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A REGIONAL REVIEW WITH RECOMMENDATIONS FOR MANAGEMENT

Cover photograph:
Parrotfishes for sale at a market in Jamaica © Chelsea Harms-Tuohy

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PARROTFISHES IN THE CARIBBEAN
A REGIONAL REVIEW WITH RECOMMENDATIONS FOR MANAGEMENT

by

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PREPARATION OF THIS DOCUMENT

This FAO Fisheries and Aquaculture Circular presents the information gathered during a meta-analysis conducted to obtain regional information about parrotfishes of the Caribbean – their biology, presence within the respective fisheries and the availability of parrotfish-specific outreach and education materials. The report synthesizes the information, provides summaries on each of the three key themes, and concludes with recommendations for management. The regional review was driven by the deliberations of the 17th Session of the Western Central Atlantic Fishery Commission (WECAFC) and was funded by the Caribbean Fishery Management Council (CFMC). It was conducted by Chelsea Harms-Tuohy of Isla Mar Research Expeditions, Puerto Rico, from June 2020 to October 2020. The report was presented to the fourth meeting of the CFMC/WECAF/Central American Organization of the Fisheries and Aquaculture Sector/ Caribbean Regional Fisheries Mechanism Working Group on Spawning Aggregations on 11 November 2020.

The Circular was thoroughly reviewed by technical officers of the Food and Agriculture Organization of the United Nations (FAO) before the final version was edited and published.

ABSTRACT

Parrotfishes (specifically of the genus *Scarus* and *Sparisoma*) are coral reef-associated fishes of high commercial value in the Caribbean, often replacing the traditional snapper/grouper fishery in many countries. Parrotfishes enhance coral recruitment through feeding on algal turfs, and contribute to bioerosion and sediment transport. While they are often recognized for these valuable ecological roles, they are also becoming a critical resource for food security and income for thousands of coastal communities across the region.

This report is based on information about parrotfishes gathered from 37 out of 45 Caribbean countries and overseas territories. In general, 73 percent of the countries that participated in this regional review reported that parrotfishes are being fished, with the stoplight parrotfish (*Sparisoma viride*) and the queen parrotfish (*Scarus vetula*) being the most commonly caught. Unfortunately, most countries (73 percent) indicated that they either do not record landings or do not record species details from landings. Parrotfishes are caught primarily by fish traps and spearfishing (targeted and incidental) for personal and commercial consumption. Over half (65 percent) of the responding countries and overseas territories indicated that they have either a complete harvesting ban or fishing regulations in place to promote the protection of parrotfishes to some extent. About half (56 percent) of the responding countries have fishery-independent surveys for parrotfishes, but the metrics evaluated by these surveys are not the same. Similarly, parrotfish-related outreach and education was varied throughout the Caribbean. Twelve countries (32 percent) report having specific parrotfish outreach campaigns or materials, while in other countries campaigns and materials were geared towards marine conservation in general. Most countries agree that long-term protection for parrotfishes is critical, but consensus about the specific measures required to achieve this is lacking.

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ACKNOWLEDGEMENTS

The consultancy for this report was funded by the CFMC. Special thanks is extended to each person who provided responses on behalf of their country.

ABBREVIATIONS AND ACRONYMS

ACL	annual catch limit
AGGRA	Atlantic and Gulf Rapid Reef Assessment
AGRNSM	National Nature Reserve of Saint-Martin
AIDA	Interamerican Association for Environmental Defense
ARAP	Aquatic Resources Authority of Panama
CFMC	Caribbean Fishery Management Council
CNSI	Caribbean Netherlands Science Institute
COVID-19	coronavirus disease 2019
DAFM	Department of Agriculture and Fisheries Management (of Curaçao)
DBES	Department of Biological and Environmental Sciences (of Colombia)
DENR	Department of Environment and Natural Resources (of Bermuda)
DNER	Department of Natural and Environmental Resources (of Puerto Rico)
DoE	Department of Environment (Cayman Islands)
DPNR	Department of Planning and Natural Resources (Saint Thomas and Saint John, United States Virgin Islands)
DPAQ	Department of Fisheries and Aquaculture (of Haiti)
EEZ	exclusive economic zone
FAO	Food and Agriculture Organization of the United Nations
FD	Fisheries Division (of Grenada)
FMRU	Fisheries and Marine Resources Unit (of Anguilla)
FWC	Florida Fish and Wildlife Commission
Ifremer	French Research Institute for Exploitation of the Sea
INSOPESCA	*El Instituto Socialista de la Pesca y Acuicultura* (of Venezuela)
IUCN	International Union for Conservation of Nature
IUU fishing	illegal, unreported and unregulated fishing
NGO	non-governmental organization
NOAA	National Oceanic and Atmospheric Administration (of the United States of America)
PIMS	Perry Institute for Marine Science
PRCRMP	Puerto Rico Coral Reef Monitoring Program
SEMARNAT	*Secretaría de Medio Ambiente y Recursos Naturales* (of Mexico)
SPAW	Specially Protected Areas and Wildlife
UVI	University of the Virgin Islands
WECAFC	Western Central Atlantic Fishery Commission

EXECUTIVE SUMMARY

Parrotfishes (specifically of the genus *Scarus* and *Sparisoma*) are coral reef-associated fishes that have high commercial value in the Caribbean region, often replacing the traditional snapper/grouper fishery in many countries. This fish family consists of 16 species that occupy several coral reef and seagrass habitats and have diverse feeding strategies and life histories. Parrotfishes are relatively short-lived, averaging seven to nine years. The majority of the group displays sexual dimorphism (characteristic colour patterns) and most species are hermaphrodites (born female and transition to male later in life). Body size is an indicator of local fishing pressure because larger individuals (generally males) are usually absent on heavily fished reefs, which leads to altered sex ratios in the population. Parrotfishes are pair spawners but certain species can form spawning aggregations. Only some species use the same specific sites for reproduction.

Parrotfishes enhance coral recruitment through feeding on algal turfs, and they contribute to bioerosion and sediment transport. While they are often recognized for these valuable ecological roles, they are also becoming a critical resource for food security and income for thousands of coastal communities across the wider Caribbean region. It was within this dual context that country representatives at the 17th session of WECAFC, which took place on 15 to 18 July 2019, discussed the ecological and commercial value of parrotfishes and recommended that the Regional Working Group on Spawning Aggregations should conduct a review to better understand how parrotfishes are being exploited in the region. The topic was discussed at the working group's third meeting (18 to 19 December 2019), when this review was approved as a first step towards improving the regional fisheries management response to the WECAFC recommendation. The CFMC agreed to lead this effort through a specific and participative consultancy.

The resulting technical document is based on responses gathered from 37 out of 45 Caribbean countries and overseas territories. In general, 73 percent of responding countries reported that parrotfishes are being fished, with the stoplight parrotfish (*Sparisoma viride*) and the queen parrotfish (*Scarus vetula*) being the most commonly caught. Unfortunately, 73 percent of responding countries indicated that they either do not record landing information or do not record species details from landings. Parrotfishes are caught primarily by fish traps and spearfishing, and can also contribute to bycatch (incidental fishing). It appears they are harvested for personal and commercial use in similar proportions.

Over half (65 percent) of the responding countries indicated that they have either a complete harvesting ban or fishing regulation in place to promote the protection of parrotfishes to some extent. The fishing regulations include at least one of the following: minimum and/or maximum size requirements, gear restrictions, bag limits, annual catch limits and seasonal closures. The harvesting bans were based on local scientific surveys (fishery-independent) and/or catch data (fishery-dependent), while others were enacted in keeping with the precautionary principle. A few countries (19 percent) did not include fishers in the decision-making progress and experience problems with compliance. Evaluations of harvesting bans have been conducted for six countries.

About half (56 percent) of the responding countries have fishery-independent surveys for parrotfishes, but the metrics evaluated by these surveys are not the same across the region. For example, data on fish abundance and diversity are available in some countries, while in others habitat information and reproductive aspects of parrotfishes are also available. Some

countries (43 percent) reported they did not have any fishery-independent surveys, yet regional non-governmental organizations (NGOs) report that this information is available for some of these nations.

Similarly, parrotfish-related outreach and education activities varied across the Caribbean region. Twelve countries (32 percent) report having specific parrotfish outreach campaigns or materials, while in other countries campaigns and materials are geared towards marine conservation in general. The audience for outreach varied from children and their parents to fishers and consumers. Outreach effectiveness was rarely evaluated. There are also subregional outreach campaigns and collaborations between NGOs that have proven effective and successful, especially in the Mesoamerican region.

Most countries agree that long-term protection for parrotfishes is critical, but consensus about the specific measures that must be taken to achieve this is lacking. On this point, conservationists, fisheries managers and the fishing communities should be united and each country will need to assess its capacity to enforce the national and regional recommendations. Some regional restrictions could be applied for species in a more critical situation, such as the rainbow parrotfish (*Scarus guacamaia*), blue parrotfish (*Scarus coeruleus*), midnight parrotfish (*Scarus coelestinus*), and stoplight parrotfish (*Sparisoma viride*). In addition, regional restrictions for the use of non-selective gears might also be explored. Overall, promoting an ecosystem approach to fisheries protection of juvenile and reproductive habitats will be of critical importance.

Regional management should seek to develop plans and funds for improvements to these measures, but ultimately trends (i.e. changes in parrotfish biomass and diversity) and efficacy of regulations cannot be measured without species-specific landings data coupled with long-term fishery-independent monitoring. Therefore, this initial review highlights the individual needs to be addressed to achieve a cohesive regional response to the challenges facing parrotfishes and the marine environment. Communities, resource managers and conservation practitioners have an opportunity to take a unified decision regarding the future of parrotfishes in the Caribbean.

PLATE 1
Parrotfish beak

1. Introduction and rationale

The diverse family of parrotfishes in the Caribbean consists of 16 species that occupy a variety of marine habitats and display diverse feeding strategies and life histories. Although they are often considered as part of one overarching functional group of herbivores (together with Acanthurids, for example), the complementarity among parrotfishes makes their diversity a critical component of an intact coral reef ecosystem. Parrotfishes provide a suite of critical ecological processes to Caribbean coral reefs, including enhancing coral recruitment through feeding on algal turfs, assisting coral competition with larger macroalgae, and bioerosion and sediment transport. However, each species is not responsible for performing all of these roles and certain species contribute to some processes at levels of magnitude greater than others.

Parrotfishes in the Caribbean are relatively short-lived with a range of lifespan from four to 12 years. Some parrotfishes require nursery habitats such as mangroves and seagrass beds for juvenile life history stages, while others recruit directly to inshore reefs where they remain or later migrate to offshore reefs. Thus, parrotfishes use the same essential fish habitat as many aggregating reef fish species like snappers and groupers. In contrast, there is little evidence to suggest that all parrotfishes engage in mass spawning aggregations, and instead, reproduce throughout the year in resident spawning activities but with select species exhibiting reproductive activity that can be spatially and temporally predictable.

Similar to the plight of groupers in the Caribbean, large-bodied parrotfish species have fallen victim to the anthropogenic process of "fishing down the food web" (Pauly *et al.*, 1998). Parrotfishes now have a commercial value, often replacing the traditional snapper/grouper fishery in many countries, and should therefore require some level of management or conservation. Regulating the parrotfish harvest has proved difficult in countries where reliance on the herbivores have become a critical source of protein and income. As with the unfortunate die-off of the urchin *Diadema antillarum* in the 1980s – and its subsequent failure to recover – the Caribbean cannot afford to lose such a diverse set of herbivores that provide critical ecological processes on coral reefs. Conservationists propose harvesting bans while management recognizes the importance of parrotfishes to the fisheries. These competing interests have led to different recommendations, but in order to move forward, conservation and management must marry their concepts and agree on a solution.

Throughout this document, the term "parrotfishes" is adopted to describe the family, specifically six species of the genus *Scarus* (*Scarus guacamaia*, *Scarus coelestinus*, *Scarus coeruleus*, *Scarus vetula*, *Scarus taeniopterus* and *Scarus iseri*) and four species of the genus *Sparisoma* (*Sparisoma viride*, *Sparisoma chrysopterum*, *Sparisoma rubripinne* and *Sparisoma aurofrenatum*). *Scarus* and *Sparisoma* differ in their feeding strategies, dietary preferences, ecological roles and presence in the fishery. Other parrotfish species will not be discussed in this review because of their lack of fishery relevance. The singular "parrotfish" may be used in some cases where this is a better grammatical fit but it does not denote that parrotfishes should be treated as a singular complex. The term "big three" is used to discuss *Scarus guacamaia*, *Scarus coeruleus* and *Scarus coelestinus* throughout the report.

The 17th session of the WECAFC was held on 15 to 18 July 2019 in Miami, Florida, United States of America. During the session, the Working Group on Spawning Aggregations discussed the ecological and commercial value of parrotfishes in the Caribbean, recognizing the need to better understand how parrotfishes are being exploited in the region (FAO, 2020a). The CFMC agreed to lead the effort by contracting a scientist to gather relevant information from each

Caribbean country, synthesize the information and provide a review of the biology of parrotfishes, their relevance to the fishery, and governance and outreach initiatives specific to parrotfishes.

The review was conducted to address the following questions:

- What do we know about the biology of parrotfishes?
- How are parrotfishes represented in Caribbean fisheries?
- What outreach related to parrotfishes is underway?

This report attempts to answer these questions, presents recommendations to management, and identifies knowledge gaps specific to these three questions which require further review.

2. Methods

This review was conducted using two strategies:

- Consultation with fisheries managers, scientists, and conservationists across the Caribbean region (Bermuda to Brazil) through a questionnaire (Appendix 1) aimed at better understanding the importance of parrotfishes in each country's fishery; what is known about their biology, and whether parrotfish-specific outreach was being conducted in the country (among other questions); and
- An online literature search to identify information on fishery-independent surveys and outreach campaigns specific to parrotfishes. Peer-reviewed literature, technical reports, the database Fishbase.org, webinars, student theses, news sources, personal communications and unpublished information were used to meet the robust needs of this review.

The consultation process was conducted by emailing the questionnaire to fishery managers, scientists and conservation practitioners. Responses were generally received from only one source, but occasionally responses from two sources (e.g. a fishery manager and a conservation practitioner) could be assessed for a single country. With the gathered information, a concise description of each country was prepared that highlighted specific species harvested, the purpose of the catch and the gear used, the existence of fishing regulations and associated compliance and the existence of outreach activities specific to parrotfishes, among other metrics. Throughout the document, various countries are mentioned by name based on information obtained from previously published sources that were not generated from this specific review.

Country responses differed in the level of detail provided. Overall, information was requested from 45 countries and territories (Florida, the United States of America's Federal exclusive economic zone [EEZ] and the United States of America's territories were treated separately) and only the British Virgin Islands, Tobago (Trinidad and Tobago), Guadeloupe, Saint Kitts and Nevis, Montserrat and Saint Barthélemy did not respond to the call. Suriname, Guyana and Trinidad (Trinidad and Tobago) indicated that parrotfishes were not part of their fishery. Thus, 37 countries and territories provided information for this review.

3. Results and analysis

3.1 Biology of parrotfishes

Parrotfishes are among the most well-studied fish groups on coral reefs and a wealth of knowledge is available, yet areas remain where further investigation is necessary. A complete discussion of all available literature was beyond the scope of this review, but the literature

(over 697 publications) has been thoroughly examined in the recently published book *Biology of Parrotfishes* (Hoey and Bonaldo, 2018). The authors provide an extensive review of the literature regarding parrotfish biology, feeding ecology, functional morphology, functional roles, management considerations, and more. This review did attempt to pair current parrotfish fishery-independent research with each country in which it occurred to identify those that are lacking this kind of information. The biological aspects discussed herein provide initial insight as it relates to the management of parrotfishes, but for a comprehensive analysis readers are directed to Chapter 16 of the *Biology of Parrotfishes* mentioned above.

3.1.1 Feeding ecology and functional roles

Parrotfishes have a unique and fascinating jaw morphology ideal for their lifestyle on the reef. These mechanisms are the pharyngeal mill, the intramandibular joint, and cutting-edge dentition which together have enabled parrotfishes to diversify their roles in the marine ecosystem. The pharyngeal mill (the second set of jaws) is equipped to grind sediment into fine powder or smaller grains which are then wrapped in mucous so that they may easily pass through the stomachless digestive tract, before being excreted onto the reef as fine sand (Bellwood and Choat, 1990; Choat 1991; Choat, Clements and Robbins, 2002). The intramandibular joint permits a range of lower jaw mobility to scrape and excavate the reef without causing damage to the jaw itself. Lastly, the cutting edge dentition describes the sharp beak-like fused teeth (unique to *Scarus* and some *Sparisoma*) that enable parrotfishes to scrape and excavate. Dentition also explains the distribution of *Scarus* as reef-dwellers and *Sparisoma* as seagrass occupants because seagrass does not require the sharp cutting edge necessary for hard bottom feeding (Clements and Bellwood, 1988; Bellwood and Choat, 1990). Of course, there are exceptions like *Sparisoma viride* which seems to be a crossover species, capable of feeding on hard bottoms.

These three morphological features alone are not unique to parrotfishes but are exceptional in that they have led to their functional diversity. One genus, *Scarus*, is equipped with all three of these features. Functional morphology studies used these traits to define the ecological roles of parrotfishes, separating them into feeding strategies of browsing, scraping/grazing, excavating and coral predation (Bellwood, 1994; Bonaldo, Hoey and Bellwood, 2014; Adam *et al*., 2015). Although useful to help understand diversity in function, this strategy was lacking true identification of what a parrotfish actually consumes. Additionally, some species did not fit this model, such as *Sparisoma viride* which has cutting edge dentition that is lacking in other *Sparisoma* and can be found excavating hardbottom on coral reefs rather than snipping seagrasses. Browsing is considered biting on long blades of macroalgae or seagrass (e.g. *Sparisoma*, but not all species); grazing is scraping algal-covered substrates like pavement or coral reefs (*Scarus*); excavating is taking bites from a hard substrate that includes epilithic and endolithic algae (*Scarus* and some *Sparisoma*); and coral predation is selectively consuming live coral polyps (i.e. *Sparisoma viride*, Bruckner and Bruckner, 1998). However, in 2017 Clements *et al*. (2017) evaluated the nutritional aspects of the parrotfish diet from stable isotope analysis and tissue fatty acid analysis to demonstrate that these herbivores also consume cyanobacteria and other epiphytes and are likely preferentially targeting these organisms over the algae. High protein content was characteristic of cyanobacteria, rather than algae, which led the authors to conclude that parrotfishes are even more diverse in their feeding habits than was previously thought.

Thus, parrotfishes consume a variety of benthic dietary resources – turf algae, macroalgae, endolithic algae, cyanobacteria and invertebrate epiphytes, sponges, seagrasses and even corals themselves (Bruggemann, van Oppen and Breeman, 1994; Bruggemann *et al*., 1994;

Bruggemann, Kuyper and Breeman, 1994; Bruggeman *et al*., 1996; Clements *et al*., 2017). Their impact on the benthos has been observed from what and how they eat, such as maintaining low algal turf terrain that promotes coral recruitment (mostly *Scarus*, Adam *et al*., 2015); targeting later successional stages of macroalgae on low coral cover reefs to assist in reducing competition (mostly *Sparisoma*, Adam *et al*., 2015); bioeroding the reef and contributing to sediment reworking, production and transport (Bonaldo, Hoey and Bellwood, 2014) which directly contributes to the reef's carbonate budget (Hubbard, Miller and Scaturo, 1990). And, due to the large complementarity (and redundancy in some aspects) observed among parrotfishes – in their dietary choices, the microhabitats they inhabit, and the extent of foraging – their effects are additive in these important ecological processes (Adam *et al*., 2015).

One process, however, appears to be restricted almost exclusively to one species – bioerosion by *Sparisoma viride*. It was hypothesized that this process was also likely performed by the big three, but their small populations have left them functionally extinct on Caribbean coral reefs. That means the limited redundancy in this ecological process puts significant pressure on *Sparisoma viride* and bioerosion rates have already been observed to decline with reductions in this species (Bonaldo, Hoey and Bellwood, 2014). Parrotfish bioerosion was observed to reintroduce 58 percent of sediments into the reef framework (Hubbard, Miller and Scaturo, 1990). Thus, decreased bioerosion rates from the exploitation of this last prominent bioeroder can result in increased susceptibility to disturbances like hurricanes and swell events as coral reefs become more unstable. Each of these processes is reviewed in detail in Hoey and Bonaldo, 2018, and is described briefly in Table 1 by identifying the key parrotfish species responsible for each process.

TABLE 1.
Summary of main ecological processes performed by parrotfishes in the Caribbean

Process	Species	Description	References
Promoting coral recruitment	*Scarus* spp. *Sparisoma viride* *Sparisoma aurofrenatum*	By grazing and scraping turf algae and clearing the benthos, parrotfishes make space available for corals to recruit. This occurs on reefs with early successional-stage algae.	Bruggemann, Kuyper and Breeman, 1994; Adam *et al*., 2015 McAfee and Morgan, 1996; Bernardi *et al*., 2000
Reducing competition between macroalgae and corals	*Sparisoma* spp.	By browsing large blade macroalgae like *Dictyota* and *Lobophora*, parrotfish help reduce competition between corals and algae on macroalgal-dominated reefs. This occurs on reefs with later successional-stage algae.	Bruggemann, van Oppen and Breeman, 1994 Bonaldo, Hoey and Bellwood, 2014; Adam *et al*., 2015

Process	Species	Description	References
Bioerosion	*Sparisoma viride*	By excavating carbonate from the reef, the material is processed into fine particles and made available to be reconsolidated back into the reef matrix.	Hubbard, Miller and Scaturo, 1990; Bruggemann *et al*., 1994, 1996; Mallela and Perry, 2007 Mumby *et al*., 2007; Bonaldo, Hoey and Bellwood, 2014; Adam *et al*., 2015
Sediment and energy transport	*Sparisoma* spp.*; Scarus vetula*	By reworking the sediments into smaller grains, parrotfishes can produce sand for the reef. Faeces can also be transported away from the reef, depositing that detrital energy source elsewhere.	Bruggemann *et al*., 1996; Adam *et al*., 2015

Source: Hoey and Bonaldo, 2018.
For more details, see Figure 1 of Chapter 8 of Hoey and Bonaldo, 2018.

Parrotfish body size is an important metric that affects feeding rate and bioeroding impacts. Both factors increase with body size and show species-specific variation, but this metric has been paid little attention in the Caribbean (Bruggemann, van Oppen and Breeman, 1994; Bruggemann *et al*., 1994; Bruggemann *et al*., 1996). Likewise, ontogenetic changes in feeding influence grazing and bioerosion, where oftentimes many adult feeding strategies are not mirrored in juveniles because earlier life-history stages use scraping (Hoey, 2018). Furthermore, parrotfish body size is an indicator of local fishing pressure within the Caribbean (Valles and Oxenford, 2014). Large parrotfishes (40 cm to 120 cm) are relatively absent on heavily fished reefs, such as in Jamaica where smaller-bodied (15 cm to 30 cm) *Scarus iseri*, *Scarus taeniopterus* and *Sparisoma aurofrenatum* are more dominant (Hawkins and Roberts, 2004) versus lightly fished reefs, such as in Bonaire (Bonaire, Sint Eustatius and Saba), where *Sparisoma viride* and *Scarus vetula* are dominant (Bruggemann *et al*., 1996; Hawkins and Roberts, 2004). In the Florida Keys, United States of America, different species dominate at different depths of the reef; *Sparisoma viride* and *Scarus iseri* are more abundant in shallow areas, while *Scarus taeniopterus* and *Sparisoma aurofrenatum* are more abundant in deeper water (Paddack, Cowen and Sponaugle, 2006; Burkepile and Hay, 2009). Fishery-independent surveys may indicate distributions and prevalence similar to those described here, but evaluation of catch data by way of comparison would be a useful exercise to understand if the fishery is selecting those fish which are dominant, or indiscriminately harvesting parrotfishes. This scenario is described in more detail in Section 2, Presence in the fishery.

The diversity of parrotfishes appears to be related to the structural complexity of the reef (Tzadik and Appeldoorn, 2013) and parrotfishes do not seem to be highly disturbed by loss of live coral cover as long as it does not simultaneously occur with significant loss of complexity (Graham *et al*., 2006; Emslie, Cheal and Johns, 2014). In addition, a review of the literature suggests that low complexity, along with low coral cover and high turf algae cover, could be the most preferred parrotfish habitat, regardless of fish size (Fox, 2018).

PLATE 2
Parrotfish swimming over hardbottom

3.1.2 Life history and reproduction

On average, parrotfishes in the Caribbean Sea and the Atlantic Ocean are smaller and shorter-lived than those in the Pacific and Indian Oceans. Parrotfish larval duration is about 29 days to 47 days (Lou, 1993; Schultz and Cowen, 1994; Ishihara and Tachihara; 2011) but it appears that not much is known about their pre-settlement larval phase. An age-based study on one of the most abundant parrotfish, *Sparisoma viride*, from several locations around the Caribbean, found that on average this species lives for a short seven to nine years, and a maximum of 12 years (Choat *et al*., 2003). A study in Bonaire (Bonaire, Sint Eustatius and Saba), observed that growth tends to occur fast in juveniles, followed by sexually inactive terminal males, and slowest in initial phase females and sexually active terminal males (van Rooij *et al*., 1995). The authors suggest this is a tradeoff between growth and reproduction and favours the opportunity to convert to the active terminal male.

Parrotfishes in the Caribbean are reef- and seagrass-associated, both as adults and as juveniles, with *Scarus* being reef-dwelling as adults and many *Sparisoma* only occupying seagrass, with some exceptions like *Sparisoma viride* which has been observed to recruit to *Porites porites* corals in Saint Croix (United States Virgin Islands) (Tolimieri, 1998). Also, as juveniles, some species use nursery habitats like seagrass beds, mangroves and inshore reefs before migrating as adults to offshore reef habitats (Nagelkerken *et al*., 2000, 2002; Mumby *et al*., 2004). For example, *Scarus guacamaia* is intimately connected to mangroves and seagrass habitats during its juvenile life stages. In fact, the destruction of these habitats has been directly linked to declines or local extinction of this species in various parts of the Caribbean (Mumby *et al*., 2004).

Based on their daily diurnal migrations and their relatively small home ranges, it can be inferred that parrotfishes are resident spawners, with terminal phase males spawning with a harem of females (Bruggemann, van Oppen and Breeman, 1994; van Rooij *et al*., 1996) with the exception of *Sparisoma rubripinne*. In Puerto Rico, gamete release was observed at an aggregation of roughly 300 individuals of *Sparisoma rubripinne* at Mona Island during the summer of 2014 (E. Tuohy, personal communication), and in the United States Virgin Islands this species was observed to migrate to a specific site and form an aggregation (100 to 400 individuals) that is predictable each year (R. Nemeth, personal communication). Older studies observed *Scarus coeruleus* to form a spawning aggregation (CFMC, 2013) and an unnamed location off southwestern Puerto Rico harboured a spawning site for *Scarus iseri* (Rielinger, 1999 in CFMC, 2013). In Bermuda, a shallow patch reef habitat was observed to host a multi-species parrotfish spawning aggregation site where *Sparisoma rubripinne*, *Scarus vetula* and *Sparisoma viride* engaged in group or pair spawning in summer months (Luckhurst, 2011). However, it appears most of the other *Scarus* and *Sparisoma* species engage in pair spawning (CFMC, 2013) and most studies that report historical parrotfish spawning aggregations at specific sites are very dated (Randall and Randall, 1963; Colin, 1978; Colin and Clavijo, 1988) and these have not been reported again. For a more detailed overview of parrotfish spawning aggregations in the Caribbean, please see Harms-Tuohy (2021).

Reproductive studies vary in their methods of assessing activity. Where some use gonad maturation, others use recruitment evidence, and finally, a select few studies witness actual spawning events. These studies are not congruent in suggesting that parrotfishes have specific spawning times but in general point to year-round spawning potential with some higher activity levels during certain months that vary by location in the Caribbean (Table 1 in Afeworki and Bruggemann, 2018). Most species are protogynous hermaphrodites, almost all species display sexual dimorphism in their colouration, and males are typically larger than females. The sexual change from female to male is driven by the social structure of the local population (Muñoz and Warner, 2003) and impacts from fishing are generally observed to reduce the number of males in the population, leading to altered sex ratios.

It does not appear that specific sites of reproduction can be sought for protection and management, as with groupers (Harborne and Mumby, 2018) except for the aforementioned multi-species spawning site in Bermuda that is already part of a protected area. However, to circumvent this, ecosystem-based management that protects juvenile habitat for parrotfishes, along with their adult habitats (seagrass/mangroves to nearshore reefs), will be a critical step towards protecting adult populations.

3.1.3 Current status and needs in the biological aspects

The following seven topics were identified as knowledge gaps in the biology and ecology of parrotfishes. Future research into these topics will benefit regional understanding of how parrotfishes provide critical ecological services, and how these may be affected by a changing climate; identify what parrotfishes are truly eating; document how they interact with each other; and identify how we can better define spawning aggregations for those species that participate in such.

- **Surveys of key biological and ecological metrics for missing countries**

  Gather fishery-independent information on abundance, diversity, habitat use and other key metrics from the countries that lack this information. Collaboration with long-term monitoring programmes, such as the Atlantic and Gulf Rapid Reef Assessment (AGGRA)

and ReefCheck, could assist in providing baseline information and basic metrics, especially where countries may lack the financial means to begin such a biological monitoring programme. This is also suggested under Section 4, Recommendations and future needs, at the end of this report. About 43 percent of the countries reviewed indicated they do not have this type of programme in place.

- **The actual identification of dietary components**

  Better understanding of the parrotfish diet. So far, literature has only investigated what parrotfishes appear to be eating based on field-observational studies, or from stable isotope analysis and tissue fatty acid analysis which do not specifically identify dietary items to the species taxonomic level. The use of DNA barcoding/metabarcoding will be useful for this investigation, especially in cases where gut contents are mostly digested and unidentifiable by morphological study. Projects of this nature are already underway.

- **Age-based studies to understand population structure**

  The structure of the population, especially in areas where fisheries are emerging, presents an opportunity to gather baseline information for future stock assessments. Considering that some countries have just recently introduced parrotfishes into their fishery (e.g. the Bahamas, Sherman *et al*., 2018), gathering age-based data is both timely and critical.

- **Parrotfish movement and foraging within their microhabitats**

  Better understanding of how parrotfishes forage and move within their microhabitats and how that translates on the regional scale, especially in terms of dietary choices, ontogenetic use of habitats, and how these influence their contribution to the ecological processes on the reef, such as bioerosion.

- **Better define parrotfish spawning aggregations**

  Habitat use for spawning purposes, in-depth information on species that form spawning aggregations, how often, at what spatial scale, how many individuals participate, and is there predictability in time and space?

- **Influence of abiotic factors on feeding**

  Abiotic factors like relationships between temperature (and other factors associated with climate change) and feeding and bioerosion patterns (Hoey 2018). Long-term monitoring of parrotfish communities at key locations throughout the Caribbean can assist with understanding how climate change may impact their ecological roles.

- **Competition among parrotfishes**

  More information about competition among parrotfishes. This could enhance understanding of complementarity and redundancy in this family. For example, *Scarus vetula* was observed to territorially prefer high rugosity coral reefs with low sediment and low algal turfs (Adam *et al*., 2015) and a loss of this particular species could impact benthic composition on this type of coral reef, and thus affect coral recruitment.

3.2 Presence in the fishery

This section provides an overview of the parrotfish fishery, including the abundance of the harvested species, gears used, intended use of harvested individuals, and an overview of regulations, management examples and required research. It is important to note that for this review, the term “country” or “countries” also incorporates the territories of specific countries, except where specifically indicated otherwise.

3.2.1 Landing and catch overview

Thirty-seven countries responded with details about parrotfish species harvested, the intention of the catch (personal or commercial use), and details regarding the relevance of parrotfishes in the fishery, e.g. whether parrotfish is a staple food source and if regulations specific to parrotfishes exist (Table 2). Twenty-seven countries provided species-specific details about which parrotfishes were harvested, although this information was not necessarily reported from landings or catch data. Based on this information, the most commonly harvested parrotfish is *Sparisoma viride* (14 percent), followed by *Scarus vetula* (12 percent) (Figure 1). However, overall, these two species are only marginally more common than the other eight parrotfish species considered in this review (ranging from 7 percent to 11 percent). This result is likely an effect of the non-selective gears utilized and indiscriminate harvesting practiced by many of the fisheries.

Unfortunately, most countries (27 out of 37) either do not record landing information at all or do not report landings at the species taxonomic level. Of those, ten countries are not reporting because of a harvesting ban and no landings information exists for the period prior to the ban. One country mentioned that it does not have the capacity to collect landings and catch data. Of the ten countries that report to the species level, four provided this landing information in a spreadsheet format for further regional review.

Trap fishing and spearfishing are the two primary methods used to harvest parrotfishes (Figure 2). The non-selective trap method was used in 13 countries, but not exclusively because some of these countries reported that spearfishing was used equally as often. Only four countries indicated that spearfishing was the only method used. Parrotfishes are almost equally targeted (n=24 countries) and caught as bycatch in trap fisheries for lobster and mixed fish catch (n= 20 countries), but only 13 countries indicated that parrotfishes are both targeted and caught as incidental bycatch (Table 2). Similarly, there is an almost equal occurrence of parrotfishes being used for personal or commercial consumption and 19 countries indicated harvested parrotfishes are utilized for both purposes (Table 2). Two countries specifically indicated that although parrotfishes are not targeted, owing to the indiscriminate nature of the fishery various species are often caught and sold simply because they are caught in the traps.

Of the countries that responded to this question (n=24), seven indicated that parrotfishes were a staple food source, while 18 countries indicated that they were not. Of those 18 countries, ten have complete harvesting bans or some level of regulation for parrotfishes. Of the seven that consider parrotfishes a staple food source, only four countries have some level of regulation for parrotfishes. Sixteen countries said fishers are able to identify parrotfish species, while seven said they could not.

PLATE 3
Fishtrap

TABLE 2.
Overview of information received

	No. Species	Targeted	ByCatch	Personal	Commercial	Staple	ID	Ban
Anguilla	8	Y	Y	Y	Y	Y	N	
Antigua and Barbuda	10	Y			Y	N	N	Y
Aruba			Y	Y		N		Y
Bahamas			Y	Y		N		
Barbados	6	Y						
Belize								Y
Bermuda						N	Y	Y
Bonaire (Bonaire, Sint Eustatius and Saba)						N	Y	Y
Brazil[*1]	1	Y		Y	Y	Y	Y	Y
Cayman Islands	2	Y		Y				
Colombia	5	Y	Y	Y				Y
Costa Rica			Y	Y		N	N	
Cuba	10	Y	Y	Y	Y	N	N	Y
Curaçao	10	Y		Y	Y	Y	Y	
Dominica	5	Y	Y	Y	Y	N	N	
Dominican Republic	7	Y	Y	Y	Y	Y	Y	Y^
Grenada		Y	Y	Y	Y			
Guatemala						N	Y	Y
Haiti	10	Y	Y	Y	Y	Y	Y	
Honduras	10		Y	Y	Y	N	Y	Y
Jamaica	8	Y	Y	Y	Y	Y	Y	
Martinique	10	Y		Y	Y			Y
Mexico	3	Y		Y				
Nicaragua	4		Y	Y	Y	N		
Panama			Y			N		
Puerto Rico	10	Y	Y	Y	Y	N	Y	Y
Saba (Bonaire, Sint Eustatius and Saba)	4		Y			N	Y	
Saint Croix (United States Virgin Islands)	10	Y		Y	Y	Y	Y	Y
Sint Eustatius (Bonaire, Sint Eustatius and Saba)	6	Y			Y	N	N	
Saint Lucia	8			Y	Y	N	N	
Saint-Martin (French part)	10	Y		Y	Y	Y	Y	Y
Saint John and Saint Thomas (United States Virgin Islands)	7	Y	Y	Y	Y			Y
Saint Vincent and the Grenadines	5	Y	Y			N	Y	Y
Turks and Caicos Islands							Y	Y
United States of America, Federal EEZ	10	Y	Y	Y	Y	N	Y	Y
United States of America, Florida	8	Y	Y	Y	Y	N	Y	Y
Venezuela	3	Y	Y	Y	Y			Y

If a number of species is not indicated (column 2), then the information was not available prior to a ban or because landing information was not recorded. “Ban” includes a complete harvesting ban or some type of regulation.

[*1] Brazil has other species not represented elsewhere in the Caribbean so this review only considered the one species, *Sparisoma chrysopterum*.

^ The Dominican Republic has a harvesting ban that expired in 2019 but is being considered for renewal.

PLATE 4
Fishing boat in Haiti

Figure 1. Representation of the various parrotfishes in the Caribbean fishery based on the frequency the species was reported in Table 2

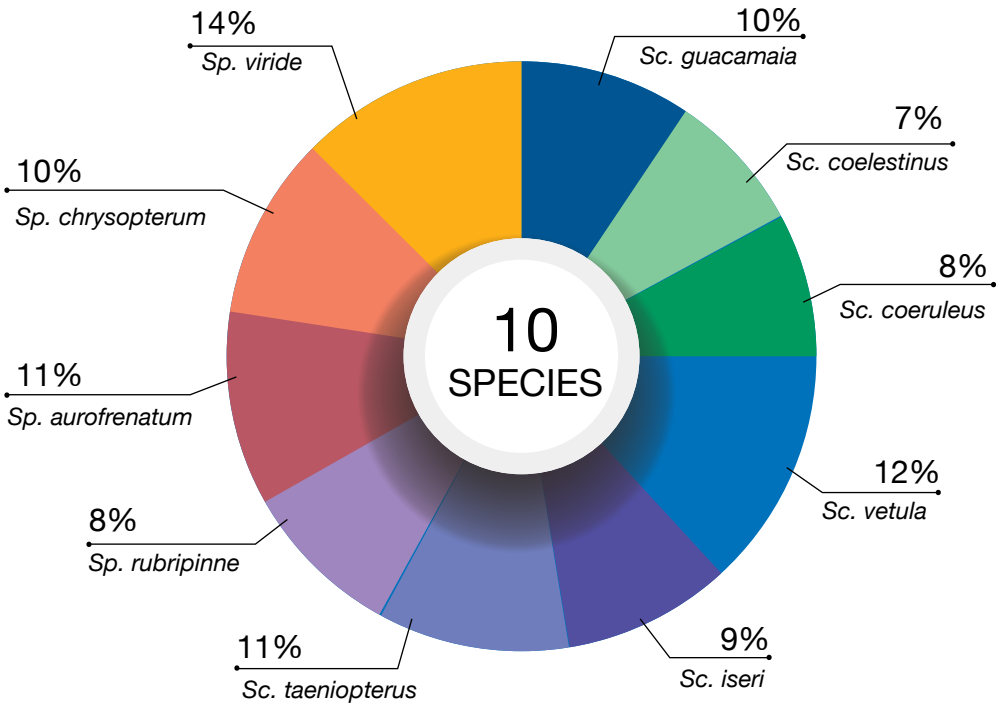
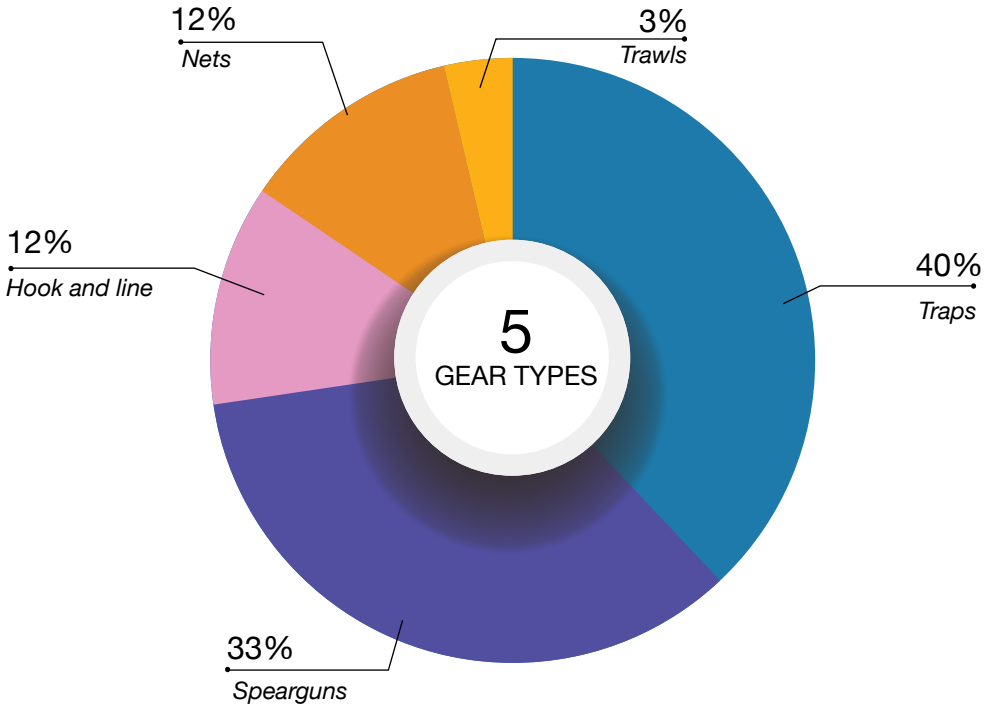


Figure 2. Frequency of the various fishing methods used to harvest parrotfishes



3.2.2 Harvesting bans and regulations

Of the countries that responded to the questionnaire, 12 indicated that they have a complete harvesting ban on parrotfishes, and 12 countries indicated they have some level of regulation that protects parrotfishes to some extent (Table 3). The regulations vary from minimum size requirements; prohibition of harvesting for the big three; gear restrictions and requirements; bag limits and annual catch limits (ACLs); and seasonal closures. Although no single country included all these types of regulations, Saint Croix (United States Virgin Islands) does have four out of the five regulation types mentioned. It is also worth noting that 26 countries in the Caribbean either endorse or act as observers of the Specially Protected Areas and Wildlife (SPAW) Protocol, through which 22 countries in this review currently have some type of protection for parrotfishes in place (Table 3).

The oldest form of protection is the harvesting ban enacted in 1993 in Bermuda, while the newest harvesting ban was put in place very recently, i.e. in 2019 in Saint Vincent and the Grenadines. The harvesting bans varied in their rationale; some were based on local scientific surveys (n=11) and analysis of catch data, others were put in place in keeping with the precautionary principle (n= 3), and the remaining countries did not indicate a rationale for the harvesting ban. Similarly, in some countries, fishers participated in the decision to put harvesting bans and regulations in place (n=11), while others did not, or participation by fishers was unknown.

Management example 1

One country indicated that its parrotfish harvesting ban was enacted without any input from the fishing community and was not based on scientific data. Instead, the ban was enacted based on the precautionary principle which was driven by international pressure and social media influence. This has resulted in significant resistance from the fishing community – in a country where parrotfishes did not previously constitute a staple food source. Fishers now target parrotfishes as an act of defiance against the government.

This scenario highlights the detrimental effect that excluding key stakeholders from the decision-making process can have. In contrast, another country indicated that its fishers were directly involved in the process of creating regulations, which were based on local scientific data. These regulations afford parrotfishes a seasonal closure and include specific gear restrictions. Fishers are also required to participate in an educational programme that re-trained those who were displaced by the regulations, and raised awareness about the importance of key ecological species, and the rationale behind the regulations. This country also indicated that parrotfishes were not a staple food source prior to the ban. This latter scenario is in stark contrast to the former, indicating that fisher participation and proper education are vital assets for compliance.

TABLE 3.
Regulations for harvesting parrotfishes vary by country and level of protection

	SPAW	Reg. type	Reg. no. and year	Description
Antigua	Y	Regulation	Fisheries regulations Section 47, 54, 56; 2013	Net mesh size must be greater than 76.25 mm stretched mesh; total length must not exceed 548.64 m per fishing vessel; soak time no more than 4 hrs. Closed season from 1 May to 31 July.
Barbuda	Y	Ban	2014	Harvesting ban on all parrotfishes
Aruba	Y	Ban	2017	Harvesting ban on all parrotfishes
Belize	Y	Ban	2009	Harvesting ban on all parrotfishes
Bermuda		Ban	Protected Species Order 1993	Harvesting ban on all parrotfishes
Bonaire (Bonaire, Sint Eustatius and Saba)	Y	Ban	2010	Harvesting ban on all parrotfishes
Brazil		Regulation	2011 Portaria MMA #445 2014 2018	No take for some species
Colombia	Y	Ban	Resolution 1912, 2017 Resolution 369, 2019	No take of big three, with additional protection for other parrotfishes in the Red Book at specific areas
Cuba	Y	Regulation	Resolution 160, in 2011	Restricts commercial sale
Dominica	Y	Regulation	Statutory Rules & Orders 2004	Mesh size restrictions that do impact parrotfish catch
Dominican Republic	Y	Ban	2017–2019	Harvesting ban on all parrotfishes, expired
Guatemala	Y	Ban	Ministerial Agreement 175 2015	Harvesting ban on all parrotfishes, recently renewed until 2025
Honduras	Y	Ban	Decree 106–2015, 2010	Harvesting ban on all parrotfishes
Martinique	Y	Regulation	Decree R02-2019-04-08-004, 2019	Limited 3 fish/person for all species except big three which cannot be harvested

3.2.3 Efficacy of harvesting bans

Some level of evaluation of the harvesting ban has been conducted for six countries – Bermuda, Mexico, Honduras, Guatemala, Belize and the Dominican Republic. The evaluation assessed biological indicators (biomass), socio-economic (compliance), or governance (enforcement) but did not include all three factors.

Biomass

Bermuda, which prohibited trap fishing in 1990 and parrotfish harvesting in 1993, identified that in a relatively short amount of time (nine years) there was a significant increase in parrotfish biomass (O'Farrell *et al*., 2015). Although recruitment was not enhanced, the effectiveness of the fish trap ban was illustrated in the resulting increase in parrotfish biomass. The Mesoamerican countries

(Mexico, Honduras, Guatemala and Belize) enacted parrotfish bans on various dates (Table 3) and effectiveness surveys (i.e. biomass assessments) conducted by the Healthy Reefs Initiative (McField *et al*., 2020) concluded that across the region only 18 percent of parrotfishes were larger than 20 cm, but biomass had increased since 2006 for all study sites, except Honduras, with Belize experiencing the largest rebound of parrotfish biomass. A forensic-like DNA barcoding study of fish fillets sold in markets in Belize found that parrotfishes were identified in about 7 percent of all fillets sampled, indicating that although some harvesting was still occurring, the ban had significantly reduced the catch of parrotfish (Cox *et al*., 2013). Guatemala's parrotfish ban was set to expire in 2020, but was recently renewed until 2025. Despite the overall increase in parrotfish biomass, other indicators of reef health actually demonstrated a decline in the Mesoamerican reef system for the first time in 12 years, indicating that other factors need to be addressed (McField *et al*., 2020) and demonstrating that reliance on parrotfishes as a miracle cure to resolve stressors to coral reefs is imprudent (see Section 4, Recommendations and future needs in this report). In the Dominican Republic, surveys of parrotfish by ReefCheck Dominican Republic did not observe an increase in parrotfish biomass during the two years of the harvesting ban 2017 to 2019 (Zambrano, 2020) but rather biomass was observed to decline.

Compliance

An assessment by The Nature Conservancy evaluated the effectiveness (i.e. compliance) of the parrotfish harvest ban in the Dominican Republic through interviews with fishers, fishmongers, and restaurants (Guzmán, 2019). The responses indicated an overall negative reaction to the ban but mixed responses for various indicators of impact. For example, fishers that use non-selective gears indicated the ban has negatively impacted their fishing activities. However, when asked if their overall fishing activity has been affected by the ban, 44 percent of fishers said it has decreased and 42 percent said it has remained the same. When asked if their income had been directly affected by the ban, 56 percent indicated that it had been, even though 62 percent of respondents said their clients do not specifically request parrotfish. A majority (58 percent) of fishmongers indicated that their purchase from fishers had decreased and of those 21 percent indicated their sales had decreased after the ban. Despite this, 70 percent of fishmongers said they no longer purchase parrotfishes even if fishers try to sell it to them and in spite of that, their customers continue to demand it. Restaurants (60 percent) responded that their sales remained good or fair despite the harvest ban, but 24 percent of restaurants continue to offer parrotfishes even though 91 percent indicated that they no longer buy parrotfishes.

Governance

Alarmingly, when The Nature Conservancy in the Dominican Republic (Guzmán, 2019) questioned authorities responsible for implementing the ban and documenting infractions, 64 percent of those interviewed indicated that they either do not document infractions or do not know where such information is recorded. However, 74 percent of authorities registered positive reactions to the harvesting ban and 52 percent said the ban should be extended.

These scenarios demonstrate that evaluations of harvesting bans should include biological indicators, socio-economic factors, and governance. Similarly, prospective analyses can be implemented to gain a better understanding of reactions from the community, the biological status of the parrotfish population, market responses, and enforcement capacity prior to the initiation of a harvesting ban. A prospective study in Jamaica (Edwards, 2018) suggested that the management of parrotfishes could take several forms and still provide a livelihood for fishers: a temporary moratorium, such as in the Dominican Republic, or closed seasons, which the study suggested would only work if stakeholders were involved and displaced fishers were

assisted. Also suggested were slot limits, bans on certain fishing gear, such as traps, and commercialization of parrotfishes harvested by spearguns. Besides these suggestions, the study also proposed an action plan with a timeline to outline the steps necessary for achieving the goals of a harvesting ban. Perhaps the most important message was that no matter what management options are selected, they must consider all stakeholders, be strongly backed by science, have financial and technical support, and involve some measurement of effectiveness (i.e. employing an adaptive management strategy). Studies such as these will be critical to developing a pathway to conserving and managing parrotfishes in countries where no such protection currently exists. Likewise, countries with regulations and harvesting bans can benefit from evaluating the protection to determine the impact on local parrotfish populations, while also contributing "best practice" guidelines and "lessons learned" for others countries in the Caribbean to follow or model.

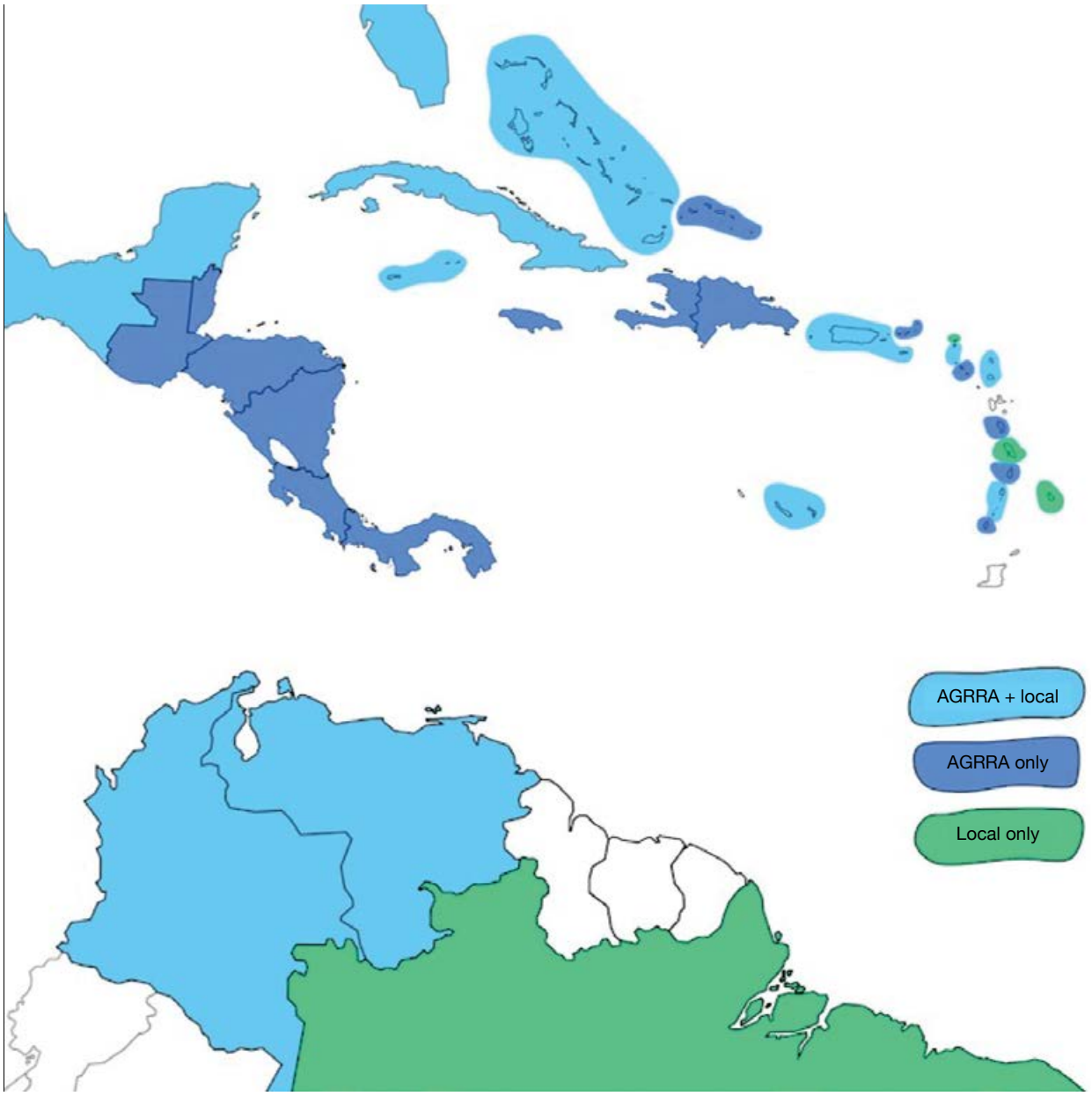
PLATE 5
Parrotfish and a fisher in Jamaica

3.2.4 Biological monitoring

Twenty-one countries reported that they have some type of fishery-independent surveys that record information on parrotfishes abundance, diversity, habitat use, reproduction, or other biological metrics. However, of those 21 countries, not every country conducts the same degree of detailed survey. For example, some countries indicated they had information about parrotfish abundance and diversity, but lacked surveys of habitat preferences, reproductive aspects, or other ecological characteristics. Only seven countries indicated that they have long-term biological monitoring programmes in place to assess fish communities, and four of these countries were within the United States and its territories, i.e. National Coral Reef Monitoring Program (Florida, United States of America, United States Virgin Islands, Puerto Rico; National Coral Reef Monitoring Plan; Puerto Rico Long-term Coral Reef Monitoring Program, etc.). Some countries (n=12) that indicated a lack of fishery-independent surveys were also unaware of any other type of independent research, or work by NGOs. Of those countries, either the Atlantic and Gulf Rapid Reef Assessment (AGGRA) or ReefCheck had some historical, current, or ongoing fish community monitoring. Although not directly targeted at assessing parrotfish populations, this type of long-term biological monitoring would have the information necessary to assess abundance, diversity and biomass of parrotfishes in the Caribbean. An overlay of the countries with fishery-independent surveys (either specifically for parrotfishes, or general fish community surveys where this data can be obtained) and those conducted by AGRRA illustrates broad coverage in the Caribbean where these data could potentially be accessed and used to investigate trends in biological metrics of parrotfishes over time (Figure 3).

In 2020, AGRRA explored its data of over 3 000 surveys from 29 countries (1997 to the present) to identify trends over time in parrotfish biomass. The preliminary analysis indicated that two of the larger bodied parrotfishes, *Scarus guacamaia* and *Sparisoma viride* were low in biomass on heavily fished reefs (i.e. Haiti, Jamaica and Dominican Republic) whereas the smaller-bodied parrotfish, *Scarus iseri* was high in biomass, but at small sizes (~9 cm) (Kramer, 2020). Based on this evidence, AGRRA suggested protection for larger-bodied parrotfishes like *Sparisoma viride* (or a ban on the harvest of this bioeroder) and prohibiting the harvest of *Scarus guacamaia* across the region, especially given its current International Union for Conservation of Nature (IUCN) status of near threatened (Table 4). Also of concern is the status of the other two large bodied parrotfishes with unknown population trends, which makes it difficult to inform management decisions. In Colombia, the two parrotfishes *Sparisoma viride* and *Scarus vetula* are listed as near threatened in the Colombian Red Book of Marine Fishes because they have been captured extensively by artisanal fishers (Cubillos and Hooker, 2020). Trends such as these, as observed through long-term biological monitoring, should be considered in directing future monitoring (especially based on location within the region) and potential management decisions for these species.

Figure 3. Map of the Caribbean (above) and South America (below) illustrating where fishery-independent surveys have occurred.



Light blue indicates that both a local fishery-independent survey and AGRRA surveys are reported for the country (historic, current or ongoing). Darker blue indicates that only AGRRA surveys are reported (historic, current or ongoing). Green indicates that only local fishery-independent surveys are reported. Countries without colour are not included in the review or reported that they do not have fishery-independent surveys.

Map is not to scale.

Source: Semicircular, 2016 modified with data from Harms-Tuohy, 2021.

TABLE 4.
IUCN status and details regarding the big three parrotfishes of the Caribbean

	IUCN status	Year evaluated	Population trend
Scarus guacamaia	Near threatened	2012	Decreasing
Scarus coeruleus	Least concern	2009	Unknown
Scarus coelestinus	Data deficient	2009	Unknown

Scientists have also studied parrotfishes in various Caribbean countries, as evidenced by the expansive literature (~700 publications, Hoey and Bonaldo, 2018). This review identified only a few countries without any peer-reviewed studies (n=15, but six were represented in regional studies). However, much of this research investigated various aspects of parrotfish biology and ecology, rather than a local assessment of parrotfish population status or trends over time. Certain NGOs have used their own assessments to develop "report cards" and status reports for parrotfishes for the countries in which they operate (e.g. Healthy Reefs Initiative; AGRRA), but perhaps one of the most paramount studies on parrotfishes was the 2014 Coral Reef Status Report by Jackson *et al*. (2014) which concluded that overfishing of herbivores, like parrotfish, was driving coral reef declines throughout the region. The study called for stronger protection and management for parrotfishes while at the same time recommending long-term, annual monitoring of coral reefs and associated fish populations because this information can be used for adaptive management.

The important message in this section speaks to the need for developing long-term monitoring in countries where it is lacking, and to build better communication between NGOs and governmental resource management bodies. Because the life histories of the various species of parrotfish vary, management will benefit from long-term data that includes biomass and size-specific metrics of parrotfishes observed.

3.2.5 Current status and needs in fishery management

Several limitations are highlighted, including the type of data recording, availability of information, responses to regulations, and resources available for management.

- Lack of data or non-specific data

  Twenty-seven countries reported that they either did not record landings or the information was not recorded to the species level. There is a need to enhance species-specific data on landings. An opportunity exists for regional management to offer specific training on how to collect this type of data and facilitate collaborative learning between countries that already sample in this way, and countries that would like to learn.

- Lack of or poor communication between stakeholders

  It was evident that there is a severe communication breakdown between fisheries management divisions, scientists and/or NGOs and the fishing community. There is a need to promote better communication between these groups, especially by including all stakeholders in the regulatory decision-making process.

- Lack of long-term monitoring

  Some countries indicated that they do not have the financial means to conduct long-term biological monitoring. In these situations, collaborative partnerships with local or regional NGOs could enhance the ability of local resource managers to start or continue such a programme.

- Lack of enforcement and compliance

  Many countries indicated that they have problems with enforcement of parrotfish harvesting bans or regulations, especially in areas where fishers were not included in the regulatory decision-making process. Additionally, difficulty in finding regulatory information hampered the ability of fishers to comply and resulted in illegal, unregulated and unreported (IUU) fishing. There is a need to enhance enforcement for countries with existing regulations and to support outreach by making regulations easy to locate and understand.

- Inability to identify parrotfish species

  Seven countries indicated that their fishers likely cannot tell the difference between the various parrotfish species. There is a need for enhanced education and outreach regarding the ecological importance of parrotfishes and how their roles vary by species. This is especially necessary in countries where outreach programmes are non-existent.

- Impacts of COVID-19

  A timely issue is the need to understand how the COVID-19 pandemic is influencing change within the fishing sector. Two countries specifically blamed COVID-19 for a surge of new fishers entering the industry, and the subsequent targeting of parrotfishes as a necessary means to provide food and income. FAO indicated that COVID-19 has reduced enforcement and fisheries management, and suggested IUU fishing could increase (FAO, 2020b). Another report indicated that the closure of government offices could also be driving illegal harvesting because new fishers would not have access to fishing licenses (Eugui and Contreras, 2020). Whenever possible, management should take a special interest in monitoring parrotfish harvests to observe if these trends are occurring regionally, or within a limited number of countries. The pandemic could provide a unique opportunity to focus on identifying alternative livelihoods and ways to incorporate fisher participation in marine conservation and ecotourism (Eugui and Contreras, 2020). Such participation has already been identified as a successful solution in Honduras.

3.3 Outreach and education

3.3.1 Overview

The level, or presence, of outreach and education varied throughout the Caribbean. Only 12 countries said that they had some type of outreach campaign or materials, with some countries (n=3) explaining that these were not specific to parrotfish, although they did discuss their ecological role to some degree. The audience of these outreach messages varied from children and parents to fishers and consumers, essentially encompassing all types of stakeholders. Outreach effectiveness was rarely evaluated, but one country indicated that it knew the outreach was effective because parrotfishes were no longer seen in the market. Some countries may not have the financial resources to develop outreach programmes, and at least three countries mentioned that they were not aware of any NGOs in their country that were currently addressing parrotfish conservation. Listed below are examples of outreach within the region (not intended to be an exhaustive list of all parrotfish outreach campaigns).

Mesoamerica and South America

In the countries of Mexico, Honduras, Guatemala, and Belize, the organization Healthy Reefs for Healthy People Initiative and the Interamerican Association for Environmental Defense (AIDA) have worked extensively in each country individually, and also on a regional scale, and were prominent in supporting parrotfish harvesting bans for each country and subsequently promoting awareness for the bans throughout the region and reporting on their effectiveness. In Colombia, the Corporation for the Sustainable Development of the Archipelago of San Andrés, Providencia and Santa Catalina (CORALINA), a public entity formed by the aforementioned jurisdictions, has been instrumental in leading the efforts to list particular parrotfish species in the Red Book of Marine Fish and has prohibited the harvesting of parrotfishes in their jurisdictional waters.

Greater Antilles and Eastern Caribbean

In 2018, The Nature Conservancy in the Caribbean conducted its "Pass on Parrotfish" campaign which was promoted in Haiti, Dominican Republic, Jamaica, Grenada and Saint Vincent and the Grenadines and also promoted widely on the organization's regional social media platforms and therefore accessible to anyone. Other local organizations expanded on the campaign, including the Institute for Socioecological Research in the Caribbean, which focused on the Bahamas and the Dominican Republic. The social media campaign encouraged other industries to get involved in outreach activities, including the hospitality industry (e.g. Sandals Jamaica) and the local dive industry. Although the use of social media as a platform for dissemination is useful, it can also have a negative effect such as the case described in management example 1.

The Nature Conservancy study on the effectiveness of the harvesting ban in the Dominican Republic suggested that a lack of education regarding the ban was not a problem. About 70 percent of fishers indicated they knew about the ban and the rationale behind it. In fact, when questioning fishers, fishmongers, restaurants, and the authorities, 98 percent of respondents indicated they were fully aware of the harvesting ban. However, fishers indicated they were caught by surprise when the law was enacted and they did not receive any alternative livelihood training or assistance to invest in new gear, or instruction on the use of alternative gears.

Northern Caribbean

In the Bahamas, the Perry Institute of Marine Science has developed an educational poster about the ecological importance of parrotfishes. This poster was provided to other regional partners, including AIDA Americas for distribution in the Mesoamerican region.

Media outlets like local newspapers and blogs help spread the word about the roles of parrotfishes on coral reefs (e.g. Trinidad and Honduras), report on parrotfish conservation initiatives (e.g. Colombia) and promote or encourage new fishing regulations and parrotfish harvesting bans (e.g. Saint Vincent and the Grenadines and Jamaica). These outlets can be very useful for reaching diverse stakeholders but many countries indicated that the best outreach for their circumstances involved targeted messaging for children/families and fishing communities. One country indicated that its programme teaches school-aged children about the ecological importance of parrotfishes, and the information is then passed on to the children's parents at home. Other countries (n=8) suggested effective outreach to the fishing community currently involves (or would involve, if a programme was developed) one-on-one, or boat-to-boat, discussions, and small-scale workshops that engage fishers in the conversation about parrotfishes. One country suggested that involving fishers in scientific data collection would be an innovative way to build stewardship in their community.

Management example 2

Compliance with regulations can be bolstered by education. One country implemented a fisher training programme that is mandatory for all new commercial fishers to attend. In this programme, the fisher learns about the regulations, conservation rationale behind those regulations, and the ecological importance of some key fishery species like parrotfishes. This programme took nine years to implement but is now considered to be a successful way to assist compliance with and enforcement of regulations. The same country sends out notifications about upcoming fishery closed seasons at least 30 days before the closures begin.

3.3.2 *Current status and needs in outreach and education*

Four main limitations to outreach were identified in this review. These are a lack of resources, specificity in campaign messaging, dissemination and evaluation of current programmes.

- **Lack of resources for outreach programmes**

  Governments may not have the financial, human or infrastructural resources to develop and maintain outreach and education programmes. A useful effort would be to identify which countries could benefit from assistance in this respect and connect them with regional or local NGOs that could assist, or identify parrotfish outreach programmes that can be affordably scaled and replicated. Many countries said that although they do not have outreach – or outreach actions have not been prioritized – they are aware of the type of outreach that would be effective for their communities.

- **No evaluation of outreach programmes**

  Very few outreach programmes have evaluated the impact of their campaigns. This is a critical step in understanding the success of the campaign and to ensure messaging is targeted and achieving the desired outcome (e.g. awareness of regulations, behavioural change). Collaborative partnerships with local or regional NGOs and universities (e.g. student theses) could facilitate the evaluation of current programmes.

- **Few specific campaigns pertaining to parrotfish**

  Considering the number of countries reviewed, there were few specific parrotfish outreach campaigns. There is a need to increase awareness of the ecological importance of parrotfishes and the roles that each stakeholder can play in promoting resilience and/or growth in their local parrotfish populations. We can learn from the proactive example of the lionfish (*Pterois volitans*) invasion, when regional outreach, often initiated at the national level, made a significant impact on awareness, with measureable actions to indicate success (e.g. restaurants serving lionfish as a substitute for other unsustainable choices, fishers hunting lionfish as an alternative, artisans using lionfish in their crafts, etc.).

- **Timing of outreach messaging and delivery regarding bans**

  For countries with regulations or harvesting bans on parrotfishes, associated outreach (e.g. announcing the regulations, promoting awareness) was either missing altogether or was not provided promptly to inform fishers and stakeholders before the start of the ban. There is a need to develop local messaging strategies with timelines for dissemination and widely distribute outreach messaging using a variety of sources (e.g. news, radio, social media and printed materials).

4. Recommendations and future needs

The following four questions were used to define specific recommendations that should be considered when moving forward with conservation or management programmes and/or strategies targeting parrotfish harvesting in the Caribbean region:

- How do we protect parrotfishes at the regional level?
- Besides harvesting, what other factors impact parrotfishes?
- How can we improve fishery-independent and fishery-dependent monitoring?
- How can we achieve better communication between conservationists, scientists and fishery managers?

4.1 How do we protect parrotfishes at the regional level?

Effective implementation of a regional harvesting ban on all parrotfishes would not be feasible because several parrotfish species are important for livelihoods in many countries. It would also be logistically challenging to implement and enforce, especially for countries without the necessary resources. From an ecological point of view, indiscriminately prohibiting the catch of all parrotfishes may not be the most appropriate measure, considering the variable functional roles, redundancy among some species, and local variations in diversity and abundance of parrotfishes. However, it is possible to arrange subregional agreements to improve protection, as evidenced in the Mesoamerican reef system. Measures might include enacting seasonal closures; gear restrictions (e.g. banning non-selective gears like traps, or implementing ways to limit incidental parrotfish harvest in traps); size limits; bag limits; and other measures. Additionally it would be beneficial to restrict the harvest of the more functionally critical species such as *Sparisoma viride*, which appears to be performing a similar role as the ecologically extinct *Scarus guacamaia* and the other two large-bodied Scarids, and is now considered the only major bioeroder for the region. In some areas, such as Colombia, *Sparisoma viride* and the medium-bodied *Scarus vetula* are already considered near threatened.

Recommended actions A

- Determine which countries are open to elective total protection versus fishery management.
- Work directly with the United Nations Environment Programme's Caribbean Environment Programme and the Regional Activity Centre for the Protocol Concerning Specially Protected Areas and Wildlife for the Wider Caribbean Region to facilitate the discussion about conservation and management of parrotfishes.
- Generate group discussions with WECAFC leaders and members of the fishery, fishery managers, and conservation sectors of each country as a starting point to understanding the feasibility of enacting regional protection.
- Identify where subregional collaboration could be effective (i.e. geographic vicinity, shared governmental structures) and learn from the collaborations that already exist, such as the Mesoamerican system, or integrate parrotfishes into existing regional working group priorities.
- Perform a fine-scale review and effectiveness analysis of the countries with harvesting bans to identify commonalities, legal framework, decision-making process, involvement from stakeholders, and inclusion of scientific data. Prepare an action plan that can assist interested countries to develop harvesting bans or regulations.

Recommended actions B

- Discuss banning the harvest of the large-bodied parrotfish region-wide, and placing restrictions on the other species, including a ban on import/export.
- Identify methods and actions to help resource managers achieve this specific recommended action (e.g. their financial needs, outreach needs, enforcement needs, etc.).
- Consider a minimum size limit of 30 cm tail length and an annual catch limit of less than 10 percent of the fishable population (Bozec *et al*., 2016) for all parrotfishes across the region, and consider a maximum size limit for some species.
- Conduct a socio-economic evaluation of the relevance of particular parrotfish species in the fishery, such *Sparisoma viride*.
- Discuss and consider regulations to be applied to diving activities aimed at increasing safety for fishers and increasing the natural population performance of parrotfishes, such as prohibiting harvest at night.

- Identify trade networks (major importers/exporters) of parrotfishes.

Recommended actions C

- Identify priority countries that would need to transition fishers into alternative livelihoods.
- Identify what resources governments need to assist with this transition and determine how regional organizations could assist further; e.g. microfunds for alternative livelihood feasibility studies (Caribbean Natural Resources Institute).
- Review where alternative livelihoods have worked in the Caribbean (e.g. seaweed farming in Belize, ecotourism in Honduras).
- Consider promoting or assisting fisher integration with other existing fisheries, or strengthening incipient regional alternative livelihood initiatives.
- Investigate the impact of COVID-19 on parrotfish harvest in countries that previously did not report large landings of the various species.

In Bonaire (Bonaire, Sint Eustatius and Saba), strong fisheries management combined with engaged fishers is exemplified through an intact herbivore guild and resilient coral reefs. In 1971, fishers voluntarily elected to prohibit spearfishing and subsequently phased out fish traps in 2010 and banned parrotfish harvesting. Hook and line fishing is the only extractive method that is used for fishing and consequently, parrotfishes and other herbivores are abundant. Bonaire's reefs have not been immune to stressors like coral bleaching and hurricanes, but the reefs did rebound after these events, due to an intact coral reef ecosystem where parrotfish biomass is twice that of other eastern Caribbean no-take marine reserves. Bonaire reefs boast an astonishing 45 percent live coral cover, a relatively non-existent figure for the majority of the Caribbean. To date, this example in Bonaire may be the only case study of true coral reef recovery resilience in the Caribbean. Bonaire demonstrates that with stewardship and stakeholder involvement, agreements can be made that marry conservation and livelihoods for those who depend on ocean resources (Steneck *et al*., 2019; Steneck, 2020).

Recommended actions D

- Build on this review to create a more extensive investigation of fishery-independent and fishery-dependent data.
- Collect country-specific fishery-dependent data to evaluate parrotfish landings patterns, mean sizes landed, and the species composition of landings.
- Work with NGOs and local scientists to assess parrotfish fishery-independent data to evaluate regional and local trends.
- Expand the review to include individual overviews for each country based on their responses.

4.2 Besides harvesting, what other factors impact parrotfishes?

Coastal degradation like sedimentation and eutrophication need to be addressed, especially in areas with significant nearshore coral reefs. Parrotfishes do not prefer high macroalgal cover and grazing on turf algae is restricted by severe sedimentation. We cannot rely on a single species to serve the ecological role of limiting late-stage macroalgal growth, but we can facilitate and hopefully compound its impacts by reducing the eutrophication of the system that

allows macroalgal dominance. Addressing these two issues will improve water quality and also slow the decline of reefs where parrotfishes already exist in greater abundance.

Recommended actions A

- Identify the countries that have current and enforced management plans in place that limit eutrophication and sedimentation on coral reefs.
- Review management plans, evaluate effectiveness and generate case studies that highlight where these measures have been successful and how other countries can learn and implement these measures.
  - Identify and report case studies where proper septic maintenance and sewage management has reduced eutrophication in coastal towns. Develop a protocol to assist Caribbean countries to evaluate their situation. Direct funds towards studies to assess economic feasibility in upgrading these systems.
  - Identify and report case studies with successful coastal protection (legal frameworks, scalability, involvement of stakeholders) and what measures were used to hamper run-off from development.
- Identify countries with current water quality monitoring programmes, review their programme protocols, and identify if particular practices could be easily replicated elsewhere in the region.

Recommended actions B

- Identify the existence of long-term monitoring of eutrophication, water quality and sedimentation at the national and regional levels.
- Perform a meta-analysis of national and/or regional long-term monitoring initiatives that measure water quality, eutrophication and sedimentation throughout the Caribbean. Identify spatial and temporal trends.
- Develop a report that highlights where long-term monitoring of these factors has directly resulted in local regulatory changes that show measurable improvement to the marine environment.

4.3 How can we improve fishery-independent and fishery-dependent monitoring?

Build the capacity for countries to record landing data and start long-term biological monitoring of their coral reefs. This is largely lacking for the Caribbean, with a few exceptions. Jackson *et al*. (2014) recommended that long-term biological monitoring be implemented throughout the region. Now, in 2020, it is evident that the recommendation has not been applied in several countries. This is often due to a lack of financial resources and trained personnel. Additionally, without specific catch data, it is difficult to evaluate parrotfish relevance in the fishery and without temporal monitoring of parrotfish abundance, biomass and diversity, it is impossible to evaluate any changes in population dynamics. Also, most countries did not have information on the reproductive status of their parrotfish populations, thus providing training in how to age and sex parrotfishes would be beneficial.

Recommended actions A

- Facilitate partnerships between national or regional NGOs and fishery managers to build data collection capacity.

- Use the knowledge gained to introduce the respective fishery/resource manager to the NGOs working in their country and recording biological data.
- Collaborate with NGOs to direct monitoring needs in countries where long-term biological monitoring is lacking.

Recommended actions B

- Identify the needs of the individual country and develop or utilize existing platforms to implement solutions.
- Collate sources of external funding available to governments to assist with establishing or maintaining long-term monitoring programmes, such as SPAW.
- Develop or use existing platforms to host virtual or in-person training workshops to teach fishery managers how to collect biological data (i.e. how to conduct fish surveys, tools needed, standardized protocols being used in the region, etc.) and provide basic resources to assist in the sustainability of the programme (e.g. template data sheets, protocol resources and basic materials).
- Develop or use existing platforms to host virtual workshops to train managers and their teams on how to identify Caribbean reef fish and what metrics to record for catch data (e.g. how to measure standard length, weight, sex, gear used, habitat, etc.). Develop sturdy, reusable materials that identify (by name and image) the basic fishery species relevant to each country to assist port sampling.
- Develop or use existing platforms to host a virtual or in-person workshop to teach fishery managers and their teams the skills needed to assess the age and sex of local parrotfish populations. Provide the tools necessary.
- Develop a plan that guides best practices in catch data handling, organization and reporting.
- Develop a strategy to partner fishery managers from countries with proper catch data procurement and organization protocols with fishery managers from countries that could benefit from directed guidance.

Recommended actions C

- Consider using complementary sources to document the presence/absence of parrotfishes in the fishery.
- Conduct interviews with fishers to harness traditional ecological knowledge with a view to understanding historic catch or abundance of parrotfishes on Caribbean coral reefs.
- Use social media as a resource to identify the presence of particular parrotfish species in the fishery, similar to how Shiffman *et al*. (2017) used this tool to identify shark diversity in the recreational catch.

4.4 How can we achieve better communication between conservationists, scientists and fishery managers?

As evidenced in this review, there is a lack of communication between stakeholders and organizations that are ultimately discussing solutions to the same problem. Many countries have enacted harvesting bans that were encouraged strictly by one sector. Biological monitoring programmes are ongoing in countries where government officials are unaware of them. Fishery managers are excluded from the discussion of parrotfish management and conservation. These situations can and should be avoided. WECAFC leadership can assist in connecting the various stakeholders to promote a coherent discussion of how to move forward with protecting and conserving parrotfishes.

Recommended actions A

- Facilitate linkages between stakeholders at the national level.
- Increase coordination by encouraging resource management to develop a voluntary contact list of potential interested stakeholders, such as conservationists, scientists, fishers' unions, the ecotourism sector, etc.
- Increase coordination by hosting virtual workshops for each country that introduce the various stakeholders and discuss the importance of collaboration. Assign a facilitator to lead this process and maintain support and communication between the groups.

Recommended actions B

- Encourage national and regional collaboration.
- Explore existing initiatives that have strengthened local collaboration between stakeholders, such as opportunities where fishery managers have engaged with scientists and conservationists to achieve a common goal. Document how these efforts unfolded to better understand how this type of collaboration could be reproduced elsewhere in the region.
- Encourage regional working groups to expand their communication network by inviting potential stakeholders to join meetings and discussions.

PLATE 6
Close-up of a parrotfish eye

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Appendices

Appendix 1: Questionnaire

The FAO/WECAFC and the Caribbean Fisheries Management Council are conducting an evaluation of the current knowledge gaps in parrotfish management and/or conservation for our region. The information obtained from this document will help us determine the next steps in our review. Please answer the following questions based on your knowledge of parrotfish in your country. You are welcome to send this document to colleagues who may be able to provide additional insight.

Country: _____

1. Please complete the table below regarding your parrotfish fishery, using as many rows as needed (please add as many rows as necessary or use another page)

Common name	Scientific name	Targeted (Y or N)	By-catch (Y or N)	Purpose of the fishery (commercial/ personal consumption)

2. Please select the most appropriate answer:

a) Do you have landings data for the parrotfish fishery? Yes ☐ No ☐

b) Is this data in digital format? Yes ☐ No ☐

c) Is this data recorded at the species level? Yes ☐ No ☐

d) Is this data available for regional analysis? Yes ☐ No ☐

e) Do you have any fishing effort data (sites, gears, seasons, etc) Yes ☐ No ☐

f) Do you have any other fishery related data? Please specify:

_____

_____

_____

_____

3. Regarding the fishery-independent information, please respond to the following questions:

a) Do you have field studies on parrotfish abundance? Yes ☐ No ☐

b) Do you have field studies on parrotfish diversity? Yes ☐ No ☐

c) Do you have field studies on parrotfish reproduction? Yes ☐ No ☐

d) Do you have field studies on parrotfish habitats? Yes ☐ No ☐

e) Do you have any other biological/ecological information? Yes ☐ No ☐

(such as studies addressing their role on your reefs (bioeroders, etc)

4. Regarding regulations on fishing parrotfish, please respond to the following questions:

a) Do you have any parrotfish fishery-related regulation? Yes ☐ No ☐

b) Do you have any parrotfish conservation-related regulation? Yes ☐ No ☐

c) Do you have any information of illegal parrotfish captures? Yes ☐ No ☐

5. Regarding outreach and education specific to parrotfish, please respond to the following questions:

a) Have you developed any educational material? Yes ☐ No ☐

Please specify:

b) Do you have a current educational program specific to parrotfish? Yes ☐ No ☐

Please specify:

c) Have you, in some way, evaluated your educational activities? Yes ☐ No ☐

6. Are you willing in continue working for the improvement of the parrotfish regional fisheries or conservation management? Yes ☐ No ☐

If so, please explain to us in what ways:

Please provide your contact information if you are willing to provide more details about your answers.

Name and email:

If you would prefer that we contact someone else, please provide their contact information:

The FAO/WECAFC Secretariat and the Caribbean Fisheries Management Council sincerely appreciate your responses and interest in assisting our investigation into the current status of the parrotfish fishery, management and conservation for our region.

Please feel free to reach out to us directly via our Consultant: Dr. Chelsea Harms-Tuohy, chelsea.harms@upr.edu

La COMISIÓN DE PESCA DEL ATLÁNTICO CENTRO-OCCIDENTAL de la Organización de las Naciones Unidas para la Agricultura y la Alimentación y el Consejo de Administración Pesquera del Caribe están llevando a cabo una evaluación de los vacíos de información para actualizar la ordenación pesquera y la conservación de los peces loro en nuestra región. La información obtenida con este documento nos ayudará a determinar los próximos pasos de esta investigación. Favor responda las siguientes preguntas según su mejor conocimiento de los peces loro en su país. Le invitamos a enviar este documento a colegas que puedan proporcionar información adicional.

País: _____

1. Complete la siguiente tabla referente a temas pesqueros de los peces loro, utilizando tantas filas como sea necesario (agregue tantas filas como sea necesario o use otra página)

Nombre común	Nombre científico	Pesca dirigido (Sí o N)	Pesca incidental (Sí o N)	Uso del producto (consumo comercial / personal)

2. Por favor seleccione la respuesta más apropiada:

a) ¿Tiene datos de desembarques para la pesquería de peces loro? Sí ☐ No ☐

b) ¿Están estos datos en formato digital? Sí ☐ No ☐

c) ¿Se registran estos datos a nivel de especie? Sí ☐ No ☐

d) ¿Están disponibles estos datos para un análisis regional? Sí ☐ No ☐

e) ¿Tiene datos del esfuerzo de pesca (áreas geográficas, artes, estaciones,etc) Sí ☐ No ☐

f) ¿Tiene alguna otra información relacionada con la pesca? Por favor especifique:

_____

_____

_____

_____

3. Con respecto a la información independiente de la pesquería, responda las siguientes preguntas:

a) ¿Tiene estudios sobre la abundancia de peces loro? Sí ☐ No ☐

b) ¿Tiene estudios sobre la diversidad de peces loro? Sí ☐ No ☐

c) ¿Tiene estudios sobre reproducción de peces loro? Sí ☐ No ☐

d) ¿Tiene estudios sobre los hábitats de peces loro? Sí ☐ No ☐

e) ¿Tiene alguna otra información biológica / ecológica? Sí ☐ No ☐
(como estudios sobre rol en los su arrecifes (bioerosionadores, etc.)

4. Con respecto a las regulaciones sobre la pesca de los peces loro, responda las siguientes preguntas:

a) ¿Tiene alguna regulación relacionada con la pesca de peces loro? Sí ☐ No ☐

b) ¿Tiene alguna regulación relacionada con la conservación de los peces loro? Sí ☐ No ☐

c) ¿Tienes alguna información sobre capturas ilegales de peces loro? Sí ☐ No ☐

5. Con respecto a la divulgación y educación específica para los peces loro, responda las siguientes preguntas:

a) ¿Se han desarrollado materiales educativos? Sí ☐ No ☐

Por favor especificar:

_____

_____

_____

b) ¿En la actualidad, tiene un programa focalizado para los peces loro? Sí ☐ No ☐

Por favor especificar:

_____

_____

_____

c) ¿Ha evaluado de alguna manera sus actividades educativas? Sí ☐ No ☐

6. ¿Está interesado a continuar trabajando para mejorar la pesca regional o la gestión de la conservación de los peces loro? Sí ☐ No ☐

Si es así, explíquenos de qué manera:

_____

_____

_____

_____

_____

Proporcione su información de contacto si está disponible proporcionar información adicional sobre sus respuestas:

Nom et email:

_____

_____

Si prefiere que nos comuniquemos con otra persona, proporcione su información de contacto:

_____

_____

La COMISIÓN DE PESCA DEL ATLÁNTICO CENTRO-OCCIDENTAL de la Organización de las Naciones Unidas para la Agricultura y la Alimentación y el Consejo de Administración Pesquera del Caribe agradecen sinceramente sus respuestas e interés en ayudarnos en nuestra investigación sobre el estado actual de la pesca, gestión y conservación de los peces loro para nuestra región. No dude en comunicarse con nosotros directamente a través de nuestra consultora: Dra. Chelsea Harms-Tuohy, chelsea.harms@upr.edu

Appendix 2: Individual country highlights

This section highlights the individual responses from each country. The information was obtained from the questionnaire (Appendix 1) followed by additional questions, if necessary. Although each country below responded to the survey, not all countries provided the same level of detail in their response or responded to the follow-up questions. The following countries/territories did not provide information: Saint Barthélemy, Guadeloupe, Saint Kitts and Nevis, Montserrat, Tobago (Trinidad and Tobago), and the British Virgin Islands. Countries that reported no parrotfishes in their fishery include Trinidad (Trinidad and Tobago), Guyana and Suriname.

*Use of the "big three" in the document refers to *Scarus guacamaia*, *Scarus coelestinus* and *Scarus coeruleus*.

TABLE A1.
For ease of reading, all blank spaces are denoted by an "N" for countries that reported "no" to the five categories

	Species specific landings	Harvesting ban, year enacted	Fishing regulations	Fishery-independent surveys	Current outreach
Anguilla					
Antigua and Barbuda		Y, 2014[1]	Y	Y	Y
Aruba		Y, 2017			
Bahamas				Y	
Barbados				Y	
Belize		Y, 2009			Y
Bermuda		Y, 1993			Y
Bonaire (Bonaire, Sint Eustatius and Saba)		Y, 2010		Y	Y
Brazil*			Y	Y	
Cayman Islands				Y	
Colombia		Y, 2019		Y	
Costa Rica					
Cuba			Y	Y	
Curaçao				Y	Y
Dominica	Y		Y		
Dominican Republic		Y, 2017[1]			Y
Grenada	Y				
Guatemala		Y, 2015			
Haiti					
Honduras		Y, 2010			
Jamaica					
Martinique			Y	Y	
Mexico			Y	Y	

1 Barbuda enacted the harvesting ban, Antigua has regulations on parrotfish harvest. The harvesting ban on parrotfish in the Dominican Republic expired in 2019.

	Species specific landings	Harvesting ban, year enacted	Fishing regulations	Fishery-independent surveys	Current outreach
Nicaragua					
Panama		Y, 1994			
Puerto Rico	Y		Y	Y	Y
Saba (Bonaire, Sint Eustatius and Saba)	Y			Y	
Saint Croix (United States Virgin Islands)			Y	Y	
Sint Eustatius (Bonaire, Sint Eustatius and Saba)	Y			Y	
Saint Lucia	Y				
Saint-Martin (French part)			Y	Y	Y
Saint John and Saint Thomas (United States Virgin Islands)	Y		Y	Y	
Saint Vincent	Y	Y, 2019		Y	Y
Turks & Caicos		Y, 2011			
United States of America, Federal EEZ	Y		Y	Y	Y
United States of America, Florida	Y		Y	Y	
Venezuela (Bolivarian Republic of)			Y	Y	Y

TABLE A2.
Summary of the regulations and involvement of the fishers, including rationale for the harvesting ban or regulations

	Reg. type	Year enacted	Fishers involved	Rationale
Antigua	Regulation	2013	Y	Scientific
Barbuda	Ban	2014	Y	Scientific
Aruba	Ban	2017	N	Precautionary Principle
Belize	Ban	2009	?	?
Bermuda	Ban	1993	N	Scientific
Bonaire (Bonaire, Sint Eustatius and Saba)	Ban	2010	Y	?
Brazil	Regulation	2011, 2014, 2018	N	?
Colombia	Ban	2017, 2019	?	?
Cuba	Regulation	2011	N	?
Dominica	Regulation	2004	?	?
Dominican Republic	Ban	2017–2019	N	Precautionary Principle
Guatemala	Ban	2015	Y	?
Honduras	Ban	2010	Y	Scientific

	Reg. type	Year enacted	Fishers involved	Rationale
Martinique	Regulation	2019	?	?
Mexico	Regulation	2018	?	Scientific
Panama	Ban	1994	?	?
Puerto Rico	Regulation	2012	Y	Scientific
Saint Croix (United States Virgin Islands)	Regulation	2008, 2011	Y	Scientific
Saint-Martin (French part)	Regulation	2019	Y	Scientific
Saint John and Saint Thomas (United States Virgin Islands)	Regulation	2012	Y	Scientific
Saint Vincent and the Grenadines	Ban	2019	N	Precautionary Principle
Turks and Caicos Islands	Ban	2011	N	?
United States of America, Federal EEZ	Regulation	2012	Y	Scientific
United States of America, Florida	Regulation	2012	Y	Scientific

Anguilla

Information was provided by the Fisheries and Marine Resources Unit (FMRU) of Anguilla.

Parrotfishes are a staple food source in Anguilla and the main species harvested are *Scarus vetula*, *Scarus iseri*, *Scarus taeniopterus*, *Sparisoma rubripinne* and *Sparisoma viride*. These species are targeted for both personal and commercial consumption, primarily using spearguns. They are sometimes caught as bycatch in other fisheries and some fishers use them to bait lobster traps. The FMRU indicated that fishers cannot confidently identify the different parrotfish species.

No landing information is recorded specifically for parrotfishes because landings are only reported as e.g. “reef fish” or “pelagic fish” and are not separated by species. However, through market observation, fisher and consumer inquiry, the FMRU is aware of the species of parrotfishes that are landed but are officially unrecorded. Since the onset of the COVID-19 pandemic, additional residents have chosen fishing as a means of income and have started targeting parrotfish more heavily. There are no fishery-independent programmes specific to parrotfishes but the government does conduct annual marine monitoring and through this programme, it is aware of parrotfishes diversity and abundance in Anguilla. Currently, there are no fishing regulations regarding parrotfishes.

Outreach is limited and not specific to parrotfishes, but current general marine conservation-related outreach is geared towards students and children. The FMRU indicated that social media, small group sessions and radio announcements would be viable media for outreach. If a regulation concerning parrotfishes was considered, the FMRU stated that fishers would be included in the decision-making process.

Information verified by Kafi Gumbs, FMRU.

Antigua and Barbuda

Information was provided by the Fisheries Department of Antigua and Barbuda.

The fishing strategy utilized by fishers is to have a mixed catch of species to provide to their diverse clientele, and parrotfishes are landed as part of a demersal reef fish fishery. Smaller species of parrotfishes are targeted for this purpose (e.g. stoplight, redtail, redfin and queen parrotfish) and the main gear used is gill nets and spearguns. Larger species of parrotfish (e.g. the big three) are generally not landed because they are not considered as "good eating" fish. Due to the protection afforded to the nearshore shallow-water habitats (< 20 m), the mean sizes landed are generally larger than the size at 50 percent maturity. Reef fishes, including parrotfishes, are a staple food source for the islands, and only about 10 active gillnet units consistently land parrotfishes; this activity is generally complemented by handlining for other reef species during net soak duration. It should be noted that yield of parrotfish per fish-pot or trap is marginal, but because traps are the most abundant gear in Antigua and Barbuda's fishery, the total contribution to overall parrotfish landings is significant. The Fisheries Department indicated that most fishers cannot confidently identify the difference between the various parrotfish species.

The islands do record landing information but not to the species taxonomic level. There are specific gear restrictions in place, including requirements for mesh size, total net length, and soak duration. Additionally, there is a specific seasonal closure for parrotfishes (May to July). In Barbuda specifically, it is illegal to harvest and be in possession of parrotfishes up to 3 nm from the island. Fishers were included in the decision-making process for all regulations and the closures and fishing regulations were based on local scientific data.

There is currently an outreach to the fishing community, students and consumers. The fisher training programme is mandatory for all commercial fishers. In this programme, fishers learn about the regulations, the conservation rationale behind the regulations, and the ecological role of particular species (e.g. parrotfishes). This programme is successful but it did require nine years to properly implement. The other outreach initiatives are geared towards students and consumers and include culinary guides and notifications sent out 30 days before the start of a specific closed season. The Fisheries Department indicated that there is a fishery-independent monitoring programme. Some fishers are even active in the research process.

Information verified by Ian Horsford, Fisheries Department.

Aruba

The information was provided by the Fisheries Section of the Department of Agriculture, Husbandry and Fisheries of Aruba.

Parrotfishes were caught only opportunistically and retained generally for personal consumption. They are not considered a staple food source and there is little demand for them in a commercial setting. Parrotfish harvesting was banned in 2017, as an addition to the Nature Protection Ordinance of 1995. No landing information regarding parrotfishes was recorded before the harvesting ban due to the limited resources available to record this information, and the fact that parrotfish were rarely landed.

Fishers and other stakeholders were not included in the decision-making process that resulted in the parrotfishes harvesting ban. There was no outreach before or after the harvesting ban. According to the Fisheries Section, the harvesting ban was enacted due to international pressure and social media influence. Fishers are not compliant with the ban and often defy it intentionally. Fishers also indicate that "catch and release" is not allowed under the ban.

Additionally, there is no fishery-independent monitoring and the Fisheries Section is not aware of any NGOs conducting independent surveys or outreach in Aruba.

Information verified by Byron Boekhoudt, Department of Agriculture, Husbandry and Fisheries.

Bahamas

The information was provided by the Perry Institute for Marine Science (PIMS).

Parrotfishes are an emerging fishery within the Bahamian archipelago and are currently landed primarily as bycatch from handlines and fish traps. They are not a staple food source for the country but are sold commercially and retained for personal consumption. Landing information is not available for parrotfishes because they are classified as "other". There is currently no fishing regulation or conservation measure specific to parrotfishes in Bahamas.

PIMS stated that fishers would be consulted as part of the decision-making process if a harvesting or conservation regulation were proposed and indicated that this process would be facilitated by the Department of Marine Resources.

Fishery-independent monitoring is conducted by PIMS with support from local partners and information is available regarding parrotfish abundance, diversity, and habitat preferences, or this information is currently being compiled. Outreach to the fishing community requires employing multiple media such as social media, printed materials and radio, among others.

Information verified by Krista Sherman, PIMS.

Barbados

Information was provided by the Fisheries Division of Barbados.

Parrotfishes are a component of the fishery and are caught by spearfishing and fish traps. The following species are recorded: *Scarus iseri, Scarus vetula, Scarus taeniopterus, Sparisoma viride, Sparisoma aurofrenatum,* and *Sparisoma chrysopterum*. Landing information is limited because parrotfish catches are not recorded at the species taxonomic level and are generally aggregated with other reef fish harvested from fish traps. However, parrotfishes as a "group" are recorded in landings from one site in Barbados but that particular site was not specified in the survey response.

The Fisheries Division indicated that fishery-independent surveys of parrotfishes abundance and diversity have been conducted by the University of the West Indies. There are currently no fishing or conservation regulations specific to parrotfishes but the issue is currently being discussed by government and industry stakeholders. There is currently no parrotfishes-specific outreach.

Information verified by the Fisheries Division of Barbados.

Belize

Information was provided by the Policy and Planning Unit of the Fisheries Department of Belize.

Parrotfishes are not targeted and are not landed, due to a harvesting ban enacted in 2009. The Fisheries Department indicated that there is no fishery-independent monitoring of parrotfishes in Belize, but review of the literature indicated extensive research on parrotfishes and AGRRA stated it has over ten years of fish survey data that would include parrotfishes.

Radio announcements and flyers were used to disseminate information about the parrotfish harvesting regulation. There is current outreach aimed at fishers using a boat-to-boat method where fishers are educated about the regulations and prohibition of harvesting parrotfishes. Although formal evaluation of the outreach has not been conducted, the Fisheries Department considers the outreach campaigns to have been successful because parrotfishes are no longer seen in the fish markets.

Information verified by Mauro Gongora, Policy and Planning Unit of the Fisheries Department of Belize.

Bermuda

Information was provided by the Department of Environment and Natural Resources (DENR) of Bermuda.

Fish traps, which indiscriminately target parrotfishes, were banned in 1990 and an additional layer of protection was added to the regulations in 1993, preventing the harvesting of parrotfishes altogether. However, occasional illegal spearfishing of parrotfish does occur and it is thought that most of the illegal catch is from work permit holders who are not aware of the regulations. Parrotfishes were not considered a staple food prior to the ban. Compensation was provided to fishers who were displaced by the fish trap ban.

No landing information was provided and the DENR indicated that data only exists at the family taxonomic level for the period before the ban, i.e. prior to 1990. Fishers were not considered in the decision-making process that led to the bans on fish traps and parrotfish harvesting, but the decision was based on scientific data and relevant catch data. Despite this, the DENR indicated that fishers are generally compliant with the regulations and are often defensive of parrotfishes when confronting others performing illegal harvesting. The DENR indicated that most fishers can confidently identify parrotfish species.

Extensive fishery-independent research and monitoring have been conducted. The DENR recognizes that outreach to work permit holders would be useful in reducing the illegal catch of parrotfishes. Currently, parrotfish-related outreach is being conducted by the Bermuda Zoological Society and the DENR indicated explicitly that children grow up learning about parrotfishes.

Regulations: (1) Fisheries Act, (2) Fisheries Regulations, (3) Fisheries Protected Species Order

Information verified by Joanna Pitt, Department of Environment and Natural Resources.

Bonaire (Bonaire, Sint Eustatius and Saba)

The information was provided by the Department of Environment and Natural Resources of Bonaire.

Parrotfishes are not a staple food on the island. They are not currently landed in high numbers due to the conservation regulation for parrotfishes that was enacted in 2010 as part of the Nature Ordinance. Parrotfishes were not traditionally harvested before the ban so no landing information is available for the species. Fishers were mostly compliant with the harvesting ban and limited specific outreach was necessary to promote the new regulation because parrotfishes were not heavily targeted.

Fishery-independent monitoring has been conducted to evaluate the abundance and diversity of herbivorous fish and parrotfishes were specifically mentioned. No specific outreach was indicated.

Information verified by Frank Slobbe, Department of Environment and Natural Resources of Bonaire.

Brazil

Information was provided by the Ministry of Agriculture, Livestock and Supply of Brazil.

Parrotfishes are targeted for both personal and commercial consumption. Of the parrotfishes in Brazil, only one is also found in other parts of the Caribbean – *Sparisoma chrysopterum*. The Ministry indicated that parrotfishes are a staple food source for some communities in Brazil and are often caught by hook-and-line and spearguns. Fishers can identify the difference between the various parrotfish species.

Landing data is not available for parrotfishes. There are some fishery-independent surveys on abundance, diversity, reproduction, habitat preference and the ecological importance of parrotfishes in Brazil. Three fishing regulations/conservation measures pertain to parrotfishes; these were enacted in 2011, 2014 and 2018. Fishers were not included in the decision-making process that resulted in these regulations. The Ministry completed a recovery plan for parrotfishes in 2016. A specific outreach project for parrotfishes is underway and involves seven universities, the federal government and the petroleum industry. This outreach initiative has not been evaluated.

Information verified by Carolina Bittencourt, Office of the Secretariat of Aquaculture and Fisheries of the Ministry of Agriculture, Livestock and Supply.

Cayman Islands

The information was provided by the Department of Environment (DoE) of the Cayman Islands.

Two species of parrotfish are targeted, mainly for personal consumption – *Sparisoma viride* and *Sparisoma rubripinne*. These two species are caught by hook and line and licensed traditional Caymanian fish traps. To date, no means of mandatory fisheries landing data collection has been implemented because there are no commercial fisheries in the Cayman Islands. The DoE indicated they are aware of parrotfish harvesting because they occasionally see the fish available at the local fish market, but the artisanal and recreational fisheries provide insight to their catch which is used to document parrotfish biomass and extraction. The DoE indicated that parrotfishes cannot be harvested by speargun or seine nets and fishes harvested by legal means must be larger than 20 cm. There are also catch limits for fish traps which do impact parrotfish harvesting. Illegal catch is reported for parrotfishes taken from marine protected areas.

Fishery-independent monitoring of parrotfishes does occur and information about diversity, abundance, habitat preferences and other ecological value is available for the Cayman Islands. Outreach programmes are geared towards general marine conservation which is presented at schools, with some outreach about MPAs to the wider public, and these presentations do introduce the ecological importance of parrotfishes.

Information verified by Croy McCoy, DoE.

Colombia

The information was provided by the University of Bogota, Jorge Tadeo Lozano Department of Biological and Environmental Sciences of Colombia (DBES).

Parrotfishes are targeted for personal consumption and constitute bycatch in other fisheries. The two species that are specifically targeted are *Scarus vetula* and *Sparisoma viride* and the bycatch species are *Scarus iseri, Scarus taeniopterus* and *Sparisoma aurofrenatum*. Parrotfishes are not allowed to be caught for commercial purposes, only for personal consumption. For this reason, there is no landing data available for parrotfishes.

In July 2019, a conservation regulation for parrotfishes was enacted that protects 14 species from harvesting, especially those considered threatened and listed in the Red Book of Marine Fish of Colombia.

The DBES has conducted fishery-independent research on parrotfish abundance, diversity, habitat preferences and ecological value, but this information is currently being processed. A review of the literature found additional scientific surveys of parrotfishes. The department expressed interest in establishing a citizen science programme to raise awareness of the importance of parrotfishes to the ecosystem.

Information verified by Adolfo Sanjuan Muñoz, DBES.

Costa Rica

The information was provided by AIDA Americas and Fundación Keto for Costa Rica.

Parrotfishes do not constitute a large portion of the fishery for the Caribbean coast of the country and therefore no landing data is available. They are often harvested as bycatch and retained for personal consumption. The species are not considered a staple food source. A 2009 study by the *Fundación Keto* indicated that parrotfish fillets were previously sold in the markets as *corvina* due to lack of consumer awareness. However, consumers have now developed a taste for parrotfish and they are becoming more available in the market. *Fundación Keto* indicated that fishers usually catch parrotfishes at night using spearguns. There are currently no fishing or conservation regulations specific to parrotfishes.

No fishery-independent studies of abundance, diversity, etc. have been conducted on parrotfishes in Costa Rica. AIDA has produced a fact sheet for parrotfishes outreach but there are no specific, ongoing educational programmes.

Information verified by Magie Rodriguez, AIDA Americas and Cristina Sanchez, Fundación Keto.

Cuba

The information was provided by the Environmental Advisor of Avalon Fishing and Dive Centers of Cuba.

Many species of parrotfishes are consumed for personal and commercial purposes, depending on their size. The large species (*Scarus guacamaia*, *Scarus coeruleus* and *Scarus coelestinus*) and medium-sized species (*Sparisoma viride*, *Sparisoma chrysopterum*, *Sparisoma rubripinne* and *Scarus vetula*) are targeted by spearfishers and the small species (*Scarus taeniopterus, Scarus iseri* and *Sparisoma aurofrenatum*) are typically landed as bycatch by commercial fishers. Besides spearfishing, parrotfishes are harvested by nets, trawls and traps but they are a secondary food source in Cuba because other, more desirable fish are still available.

Fisheries data classifies all parrotfishes as "*loros*" and does not distinguish to the species taxonomic level. The information is not available for regional review. There is a conservation regulation that prohibits the commercial sale of parrotfishes, but the use of non-selective gear does not discriminate between species so the regulation is difficult to enforce and fishers do not comply with it. Fishers were not considered in the decision-making process that resulted in the regulation and very limited outreach was conducted with the fishing community to promote the new restriction. Several scientific institutions have conducted some fishery-independent monitoring for parrotfishes but this information is not yet available for review.

Information verified by Fabian Pina Amargos, Avalon Fishing and Dive Centers.

Curaçao

The information was provided by the Department of Agriculture and Fisheries Management (DAFM).

Parrotfishes are part of the fishery for the island and have become a staple food because of the decline in catches of other, more desirable fish. The common species harvested are *Scarus iseri, Scarus taeniopterus, Scarus vetula, Scarus guacamaia, Scarus coelestinus, Scarus coeruleus, Sparisoma viride, Sparisoma aurofrenatum, Sparisoma rubripinne* and *Sparisoma chrysopterum*. These are targeted for both personal and commercial consumption using spearfishing – which is illegal – fish traps and hook-and-line. The DAFM indicated that fishers in general cannot identify the different parrotfish species.

Landing information is not recorded for parrotfishes or any other fish. There is no fishing or conservation regulation for parrotfishes. The DAFM indicated that should regulations be proposed, fishers would be considered in the process and the government would be able to enforce a regulation using its Coast Guard.

Fishery-independent surveys of parrotfishes abundance, diversity, and other metrics are available. A marine environmental education programme is currently underway, but it is not specific to parrotfish, and this programme is evaluated annually. The DAFM enjoys outreach support from two NGOs – the Carmabi Foundation and the Waitt Institute.

Information verified by Faisal Dilrosun, DAFM.

Dominica

The information was provided by the Ministry of Blue and Green Economy, Agriculture and National Food Security.

Five species of parrotfishes are found in the catch record. These species are targeted and landed as bycatch. They are used for both personal and commercial consumption and include *Scarus guacamaia, Scarus coeruleus, Scarus coelestinus, Scarus taeniopterus, Sparisoma viride*, and *Sparisoma aurofrenatum*. Parrotfishes are caught primarily by fish traps – which are subject to gear restrictions as imposed by the revised fisheries regulations Statutory Rules and Orders of 2004 – but they are not a staple food source for Dominica as the fishery is mainly focused on pelagic fish. The Ministry indicated that not all fishers know how to identify the parrotfish species.

Landing data is available and classified to the species taxonomic level but the information has not yet been used for regional analysis. Fishery-independent surveys of parrotfish abundance were conducted in 2002 by the Institute for Tropical Marine Ecology and are available for review. AGGRA has data from 2005. When the gear restrictions were enacted, outreach was employed

to instruct fishers about the new regulations. This was successful as a one-to-one interaction, and a training programme for displaced fishers helped them gain access to the pelagic fishery. The Ministry has external assistance from governmental organizations and NGOs for outreach.

Information verified by Derrick Theophille, Ministry of Blue and Green Economy, Agriculture and National Food Security.

Dominican Republic

The information was provided by The Nature Conservancy's Dominican Republic programme and the *Red Arrecifal Dominicana*.

Although there was a harvesting ban on parrotfish from 2017 to 2019, there are several species that contribute to the fishery for personal and commercial consumption. The larger species are targeted and the smaller species are landed as bycatch. They include *Sparisoma viride, Sparisoma aurofrenatum, Sparisoma rubripinne, Scarus vetula, Scarus guacamaia, Scarus coelestinus* and *Scarus coeruleus*. Parrotfishes are harvested by traps, nets and spearguns. The NGOs stated that parrotfish are a staple food source for the island and fishers can identify them at a family taxonomic level.

Landing information is not recorded for parrotfishes but efforts are underway to improve data collection. The NGOs indicated that there are no fishery-independent surveys concerning parrotfishes abundance, diversity, etc., but groups such as AGRRA, ReefCheck, *Grupo Puntacana* and *Fundemar* have fish survey data that would include parrotfishes. The harvesting ban was enacted for 2017 to 2019 and renewed in September 2020 for an additional year. It was based on the precautionary principle rather than on scientific data. Fishers and the fishery management division were not involved in the decision-making process that resulted in the harvesting ban. There was no real outreach to promote the regulation and little coordination between the lawmakers and the enforcement. The Nature Conservancy conducted a study to evaluate the effectiveness of the harvesting ban.

Outreach does exist in general for marine conservation and specifically for parrotfish, including a festival and targeted messaging on social media and through direct interactions.

Information verified by Aldo Croquer, The Nature Conservancy, and Someria Zambrano, Red Arrecifal Dominicana.

Grenada

The information was provided by the Fisheries Division (FD) of the Ministry of Climate Resilience, the Environment, Forestry, Fisheries, Disaster Management & Information of Grenada.

The FD indicated that all parrotfish species are targeted and caught for both personal and commercial consumption. Landing data is recorded for parrotfishes and available at the species taxonomic level, however it was not provided for review. There are no fishery-independent surveys of parrotfishes abundance, diversity, etc. but AGRRA indicated that its database contains fish survey data that would include parrotfishes.

There are no fishing or conservation regulations specific to parrotfishes. District extension officers have begun an outreach programme to inform fishers and divers about the ecological importance of parrotfishes.

Information verified by Moran Mitchell, FD.

Guatemala

The information was provided by AIDA Americas.

Parrotfishes are no longer harvested and never did contribute greatly to the fishery on the Caribbean coast. Landing information from before the ban was enacted is not available. Healthy Reefs Initiative indicated that the harvesting ban was set to expire in 2020 and motivated for it to be extended. As of April 2020, the harvesting ban will continue into 2025. AIDA indicated that fishers can identify the parrotfish species. There are fishing and conservation regulations in place for parrotfishes and the decision-making process included fishers. AIDA indicated that fishers were very participative in the meetings and reached a consensus to ban the harvesting of parrotfish because of the ecological value they provide. Additionally, parrotfishes were never a staple food source for Guatemala and no fishers were displaced by the harvesting ban.

Fishery-independent monitoring has been conducted by the Healthy Reefs Initiative, which includes information about parrotfishes, and also by AGRRA which indicated its database has historic and current fish survey data that would include parrotfishes.

Specific parrotfish-based outreach has been conducted which includes poster presentations, a video, a fact sheet and face-to-face interactions with the community.

Information verified by María José González-Bernat, AIDA Americas.

Haiti

The information was provided by the Department of Fisheries and Aquaculture (DPAQ) of Haiti.

All species of parrotfishes are harvested in Haiti for personal and commercial consumption, primarily using spearguns (which are illegal) and traps. They are a staple food source for the island and the DPAQ indicated that fishers can identify the different parrotfish species. No landing information is recorded but the DPAQ indicated that parrotfishes are usually harvested from the coral reef habitat. There are no fishing or conservation regulations for parrotfishes and the DPAQ indicated that if such regulations were put in place, alternative livelihoods must be provided as they would severely affect fishers.

There are no fishery-independent surveys for parrotfishes, but the DPAQ indicated that a French institution (*Institute of Research for Developpement*) is conducting this work but it is not yet published.

There are no outreach programmes specifically focused on parrotfishes but the DPAQ indicated that workshops, or any outreach that allowed for face-to-face interaction, would be effective.

Information verified by Jean Wiener, Fondation pour la Protection de la Biodiversité Marine *and Moramade Blanc*, Aquaculture et Peche.

Honduras

The information was provided by the General Directorate of Fisheries and Aquaculture of Honduras.

A harvesting ban was enacted on parrotfishes (Decree No. 106–2015), but before the ban they were harvested only as bycatch and not recorded in landings. Prior to the harvesting ban, parrotfishes were not a staple food source. The ban was based on scientific data recorded by NGOs and fishers were involved in the decision-making process. Fishers comply with the

regulation and there is sufficient enforcement. Alternative livelihoods were provided to the fishers who were displaced, including involvement in tourism, which has been successful.

At the time of enacting the harvesting ban, outreach included workshops and environmental presentations. The Directorate mentioned that fishers actively take part in marine conservation because of the value that ocean tourism brings to their economy. AGRRA indicated they have over 10 years of fish survey data that would include parrotfishes.

Jamaica

The information was provided by the National Fisheries Authority of the Ministry of Industry, Commerce, Agriculture, and Fisheries of Jamaica and the Oracabessa Foundation.

Parrotfishes are targeted by nets, spearguns and fish traps and are also landed as bycatch in other fisheries. The following species are harvested for both personal and commercial consumption: S*carus vetula, Scarus coelestinus, Scarus taeniopterus, Scarus guacamaia, Sparisoma aurofrenatum, Sparisoma rubripinne, Sparisoma chrysopterum* and *Sparisoma viride*. Parrotfishes are a staple food source in Jamaica and fishers can identify the different parrotfish species.

Landing information is available for parrotfish, but not to the species taxonomic level and the information is not available for regional analysis. There are no specific fishery-independent surveys for parrotfish abundance, diversity, and other metrics, but the Oracabessa Foundation indicated that parrotfishes are generally the most abundant fish observed on their surveys and the foundation mentioned that consequently, they are also the most abundant fish landed.

There is no fishing regulation or conservation regulation for parrotfishes. The Oracabessa Foundation indicated that fishers have been against the recent promotion of a harvesting ban because this would severely and negatively impact their livelihoods. Furthermore, the Foundation indicated that a single-species approach to management would not be advantageous due to the non-selective gear used for fishing. Outreach would be most successful as one-to-one or group interactions, workshops, and specific training in other livelihoods.

Information verified by Inilek Wilmot, Oracabessa Foundation.

Martinique

The information was provided by the French Research Institute for Exploitation of the Sea (Ifremer), Delegation of Martinique.

Parrotfishes are targeted for personal and commercial consumption, specifically the six *Scarus* species and four *Sparisoma* species – *Sparisoma chrysopterum, Sparisoma viride, Sparisoma rubripinne* and *Sparisoma aurofrenatum*. Landing information is recorded each year but not to the species taxonomic level. Ifremer indicated that some Von Bertlanffy growth parameters have been calculated for some parrotfishes. Field studies on fish assemblages and communities (mangroves, seagrass beds and coral reefs) have been conducted which do contain information about parrotfishes.

There are fishing regulations (size limits and bag limits) for specific parrotfish species, specifically *Scarus coeruleus, Scarus guacamaia* and *Scarus coelestinus* which may not be harvested by recreational or commercial fishers in the four French territories (Martinique, Guadeloupe, Saint-Martin [French part] and Saint Barthélemy).

There is no current outreach specific to parrotfishes but Ifremer mentioned that it is establishing a new one-year monitoring programme in 2021 to collect biological data which will include parrotfishes. The organization is not aware of any NGOs working on the island in outreach or fishery-independent monitoring.

Regulations: Martinique and Guadeloupe

Information verified by Jérôme Baudrier, Ifremer.

Mexico

The information was provided specifically by Alfonso Aguilar of the *Universidad Autónoma de Yucatán*, Department of Marine Biology.

Dr Aguilar has observed that three species – *Scarus guacamaia, Scarus vetula* and *Sparisoma viride* – are harvested for personal consumption from the Alacranes reef in the southern Gulf of Mexico. This area does not report any landing data for parrotfishes.

There are fishery-independent studies of parrotfish abundance, diversity, habitat preferences, and other ecological values. In 2018, *Secretaría de Medio Ambiente y Recursos Naturales* (SEMARNAT) added ten parrotfishes (those featured in this report) to NOM-59 SEMARNAT 2010 which prohibits the harvest of these species.

Outreach consists of developing species identification guides.

Regulations: Species protection

Information verified by Alfonso Aguilar, Universidad Autónoma de Yucatán *Department of Marine Biology.*

Nicaragua

The information was provided by the Directorate of Fisheries Investigations of INPESCA in Nicaragua.

Four parrotfishes are harvested as bycatch in the lobster fishery – *Sparisoma chrysopterum, Scarus vetula, Scarus guacamaia* and *Scarus coeruleus*. Parrotfishes are not a staple food source in Nicaragua. Landing information is available but not classified to the species taxonomic level. There are no fishery-independent studies on parrotfishes abundance, diversity, etc. but AGRRA indicated that it has limited fish survey data that would include parrotfishes.

There are no fishing or conservation regulations regarding parrotfishes. There are no specific outreach campaigns for parrotfishes.

Panama

The information was provided by the Aquatic Resources Authority of Panama (ARAP).

Parrotfishes are not a staple food source for the Caribbean coast of Panama and are therefore infrequently landed or reported in the catch. Occasionally they are caught as bycatch but no species-specific information is available. However, the ARAP is aware that parrotfishes are infrequently landed based on seize reports and occasionally observing them in the fish market. There is a conservation regulation (Executive Decree No. 29 of June 29, 1994 of the Ministry of Commerce and Industries) that restricts the harvest and export of parrotfish (as a coral reef fish) yet some illegal catch is still reported, albeit infrequently and usually in small,

remote fishing towns that are difficult to access and enforce regulations. The ARAP expressed specific interest in working regionally on a plan to better conserve parrotfishes.

The ARAP indicated that there are no fishery-independent studies on parrotfishes, but it recognizes that the Smithsonian Institute is likely conducting this type of research and a literature search found historical research on parrotfishes harvesting on the Caribbean coast of Panama. Additionally, AGRRA indicated it has historic baseline fish survey data that would include information on parrotfishes.

There are no current outreach programmes but ARAP suggests including fishers in educational and research programmes so that they can learn first hand the value of the research and the importance of conservation.

Information verified by Yesuri Pino, ARAP.

Puerto Rico

The information was provided by the recreational sector of the Department of Natural and Environmental Resources (DNER) and obtained from summaries using data from the Puerto Rico Coral Reef Monitoring Program (PRCRMP).

Parrotfishes are harvested by recreational fishers who retain the catch for personal consumption. Five parrotfish species are retained: *Sparisoma rubripinne, Sparisoma viride, Scarus taeniopterus, Scarus vetula* and *Scarus iseri*. The recreational fishery does record landing data to the species level. The commercial sector of DNER did not respond to the survey and did not provide any information about the landing of parrotfishes in the commercial fishery.

Information on parrotfish biomass and abundance is available from the PRCRMP database and through the National Oceanic and Atmospheric Administration's (NOAA's) National Coral Reef Monitoring Program. There are regulations that prohibit the harvest of the big three within federal waters around Puerto Rico but there are no territorial fishing regulations specific to parrotfishes. Parrotfishes are not considered a staple food source for the island, except for some communities on the east coast, and most fishers can identify the different species of parrotfish.

The DNER does not have outreach programmes that focus specifically on parrotfishes, but several local NGOs raise awareness about general marine conservation, including parrotfishes.

Information verified by the DNER.

Saba (Bonaire, Sint Eustatius and Saba)

The information was provided by the Saba Bank Management Unit.

Parrotfishes are harvested as bycatch from lobster traps and are not a staple food source in Saba due to the availability of other more desirable options. The Unit indicated that fishers know the identities of the various parrotfish species. Landing information is collected by species but is not available for regional analysis, except by special request. Fishery-independent surveys of parrotfish abundance, diversity, habitat preferences, and other ecological value have been reported and would be available in the Dutch Caribbean Biodiversity Database.

There are no fishing or conservation regulations specific to parrotfishes. Outreach is limited in Saba but fishers do respond well to organized workshops and they tend to educate themselves from internet resources.

Information verified by Ayumi Kuramae Izioka, Saba Bank Management Unit.

Saint Croix (United States Virgin Islands)

The information was provided by a member of the CFMC.

The six *Scarus* species and four *Sparisoma* species (*Sparisoma rubripinne, Sparisoma viride, Sparisoma chrysopterum* and *Sparisoma aurofrenatum*) are targeted for personal and commercial consumption. Parrotfishes are considered a staple food source in Saint Croix since 1995. Various fishing regulations are in place, including a harvesting ban on the big three in the United States of America's federal waters. In territorial waters, a buy-back programme instituted the ban on the use of gillnets and trammel nets in 2008 and resulted in a reduced impact on parrotfishes. Fishers were involved in this gear ban and were supportive of fishery management plans that introduced the 2011 implementation of annual catch limits and size limits.

Landing information was not provided but details can be found in the United States of America, Federal section. Fishery-independent studies have been conducted and a literature search found several publications. Outreach is ongoing in Saint Croix by the CFMC as a "go-slow" approach to consuming parrotfishes.

Information verified by Carlos Farchette, CFMC.

Sint Eustatius (Bonaire, Sint Eustatius and Saba)

The information was provided by the Caribbean Netherlands Science Institute (CNSI) in Sint Eustatius through the Data Monitoring Officer Project funded by the Dutch Ministry of Agriculture, Nature and Food Quality.

Parrotfishes are not a staple food source for the island but the following species are harvested: *Scarus taeniopterus, Scarus vetula, Sparisoma viride, Sparisoma aurofrenatum, Sparisoma rubripinne* and *Sparisoma chrysopterum*. These species are targeted by small-scale artisanal fishers and spearfishing is the main gear of choice for targeted catches. However, occasional catch by fishpots (the island's most abundant gear type) far outweigh the catch of spearfishers. The fishery consists of < 10 active spearfishers each year. The CNSI indicated that fishers do not know the difference between the various parrotfishes.

Landings have been recorded from 2012 to present and include information about the catch, effort and length for most harvested species of parrotfishes. Some fishery-independent information is available on the abundance and diversity of parrotfishes. There are no regulations regarding parrotfish harvest, but a recent stakeholder meeting involved fishers to discuss a harvesting ban on the big three. Fishers are open to discussing regulations backed by scientific data, as long as it can be easily interpreted and applied. However, it was explicitly stated that enforcement would be challenging due to limited infrastructure to meet this need.

There is currently no outreach, except for a collaborating NGO – St Eustatius National Parks Foundation – but it is believed that the most effective form of outreach would be after-hours meetings and workshops because most fishers only fish part-time.

Information verified by Kimani Kitson-Walters, CNSI.

Saint Lucia

The information was provided by the Ministry of Agriculture, Fisheries, Physical Planning, Natural Resources and Co-operatives of Saint Lucia.

Due to the multi-species nature of the fishery, parrotfishes are harvested but are not directly targeted and do not constitute a staple source of fish protein. The following parrotfish species

are represented in catch data: *Scarus iseri, Scarus guacamaia, Scarus vetula, Scarus coeruleus, Scarus taeniopterus, Sparisoma chrysopterum, Sparisoma viride* and *Sparisoma aurofrenatum*. These parrotfishes are harvested for personal and commercial consumption, primarily using fish traps. The Ministry indicated that fishers can recognize parrotfishes on the family taxonomic level but not necessarily at the species taxonomic level.

Landing information is available and recorded to the species taxonomic level. Fishery-independent surveys on parrotfishes are not available but the Ministry expressed interest in receiving training to be able to conduct this type of monitoring. AGRRA indicated that fish surveys have been conducted in Saint Lucia and would include information on parrotfishes.

There is no specific outreach regarding parrotfishes. Should a management plan be developed to conserve and manage parrotfishes, it would need to consider the non-selective gear used in Saint Lucia, provide fishers with alternative livelihoods, and consider the increased need for enforcement which the Ministry stated it does not have the capacity to conduct. The Ministry also indicated that fishing effort has grown as people search for economic stability in the face of COVID-19 job losses.

Information verified by Makeba Felix, Ministry of Agriculture, Fisheries, Physical Planning, Natural Resources and Co-operatives.

Saint-Martin (French part)

The information was provided by the manager of the National Nature Reserve of Saint-Martin (AGRNSM).

All species of parrotfishes are targeted for personal and commercial consumption using fish traps and spearguns. Parrotfishes are a staple food source for the island and the AGRNSM indicated that fishers do know the difference between the various parrotfishes. Limited landing information is available but the AGRNSM is aware of harvested parrotfishes primarily from observing them in fish markets and encountering illegal fishing. There are fishing regulations for commercial fishers that indicate minimum size, gears, techniques, areas available to fish, and rights to sell the catch. There is a new fishing regulation for recreational fishers (2020) that includes similar details, including specific species available to recreational fishers (but selling catch is illegal). There is a no-take marine protected area that protects parrotfishes and other fish species but the AGRNSM indicated that there is little enforcement (six rangers over 3 100 ha) and little compliance. Another source indicated that only the big three were prohibited catch in Saint-Martin. Regulations were based on regional scientific reports and data from IUCN, not necessarily local data. The fisher council is involved in the decision-making process.

Some fishery-independent monitoring began in 2009 and occurs annually, studying fish communities including parrotfishes. There is ongoing outreach in general marine conservation topics that includes 17 schools, 47 classes, and 148 presentations just for 2020 alone. The AGRNSM indicated that outreach is most effective when it starts with the children and parents.

Regulations: (1) Recreational, (2) Commercial, (3) Marine protected areas

Information verified by Julien Chalifour, National Nature Reserve of Saint Martin.

Saint Thomas and Saint John (United States Virgin Islands)

The information was provided by the University of the Virgin Islands (UVI) and the Department of Planning and Natural Resources (DPNR) with additional insight from independent scientists.

The following parrotfishes are targeted and also caught as bycatch, for both personal and commercial consumption: *Sparisoma viride, Sparisoma chrysopterum, Scarus vetula* and *Scarus iseri*. The following species are strictly landed as bycatch: *Sparisoma* aurofrenatum, *Sparisoma* rubripinne and *Scarus taeniopterus*. Landing information is available to the species taxonomic level and is provided upon request. The DPNR indicated that there are fishing and conservation regulations associated with parrotfishes. The UVI indicated that there are fishery-independent surveys of parrotfishes abundance, diversity, reproduction and habitat use and a literature search identified several publications.

The DPNR indicated that there are no outreach programmes for parrotfishes, but the UVI said that a children's colouring book exists from the Virgin Islands Marine Advisory Service that is available for outreach purposes.

Information verified by UVI and the DPNR.

Saint Vincent and the Grenadines

The information was provided by the Fisheries Division of the Ministry of Agriculture, Forestry, Fisheries, Rural Transformation, Industry and Labour of Saint Vincent and the Grenadines.

Parrotfishes are no longer harvested in the islands, but based on some landing data the following species were previously caught using spearguns and fish traps: *Scarus vetula, Scarus taeniopterus, Scarus iseri, Sparisoma aurofrenatum* and *Sparisoma viride*. Parrotfishes were not a staple food source for the majority of the islands, but some specific areas did depend on them. The conservation regulation of December 2019 prohibited the catch of parrotfishes and the Ministry does not have a record of any illegal catch thereafter. It indicated that fishers can confidently identify the different species of parrotfishes.

Fishers and scientific data were not considered in the decision-making process that resulted in the ban; it was based on the precautionary principle. The Ministry indicated that there are some fishery-independent surveys of parrotfishes abundance and habitat preferences, as evidenced by the AGRRA database. Outreach exists in the form of posters and current programmes are geared towards promoting the harvesting ban and educating about the importance of parrotfishes in the ecosystem. The Ministry feels that one-on-one interactions, flyers and brochures have been the most effective means of outreach.

Turks and Caicos Islands

Information was provided by the Department of Environment and Coastal Resources.

Parrotfish harvesting was banned in 2011. There are no landing data for parrotfishes and no fishery-independent information is available, but a literature search revealed several parrotfish studies conducted in the islands and AGRRA indicated the availability of fish survey data from 1997 which would include some information about parrotfishes.

Parrotfish was not considered a staple food source before the harvesting ban and there was no commercialization of parrotfishes. Although fishers were not considered in the regulatory decision-making process, there was little disagreement on the regulation at stakeholder meetings. Fishers can identify the species of parrotfishes. There are no outreach programmes specific to parrotfishes.

Regulation: Fishing regulation

Information verified by the Department of Environment and Coastal Resources.

United States of America (Federal EEZ)

The information was obtained from the CFMC's Comprehensive Fishery Management Plans for the Puerto Rico, Saint Thomas and Saint John, and Saint Croix (United States Virgin Islands) EEZ island-based fishery management plans with regard to the federal waters of Puerto Rico (9 nm to 200 nm) and the US Virgin Islands (3 nm to 200 nm), with some additional insight for each territory.

The following species are targeted for commercial and personal consumption: all six *Scarus* species and *Sparisoma viride, Sparisoma aurofrenatum, Sparisoma chrysopterum* and *Sparisoma rubripinne*. The big three are prohibited from harvesting within each of the Puerto Rico, Saint Thomas/Saint John and Saint Croix EEZs and there are gear restrictions and bag limits for the other species in all three islands/islands groups, as well as size limits for the harvest of species in the Saint Croix EEZ.

Parrotfishes are not considered a staple food source in Puerto Rico or Saint Thomas/Saint John, but they are in demand in Saint Croix. The island-based fishery management plans provide details specific to each territory. There are landings information for each island/island group, as well as fishery-independent surveys of parrotfishes abundance, diversity, reproduction, habitat preferences and ecological roles available in the NOAA Coral Reef Information System database.

Outreach is performed primarily by the CFMC but NOAA also supplies outreach materials.

Regulations: CFR 50 CFR Part 22 (annual catch limits, bag limits, prohibited gears – SubPart A General Provisions; additional information specific to parrotfish Subpart S); island based fishery management plans.

Information verified from the Island-based Fishery Management Plans.

United States of America, Florida

The information was provided by the Florida Fish and Wildlife Conservation Commission (FWC).

In Florida, parrotfishes are harvested mainly by the commercial marine life trade (i.e. the aquarium trade) and incidentally caught as bycatch by hook-and-line fishers for personal consumption. The following species have historically been targeted by the marine life trade and/or landed as bycatch for personal consumption: *Scarus guacamaia, Scarus coelestinus, Scarus coeruleus, Scarus iseri, Scarus vetula, Scarus taeniopterus, Sparisoma viride* and *Sparisoma aurofrenatum*. Fishing regulations for parrotfishes require specific permits for recreational and commercial harvest, and Florida state regulations extend into federal waters. Although rare or uncommon, illegal parrotfish harvest has been documented.

Landing information is available and recorded at the species taxonomic level. Fishery-independent surveys of parrotfishes are also available with a review soon to be published.

Outreach is specific to law enforcement and permit holders to educate about parrotfishes and the regulations.

Regulations: (1) Florida Administrative Code, (2) Recreational sector, (3) Commercial sector

Information verified by Christopher Sweetman, Florida Fish and Wildlife Conservation Commission.

Venezuela

The information was provided by the Fisheries Management division of *El Instituto Socialista de la Pesca y Acuicultura* (INSOPESCA) in Venezuela. Parrotfishes – *Scarus guacamaia, Scarus vetula*, and *Sparisoma viride* – are harvested for personal and commercial consumption, targeted and caught as bycatch in lobster traps and fish traps. There is a fishing regulation that prohibits harvesting parrotfishes using spearguns, but compliance with this regulation has been strained due to economic distress and increased demand for parrotfishes.

There is no landing information, but the INSOPESCA is aware of specific areas in Venezuela where the majority of parrotfish harvesting occurs. They also indicated that parrotfishes are commonly – albeit illegally – exported to Aruba, Bonaire (Bonaire, Sint Eustatius and Saba), Curacao, Martinique, Grenada, Saint Vincent and Trinidad (Trinidad and Tobago). Fishery-independent surveys of parrotfishes are available. Outreach specific to parrotfishes is underway, targeted at students and culinary institutes. Additional outreach is in development to educate fishing communities and divers about the ecological importance of parrotfishes.

Information verified by Freddy Bustillos, INSOPESCA.

PLATE 7
Coastal Caribbean homes

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