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Immediate impact of COVID-19 across tropical small-scale fishing communities

Stuart J. Campbell [a,*], Raymond Jakub [a], Abel Valdivia [b], Haris Setiawan [c], Agus Setiawan [c], Courtney Cox [b], Askabul Kiyo [d], Darman [e], Lely Fajriah Djafar [d], Emilio de la Rosa [a], Wahid Suherfian [a], Ade Yuliani [a], Hari Kushardanto [a], Umi Muawanah [f], Arwandrija Rukma [a], Taufiq Alimi [a], Stephen Box [b]

[a] Rare Indonesia, Jl. Gunung Gede I No. 6, Kota Bogor, Jawa Barat, 16153, Indonesia
[b] Rare, 1310 N Courthouse Rd Suite 110, Arlington, VA, 22201, USA
[c] Rare Southeast Sulawesi, Jl. Sao Sao No.6, BTN 1, Bende, Kota Kendari, Sulawesi Tenggara, 93117, Indonesia
[d] Marine and Fisheries Office of Southeast Sulawesi Province, Jl. Balai Kota No. 4, Mandonga, Kota Kendari, Sulawesi Tenggara, 93111, Indonesia
[e] Wakatobi National Park Office, Jl. Dayanu Ikhsanuddin No. 71, Betoambari, Kota Bau-bau, Sulawesi Tenggara, 93724, Indonesia
[f] Agency of Marine and Fisheries Research and Human Resources Development, Ministry of Marine Affairs and Fisheries, Jl. Pasir Putih I, Ancol Timur, Jakarta Utara, 14430, Indonesia

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ABSTRACT

The volume and value of fish catches by Indonesia's small-scale fisheries have declined significantly since national government restrictions on travel and social distancing were imposed in response to the COVID-19 pandemic. Using a digital data collection system (OurFish), that records purchases by fish traders from small-scale fishers, data was collected across 82 coastal communities in Southeast Sulawesi. We found that the number of active fishers and traders declined by more than 90% after the onset of the pandemic and the average weight of catch per fishing trip increased across fishers. Although the average price per kilogram of fish declined after the pandemic began, fishers that were able to maintain fishing had on average higher catches and therefore daily catch value was maintained. High value fisheries that usually enter export supply chains were more negatively impacted compared with lower value species that are commonly sold to local markets. We interviewed 185 small scale fishers and fish traders across 20 of the 82 communities in Southeast Sulawesi province, recording the perceived level of impact on local fisheries and the fish trade, causes of this impact and proposed coping strategies. Over 50% of both fishers and fish traders believed low demand for fish from traders and a decline in the price received for fish were disrupting their lives. Approximately 75% of both male and female fishers are coping by continuing to fish, highlighting that there were few alternative livelihoods available at the time of the interviews. Our results provide key insights into the vulnerability of small-scale fishing communities to impacts of the COVID-19 pandemic.

1. Introduction

The COVID-19 pandemic is impacting all parts of human society (Corlett et al., 2020). Negative impacts on the fisheries sector includes closure of some fisheries, market disruptions, increased health risks for cosatal costal communities, exacerbated vulnerabilities to marginalized groups and increased illegal and unregulated fishing (Bennett et al., 2020). In Indonesia, reports of impacts on trade in many sectors including fisheries, may have far-reaching effects on the economy, jobs, health and standard of living (Djalante et al., 2020). The fisheries sector is an important contributor to national food security in tropical nations (Béné et al, 2015, 2016) particularly for SE Asia (Teh and Pauly, 2018). Indonesia is the second largest fish producer globally, with 55% sourced from coastal areas (CEA, 2018). It is the eighth-most fish-dependent nation in the world, measured by dependence on fish-derived animal protein (CEA, 2018), supporting 2.7 million workers in the wild capture sector and 1.7 million fishers dependent on coral reef species, the highest number globally (Teh et al., 2013). Small-scale coastal fisheries,

* Corresponding author.
E-mail address: scampbell@rare.org (S.J. Campbell).

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defined as those operating boats under gross 10 Gross Tonnes (GT) (Suadi and Kusano, 2019), dominate multi-species coastal fisheries in Indonesia and deploy low technology fishing gears, including hooks and line, nets and traps (Halim et al., 2019; McDonald et al., 2018). While these fisheries underpin the economy of coastal communities (FAO, 2020a; Kovac, 2020), most lack the resources and capital to cope with economic shocks (Anderson et al., 2015).

The first confirmed cases of COVID-19 in Indonesia were reported on March 2, 2020 (Government of Republic of Indonesia, 2020a) shortly before COVID-19 was declared a global pandemic on March 11, 2020 by the World Health Organization (WHO). Before the pandemic declaration, Indonesia had already started implementing precautionary measures to contain the spread of COVID-19 in February 2020, increasing the restrictions through to April 2020, including travel bans, partial lockdowns, social distancing, and intensified border control inspections and regulations (Djalante et al., 2020). During the month of February, international flights from China were halted, and the export trade of live animals from China to Indonesia was banned (Government of Republic of Indonesia, 2020a). In March, the Indonesian government announced the closure of some government operated fish landing port facilities, which provide logistical support, cold storage, fishing vessel permits, re-fueling, auctioning of fish and other services for the industrial fisheries sector, comprised of licensed vessels greater than 10 GT.

Closure of government managed fish landing port facilities disrupted the trade of fisheries products across Indonesia's provinces, resulting in the stock piling of fish in cold storage at fishing ports (Amysyah, 2020). Reported exports of fish from Indonesia to countries including France, Italy, the Netherlands, the U.S., Thailand, Taiwan, and China declined by as much as 70% since February (Mubarok and Ambari, 2020). Emergency and stimulus actions were announced by the government to guarantee export and import distribution of processed fish products (Dinatri, 2020), ensure that idle cold storage facilities are available for fish, and to support domestic supplies of capture fisheries and aquaculture production (Susanto, 2020). That support, however, was focused on the industrial fisheries and port infrastructure.

The government assistance to the small scale sector has been less definitive. This may be a consequence of the limited information available on the economic impacts on the small scale fisheries sector. In contrast to the industrial fishing sector, which is a formal productive sector of the Indonesian economy with official statistics available from the number of registered boats, the operations of large infrastructure facilities in ports and processing plants, and clear volume and value statistics from official landing records and export statistics, the small scale sector does not have that statistical clarity. Small scale fisheries lie largely in the fragmented and decentralized informal productive sector of the economy. The sector is composed of thousands of independent actors as owner operators, microenterprises and small businesses, who fish, process and trade through a diverse network of markets, largely without formal financial records or connecting to financial institutions (Pomeroy et al., 2020). This results in systematic under reports of accurate data on employment and the economy of the sector. The lack of data means that governments are less able to identify, measure and respond to the impacts of economic shocks in the informal sector and may lack mechanisms to provide economic stimulus packages to affected households and small businesses if they are not part of formal financial systems.

Here we examine disruptions to small scale fisheries operations associated with restrictions implemented in response to the COVID-19 pandemic across the Southeast Sulawesi province, Indonesia where the first cases of the virus were recorded in early April. To date, few reports are available on the disruption to small scale fisheries in Indonesia due to the COVID-19 pandemic (Blue Ventures, 2020). Fishing communities across the region may be indirectly and directly impacted by COVID-19 cases through trade disruptions, infected people unable to work, and government response policies. We use a novel approach to collecting small scale fisheries catch data through the transaction records at the first point of sale by fishers to fish traders across 82 coastal communities in the province of Southeast Sulawesi. These traders have been recording transactions since January 2019 through the digital fisheries data collection system, OurFish. To augment this catch data, telephone interviews (using WhatsApp) were conducted with fishers and fish traders to record their perceptions of the level of impact on their lives, the causes of disruption, and the coping strategies they are adopting. Based on this unique set of empirical data, we assess the status and responses of these fishing communities and describe strategies that can assist them to cope and recover from the economic consequences of the pandemic.

2. Methods

This study was conducted in Southeast Sulawesi province, Indonesia (Fig. 1) where coastal small scale fisheries account for 73% of household income on average (Rare unpublished data). Small scale fisheries in Southeast Sulawesi may differ from other provinces with respect to cultural approaches that pertain to fisheries governance. For example, in Aceh, West Papua and Maluku some communities practice customary laws which can regulate fisheries practices, while in Southeast Sulawesi few fishing communities have customary or 'adat' laws. However, the boats and fishing gears used by fishing communities in Southeast Sulawesi, which are characterized as small scale (Halim et al., 2019), are comparable with many other small scale fisheries in Indonesia (Pet-Soede et al., 2001; Campbell et al., 2014). Fishing operations are managed at the household level, fishing is from boats less than 5 GT (4–6 metres in length), and non-mechanized fishing gears, primarily handline and speargun are used.

We calculated the number of daily cumulative confirmed COVID-19 cases nationwide and at the province level reported by the Indonesian Task Force for the Acceleration of Handling COVID-19 (Figs. 1 and 2A). To better understand disruptions associated with the COVID-19 pandemic to small scale fishing communities across Southeast Sulawesi, we assessed trends in fish production and value and perceptions of fishers and fish traders to COVID-19 related social impacts.

2.1. Fisheries and weather condition data

Using the OurFish app – an Android-based application that records the purchase records of fish traders at the first point of sale by community based fishers – we collated catch and catch value data across 82 small scale fishing communities in Southeast Sulawesi from June 1, 2019 to May 31, 2020.

The OurFish application uses mobile technology to characterize fishing activity and catch value by recording financial transactions between fish traders (buyers who directly purchase fish from fishers) and fishers. OurFish was designed to simplify a fish trader's business records providing an image-based, user-friendly alternative to paper records. The OurFish app digitally captures data that includes location of sale, fisher and trader identity, fish species or family, quantity, weight, price, and fisheries related disbursements (ice and fuel). Fishing gears used are not recorded by the Ourfish application. All catches recorded from fishers in this study were caught from handline or speargun. The use of these gears does not differ seasonally, and therefore we have assumed that the catch per fishing trip from these two fishing gears does not significantly change overtime. Fishing trips recorded are for the most part performed in a single day, and all catch is normalized to one day of fishing. Catch per Unit Effort (CPUE) is reported as daily catch per fishing trip (kg/trip). The data recorded is uploaded to the cloud and made available through Rare's data portal (https://portal.rare.org/en/) providing users with access to advanced data analyses and visualizations.

The Ourfish application captures the amount of fish being sold to traders allowing measures of declines in market demand and impacts on fisher income. Across 6007 households surveyed prior to the pandemic,

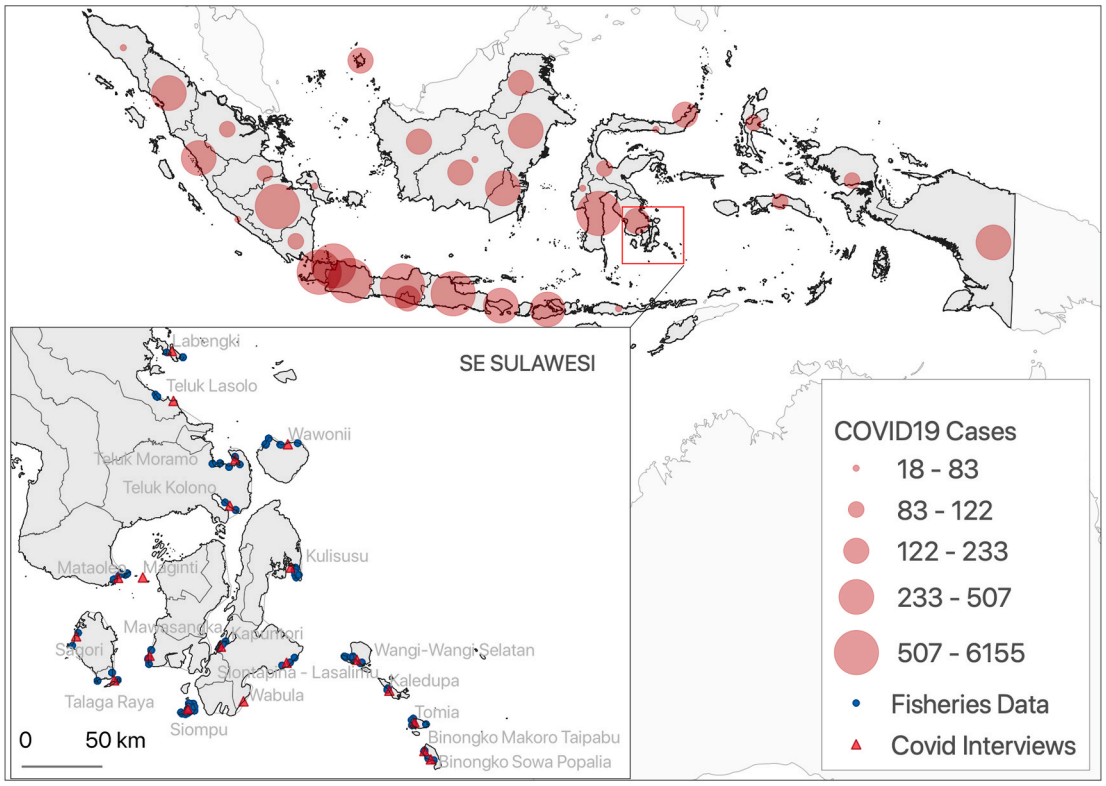

Fig. 1. Confirmed number of Covid-19 cases by provinces in Indonesia as of May 31, 2020. Insert map is the Southeast Sulawesi province with the locations of 82 coastal communities (blue dots) where fisheries catch data was recorded, and 20 coastal areas (red triangles) where interviews were conducted. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

on average 82% of fish caught were sold to traders and 18% were retained for household consumption (Rare unpublished data) (Fig. A.1). Therefore, while Ourfish does not measure catch retained by fishers for household consumption, it provides critical data on catch that supports fisher and trader livelihoods.

Adoption of the OurFish app steadily increased after initial roll out in January 2019; however, it was not until June 2019 that enough transactions were recorded to be able to assess fluctuations in catch. We used average daily weather condition (wind speed in miles per hour [mph] and rainfall in mm/day), which may affect fisher activity and thus fisheries catch (Chollett et al., 2017). Average daily wind speed and rainfall amount data was extracted from the meteorological station Beto Ambari in Buton, Southeast Sulawesi (Fig. 2B).

Information recorded on fisheries catch transactions through the OurFish app between fishers and first traders includes purchase location, date and time of purchase, weight of catch, and price per kilogram. The fisheries data was collected from 62 traders that have continually recorded all purchases (including fish, crustaceans, and cephalopods) from 943 fishers across 82 communities in the province (Fig. 1). We calculated seven response variables for the province that may be indirectly and directly affected by the pandemic including: daily total catches (kg/day), daily total value (IDR/day, Indonesian Rupiah), price per kilogram (IDR/kg), daily catch per trip (kg/trip), daily catch value per trip (IDR/trip), and number of daily active fishers and traders.

2.2. COVID-19 related social impacts

We conducted telephone interviews with fishers and fish traders from 28 March to April 8, 2020 using the WhatsApp application. For these interviews, we used a purposive sampling design, also known as judgmental, selective, or subjective sampling (Etikan et al., 2016). A purposive sampling is a form of non-probability sampling in which researchers rely on their own judgment when choosing members of the population to participate in their study (Etikan et al., 2016). This sampling design allowed us to perform rapid and succinct interviews to get a sense of the causes and impact that the COVID pandemic was having on small scale fisheries. These interviews aimed to target fishers and traders across the province able to be contacted using WhatsApp. Thus, this was not a balanced design across each of the areas sampled. The selection of areas sampled was based on knowledge of the areas where fishers and traders were involved in community-based fisheries management programs.

Trained interviewers conducted 185 interviews that included 114 small scale fishers (104 men, 10 women) and 71 fish traders (37 men, 34 women) from 20 coastal areas of Southeast Sulawesi (Fig. 1). The survey aimed to assess their perceptions on: 1) degree of impact caused to their lives; 2) causes of disruption to the fisheries practices they believe are associated with changes in their community; and 3) coping strategies they adopted to mitigate these perceived disruptions. The cause and strategy related questions were open ended and transcribed after completion of all interviews to determine common answers.

2.3. Data analysis

To evaluate trends in fisheries production response variables (i.e., daily catch, value of the catch, price per kg, and number of active fishers and traders) across Southeast Sulawesi, we used a Generalized Additive Model (GAM). We used a GAM structure because the trends of response variables (e.g., daily catch) were no lineal. Using time as explanatory variable, we explored three different model families (e.g., Gaussian, Gamma, and Poisson) and selected different link combinations (e.g., log, identity, inverse, and sqrt) depending on whether the response variable was continuous (e.g., daily catch, daily value) or discrete (e.g., number of fishers, number of traders). We chose a Gamma family with a log link for all response variables except for number of traders (Poisson family with log link). These family-link combinations resulted in better model

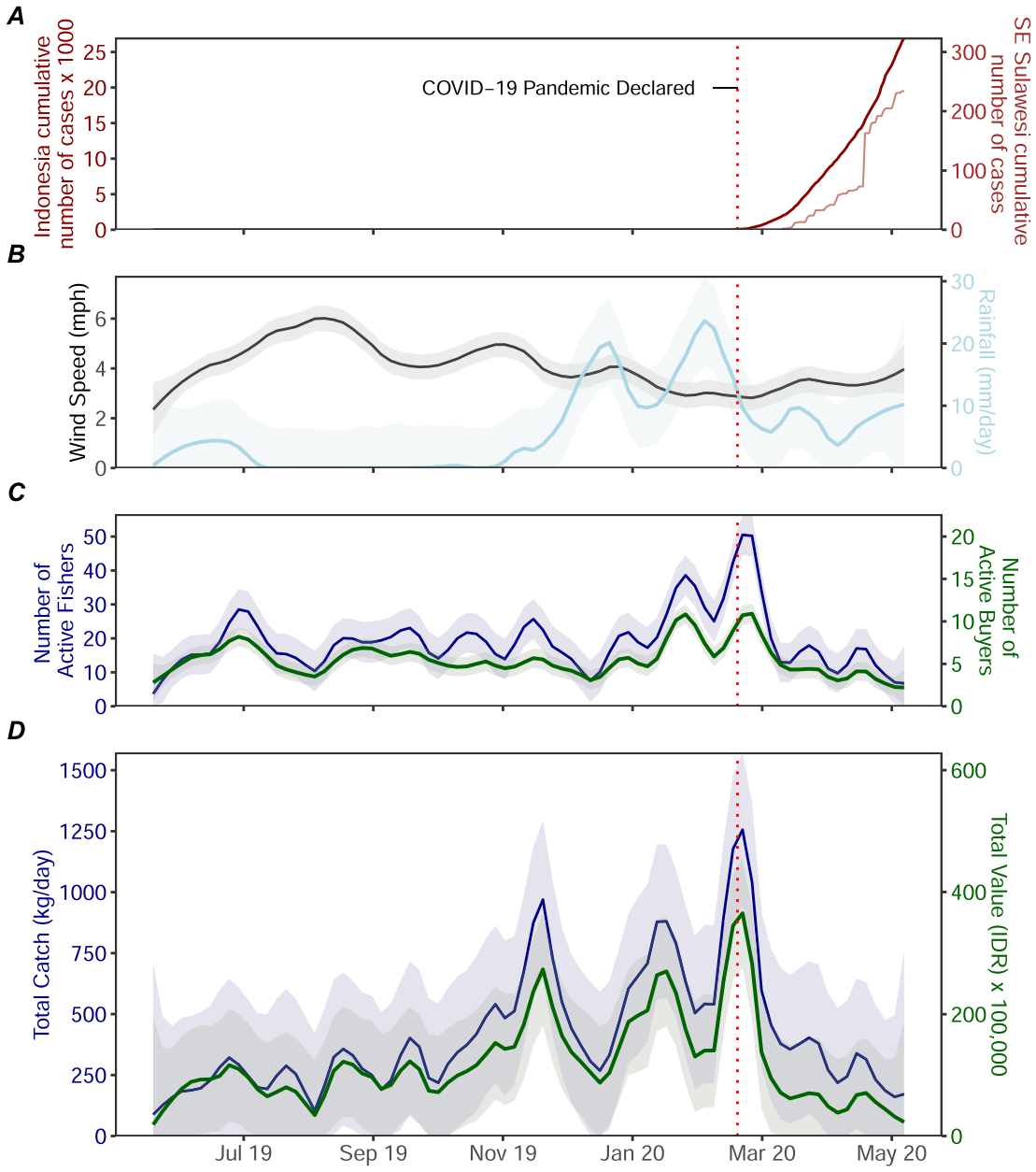

Fig. 2. Coastal fisheries and COVID-19 in Southeast Sulawesi. A). Cumulative number of confirmed cases nationally and in Southeast Sulawesi since March 2020. B) Average daily wind speed (mph) and rainfall (mm/day) for Beto Ambari station, Buton (Southeast Sulawesi). C) Total number of active fishers and traders using the OurFish app. D) Total daily catch (kg) and total value of the catch (IDR) reported. Lines are loess curves with span of 0.1 and grey area as the 95% confidence interval. Data runs from June 2019 to May 2020 across Southeast Sulawesi. Red vertical dotted line marks Mar 11, 2020 when the virus was declared a global pandemic by the World Health Organization. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

fits through lowest AICs (Tables A.1-A.6).

Each response variable was modeled against several explanatory variables that are likely to affect them directly such as, time (days), average daily weather condition (wind speed [mph], and rainfall [mm/day]), number of active fishers, and/or nationwide cumulative number of confirmed COVID-19 cases. Model structure for number of fishers, for example, was as follows:

$$Y_i = \beta_{0i} + f_{day}(X_{1i}) + f_{wind\_speed}(X_{2i}) + f_{rainfall}(X_{3i}) + f_{covid\_cases}(X_{3i}) + \varepsilon_i,$$

$$\varepsilon_i \sim N(0, \sigma^2)$$

where Y_i is the daily response variable (e.g., daily catch), $\beta 0$ is the intercept; $f$day, $f$wind_speed, $f$rainfall and $f$covid_cases are smooth functions for the covariates we are focused on; X_{1i}, X_{2i}, and X_{3i} are the values of covariates (time, weather conditions, and cumulative COVID-19 cases); and ε is the error with expectation 0 and variance σ^2.

We used an automated model selection approach for each response variable by using the dredge function of the package 'MuMIn' version 1.43.17. Starting with a global model with the full set of explanatory variables, we selected the best model(s) with a delta AIC < 4 from all potential combinations of explanatory variables (Tables A.1-A.6). For each explanatory variable, we selected a cubic regression spline (cr) as penalized smoothing basis and k value (basis dimension) large enough to represent the underlying truth reasonably well (Wood, 2017). We inspected the residuals from selected models using different basis dimensions and compared the fit of the models using the AIC values to determine the most parsimonious model. We checked multicollinearity

by assessing the correlation table of the lme portion of each model. Since cumulative number of COVID-19 cases was correlated with time, we included them in two separate models. To each model we added a low order correlation structure (corAR1 or corARMA) fitted to the residuals to account for temporal autocorrelation observed in exploratory analysis. All analysis, models, and graphs were performed in R version 3.6.2 (R Development Core Team, 2019). For the GAMs we used the package 'mgcv' version 1.8–31 (Wood, 2017).

2.4. Data availability

The data and R code that support the findings of this study are available from the corresponding author upon reasonable request.

3. Results

3.1. Fisheries data

The number of active fishers and traders significantly dropped by over 90% after March 11, 2020, when COVID-19 was declared a global pandemic by the World Health Organization (Fig. 2C). The steep decline was significantly associated with the steady increase in COVID-19 cases nationwide (Fig. 2A, Figs. A.2 and A.3, Tables A.1 and A.2).

Total daily catch weight and value recorded in the sales transactions

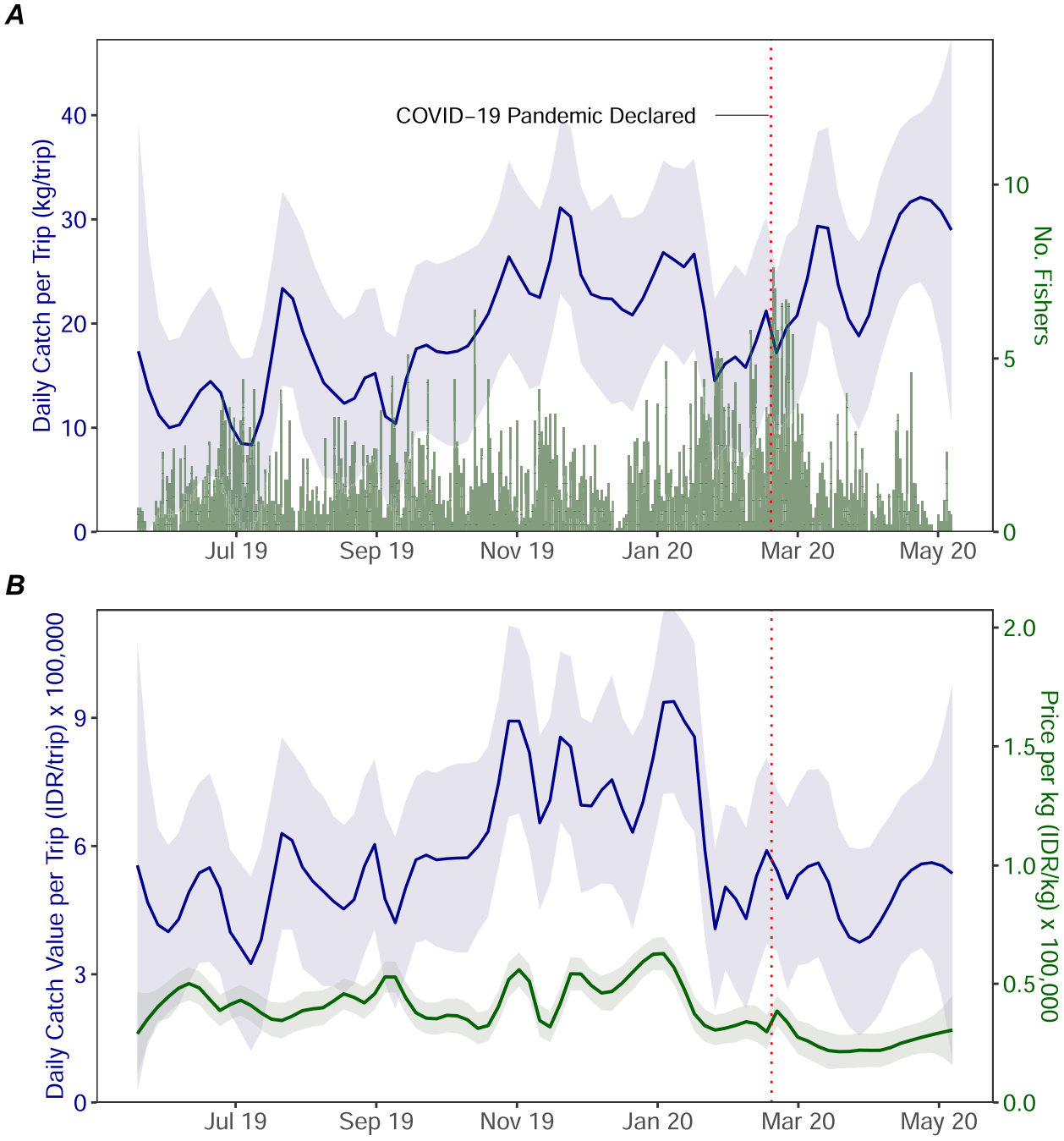

Fig. 3. Daily catch and value of the fisheries in Southeast Sulawesi from Jun 2019 to May 2020. A). Daily catch per trip (kg/trip) and average number of daily active fishers per community. B) Daily value of the catch per trip (IDR/trip) and price per kilogram of product (IDR/kg). Solid trends are loess curves with span of 0.1 and grey area the 95% confidence interval. Red vertical dotted line marks Mar 11, 2020 when the virus was declared a global pandemic by the World Health Organization. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

across Southeast Sulawesi declined after the pandemic declaration (Fig. 2D). Total daily catch decreased from 4393 kg/day to 194 kg/day (a 96% drop), while total value of the catch plummeted from 123,236,897 IDR/day (USD $8414) to 2,407,400 IDR/day (USD $172) a 98% decline, across all the communities combined from March 12 to May 31, 2020. The decline in total catch weight and value after the onset of the pandemic (Fig. 2D) was directly correlated with the steady decline in the number of active fishers selling fish to traders using the OurFish application (Fig. 2C, A.4 and A.5, Tables A.3 and A.4).

Overall, the average daily catch per trip increased from approximately 20 to over 30 kg/trip after the pandemic was declared (Fig. 3A). There was a negative correlation between the daily catch value per trip and the number of fishers capturing and selling fish. With low numbers of fishers, the daily catch value per trip increased (Fig. 3, Fig. A.6, Table A.5).

Daily catch value per trip and price per kg varied by fisheries product. Relatively sharp declines in catch value per trip after the onset of COVID-19 occurred for trevallies, emperors, snappers, breams, and mackerels; while the catch value of parrotfish increased (Fig. 4), which was related to its increased catch in kg/trip after the pandemic was announced (Fig. A.8). Average price per kg of some fish products (ie. snappers, octopus, mackerels, cuttlefish, and fresh groupers) declined after January 2020 and continued to decline after the pandemic was declared (Fig. 4, Table A.6), as did the catch in kg/trip for some fish groups (Fig. A.8). The trade of live grouper was halted in April 2020 due to the closure of access to high end consumers in restaurants and export markets, although it opened up by May 2020. Price per kilogram of live grouper, however, increased after the pandemic started, reverting a continuing declining trend observed since January 2020 (Fig. A.9).

3.2. COVID-19 related social impacts

The factors that respondents believed were causing impact on their lives were categorized into six common categories for analysis: government instructions and health; lean season for target fisheries; less fishing; limited access; low/reduced sale price; and no available fish traders (Table 1). Coping strategies were grouped into nine categories: reliance on agriculture; change fishing target; focus on fish processing and small holder farming; government subsidy; loans and savings; maintain fishing; no strategy; seek other employment; and trading in non-fish goods.

In Southeast Sulawesi, of the 71 fish traders interviewed, approximately 97% of men and 83% of women believed that their businesses were impacted or severely impacted by the pandemic. Of the 114 fishers interviewed, approximately 99% of men and 75% of women stated that their fishing practices were impacted or severely impacted (Fig. 5). Across the province, fishers and traders believed that the primary impacts to their fishing practices during the pandemic were a lack of fish

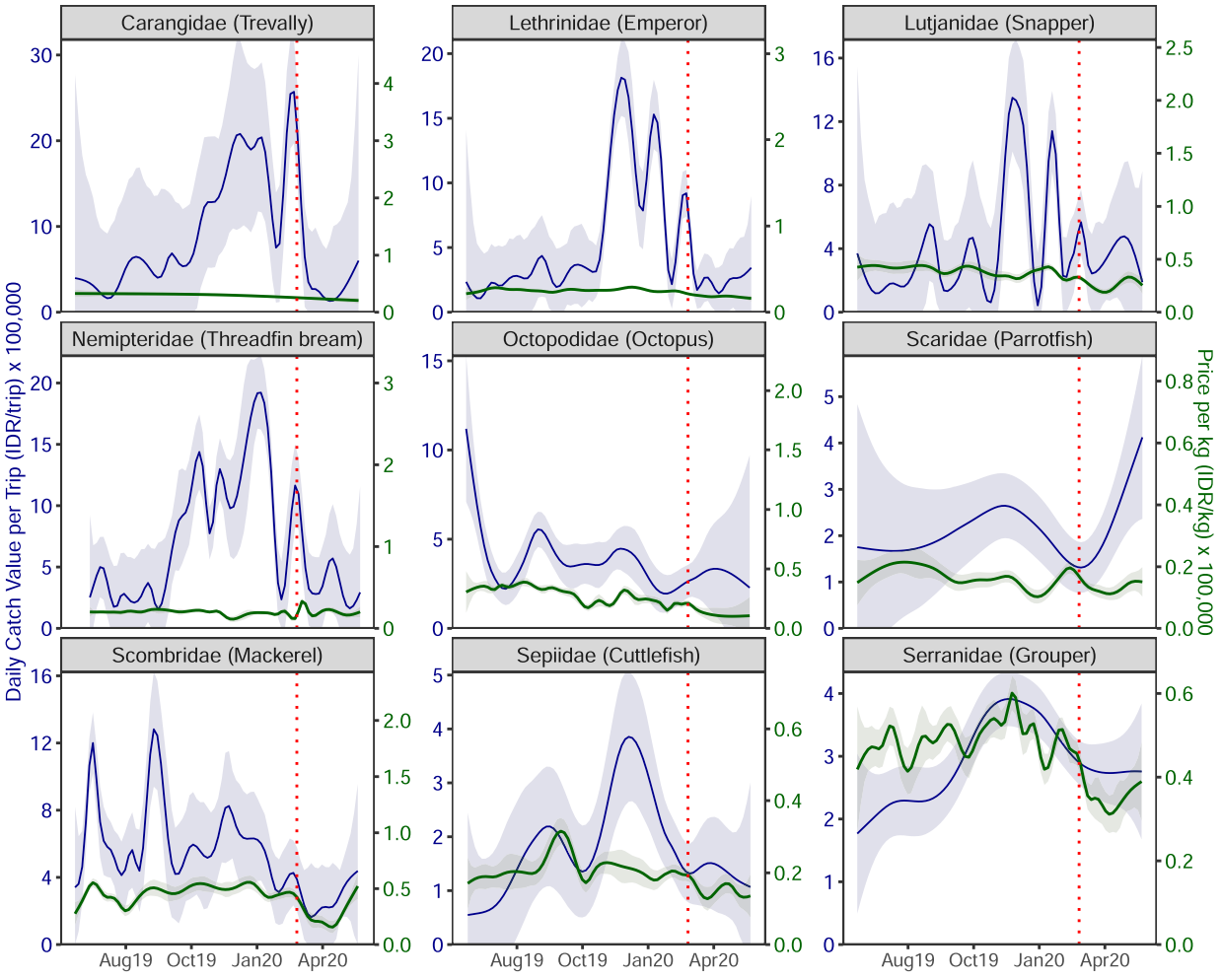

Fig. 4. Daily catch value per trip and price per kilogram for the nine most important fisheries products across Southeast Sulawesi from June 2019 to May 2020. Solid trends are fitted gam curves with a cubic regression spline basis and grey area the 95% confidence interval. Red vertical dotted line marks March 11, 2020 when the virus was declared a global pandemic by the World Health Organization. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 1
Causes of impacts by COVID-19 commonly stated by fishers and traders during interviews.

Causes	Fisher	Trader
Government Instruction and Health	Following government instructions to remain at home, self-distance due to individual and community concerns	Following government instructions to remain at home, self-distance due to individual and community concerns
Lean season for target fisheries	Currently the low season for targeted fisheries due to climatic, environment and biological factors	Currently the low season for targeted fisheries due to climatic, environmental, and biological factors
Less Fishing	Fishers have reduced their fishing activity as a general behavioral response	Fishers supplying the traders have reduced their fishing activity
Limited Access	Fuel scarcity and high prices cause barriers to fishers conducting fishing operations	Sea and land transportation important for supplying fish and other essential goods is disrupted, by increased fuel prices and other factors
Low/Reduced Price	Receive lower prices per kilogram of fish than previously, which does not cover operational costs.	Transport costs have increased and cashflows disrupted causing city traders to offer low prices for fish to first traders and local processors, which is passed on to the fisher. First traders also cannot provide loans and operational support to fishers for fishing operations
No Fish Traders	Local fish traders at fishing landing sites and at local markets have stopped buying fish	City based fish traders in Kendari have stopped buying fish from first traders and local processors

traders and a low/reduced fish value (Fig. 5). The lack of fish traders affected more women (80%) than men fishers (46%), however, low/reduced prices impacted more men (73%) than women fishers (20%) (Fig. 5). A lower proportion of men traders believed that limited access (27%) and less fishing (16%) were a cause of impact, compared with <10% of all women. A relatively low proportion of respondents (<10%) believed that government instructions on health and lean season were impacting their livelihoods (Fig. 5).

The most prevalent strategy to cope with the effect of the pandemic in Southeast Sulawesi was to continue fishing (Fig. 5). Approximately 80% of men and women fishers, and 65%–76% of men and women traders continued to fish after the onset of the pandemic (Fig. 5). Overall, men (26%) were more likely to lack a coping strategy than women (11%); changing fisheries targets was not a common strategy (6%–21% of all respondents); and women traders (21%) were four times more likely to keep processing fish than men (5%). Less than 10% of all men and women stated they were coping by using government subsidies, savings and loans, other employment, or trading in non-fish products. Less than 10% of all respondents mentioned that small holder farming was a strategy they could rely on for income during the pandemic (Fig. 5).

4. Discussion

We found that already vulnerable small scale fishers and the communities and industries that depend on them (e.g., fishers and traders) were negatively affected by the COVID-19 pandemic, as both the total catch weight and the price per kilogram of fish declined resulting in large decreases in total catch value after the onset of the pandemic. Although catch weight and value fluctuated throughout the year, they sharply declined following the announcement of the pandemic on 11 March. This negative trajectory was beyond that associated with inter-annual variations. Indeed, no discernible change in rainfall or wind-speed occurred after 11 March, that could explain these negative trajectories, relative to the upward trajectories during the north-west monsoon season from December to March. Our interview findings also showed that very few fishers or traders believed that seasonality was a cause of disruptions to fishing effort, trade and prices.

The sharp declines in total catch weight and price per kilogram were likely triggered by a closure in access to global markets resulting in collapse in demand (FAO, 2020a; 2020b) and restrictions in access to local markets, associated with travel bans, port closures, including those in Southeast Sulawesi, and lockdown regulations that prevented fishers from fishing and trading. Our interviews with fishers and fish traders on their perceptions of the causes of disruption and their coping strategies revealed that both fishers and fish traders believe that reduced demand for fish from other traders up the supply chain and decline in fish prices, were the main causes of disruption to their livelihood. To adapt to these disruptions, most fishers and traders reported that continuing in their existing occupation of fishing and trading was their principal strategy, despite lower demand and receiving lower prices for catches. However, we observed a decline in the number of fishers and traders recording catch through the OurFish app, which was likely caused by the reduced demand from traders and closure of fishing port trading centres, in the immediate aftermath of the pandemic announcement.

The sharp decline in total catch and total value that occurred in March could in part be explained by an overall decline in price per kilogram of fisheries products, as demand declined with the temporary closure of restaurants and retail shops, impacting the trade in fish across the country. Fish landed at large ports were kept idle in cold storage as local markets were over supplied and export markets closed (Mubarok and Ambari, 2020). There was limited space or access to these facilities for fish supplied by small scale fishing communities. We show that price per kilogram declined for regionally and internationally traded fisheries including grouper, octopus and snapper highlighting the vulnerability of small scale fisheries to exogenous shocks to trade (Anderson et al., 2015). Octopus and live grouper were heavily impacted with live grouper trade ceasing all together by April. Both products are commonly exported to Italy, China and Taiwan. Conversely, the prices for domestically traded fish including trevally, emperor, bream, and parrotfish appear to have suffered little overall decline over the post pandemic period. Such trends could be due to government efforts to stabilize domestic fisheries value and income, through various financial and non-financial incentives to boost local consumption, including the direct purchasing of fish from fishers and traders, for supply into local markets (KKP News, 2020).

Our interviews with fishers and traders on their perceptions of the causes of disruption and coping strategies supported findings from Ourfish records that showed a decline in total catch and sale prices in the month after the pandemic announcement. A high proportion of fishers and traders (40% and 80%, respectively) believed that low demand from traders was impacting fish trade, suggesting that disruptions to supply chains were caused by the inability of traders to sell fish, and therefore were unable to support local fishing operations (FAO, 2020a; 2020b). Despite these barriers to fishing, a high proportion of fishers and traders (65–80%) stated that their best coping strategy was to continue fishing, despite receiving lower prices for catches. Indeed, Ourfish data shows that daily catches by individual fishers increased, and the value of individual fisher catches was sustained, allowing some fishers to cope with disruptions to markets. This trend contrasts with small scale fisheries in Mexico where 48% of respondents reported that they that had stopped fishing and 44% of the fishers reported that they were unable to adapt and stopped selling their products due to lack of traders or storage space (COBI, 2020).

In several countries in the Indo-Pacific many women fish for their families or process fish for income (Kleiber et al., 2015; Thomas et al., 2020). In Southeast Sulawesi, women are primarily involved in the trade of salted, dried and smoked fish products to local villages and markets as described elsewhere (Barclay et al., 2020; Harper et al., 2020a). Women traders in our study were four times more likely to rely on processing fish

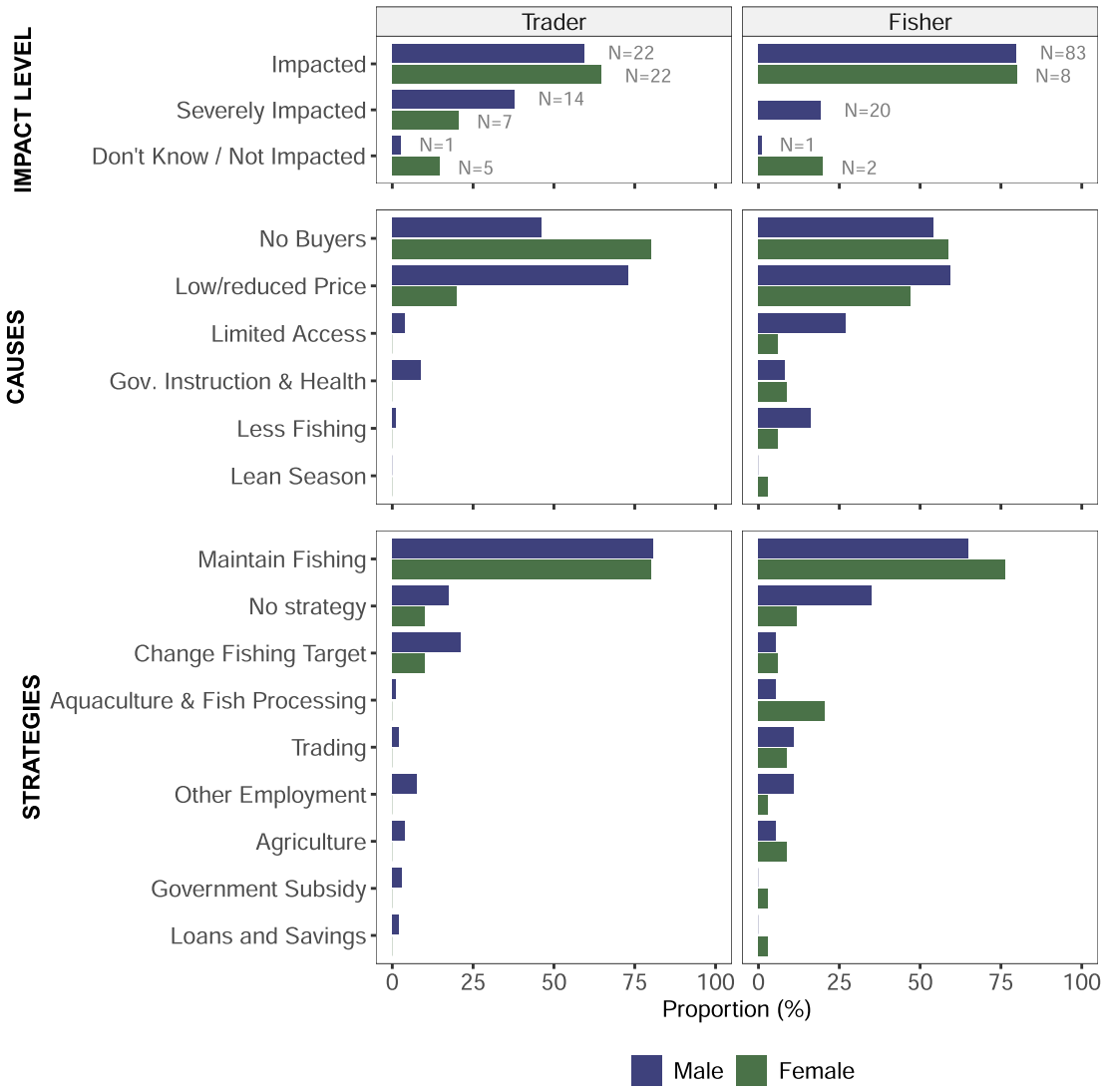

Fig. 5. Perceived impact level, causes and coping strategies in response to COVID-19. Proportion respondents interviewed (%) in Southeast Sulawesi by profession (trader and fisher) and sex (male, female). N is the number of respondents by each profession and gender.

as a coping strategy than men. Maintenance of trade in processed fish would appear to be an important economic and food security strategy for women traders, and also for some men, to preserve fresh fish being landed in villages, prevent spoilage of fish, and cope with reduced trade and lower prices of fresh fish.

The low proportion of respondents who were able to use savings, loans and seek other employment opportunities suggests that long-term strategies to improve livelihood opportunities, access to financial services and empowerment over their natural fisheries capital is urgently needed (Gurney et al., 2014; Pomeroy et al., 2020). Financial strategies that assist and strengthen local fish processing businesses can play a critical role in building financial resilience of vulnerable fishing communities (Lomboy et al., 2019). These strategies encourage domestic trade and consumption, improve the marketing and processing of fisheries products (Vitukawalu et al., 2020), and mitigate nutrient shortages to deliver good outcomes for public nutrition and health (Hicks et al., 2019; Pauly, 2019) as well as global food security (Béné et al., 2015). In addition, financial strategies that support alternative sources of income such as smallholder farming or other employment could help fishing communities increase resilience in times of unforeseen economic shocks that affect their local fisheries (Pomeroy et al., 2020). Across 6007 coastal fishing households in Southeast Sulawesi, 25% reported income from small-hold farming (Rare unpublished data). This may explain the extremely low (<10%) stated reliance on smallholder farming as a coping strategy by respondents in the present study.

As identified through interviews with fishers and traders, small scale fishing households felt that they could best cope with the impact of low demand and low price for fish by continuing fishing activities and fish processing. Following our surveys, provincial governments, including Southeast Sulawesi, began disbursing assistance. Approaches varied and included subsidizing the market chain by buying fish and fish products to maintain community income, subsidizing aquaculture production through the provision of fish (KKP News, 2020) and providing direct emergency food relief for household consumption (Amysyah, 2020).

Further assistance programs identified households in need from District Social Agency data and disbursed support through the National Village Fund to cushion the impacts of the COVID-19 epidemic on low-income families (Amnifu, 2020), as ordained by The Minister of amended Villages, Regional Development and Transmigration Ministerial regulation (Government of Republic of Indonesia, 2020b). In May 2020, the Indonesian parliament recommended that government and state-owned enterprises purchase and distribute fisheries products that cannot be absorbed by export markets. Subsequently the Ministry of Maritime Affairs and Fisheries allocated a Rp 1.02 trillion (US$69

million) stimulus package or 18% of its 2020 budget to aid COVID-19 affected small scale fishers, fish farmers and salt farmers, and for processing and marketing, surveillance efforts against poaching and internal auditing of the fishing industry (Office of Assistant to Deputy Cabinet Secretary for State Documents and Translation, 2020; Parama et al., 2020). Our finding that catch, value and price of some fisheries products showed signs of recovery, after downturns immediately after the pandemic was announced, suggests these strategies could be contributing to small scale fisher household consumption and resilience.

In addition, gender considerations are important as economic crises often disproportionately impact women and children (Harper et al., 2020b). Women are more vulnerable as they represent a relatively high percentage of the workforce in the informal economy, are rarely insured or are unable to access protection offered through health, employment or emergency policies and contributory social protection mechanisms (FAO, 2017; 2020a). In Indonesia, male fishers are more likely to be formally registered by the national fisher registration system, which provides emergency and life insurance and access to credit, than fishers who are women. For fishers and traders in the informal sector, improving access to government programs, in both times of crisis and for general assistance would benefit from improving registration systems. This would ensure that small scale fishers can build a formal financial identity with the provision of social security and insurance benefits granted for protection of workers in small scale fisheries (FAO, 2017), and access to other financial services provided by private sector providers.

5. Conclusion

Here we provide an empirical analysis of the immediate disruption caused by the COVID-19 pandemic on coastal communities dependent on small scale fishing in Southeast Sulawesi, Indonesia. Most fishers and traders believed that a lack of trade in fish and declines in the value of fish were the primary causes of impact on their lives. Fisheries catch records verified these findings with immediate declines in fishing effort, and the trade in fish including the volume and value of catches, after the onset of the pandemic, beyond seasonal effects. Government assistance programs are starting to flow to households in need, but at the time of the interviews this assistance had not reached the communities of this study. Fisheries commodities reliant on export markets suffered the most severely from declines in market demand and value, more so than locally traded species. Monitoring shifts in fishing activities as fishers adjust to the new market dynamics will be critical as increased fishing effort on certain species may well lead to overexploitation of targeted species. Fishing households struggle with insufficient and unpredictable income flows, relying on informal economies to meet basic cash flow and working capital needs. These constraints limit household capacity to absorb unforeseen expenses or disruptions to their income streams from exogenous shocks (Anderson et al., 2015; Lomboy et al., 2019). Implementing financial inclusion and gender equity strategies that move this sector into the formal economy, empower local businesses to retain the value of the fishery, and improve market access could support the long-term recovery and resilience of fishing communities (Pomeroy et al., 2020). The digital data collection system OurFish app has been critical in providing near real time data of previously unreported fisheries, by logging transactions between fishers and traders. This is especially important during a time when other large commercial enumeration programs have stopped because third party enumerators could not visit landing sites. The basic but vital information obtained through the OurFish app also has the potential to build financial identify and provide proof of income and be used to connect small scale fishing communities with financial services. Having improved data on fisheries production combined with better financial data for households and small businesses to manage their financial activities provides real opportunity to develop and improve coping strategies and to manage fisheries resources (Halim et al., 2020), for long term ecological and economic benefits.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ocecoaman.2020.105485.

Author contributions

R.J., conceived of the study with support from H.S., A.S., A.V., C.C., A.S.K., D., L.F.D., S.J.C and S.B; R.J., A.V, H.S., A.S., E.M., and W.S. developed and implemented the analyses; A.V., analyzed the fisheries data, S.J.C. led the writing of the manuscript. All other authors contributed to data collection or made substantive contributions to the text.

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Ethics statement

The activities for this study were conducted under permission and were fully supported by the Indonesian government. Verbal consent was obtained from all participants before conducting interviews. Prior to consenting to interviews fishers and traders were informed about the survey, its purpose, and how the data would be used. No animal subjects were utilized other than the recording of fish catches that already had been captured by traders using the online Ourfish app. No clinical trials were performed. All fishers had agreed to be registered through the Ourfish app and provided verbal consent for their catch to be recorded.

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