consumption. *Fish. Fish.* 22:232–239 (doi: <https://doi.org/10.1111/faf.12525>).