Food and Agriculture Organization of the United Nations

Post Disaster Damage and Needs Assessment of the Fisheries Sector in The Bahamas

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Executive summary

The Bahamas is highly vulnerable to the impacts of extreme weather events given its location, climate change and variability, and the low-lying nature of its islands. Hurricane Dorian, a Category 5 Hurricane, was the second strongest Atlantic storm on record and the strongest to ever strike The Bahamas. Hurricane Dorian is the most damaging hurricane the Bahamas has ever seen and the costliest event for the Bahamas on record. The damages of the hurricane are estimated to have cost The Bahamas USD 3.4 billion (which is equal to more than a quarter of the country's GDP), with hundreds dead or missing and with impacts on the economy that will last for years. The event particularly affected two islands and several cays, Abaco and Grand Bahama, where around 20% of the Bahamas population were living. Although Grand Bahama has a significantly higher value of buildings and infrastructure, Abaco suffered proportionally more damage.

Hurricane Dorian impacted Grand Bahama and Abaco from Sunday September 1 to Tuesday September 3, 2019 for approximately 68 hours. It devastated the islands of Abaco, Grand Bahama and the surrounding cays, with the southern eyewall remaining "stationary" for approximately 36 hours over Grand Bahama. On the 1st of September 2019, the eye of Hurricane Dorian moved over the centre of Abaco with the city of Marsh Harbor right on its path. According to the trajectory of the hurricane, the central and northern part of the island were affected by hurricane force winds, storm surge and flooding.

On 2 September, Hurricane Dorian was between the islands Abaco and Grand Bahama and passed over eastern Grand Bahama. The hurricane slowed down to the north of the centre of Grand Bahama on 3 September until it moved north away from the island. According to the descriptions of the Department of Meteorology, storm surge and flooding caused the most severe damage on Grand Bahama, especially at the eastern side of the island. The flooding on Grand Bahama began from the north and northeast towards the south of the island, this phenomenon was due to the trajectory of the hurricane and the period that Dorian remained in the northern part of The Bahamas in open ocean. At the peak of the storm, sustained winds reached 298 km/h (185 mph) with gusts up to 354 km/h (220 mph). The estimated rainfall was 305-381 mm/day (12-15 inches) and the storm surge has been estimated to be as high as 5.5-7 meters (18-23 feet) above sea level. This while at the same time e.g. Grand Bahama is low lying with most of the island below 3 meters (15 feet) above sea level.

The hurricane levelled thousands of houses, scattered debris, overturned cars, shipping containers and boats. At least 13,000 homes and many other buildings, roads and other structures were destroyed mainly by the extreme strong wind and the catastrophic flooding as a result the of storm surge. Initial assessments for Abaco found also telecommunications towers down, and water wells and roads damaged. There was very limited or no water, electricity or sanitation. The official death toll reported was 70 at the end of November 2019, but 282 people were still missing. The two islands face economic vulnerabilities. Tourism and fishing provided, together with public employment, the majority of jobs on the islands in 2019. Dorian, like other hurricanes, caused widespread damage that directly and indirectly affected these productive activities.

The fishery sector of Grand Bahama and Abaco is of critical economic importance, as the two islands and associated cays, produce approximately 40% of the Bahamian fishery production destined for exports. In terms of their importance to the fisheries sector in The Bahamas, the islands of Abaco and Grand Bahama come in third and fourth place after New Providence and Spanish Wells in their contribution to the overall catch. The sector is also critical for the food security of the local population, as fish consumption per capita is estimated at 27 kg/year (2013). Moreover, many fishers on the islands are also involved in recreational fisheries and connected to the tourist sector indirectly, as well through direct sales.

FAO was officially requested by the Ministry of Agriculture and Marine Resources of The Bahamas, to provide assistance through carrying out a Post Disaster Damage and Need Assessment (PDNA) and an assessment of the impacts on livelihoods for the agriculture sector including fisheries. A PDNA provides a picture of the "normal" fisheries patterns in areas affected by natural disasters and provides information to support recovery needs and requirements for rehabilitation so that the process of mobilizing funding is supported. A PDNA is a comprehensive assessment that estimates damages and losses, and identifies the needs of the affected population.

A pre-PDNA mission was carried out by Ms Iris Monnereau, FAO Regional Coordinator of the Climate Change Adaptation of the Eastern Caribbean Fisheries Sector Project (CC4FISH) based at the Sub-regional Office for the Caribbean in Barbados (SLC) in the period 16-24 September 2019, which included 1-day visits to both affected islands. The full PDNA was carried out from the 9-19 October 2019 by the FAO team consisting of Ms Iris Monnereau, Mr Haraldur Einarsson (fishing gear expert) and Mr Sigurdur Sigurdarson (coastal engineer) and included visits to both affected islands (Abaco and Grand Bahama) and meetings with key stakeholders. Both missions were carried out in full collaboration with the Ministry of Agriculture and Marine Resources of The Bahamas.

The PDNA mission estimated that nearly 80% of the fishery sector in Grand Bahama and Abaco was either destroyed or significantly damaged as a result of Hurricane Dorian. The spatial distribution of damages was highly unevenly, with some areas experiencing significant destruction, and others experiencing minimal impact. However, all fisherfolk interviewed during the mission had lost a large part or all of their fishing gear. This means that 20% of the households in Grand Bahama and Abaco, equaling over 13 thousand people, who were dependent on the fisheries sector for employment and income at the time of the hurricane, have difficulty making ends meet and are suffering from income loss and food insecurity. The after-Dorian fisheries production on the two islands is minimal, affecting food security, livelihood and employment, as well as export revenues of the country.

The assessment estimated that Dorian's damages to the fishing fleet were USD 4.9 million, fishing gears (mainly condo's) USD 8.6 million, buying stations USD 1 million, and processing plants USD 7.2 million. In total the damages to the fishery sector sum up to USD 21.7 million. It is worth noting that although the damages to fishing gear related only to an estimated loss of condos, these account for nearly 40% of the total damages in value terms.

The assessment estimated that until August 2020, Abaco will lose approximately USD 14.6 million and Grand Bahama for a similar period will lose approximately USD 14.0 million. The current 2019-2020 fishing season for spiny lobster, conch and stone crab is expected to encounter a significant drop in production compared to last years in The Bahamas. The main losses are expected in the lobster fishery, whereby Grand Bahama will have lost USD 11.5 million and Abaco USD 13.4 million by the end of the season. In total the losses to the fishery sector until August 2020 are expected to reach USD 28.6 million. The consequences of these losses in terms of rebuilding the economy and food security on the islands are likely to be severe. Expected export earnings may be reduced by tens of millions of USD in 2019 and 2020.

This report is divided into two sections. The first section contains the description of the event, affected population and a detailed assessment of damage and losses to the fishing sector. Additionally, this part includes some of the expected environmental effects and the macroeconomic impacts. The second part provides recommendations for resilient reconstruction of the fishing sector based on the findings by the FAO team and global best-practices.

Abbreviations

CC4FISH	Climate Change Adaptation of the Eastern Caribbean Fisheries Sector Project
DMR	Department of Marine Resources
EEZ	Exclusive Economic Zone
FAD	Fish Aggregating Device
FAO	Food and Agriculture Organization of the United Nations
GB	Grand Bahama
GDP	Gross Domestic Product
GPS	Global Positioning System
PDNA	Post-Disaster Needs Assessment
TCP	Technical Cooperation Programme
USD	US Dollar

Introduction

Hurricane Dorian impacted Grand Bahama and Abaco from Sunday, September 1 to Tuesday, September 3, 2019, for approximately 68 hours. Hurricane Dorian, a category 5 hurricane was the strongest hurricane in modern records to ever hit the archipelago. It devastated the islands of Abaco, Grand Bahama and the surrounding Cays, with the southern eyewall remaining "stationary" for approximately 36 hours over Grand Bahama. At the peak of the storm, sustained winds reached 298 km/h (185 mph) with gusts up to 354 km/h (220 mph). The estimated rainfall was 305-381 mm/day (12-15 inches) and the storm surge has been estimated as high as 5.5-7 meters (18-23 feet) above sea level.

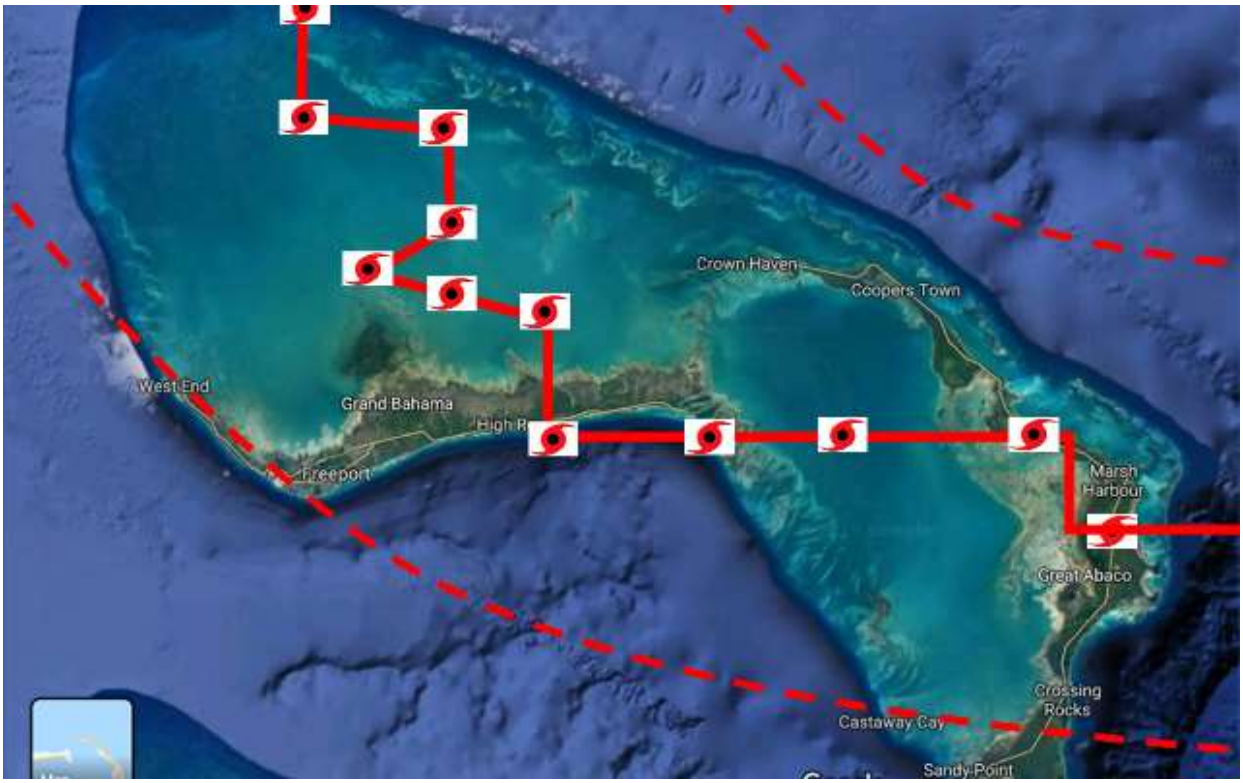

Figure 1 The path of Dorian from east to west during the period of 1 to 3 September 2019 (authors).

At least 13,000 homes (40% of the homes on Abaco and Grand Bahama) suffered severe damage or were destroyed, and many other buildings, roads and structures were destroyed on Grand Bahama and Abaco, mainly as the result of the extreme winds and the catastrophic flooding as a result of the storm surge. To date, the number of fatalities is still rising. At of the end of November, the official death toll was 70 (60 on Abaco and 10 on Grand Bahama), with 282 people still missing. Damage amounted to USD3.4 billion with insured losses alone were confirmed to be at least USD1 billion. Across the Bahamas, the storm left at least 70,000 people homeless. In the most affected areas, electricity and water were not restored until early November.

Fisheries in The Bahamas

The fisheries sector is of great importance to The Bahamas generally and in particular to the two affected islands. The fisheries sector plays a vital role in the Bahamian economy in terms of foreign currency earnings, food security and employment. The national government has reserved commercial and subsistence fisheries for exploitation by Bahamian citizens within its Exclusive Economic Zone (EEZ) and applies a system of open-access fisheries. Fisheries regulations also allow permits for foreign sports fishing operators and recreational fishers.

Fisheries in The Bahamas contribute significantly to the diet of the Bahamian people. Fishery products contribute more than 10% to the protein intake of the population.. The commercial fisheries sector supplies 27 kg/capita/year of fish and fishery products to the population. It generated in recent years some USD 80 million annually in export earnings and provides full-time employment to 9,300 commercial fishers and thousands of jobs more in recreational fisheries, vessel maintenance, fish processing, catering, retail and trade. The fishing fleet is characterized as small-scale and counts approximately 4,000 fishing vessels ranging in length from 3 meters to 30 meters (9.8 feet to 98 feet), with the large majority less than 7 meters (23 feet) in length. In 2015 the Bahamian fishing sector contributed an estimated 1.2 percent to the GDP (USD 96 million).

The total yearly commercial fisheries production over five years (2013-2017) was between 11 and 12 thousand tonnes (FAO FishStatJ). However, in 2018, the officially reported catch was only 3,029 tonnes as a result of the impacts of Hurricane Irma in 2017. The total production in volume and value terms fluctuated in recent years mainly at the result of variations in landings and prices of spiny lobster (the main export product), but the effects of hurricanes have been considerable.

The total catches are estimated to be double the official figures. A large part of the catch goes unrecorded as it is sold at the local market to local consumers as well as directly to the tourism industry. To account for this, increased figures have been used in this report.

In The Bahamas, commercial fishing takes place almost only on the continental shelf, mainly on the Great Bahama Bank and Little Bahama Bank. These two fishing areas make up the majority of the 116,550 km^2 of continental shelf area. The continental shelf is nearly 18% of the total Exclusive Economic Zone (EEZ) of The Bahamas of 654,719 km^2.

Fishing activities in The Bahamas include commercial and artisanal fisheries, aquaculture, subsistence fisheries, sports, and recreational fishing. In 2017, exports of fish and fishery products amounted to USD 87.7 million. In the same year, imports were valued at USD 18.4 million and the country is therefore a net-exporter of fish. As such, the fisheries sector is a major contributor to reducing the trade deficit of The Bahamas.

In 2018 The Bahamas capture fisheries sector harvested 3,028 metric tonnes , with Caribbean spiny lobster and queen conch accounting for, respectively, 64 and 18 percent of total catches. Spiny lobster is the most important species in terms of weight and in value with over 90 percent of the caught lobster being exported. Other important fishery resources include snappers, Nassau grouper and various mackerel species. Conch and finfishes are mostly consumed locally in restaurants, hotels and homes. However, there are significant exports of these products as well.

Spiny lobster stocks in The Bahamas are being fully exploited, while conch, snappers and groupers are, like in the rest of the Caribbean, under heavy fishing pressure and some stocks are probably overexploited. The major threats to the marine fisheries resources are coastal zone development, boat and diver damage to the reefs, over-harvesting of commercial species, Illegal, Unreported and Unregulated (IUU) fishing and disturbance of sensitive fish habitats.

The recreational and sport fisheries subsector of the fisheries sector is also very important to the country and contributes an estimated USD 500+ million annually to the national economy through related expenditures by tourists. This subsector provides employment for some 18,000 Bahamians. The recreational and sport fisheries target game fish, such as marlins and sailfishes, as well as bone fish.

Fisheries in Grand Bahama and Abaco

In terms of their importance to the fisheries sector in The Bahamas, the Abaco and Grand Bahama islands come in third and fourth place after New Providence and Spanish Wells in their contribution to the overall catches.

FAO recognizes the critical importance of the fishery sector for the two affected islands as the two islands produce approximately 40% Bahamian fishery production destined for exports. The sector is also highly crucial for food security of the local population. Moreover, many fishers on the island are also involved in recreational fisheries and connected to the tourist sector as well through direct sales.

The northernmost islands of The Bahamas (Grand Bahama and Abaco island and associated cays) are regularly exposed to hurricanes, which hit the islands approximately every three years. The islands are of low elevation, which makes the coastal communities vulnerable to flooding due to the storm surges associated with storms and hurricanes. The consequences of these hurricanes for the livelihood of the population and economy are significant. Fishers are highly dependent on fishing for their livelihoods and often there are minimal possibilities for finding alternative employment. Their access to land is generally limited and their assets, in the form of boats and gear, are more exposed to natural hazards and hence more easily lost than land-based property. As a large part of the local population in Abaco and Grand Bahama depends on the fisheries sector for its livelihood, natural disasters such as hurricanes and tropical storms cause large-scale and prolonged uncertainty, instability and insecurity.

The main fisheries in Grand Bahama and Abaco are lobster, conch, stone crab, and finfish such as groupers and snappers. Lobster fishing is the main economic activity for fishers, and at times up to 95% of the fleet is occupied in lobster fishing. The fishing vessels used for this catch are motherships, deck skips that can stay out for several days, and smaller glass fiber reinforced plastic (GRP) boats (fiberglass dinghy) with outboard engines. The fishing gear used includes lobster traps, stone crab traps, fish pots, condominiums (also known as condo's) and compressors placed on the boat for diving.

Figure 2 The most important fishery resources in Grand Bahama and Abaco from left to right: spiny lobster (Panulirus argus), queen conch (Strombus gigas) and stone crab (Menippe Mercenariea)(authors).

Grand Bahama is the second-most populous island in The Bahamas with an area of 1,373 km^2 and over 50,000 inhabitants. Most of the people on Grand Bahama depend on fisheries or related activities, particularly in the largest town Freeport. Abaco has a smaller population with just under 18,000 inhabitants, but has a larger land area of 2,009 km^2. Abaco is also very dependent on fisheries as well as on the tourism sector. The largest community in Abaco is Marsh Harbour, with a population of over 6,000 inhabitants.

Both islands and the nearby small islands and cays, coastal and shallow areas, contain important ecosystems such as mangroves, coral reefs and seagrass beds. These are especially important for the lifecycle of the most important fishery resources in Grand Bahama and Abaco, spiny lobster (*Panulirus argus*), queen conch (*Strombus gigas*) and stone crab (*Menippe Mercenariea*).

In The Bahamas, commercial fishing takes place on the continental shelf, mainly on the Great Bahama Bank and the Little Bahama Bank. Grand Bahama and Abaco are located on the Little Bahama Bank. Grand Bahama and Abaco produce nearly 33% of the total catches of the spiny lobster and queen conch in The Bahamas and nearly 60% of the total annual catch of stone crab.

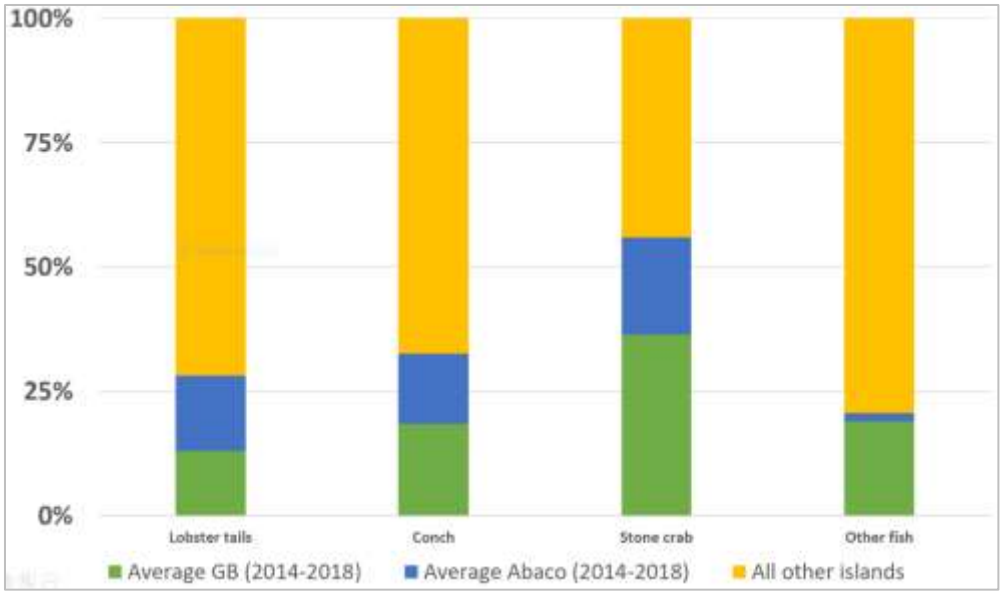

Figure 3 Average production in % contribution of Grand Bahama (GB) and Abaco versus all other islands in The Bahamas 2014-2018 (authors).

Figure 3 presents the average production of Grand Bahama and Abaco as a proportion of the overall production in The Bahamas from 2014 to 2018 based on the officially recorded landing data. The figure shows that the participation of Grand Bahama in lobster production compared to the overall production of the country is slightly smaller than of Abaco. For conch, it is the opposite situation, and Grand Bahama produces somewhat more conch than Abaco. For all other fish species combined, Grand Bahama produces more than Abaco. In contrast, Abaco does not produce much seafood aside of crustaceans and conch.

Over the last years, the annual seafood production value has been similar between Abaco and Grand Bahama. Abaco produced slightly more lobster tails than Grand Bahama, but Grand Bahama produced more of the other main target species (Figure 4). The bar plot (Figure 4) shows the average annual off-vessel value of seafood over the years 2014-2018. The average annual landed value of lobster tails was USD 8.6 million in Abaco and USD 7.4 million in Grand Bahama. For conch, the value was significantly lower with an amount of approximately USD 580,000 for Abaco and USD 770,000 for Grand Bahama annually. At the same time, discussions in the Bahamas have indicated that in addition to the total official landings, a similar amount of product goes unrecorded.

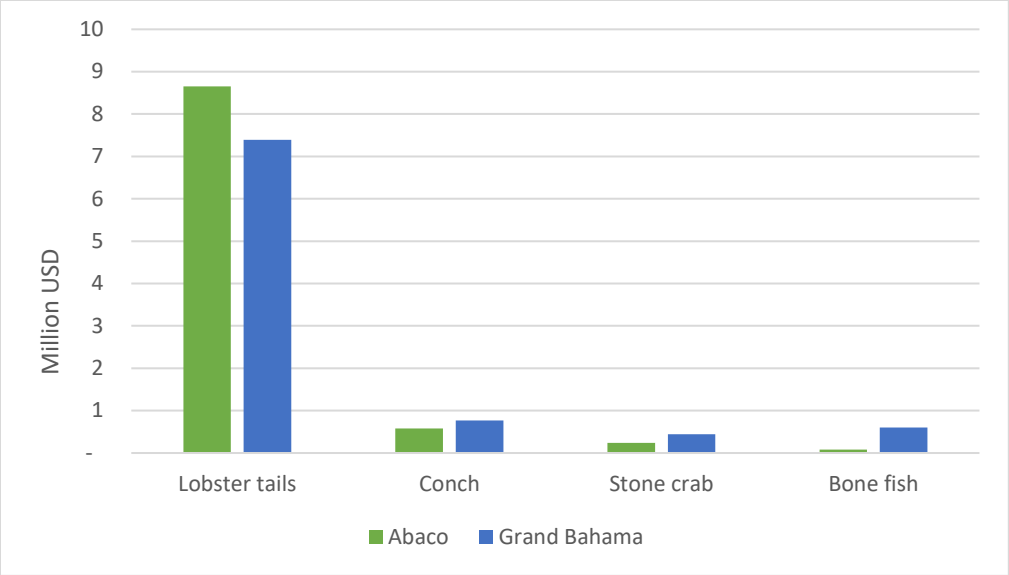

Figure 4 Average annual seafood production (recorded) value (in million USD) in Abaco and Grand Bahama 2014-2018 (authors).

In this report the communities on each of the two affected islands have been grouped into eight regions to simplify the estimate of the damages and losses and the subsequent needs for each of the affected areas in Grand Bahama and Abaco. Each region includes several communities. Figure 5 shows Grand Bahama split into three regions, West End, Central Grand Bahama and East End. Abaco and its smaller barrier cays are divided into five areas, Grand Cay which comprises the cays north of the Abaco island, the Northern communities, Central and Southern communities, with the fifth region being Moors island west of Abaco. Table 1 shows the communities in each of the 'regions.

Figure 5 The main affected areas of Grand Bahama and Abaco with the grouping of communities used in the report (authors).

Names of the main communities in each region are listed in *Table 1*.

Table 1 Communities of the affected areas in Grand Bahama and Abaco (authors).

	Region	Communities
Grand Bahama		
	West End	West End
	Central Grand Bahama	Freeport
		Williams Port
	East End	Mclean's Town
		Deep Water Cay
		Sweetings Cay
Abaco		
	Grand Cay	Grand Cay
	Northern communities	Crown Haven
		Fox Town
		Mount Hope
		Wood Cay
		Cedar Harbour
		Coopers Town
	Central Abaco	Treasure Cay
		Marsh Harbour
		Murphy Town
		Dundas Town
		Green Turtle Cay
		Guana Cay
		Man-O-War Cay
		Elbow Cay
	Southern communities	Cherokee Sound
		Crossing Rocks
		Sandy Point
	Moore's Island	Moore's Island

The Bahamas fishery is an open access fishery, as it is in most Caribbean countries. For most commercial fisheries activities not any license or permit is required if authorized fishing gearare used. There is a license requirement for fishing with diving gear (using hookah). The Government is currently working on improving the fishers and vessels registration system. As a result, there is no official (complete) dataset of the number of fisherfolk. As data availability was limited, setting a baseline to use in the PDNA process was a challenge and the FAO PDNA assessment therefore used a rough estimate compiled on the spot. The number of fisherfolk in each region as well as the number of boats and the damages to the boats and gears was based on estimates from the Department of Marine Resources (DMR), combined with information obtained during interviews with key stakeholders.

The estimates of number of fisherfolk on the two affected islands are presented in Table 2 with a total number of approximately 1,700. One can expect that for every fisher there are 4x as many

people dependent on the sector (engine mechanics, boat builders, vendors, etc.) implying that approximately 6,800 people depend directly or indirectly on the fishery sector on the two islands.

Table 2 Estimated number of fisherfolk in each affected region of Grand Bahama and Abaco (authors).

Region		Estimated number of fisherfolk per community
Grand Bahama		
	West End	250
	Central Grand Bahama	350
	East End	150
Abaco		
	Grand Cay	200
	Northern communities	250
	Central Abaco	170
	Southern communities	50
	Moore's Island	250-300
Total number of fisherfolk in affected regions		**≈1,700**

The commercial fishing fleet used on the islands is characterized by two types of vessels with two sets of activities[1]. Firstly, small vessels of around 5.5 meters (17 feet) in length, often referred to as dinghies, operate different gears or techniques, including diving, to target conch and lobsters. These vessels are typically operating on a one-day trip basis. Some of these vessels will operate together with a mothership during the season. There are also large vessels, usually above 6.6 meters (20 feet) in length, who serve as motherships and operate with the dinghies as mentioned earlier. Fishing trips of these motherships can be of several days to weeks, depending on the size of the mothership. These vessels target mainly conch and lobster, but can also operate secondary gears like nets to capture snappers, groupers and other demersal fish species. The larger vessels are also used to target other species, like stone crabs.

In a similar vein to the number of fisherfolk, there is no official dataset of the number and type of fishing vessels in The Bahamas, or specific vessel information available at the islands. To estimate the type and number of fishing vessels in each region the PDNA team grouped the fishing fleet in four categories based on the recommendations of key stakeholders: dive boats or dinghies; trapping boats or small motherships; stone crab boats and larger motherships,. Table 3 shows the number and estimated value of each boat type based on rough estimates obtained from key stakeholders.

Table 3 Number of different vessels types by affected region in Grand Bahama and Abaco, with typical length and estimated value in USD per boat type (authors).

	Dive boats, dinghies, 15' – 25' USD 5,000	Trapping boats, 35' – 55' USD 100,000	Stone crab boats, 50' – 60' USD 170,000	Motherships, 65´- 70' USD 200,000
West End	80 – 100	NA	1	NA
Central Grand Bahama	150	18	7	NA
East End	70 – 75	NA	NA	NA
Grand Cay	80 -100	NA	NA	2
North communities	100	NA	NA	2
Central Abaco	105	NA	NA	NA
South communities	15	NA	NA	NA
Moore's Island	100 – 150	NA	2+5 small	7
Total number	**700 - 800**	**18**	**10+5 small**	**11**

Assessment of total damages to the fisheries sector

Natural disasters, such as storms and hurricanes, affect the fisheries sector in many ways. The loss of lives has the most dramatic impact, affecting not only surviving household members, but also potentially upsetting the coastal communities in which they live through the economic and social activities and systems outside the immediate family. Natural disasters that strike suddenly without much warning, such as Hurricane Dorian, can cause tangible losses in the form of lost and damaged boats, gears (such as condos) and other productive assets; destruction of infrastructure, such as landing and fish processing facilities (at various levels of scale); and impacts on critical marine habitats (e.g. coral reefs, seagrass beds and mangroves) resulting in loss of production in the short- and long-term. Since the immediate impacts are often overwhelmingly visible, sometimes the longer-term impacts are less taken into consideration.

The impacts of Hurricane Dorian were particularly significant for the Abaco and Grand Bahama islands, where around 20% of the Bahamas population lived. Although Grand Bahama has a significantly higher value of buildings and infrastructure, Abaco suffered proportionally more damage.

The impacts of Hurricane Dorian have been substantial on both islands. The after-Dorian fisheries production on the two islands has decreased substantially, affecting food security, livelihood, employment and export revenues in the country. The assessment found that as a result of the impacts of Hurricane Dorian the fishing activities on the two islands were severely curtailed. The PDNA mission estimated that nearly 80% of the fishery sector in Grand Bahama and Abaco was either destroyed or significantly damaged. The status of different communities on the islands varied between almost destroyed communities and fisheries infrastructure to the loss of a few fishing vessels only. However, all fisherfolk interviewed during the mission indicated they had lost all or a large part of their fishing gear. It is estimated that about 20% of the households in Grand Bahama and Abaco, equaling over 13,000 people, who are dependent directly or indirectly on the fisheries sector for employment and income, were curtailed in making ends meet, and are still suffering from income loss and food insecurity.

Damages to vessels, engines and gears

Damages to the fisheries sector relate to damages of vessels and engines, fishing gears, and fishing centres, including buying stations and related infrastructure, as well as damages to seafood stocks and seafood processing plants.

Assessment of damages to the fisheries sector are based on observations during the field visits as well as on estimates from the DMR and key stakeholders. The estimate of the percentage of total damages to the fishing fleet in each region is presented in Table 4. These impacts vary from 20 to 30% damage on Moore's Island to about 90% damages on East End, Grand Bahama, and Central Abaco.

The total value of the estimated damages to the fishing fleet, vessels and engines, is found by multiplying the number of vessels in each category with their typical value and the estimated percentage damage in each region and adds up to USD 4.8 million.

Table 4 Estimated losses and damages of the fishing fleet by region (authors).

Region	Estimated losses and damaged to the fishing fleet (vessels and engines) in percentages	Estimated value of lost and damaged vessels and engines in USD
West End, Grand Bahama	40 – 50%	USD 279,000
Central Grand Bahama	60%	USD 2.244,000
East End, Grand Bahama	90%	USD 337,500
Grand Cay	40%	USD 340,000
North communities, Abaco	50 – 60%	USD 405,000
Central Abaco	90%	USD 472,500
South communities, Abaco	50%	USD 37,500
Moore's Island	20 – 30%	USD 716,250
Total		**USD 4,831,750**

Figure 6. One of many typical fishing vessels. Vessels washed into land, became damaged while secured on land or disappeared completely (authors).

Casitas (or condominiums) commonly called condos are not actual fishing gear, but act more like Fish Aggregating Devices (FAD) stored on the bottom, made of wood and tin, looking like a pallet. The spiny lobster likes to shelter under them and divers can easily collect them with lifting the pallet (condo). Even though other fishing gears like baited pots are widely used in the Caribbean region, the condos are the most important gear, as most of the valuable spiny lobster is collected with them. Condos made with wood do not withstand strong ocean waves and currents and are only used in shallow areas. Therefore, a large proportion of them disappeared during Hurricane Dorian. To assess the damages, we estimated that on average each dive boat used before Dorian approximately 400 condos. Due to limited information of exact losses, as many fishers were not able to go out and fish after Hurricane Dorian hit, it was assumed that the damages of the fishing gear follow the same path as the damages to the fishing fleet. Table 5 shows that with those estimates in mind, the total losses as a result of Hurricane Dorian to condos are close to USD 8.6 million.

Table 5 Estimated damage to fishing gear assuming 400 condos/casitas per dive boat and a unit price of USD 52 per condo (authors).

	Dive boats, dinghies, 15' – 25'	Estimated damage to fishing gear	Estimate damage to gears (USD)
West End	90	45%	842,400
Central Grand Bahama	150	60%	1,872,000
East End	75	90%	1,404,000
Grand Cay	90	40%	748,800
North communities	100	45%	936,000
Central Abaco	105	90%	1,965,600
South communities	15	50%	156,000
Moore's Island	125	25%	650,000
Total damage			**8,574,800**

Damages to fishing infrastructure

Fish is a highly perishable product, which needs to be delivered and consumed while still fresh unless there are cold storage or freezing facilities available. This is why buying stations and processing plants are crucial to the fishing industry in Grand Bahama and Abaco. Seafood caught by the fishers is subsequently sold to middlemen operating buying stations with freezing capacity (e.g. walk in freezers or smaller chest freezers). The middlemen are either owners of the buying stations or operate them for larger processors. The buying stations store the seafood until it is transported to the processing plants.

Infrastructure at the fish landing sites mainly consists of:

- boat ramps, jetties and quays;
- buying stations with a freezer, scale, generator, ice machine; packing into 30 to 40-pound containers;
- gas stations (not covered in this assessment).

As a result of Hurricane Dorian, the fisheries infrastructure on land, such as lobster/conch receiving or buying stations and fish processing plants, were damaged, severely damaged or destroyed. Some buying stations only had part of the walls remaining. Everything inside and the roofs were destroyed (see figure 7). Some buying stations were still standing, but did not have access to electricity. Some of these buying stations had walk-in freezers, others had facilities for cleaning, weighing and registering the catch.

In areas with limited suitable storage, processing facilities and means of transport, small-scale fishers are not able to catch large amounts of fish as they have no storage facility, resulting in low incomes and weak marketing position. The buying stations play therefore an important role in rebuilding the sector.

Figure 7. Destroyed buying station with concrete dock, in Mclean's Town. The dock is still usable, but the gas pump, which was standing next to the house wall, is gone. The small picture in the upper left corner shows the buying station from the dock side (authors).

Damages caused to the buying stations are shown in Table 6. The estimated cost of establishing a new buying station is USD 60,000. Assuming a mean price per buying station and 50% damage to the stations at Moors Island, the estimated damages to the buying stations accounts for nearly USD 1 million.

Table 6 Estimated damages to buying stations in percentages and value (USD) (authors).

	Number of buying stations	Estimated damage (percentage)	Estimated damage (USD)
Grand Bahama	3	100%	180,000
Grand Cay	4	100%	240,000
Moore's Island	4	50%	120,000
Abaco	12	60%	432,000
Total			**972,000**

Although not a part of the damage assessment but to give an estimation of the value of the catch, Table 7 *Average off-vessel price of the main targeted species, as paid to the fishers, USD*

per pound (authors). gives the average off-vessel price of seafood as was paid to the fishers in 2018- 2019.

Table 7 Average off-vessel price of the main targeted species, as paid to the fishers, USD per pound (authors).

	Average price over 5 years period, given by PB&KL[1] (USD)	DMR – Total Purchases – Abaco 2018 (USD)
Spiny lobster	12.5	9.2
Stone crab	25	N/A
Conch	4.75	4.1
Grouper	5	4.0
Snapper	4	3.4

Although some minor damages to boat ramps, jetties and quays were observed during the PDNA, to the damage was not expected to affect the restarting of the fishing activities in the affected areas. The team did not see any damages that prevented landing of catch nor were there reports of serious damages to the landing or mooring structures. Nevertheless, there were some damages on the landing and mooring structures, which are not accounted for in this report and will require further investigation.

With some exceptions, most landing areas were still standing after the disaster. At some places, with concrete quays, no or minimal damages were observed. In other places, wooden jetties had experienced some damage.

Figure 8. A typical wooden jetty in The Bahamas. The wooden deck was removed before the hurricane passed and put back on after (authors).

[1] Mr Paul Baldwin and Mr Kenneth Lewis are the owners of G & L Seafood Co Ltd in Grand Bahama and members of The Bahamas Fisheries Advisory Board.

Figure 10. Damaged quay in Crown Haven (authors).

Processing plants

The main processing plants in Grand Bahama and Abaco and estimated processing plant damages are presented in Table 8.

Figure 9. Inside two processing plants shortly after the flood: left-hand side picture shows a plant in Marsh Harbour, and the righthand side picture shows a packing area inside a processing plant in Freeport (authors).

Table 8 Estimated damages to the main processing plants in Grand Bahama and Abaco, largely based on DMR data (authors).

	Damage estimate	Cost of Repair /Replacement (USD)	Value of lost Inventory (USD)	Total damages and losses (USD)
Boardwalk Seafood, West End	Medium	83,000	7,000	90,000
G & L Seafood, Freeport	Major	340,000	800,000	1.14 million
Lightbourne's Seafood GB Ltd, Freeport	Major	100,000	26,000	126,000
Armor Seafood, Freeport	Major	220,000	80,000	300,000
Ocean Resources, Freeport	No			
Fox fisheries, Freeport	Major	63,000		63,000
Marsh Harbour Exporters & Importers		4.0 million	1.5 million	5.5 million
Total				**7.2 million**

Small-scale processors , such as the owners of stone crab fishing factory vessels, who suffered damages or losses are not included in the above table.

The PDNA assessed the damages to processing plants in Free Port, Grand Bahama, and incorporated the damage and loss estimates submitted by the plant's owners to the government. Although the plants are located inland a few kilometers from the northern coast at an estimated elevation of about 2-2.5 m (7 to 8 feet), the extent of the flooding due to the storm surge was such that at the plants the water level reached approximately 2 m (6 to 7 feet) above land. All inventory was destroyed. The sea level was as high as 4.5m (15 feet) above normal high tide level.

Adding the estimated damages in Tables 4, 5, 6 and 8, Table 9 provides the total damages to the fisheries sector in Grand Bahama and Abaco. The assessment shows that damages to the fishing fleet are USD 4.9 million, fishing gears (mainly condo's) USD 8.6 million, buying stations USD 1 million, and processing plants USD 7.2 million. It is worth noting that although the estimated damages to fishing gear only relates to condos, it is nearly 40% of the total damages.

Table 9 Estimated total damages caused by Hurricane Dorian to the fisheries sector in Grand Bahama and Abaco (in USD)

Damages to:	**Grand Bahama (USD)**	**Abaco (USD)**	**Total (USD)**
Fishing fleet	2.9 million	2.0 million	4.9 million
Fishing gear (only condos)	4.1 million	4.5 million	8.6 million
Buying stations	0.2 million	0.8 million	1.0 million
Processing plants	1.7 million	5.5 million	7.2 million
Grand total	**8.9 million**	**12.8 million**	**21.7 million**

Box 1: Damages to McLean's Town, Grand Bahama

McLean's Town, located on the south-east of the island of Grand Bahama, is an interesting example in terms of damages as it was affected twice in different ways by Hurricane Dorian. Initially, there was significant flooding from the northeast, which reached over land to McLean's Town, destroying most of the houses and washing many cars out to sea. In the second instance, when Hurricane Dorian had passed and slowed down over central Grand Bahama the flood came from the seaside. The water level was reported to have risen about 2.5 m (8 to 9 feet). As a result, many boats washed out and sunk. A buying station with a room freezer and gas station were completely destroyed. A floating pier from Deep Water Cay was transported by the water over 2 km and stranded in Mclean's Town. A concrete quay/dock and a pier were left mostly intact. Mangrove areas got hit hard and , but are expected to mostly recover. The town had experienced floods before, but interviewees indicated not at same the magnitude. It was reported that much debris stranded in the shoals offshore, including cars and boats.

Losses to the fisheries sector

Hurricane Dorian caused also significant impact on the economy through indirect losses, e.g. value of production losses, income losses and other economic losses. As fishers are not registered, and a part of the catch is also not being recorded, the losses are based on estimates of the official catch. For the losses section, the PDNA team therefore based the assessment on the official recordings of catches and their values (taking an average of 2014-2018) plus the estimates of unrecorded catches. The best estimate of DMR and key stakeholders was that the official recordings should be multiplied by a factor of two to get the total catch. Then the losses took into account the expected decline in fish catches due to, e.g. boats needing replacement or needing repair, as well as the challenges to sell catch due to buying stations and processing plants not being operational for one year after Hurricane Dorian. The expected damage to critical marine habitats (coral reefs, mangroves and seagrass beds) and seafood resources (stocks) were not taken into consideration in this PDNA due to lack of quantifiable information, but some information collected by others is presented below.

Damages to Marsh Harbour

Marsh Harbour was totally devastated; houses, boats, cars all destroyed. When Dorian passed over central Abaco from east to west, it had strengthened to Category 5 right before it struck the island. In Marsh Harbour on the eastern side, the storm surge had sent waves pumping seawater on land ahead of the storm's eye passing over the island. A combination of massive flooding and tremendous wind speed left large boats far into land, and caused massive devastation. The central processing plant the Marsh Harbour Exporters & Importers suffered total damage. At the time of the field visit of the FAO fisheries team, the cleanup was ongoing with a large wheel loader, and rumors that renewing would not happen.

Environmental impacts

Storm surge, wave action, and high winds have caused partial to severe destruction to mangroves, coral reefs, seagrass beds and forests on both Abaco and Grand Bahama (IDB, 2019). As a result, marine ecosystems were critically impacted, and pre-existing vulnerabilities were exacerbated with an expected decrease in ecosystem services provision in the short- and medium term. These ecosystems are home to a wide variety of species of flora and fauna and provide services that are essential to the development of the country.

Six weeks after the catastrophic storm, the Perry Institute for Marine Science visited 30 coral reefs, all of which were hit hard by Dorian[2]. They found that Hurricane Dorian's effects on coral reefs varied considerably, but many sites experienced significant structural degradation; reefs were buried in mud, numerous corals had bleached, and massive land debris, including ladders, trees and telephone poles, had destroyed the formerly healthy reefs.

[2] http://www.perryinstitute.org/pimsinpress12-23-19/?fbclid=IwAR2U4DU9kdDDqsmYB9RTQMV2U6JehyVLRH9lIWV-fC5cJsYAUqcMZx5irVY

Hardest hits were the reefs close to the shore. Coral heads ranging from grapefruit sizes to the size of a small car were toppled and rolled up to 50 meters (164 feet) from the reef. In several areas, mud from inshore smothered corals and buried reef stricture to nearly 0.9 meters (3 feet). Declines in coral health and fish populations were also noted on many reefs, but the level of damage varied significantly. Reefs with the greatest damage seen were the shallow reef off the Marsh Harbour coast, as well as reefs in east Grand Bahama near the Equinor facility. Non-native trees from shore steamrolled across the reef, taking out everything in their path, even a half-mile offshore. More information would be needed on the level of destruction and the impacts on fish production for the three key marine habitats to take into consideration when calculating losses.

IDB has assessed that damages to mangroves, coral reefs, seagrass beds and protected areas account for around USD 7 million. This damage is a product of impacts on coral reefs, seagrass beds, mangroves, beaches and on the infrastructure of protected zones. Due to the inherent difficulty of assigning a price tag to some of these assets, the value reflected in this damage estimation is only based on a global average of the cost of restoration projects. Numbers could go higher depending on factors such as equipment availability, local workforce, planning and monitoring.

Seafood production impacts

The Bahamas is one of the Caribbean region's largest producers of lobster. The export markets (primarily the USA) for seafood products from The Bahamas are well-settled and demand is expected to continue to be high in the coming years. Production and exports of lobster and conch in other countries in the region is relatively stable. None of the other countries will be able to fill the gap in supply left by the reduction of production and export of lobster from The Bahamas. As a result, one can expect that export prices for Bahamian lobster (after an expected short-term demand dip due to the COVID-19 pandemic and related reduced seafood demand in the restaurants/catering and tourism business) will return to similar levels as in recent years.

Fishing is a seasonal activity due to changes in the availability of stocks, weather patterns and closed fishing seasons (for spawning or reproduction of the stocks). Catches per month and per species will therefore vary. When looking into the expected decline in fish catches, the FAO PDNA team looked first at the production per month, and the team based the expected percentage decline on the monthly figures and not on the annual figures to reflect the reality better in the assessment.

The current 2019-2020 fishing season for spiny lobster and stone crab is expected to encounter an enormous drop in production compared to the previous years in The Bahamas. This will have severe consequences for rebuilding the economy and food security on the islands, while export earnings will reduce with tens of millions of USD in 2019 and 2020.

Figure 10 shows the seasonal fluctuations in seafood production of lobster tails, conch and stone crab in Grand Bahama and Abaco.

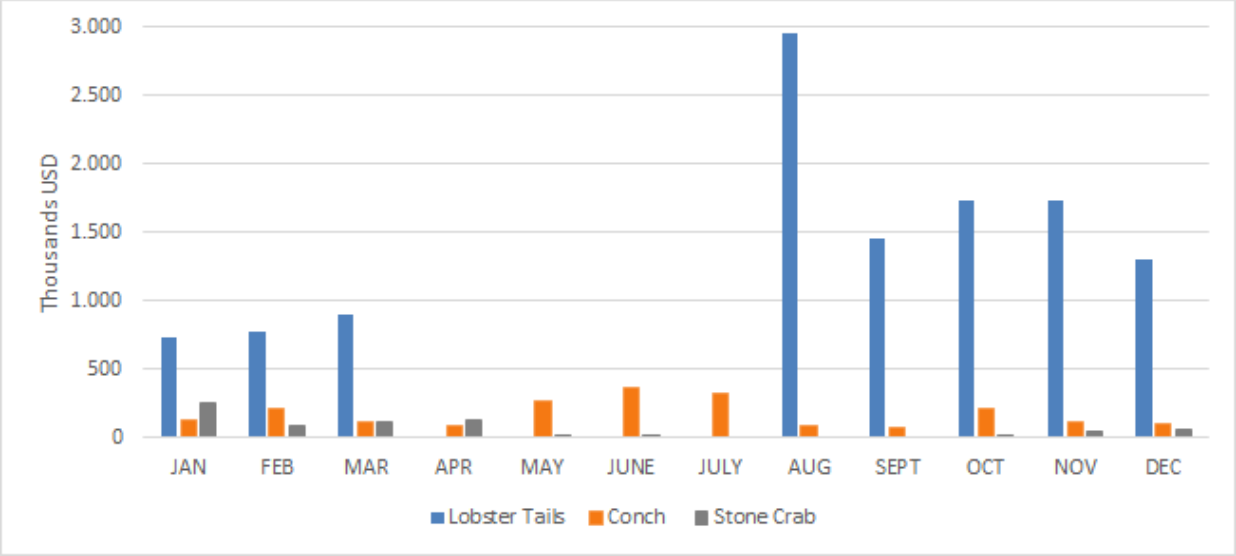

Figure 10 Shows the average seafood production per month in Grand Bahama and Abaco in thousands USD considering the closed seasons, average of 2014-2018 (authors).

The PDNA assessed the losses to the fisheries sector in Abaco and Grand Bahama between September 2019 and August 2020. Figures 11 and 12 show the expected production of the main seafood categories per month over the period September 2019 - August 2020 in Abaco and Grand Bahama respectively. The estimates depart from the average production per month based on averages for the years 2014 -2018 and the ability for the islands to slowly start producing seafood products again for exports. The expectations are that Abaco and Grand Bahama will be producing 50% of the average production from the years 2014 - 2018 by August 2020. If this will go after or not be higher, the effects of Hurricane Dorian will last considerably longer than to August 2020.

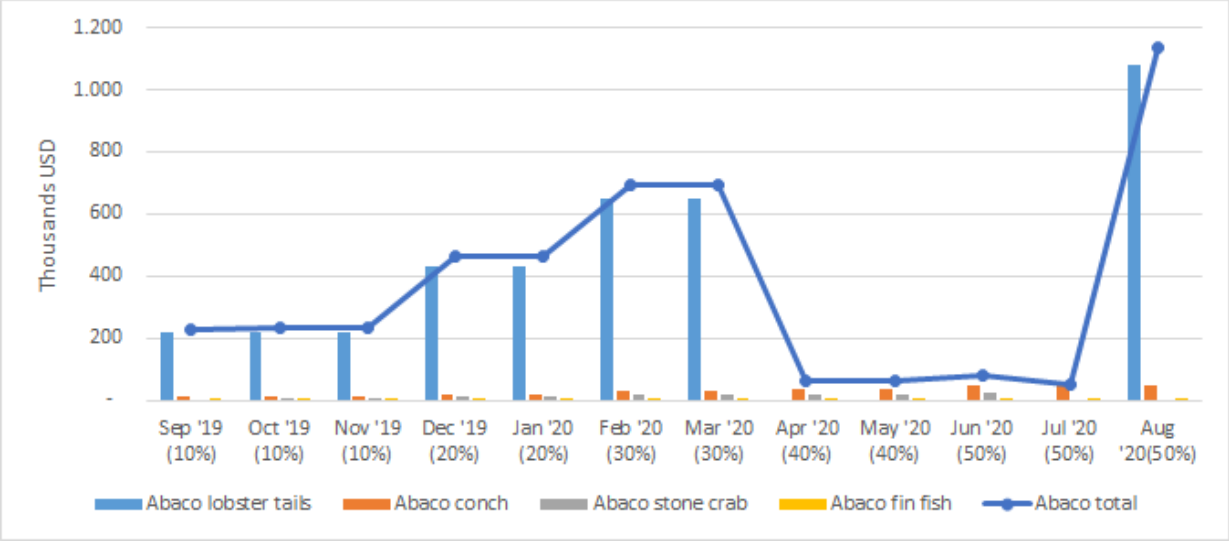

Figure 11 Estimated production in the period September 2019 to August 2020 in Abaco as a percentage of the average monthly production over the period 2014-2018 (authors).

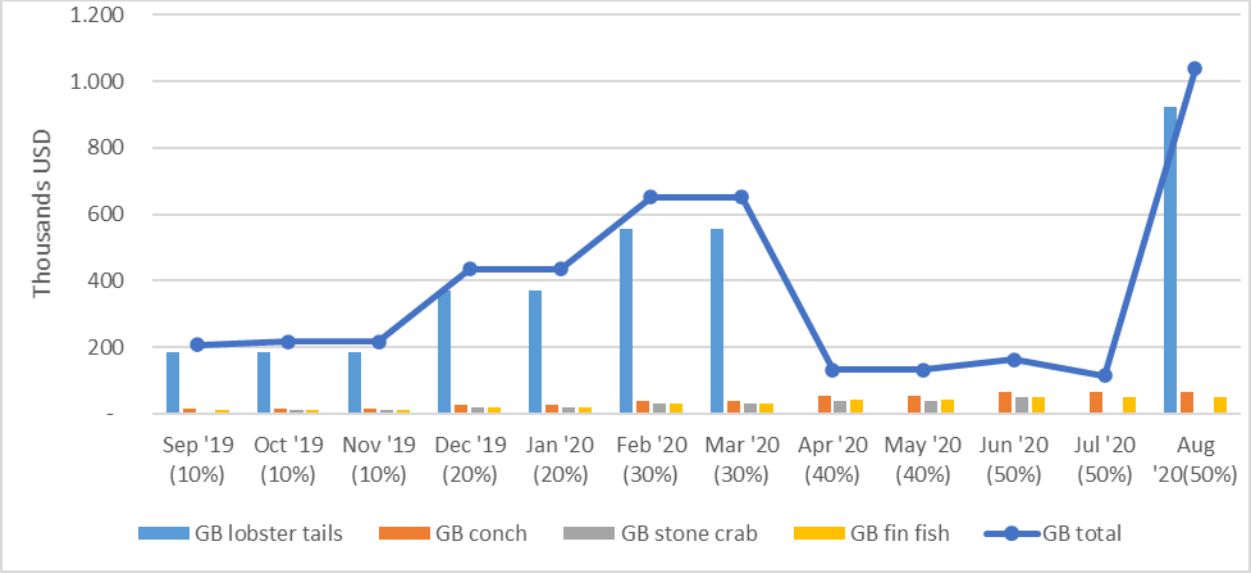

Figure 12 Estimated production in the period September 2019 to August 2020 in Grand Bahama as a percentage of the average monthly production over the period 2014-2018 (authors)

Figures 13 and 14 show the estimated annual production before and after Hurricane Dorian in Abaco and Grand Bahama and the total losses. The estimates indicate that Abaco, between September 2019 and August 2020, will lose approximately USD 14.6 million and Grand Bahamas for a similar period will lose approximately USD 14.0 million. The main losses are losses in the lobster fishery whereby Grand Bahama will have lost USD 11.5 million and Abaco USD 13.4 million in lobster alone.

The total losses for the 2019-2020 fishing season are estimated to be approximately USD 28.6 million for both islands.

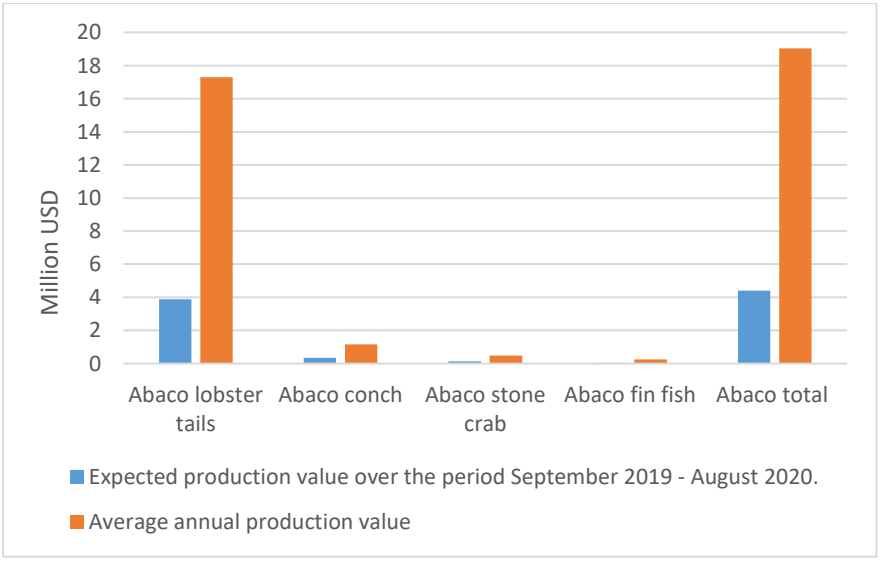

Figure 13 Estimated annual production (average 2014-2018) and for the September 2019 – August 2020 fishing season for Abaco (authors).

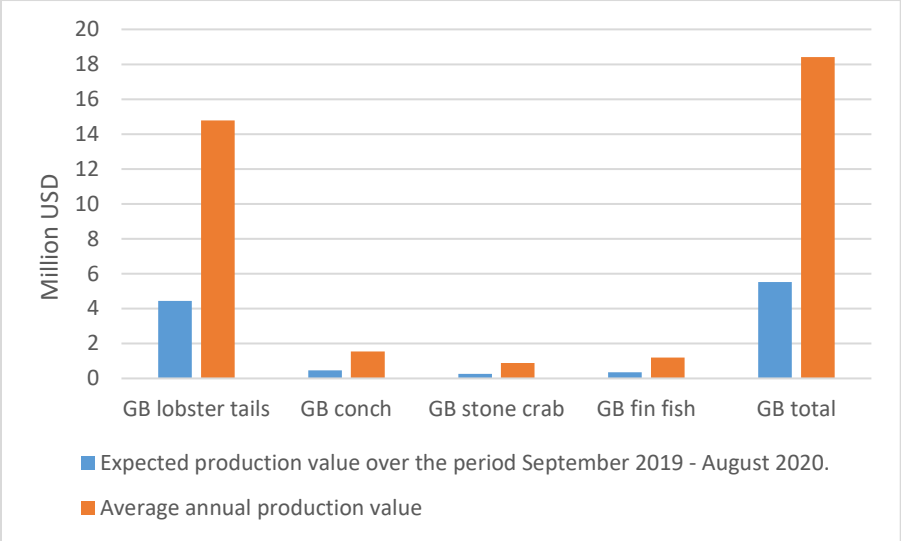

Figure 14 Estimated annual production (average 2014-2018) and for the September 2019 – August 2020 fishing season for Grand Bahama (GB) (authors).

These estimated losses in seafood production will result in significantly reduced income for fisherfolk and all associated industries, such as buyers, processing plants, boat mechanics etc.

Conclusions

Hurricane Dorian, a Category 5 Hurricane, is the second strongest Atlantic storm on record and the strongest to ever strike The Bahamas. Hurricane Dorian is the most damaging hurricane The Bahamas has ever seen and the costliest event for the Bahamas on record. Hurricane Dorian impacted the islands of Abaco and Grand Bahama and associated cays significantly.

The two islands face economic crisis because of the hurricane. Tourism and fishing provide, together with the public sector, most of the jobs on the two islands. Hurricane Dorian caused widespread damage that directly and indirectly affected the productive activities on the two islands.

Fisherfolk were among the most affected by the disaster. The fisherfolk communities accounted with many fatalities and of those who survived many lost their homes and loved ones. In addition, many fishers suffered extensive damage and losses to their productive assets (fishing gears, vessels and related infrastructure and equipment). Seafood middlemen and processing plants were also severely affected, which negatively impacted the entire value chain of fisheries in The Bahamas and reduced fish exports.

FAO was requested to carry out a post disaster needs assessment (PDNA) of the fisheries sector in The Bahamas. The PDNA mission, carried out in October 2019, estimated that nearly 80% of the fishery sector in Grand Bahama and Abaco was either destroyed or significantly damaged as a result of Hurricane Dorian. The spatial distribution of damages was highly unevenly distributed, with some areas experiencing significant destruction, and others experiencing minimal impact. However, all fisherfolk interviewed during the mission had lost all or a large part of their fishing gear. Consequently, the fishing activities cannot be resumed easily, and seafood production has

been largely reduced. This means that 20% of the households in Grand Bahama and Abaco, equaling over 13 thousand people, who are dependent on the fisheries sector for employment and income, have difficulty making ends meet and suffer from income loss and food insecurity.

The assessment estimated the damages to the fishing fleet (lost and damaged vessels and engines) at USD 4.9 million, fishing gears (mainly lost condos) at USD 8.6 million, destroyed and damaged seafood buying stations at USD 1 million, and destroyed and damaged seafood processing plants at USD 7.2 million. In total the damages to the fishery sector summed up to USD 21.7 million. Nearly 40% of the total estimated damages related to the loss of lobster condos.

The current 2019-2020 fishing season for spiny lobster, conch and stone crab is expected to encounter a significant drop in production compared to last years. The assessment estimates that until August 2020, Abaco will lose approximately USD 14.6 million and Grand Bahamas for a similar period will lose approximately USD 14.0 million in income from fisheries. The largest losses are expected in the lobster fishery whereby Grand Bahama will have lost USD 11.5 million and Abaco USD 13.4 million by the end of the fishing season. In total the losses to the fishery sector until August 2020 are expected to reach USD 28.6 million. The consequences of these losses for the capacity to rebuild the local economy and for food security on the islands will be severe. Expected seafood export earnings for The Bahamas as a whole may be reduced by tens of millions of USD in 2019 and 2020 due to the reduced production by the fisheries sector on the two islands.

The assessment highlights not just the damages and losses to the fisheries sector, but also identified some priority areas for rehabilitation, reconstruction and sustainable development of the fisheries sector. The fishing methods applied are relatively simple and immediately accessible for many fishers, once targeted assistance is made available. Production can be kick-started without large investments by using available fishing vessels and carrying out small repairs on these vessels and engines. With some assistance for in terms of replacement of lost fishing gears and repairs of vessels, the production side can restart in a relatively short time. However, the hurricane has also damaged the fisheries-related infrastructure, such seafood receiving (buying) stations and seafood processing plants, as well as some landing sites and harbours, and the rehabilitation of these need to be a prioritized as well. Without the buying stations, where the catch of the day is cleaned, weighed, registered and put in a freezer, it will be impossible for the fishers to sell their catch and make a living from fishery again. An emergency assistance project can provide equipment for e.g. fishing gear, the rent or purchase of freezing containers and generators as these are considered crucial to kickstarting the sector.

Recommendations

With climate change, the impacts of tropical storms and hurricanes in the Caribbean region are expected to increase. The Bahamas will likely be faced with disasters of increasing magnitude and intensity thus ex-ante preparedness for recovery is a must. Focus should be on proactively building national institutional arrangements, communication, coordination and planning capacities to ensure timely and resilient recovery, including contingency planning to assure business continuity not only by the private sector, but also by the public sector.

For the short term it is key to support entrepreneurial activity in the fisheries sector to kick-starts fisheries production for the local and international market. Emergency assistance projects, such as those of the FAO Technical Cooperation Programme (TCP) can provide valuable support in the

rehabilitation of productive capacities. In emergency projects the most vulnerable will be given priority assistance and efforts made will be gender sensitive.

For the mid- to long term preparedness and resilience it is essential to engage those affected in the development of the recovery strategies and measures. A Building Back Better plan needs to ensure that resilience to climate change is built into all new fisheries development initiatives and into the reconstruction of damaged infrastructure, public or private, related to the fisheries sector.

While it is recognized that recovery should be implemented under the strong leadership of the national government, other partners can bring technical skills and experience that will improve the quality of recovery. The recovery strategy for the Abaco and Grand Bahama fishery sector should be inclusive and participatory, integrating national and local authorities, the affected communities, community organizations, fishermen's groups, processors and other relevant local actors. The fundament for successful rebuilding is the participation of local communities and institutions, i.e. those directly affected by Hurricane Dorian. The longer-term effects of a disaster are not only created by the disaster itself, but also influenced by the response to the disaster. Adequate participation of stakeholders should reduce the chances of mal-adaption (e.g. sourcing of wrong equipment or measures which lead to environmental degradation). In addition, rebuilding with creating climate resilience in mind should be a cornerstone of the rehabilitation efforts. This while at the same time the aim should be to improve natural resource management and conservation capacities. Capacity building should also be an important component of the rehabilitation, reconstruction and recovery process.

The long-term recovery strategy for the Abaco and Grand Bahama fisheries sector should include disaster risk reduction measures to build resilience and reduce the impact of future hazards on the sector. The fisheries sector should also be explicitly included in the national disaster response and preparedness institutional set-up and form an integral part of the disaster preparedness plans. Such plans could not only speed up the rebuilding phase after disasters, but could be used to restructure the fisheries sector into a better and more sustainable sector. Reviewing and revising the National Disaster Management Plan and the incorporation of the fisheries sector is important. It might require revisions, for example, which better contextualize the PDNA, recovery process, national cluster system and other systemic changes introduced over time.

It is further important that strategic planning for longer-term rehabilitation and recovery of the Abaco and Grand Bahama fisheries sector is undertaken in 2020 (at the early stage of emergency interventions) to ensure long-term sustainability of livelihoods and natural resources at all stages of the disaster response.

Measures proposed for the fisheries recovery and reconstruction process

Based on the information collected during the PDNA, a Technical Cooperation Programme (TCP) Emergency Project was prepared by FAO and the DMR. The project of USD 400,000 will assist the Government of The Bahamas, to support the Hurricane Dorian affected fishers in Abaco and Grand Bahama. The TCP project will be following four lines of actions: 1) contribute to kick-starting the fishery by providing fishing gear (condos) construction materials and distribute these to affected fisherfolk; 2) support the repair of damaged fishing vessels and engines, including the provision of repair materials and spares parts for engines; 3) assist seafood middlemen and fish processors to restart the seafood buying stations and value chain; and 4) assist the Government in

the preparation of a rehabilitation and investment plan for building back better the damaged and destroyed fisheries infrastructure on Abaco and Grand Bahama islands.

Following the assessment and discussions with government officials, members of the private sector and civil society, two groups of measures are recommended: short-term measures, which can address specific needs, and strategic measures or approaches for the long term.

Recommended short term measures:

1. Improve the ability of small-scale fishers to go fishing again:
    - 1.1 Assess the need and replace lost fishing gears by providing materials and organizing distribution to the users in most need.
    - 1.2 Assess repair materials required to rebuild or repair fishing vessels and engines.
    - 1.3 Provide repair materials and spare parts required.
    - 1.4 Provide an engine maintenance and repairs course.
2. Analyze the exact needs and possibilities for repairing the larger size vessels like damaged mother ships and industry vessels as well as replacement of lost vessels, taking structural integrity and safety of the vessels into account.
3. Provide support to the buying stations in order to rebuild the seafood value chain and provide market access to fishers.
4. Prepare a rehabilitation and investment plan for building back better the damaged and destroyed fisheries infrastructure on Abaco and Grand Bahama islands.

Recommended longer term measures:

1. Strengthen disaster management capacity of fisheries officials at the national and local level.
2. Develop a hurricane preparedness plan for the fisheries sector in The Bahamas.
3. Develop a national disaster response plan for the fisheries sector in The Bahamas.
4. Build capacity at national level for disaster needs assessments and the capture of information regarding damage and loss at the community level.
5. Strengthen implementation of the Fisheries Management Information System (FISMIS) at the DMR to have available an up-to-date record of all fishing gears, vessels and fishers in The Bahamas, which may serve as baseline information for future crisis situations affecting the fisheries sector.
6. Develop construction plans and materials lists for a range of fishing gears, and have these available for future crisis situations.
7. Ensure that blueprint (technical drawings)are available of climate change adapted best-practice fishing vessels and buying stations designs for in case of future need.
8. Establish a disaster recovery fund, from which fisherfolk can obtain rapid credit and micro-finance, at conditions that suitable to the sector, for replacement and repair of their productive assets.
9. Introduce a requirement for fishers to insure their vessels, engines and third-party liability, as part of their fisher licensing/permit process, to increase sector resilience to shocks, mitigate risks and reduce the reliance on state support after (natural) disasters.

Annex A: Improvements needed in fishing gears

Fishing gear is important for the fishery sector, as fishing is impossible without gears. Therefore, fishing gear is the first link of the value chain. In the affected areas in Abaco and Grand Bahama there was a significant loss of fishing gear as a result of the hurricane. If the gear is not replaced, it will affect the fishery negatively for a long term. The lobster condos and pots are the main fishing gears used on the islands. The number of condos and pots in use at any time is a visible representation of the total landed catch over time. Most of the fishers in the affected areas lost a substantial part or all of their condos.

All condos in use were at the fishing grounds, like they usually are, when the hurricane passed. The condos are most likely all, or in large part, lost after the disaster. The experience from the previous hurricanes in the area is usually a total loss.

Figure 15. Example of condos used in Bahama (authors).

Materials needed to make the condos are generally imported. The main materials used for condo construction are wooden planks, roof tin, concrete blocks/stones, nails and rope. The cost of making one condo is about USD 52. However, when ready to put in use, there is still a need to bring them to suitable locations at the fishing grounds, which raises the total costs depending on the distance to the fishing ground. This is a time consuming and expensive part of the lobster fishery.

It is possible to build better condos that last longer and would not easily wash away during hurricanes. First, it would be useful to build a registry to know how many condos are in use at a time and in which regions. That would improve the possibility of monitoring the status of the spiny lobster stock within each region. A registry or record would inform the government of fishing pressure or effort applied, stock size and dynamics, before and after hurricanes or other natural occurrences. Planning for and introducing a more efficient and resilient condo after a disaster is advised. A noteworthy trial would be to test concrete condos like those that have been developed and are in use in Mexico.

Figure 16. Lobster hiding under condos / casitas (authors).

Condos (condominiums) / casitas are handmade by fisherfolk or workers. As a fishing gear, condos are in a grey area. They are not used to trap lobsters, but instead provide shelter to the lobsters during the day, acting as an aggregating device. Divers then lift the condos and collect the lobster. Condos can be made from a variety of materials, but are commonly made from wooden planks in a square with tin on top. The condos are stored on the bottom of the waterbody with no surface markers. The location is marked in fishers' navigational devices. Every fisher owns from a couple dozen to many thousands of condos, usually around a few hundred. Condos that do not carry any identifications have been lost.

Condo alternative: In Mexico, a new type of casitas was developed using reinforced concrete. The fishers are positive about these alternatives. They could be an excellent type for use in the Bahamian fishery as well. These concrete casitas are easy to make and likely cheaper than the wooden versions. The iron and cement required to make these casitas may need to be imported.

Pros and cons:

Pros: Simple to make, cheap, long-lasting (10-20 years), may be more likely to survive hurricanes, easy to mark (stamp in wet concrete), more difficult to move (reduced praedial larceny), and they are made from natural materials.

Cons: Heavy (150-300kg in the air, around 45% lighter in sea), only possible to take a few out to fishing ground at the time, require more force from a diver to lift them.

Wooden lobster pots are common in this area. The price to make one is approximately USD 28, and the material needs to be imported. Bait needs to be imported as well and can be as cheap as USD 1 per pot in use, but it needs to be renewed every week or so.

This fishing gear is made with natural materials and there are no clear suggestions for improvement as it is working well. It may be a good idea to require pots to carry some form of identification. This would allow pots to be returned to the owner if they were lost. Additionally, it may be useful to have a registry of the number of pots in use by every fisher in any given region at any given time. This would provide valuable information about the stock strength, fishing effort, and a baseline for future disasters.

Spiny lobster pots are a common fishing gear in The Bahamas. They are practical and do not require divers, making them useful at the deeper fishing grounds. These pots are commonly made of wood and tied together in a series of a dozen or so pots. No buoy is used to identify location. Instead, fishers will take note of their location with the GPS and return to harvest by hooking one end of the pot series to bring them all to the surface. Salted pig feet are commonly used as bait as this bait can last several days and even repeat sets.

Figure 17. Destroyed stone crab pots after Dorian (authors).

The Bahamian stone crab fishery largely uses pots imported from the USA. A significant number of pots were lost during Hurricane Dorian. There was also a significant loss of pots on land, which were thought to be properly stored, but were ultimately damaged or washed out to sea.

The final cost of a stone crab pot, after importation, and assembly, is close to USD 25. This does not include the cost of bait.

These pots are easy to handle and have a simple design but there is room for improvement. First, the pots could be made from another material than plastic, but still strong enough to withstand the stone crab's claws. Second, while it is not currently mandatory for the pots to be traceable to its owner a registry would allow for better data collection regarding stock dynamics and would simplify a post disaster damage assessment.

Stone crab pots, like other pot fisheries in the region, do not use buoys to mark the sets. One set is a chain of dozen pots connected with three-stranded rope. Salted pigs feets are typically used as bait as it is cheap, does not require cool storage and can last multiple sets. When setting out the pots, fishers mark the location of their gear by registering it on their navigation devices and they hook up the end pot when returning to harvest. The pots have a weak point meant to break and neutralize the pot if it is lost or left at sea.

The bonefish pot fishery is an important fishery. It is the primary source of seafood for the tourism industry and the inhabitants of The Bahamas. Materials to make the bonefish pots are imported from Florida. Local fisherfolk or workers at the area assemble the materials. It costs about USD 100 per pot and it take several days to make a couple hundred. Like the other pots in the region, it is not mandatory to identify or register every pot or notify someone of where the pots are or when they are in use. There is likely room to improve fish landing information and introduce less expensive fishing pots.

Bonefish pots are slightly larger than crustacean pots and are made from wire-net with square or hexagonal meshes. Bonefish pots fishery is similar to crustaceans' pots fishery in that there are 10-40 pots connected with a rope to make a chain. The fishers mark their location on navigational devices instead of using buoy's.

Figure 18. Fish pots made with square mesh wire net (auhors).

The lines/ropes between pots are made of three-strand twisted polyethylene rope 21mm (5/6 inch) in diameter. Fishers usually choose black. About 270 rolls (coil) of a line would be needed for 4000 traps (one roll for approximately 15 pots). The cost of one roll/coil is USD 70. A large proportion of ropes were lost due to the flooding of the storage space of some fishers. The ropes were either washed out to sea or ended up tangled in trees or debris.

Figure 19. Common rope in use for pot fishery in Bahama, Three stranded polyethylene in black (authors).

Pots need ropes to make a fleet of 20-40 pots usually with 30-45 meters (100-150 feet) between pots. Buoy are not used and instead fishers mark their location using GPS techniques. To harvest, the ends are hooked and hauled up using a drag hook.

Diving is the most common fishing method in The Bahamas. Divers typically harvest from condos and collect Queen Conch from the bottom. It is also common for divers to spearfish. Divers require certified diving licenses and are registered if they wish to fish commercially. There was surely some loss of diving equipment after Dorian but the PDNA mission only registered ruined or broken compressors. Some of which can be repaired, but others will need to be replaced.

Figure 20. Fisherman fixing his compressor for use on his dinghy (top right) with long hose (yellow in net). He fishes with a spear or collect lobsters and conch with a hookah (authors).

There are two methods of diving. The most common method uses a compressor on board of a small boat connected with a long hose to the diver. Compressor diving is mainly at shallow areas or lesser than 15 meters (50 feet), but the diver can remain under water for quite long time to collect lobsters and conch. Tank diving (scuba diving) is more common in deeper water and for spearfishing of bonefish.

Landing areas and processing plants

It is important to understand the needs of landings sites, quays and docks when doing the area planning. Gas stations, maintenance services, landing areas for catch, storage of engines and equipment, and space for other services are essential.

For the buying stations, it would be a worthwhile exercise to design a standard buying station with all the needed facilities for future use. It should include scales, be well-organized, easy to clean and allow for grading the catch in an air-conditioned room. These stations will need access to paper or computer systems for recording the catch, the boat information (name/number, crew number, number of fishing gear (pots, condos) visited and duration of the fishing trip and where the fishing took place). By designing a best-practice model buying station, it would make building new ones and rehabilitating older ones cheaper after a natural disaster. After hurricanes, including Dorian, it would also be possible to quickly build temporary buying stations with freezing facilities for the fisherfolk to land their catch. These could even be used as emergency facilities to store food after a disaster. This could be achieved through readymade freezing containers with generators that are easy to transport on short notice from Nassau or Miami.

In The Bahamas the seafood processing plants are owned by private companies. They are a crucial link in the value chain of lobster tails destined for export. For the most part, it is in the hands of the companies themselves to rebuild their plants after a hurricane. However, because of their importance, it may be useful to have an emergency plan to build short-term processing plants where catches are collected in large freezing containers for export.

Plan to repair and rebuild the fishing fleet

During Dorian, vessels of all sizes were damaged, lost or destroyed, often stranded on land or sunk at sea. There is a clear need to replace a part of the lost and damaged fleet. However, in many cases, it is possible to repair broken boats and to clean up engines flooded with seawater and muck.

To rebuild the fishery sector better, and taking into account the preference in The Bahamas for glass fiber reinforced plastic (GRP) dinghies, it would be worthwhile to design a standard Bahama dinghy, where all basic needs of this fishery would be considered, like a built-in cooling box for the catch, the right place for the compressor and other needs. With a standard drawing, renewing and repairing of the vessels would be much quicker and possibly cheaper as well. Regarding outboard engines, many were flooded resulting in seawater and muck penetrating into sensitive parts in the engine. Even though the boat itself was more or less intact the engine might not be useable. Most of the fishers know how to clean and basic maintenance requirements. However, engine repair and maintenance training would be important for the long-term sustainability of the sector and contribute to improved safety at sea of fishers.