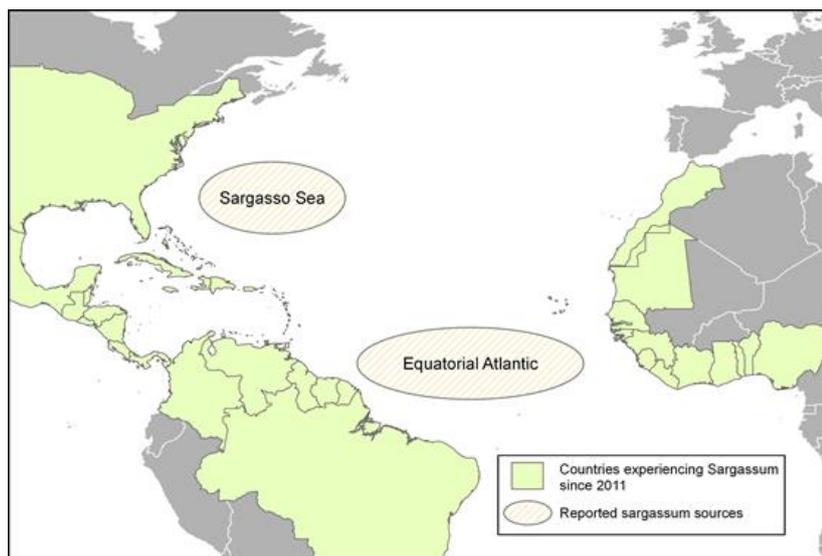




Management of *Sargassum* influxes in the Caribbean: national and regional governance of a transboundary marine species



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The views expressed in this work are those of the creators and do not represent those of ESRC and GCRF or its Boards of Governors. SARTRAC focuses on three case study countries in the Caribbean and West Africa: (i) Jamaica, (ii) Ghana (iii) St Lucia, working with various project teams from each country that are part of the consortium. Hence, the Working Paper has greatly benefited from a

number of discussions with and feedbacks from various members of the country teams during different consortium meetings and communications.

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1. Introduction

Since 2011, nations in the Caribbean and west Africa have experienced large influxes of the seaweed *Sargassum* arriving on the nearshore and coasts. These influx events often coincide with summer months, and affect fisheries, turtle nesting and beach activities including tourism. While *Sargassum* has been prevalent in these regions prior to 2011, as a response to the sudden and large increase in quantities experienced there has been a plethora of management approaches, conducted privately and by government bodies, and of regional conferences to address the “urgent threat” (‘Regional Agreement on *Sargassum* 2019’ 2019). Climate change is creating environmental phenomena that are not recognisable in the context of the past, of which *Sargassum* is one possible case (Wang et al. 2019; Johns et al. 2020). This article explores the response to *Sargassum* since 2011 as a case study of how states and regional institutions may need to develop dynamic interpretations of policy problems as to effectively adapt to a rapidly changing environment.

Sargassum is a genus to which over 300 distinct species have been identified. Of those, *Sargassum muticum* is considered to be one of the most invasive (Hardouin et al. 2014), especially affecting European coastlines (Milledge and Harvey 2016). However, in policy discourse on *Sargassum* in the Caribbean and west Africa the concern is generally focussed on two pelagic (open sea) species: *S. fluitans* and *S. natans*, and even then, of specific forms of those species (Milledge and Harvey 2016). Prior to 2011, the small body of work on pelagic *Sargassum* species in the Atlantic sought to survey and document prevalence in the oceans, with the work of Stoner (1983) comparing 1977-1981 surveys of *Sargassum* biomass to the cruises conducted in 1933-1935 (Parr 1939), for example. The changes observed in abundance and landing of *Sargassum* in recent years have been suggested to be caused by a variety of factors, including nutrient discharge, and changes in ocean upwelling, surface temperatures, and patterns (Sissini et al. 2017; Oviatt et al. 2019; Wang et al. 2019; Johns et al. 2020). While peer-reviewed literature remains sparse, the impacts of influx events on

communities and industries in most years since 2011 has been reported across Caribbean islands in the news, and captured in national reports and reports such as that by Ramlogan, McConney and Oxenford (2017) for impacts on the fisheries sector in Barbados.

Regional and national *Sargassum* policy briefs and reports emphasise the need for further investment for research and its priority in to research (Caribbean Sea Commission 2015; Cox, Oxenford, and McConney 2019; Resilify Inc 2019; SPAW Sub-Programme at the UNEnvironmentCEP Secretaria 2018). While there has been progress in attempts to monitor *Sargassum* using satellite data and model the possible origins of the recent influxes (Putman et al. 2018; Wang et al. 2019; Gower and King 2020; Johns et al. 2020), there remains a significant dearth of research into the social and governance aspects of this environmental phenomenon.

Immediate responses to the inundations of *Sargassum* on Caribbean beaches in 2011 were generally of two schools: either the *Sargassum* was left to nature, or it was remove in some capacity from the beach. In the ensuing years, many individuals, organisations and states have developed more thought through responses and preparedness measures for possible stranding events. The Cayman Islands Department of Environment, for example, specifically prefers leaving *Sargassum* on the beach where possible, raking at low tide if desired, and for any form of mechanised clean-up a consultation with the Department is required (Department of Environment 2015). Other states have developed longer-term strategies, with Dominica's plan outlining both contemporary ("this year") and long-term (1-5 years) intentions (Resilify Inc 2019). In hand with the irregular but frequent occurrence of *Sargassum* strandings, Caribbean individuals and entities have also developed a range of strategic plans to prepare for and response to these seaweed events.

Despite a significant increase in research and management strategies on *Sargassum* in the Caribbean and other areas in recent years, there has been no analysis of the articulation of the policy “problem” that *Sargassum* poses. This article explores how *Sargassum* policies have shifted from the focus of conservation efforts in the Sargasso Sea, to the subject of resource and hazard management strategies in the Caribbean. **We aim to identify existing regional and national frameworks for the management of this *Sargassum* seaweed, thereby creating a synthesis of best practice and challenges in this management area.** We achieve this through an analysis of the formal and informal literature on contemporary management of *Sargassum* at the national and regional scale in the Caribbean.

2. Methods

Regional ocean governance in the Caribbean dominated the development of early policy and management briefs regarding the *Sargassum* influxes. However, from 2015 onward, there have been an increasing number of national-scale strategic documents also. For the purposes of this study, we ran specific online searches for national management policies for all Wider Caribbean Region territories and states, as well as more general searches across regional organisations for non-state based management policies. Management briefs identified within reports and strategies were also pursued. Table 1 outlines the absence the presence and management briefs identified to be easily or publicly accessible in the Caribbean, the contents of which is further discussed in the succeeding section.

Table 1. Absence and presence of formal management briefs for Sargassum influxes in the Caribbean.

Country	Impact levels*	Document type	Report title (publication year)	Publication year
Anguilla (UK)	VH	None found	N/A	N/A
Antigua and Barbuda	VH	Invite for tender	Request for Expression of Interest For the Supply of Equipment and Machinery for Aquatic Sargassum seaweed removal in Antigua and Barbuda	2018

Country	Impact levels*	Document type	Report title (publication year)	Publication year
Aruba (NL)	M	Management brief (NL)	Prevention and clean-up of Sargassum in the Dutch Caribbean	2019
Bahamas	L	None found	N/A	N/A
Barbados	VH	Section in report to CBD	Barbados' Fifth National Report to the Convention on Biological Diversity	2016
Belize	VH	None found	N/A	N/A
Bermuda (UK)	NA	None found	N/A	N/A
Bonaire (NL)	H	Management brief (NL)	Prevention and clean-up of Sargassum in the Dutch Caribbean, and Sargassum Bonaire (presentation)	2018
British Virgin Islands	VH	Statements to parliament	Statement by Deputy Premier and Minister for Natural Resources and Labour Dr. The Honourable Kedrick D Pickering "Sargassum Seaweed Phenomenon"	2015
Cayman Islands (UK)	H	Removal guidelines	Guidelines on Removing Sargassum from Beaches	2015
Curaçao (NL)	H	Management brief (NL)	Prevention and clean-up of Sargassum in the Dutch Caribbean	2019
Dominica	H	Strategic preparedness plan	Strategic Sargassum Preparedness Plan	2019
Dominican Republic	VH	None found	N/A	N/A
Grenada	M	Model protocol	Protocol for the management of the extreme accumulations of Sargassum on the coast of Grenada	2017
Guadeloupe (Fr)	VH	Report and recommendations (FRA)	Le phénomène d'échouage des sargasses dans les Antilles et en Guyane	2016
Guyana	L	None found	N/A (supposed to be modifying CRFM protocol)	N/A
Guyane (French Guiana)	NA	Report and recommendations (FRA)	Le phénomène d'échouage des sargasses dans les Antilles et en Guyane	2016
Haiti	L	None found	N/A (Coastal Sanitation Protection of the Great South Coast)	N/A
Jamaica	VH	Strategic preparedness plan	National Response Strategy: The Sargassum Threat	2015
Martinique (Fr)	H	Report and recommendations (FRA)	Le phénomène d'échouage des sargasses dans les Antilles et en Guyane	2016
Montserrat (UK)	H	None found	N/A	N/A
Puerto Rico	H	None found	N/A (Protocol for the management of extreme accumulation of Sargassum on the coasts of Puerto Rico)	N/A
Saba (NL)	H	Management brief (NL)	Prevention and clean-up of Sargassum in the Dutch Caribbean	2019
St Eustatius (NL)	H	Management brief (NL)	Prevention and clean-up of Sargassum in the Dutch Caribbean	2019
St Kitts and Nevis	VH	Management brief	Plan for the Management of the Accumulations of Sargassum on the Coastal and Marine Ecosystem	2017
St Lucia	VH	Management brief	Saint Lucia National Strategy for the Management of Sargassum Infuxes on Beaches, Bays and Small Harbours	2017
St Maarten (NL)	VH	Management brief (NL)	Prevention and clean-up of Sargassum in the Dutch Caribbean	2019

Country	Impact levels*	Document type	Report title (publication year)	Publication year
St Martin (Fr)	NA	Green Brigade and government statements	N/A	N/A
St Vincent and the Grenadines	VH	Management brief	The Management of Extreme Accumulations of Sargassum on the Coasts of St. Vincent and the Grenadines	2018
Suriname	VH	None found	N/A	N/A
Trinidad and Tobago	H	Management brief	National Sargassum Response Plan	2016
Turks and Caicos	VH	None found	N/A	N/A
US Virgin Islands	H	None found	N/A	N/A
* According to UNEP white paper (SPAW Sub-Programme at the UNEnvironmentCEP Secretaria 2018): VH Very High; H High; M Medium; L Low; NA not included in UNEP paper				

Note: All reports found through online search, except: (i) Jamaica (2015) which was received directly from NEPA, Jamaica, and (ii) Barbados, Grenada, St Kitts and Nevis, St Lucia, St Vincent and the Grenadines, Trinidad and Tobago which were all received from Dr Shelly-Ann Cox in CERMES, Barbados.

3. Problem framing of *Sargassum* in national policies and strategies

3.1 Management strategies unpacked

Most countries and territories in the Caribbean have some form of *Sargassum* management strategy in place, although few have a publicly available policy institutionalised by national government.

Some of these strategies have been developed and released by sovereign European states to encompass their Caribbean constituent countries. The Dutch Caribbean Nature Alliance released its prevention and clean-up strategy in 2019, which includes an overview of the impacts in the Dutch Caribbean (Aruba, Bonaire, Curaçao, Saba, St. Eustatius, and St. Maarten) as well as generic management advice based off the Hinds et al. (2016) brief. Ministries of the French Republic released an initial research report and management brief in 2016 (Ministère des Outre-Mer, Ministère de l'Environnement, de l'Énergie et de la Mer, and Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt 2016), and the Agence de l'Environnement et de la Maîtrise de l'Énergie (ADEME) released an analysis of the ongoing collection operations in the West Indies in 2019 (Agence de l'Environnement et de la Maîtrise de l'Énergie (ADEME) 2019). A number of independent states have released reports and draft-reports with a similar *Sargassum* management

focus, including Dominica, Jamaica, St Lucia, St Vincent and the Grenadines, St Kitts and Nevis, and Trinidad and Tobago.

There is a marked difference in the presence and detail of the analysed strategies. Whilst the impacts of *Sargassum* influxes have been acknowledged in media social media in virtually all Caribbean countries since 2011, we were unable to identify public facing or easily accessible policy briefs for all studied states. For example, while both France and the Netherlands have released some form of report for their Caribbean constituent countries and authorities, no similar document has been produced by the United Kingdom. Furthermore, while most states have supported the management of the influxes through some form of policy or resource support, this is not necessarily underpinned by a national strategic document. The Cayman Islands has removal guidelines based off the GCFI fact sheet (Doyle and Franks 2015), and various statements have been made to Parliament in the British Virgin Islands, but for neither could an overarching management brief be identified. Even of those states for which more formalised national policy briefs were found, the contents and level of detail ranged from in-depth, country- and site-specific analysis and recommendations (Ministère des Outre-Mer, Ministère de l'Environnement, de l'Énergie et de la Mer, and Ministère de l'Agriculture, de L'Agroalimentaire et de le Forêt 2016; Resilify Inc 2019), to the development and use of model protocols – model protocols which include Puerto Rico and Grenada's management briefs, as CRFM and CERMES briefs (Caribbean Regional Fisheries Mechanism 2016; Hinds et al. 2016; Ince 2017). Some viewed protocols remain in draft status (Institute of Marine Affairs 2016; Ince 2017; Billiny 2018), and it is unclear how many have been officially adopted by government departments or agencies.

There is a lack of knowledge on *Sargassum* influxes to support management decisions and strategy development. The majority of more formal policy briefs highlight the specific location of problematic *Sargassum*, that is, on beaches and near the shoreline, and hypothesise at the origins of the influxes experienced since 2011. Of those policies hypothesising the causes of the influxes, many rely on the Hinds et al. (2016) report (Dutch Caribbean Nature Alliance 2019; Resilify Inc 2019), point out the multiple contemporary theories regarding the origins of *Sargassum* influxes (National Environment and Planning Agency (NEPA) 2015; Institute of Marine Affairs 2016; Ince 2017), and highlight the need for further research to better understand the effect of currents and other environmental parameters on the transport of *Sargassum* (Institute of Marine Affairs 2016; Sealys and Felix 2017; Williams 2017; Dutch Caribbean Nature Alliance 2019; Resilify Inc 2019).

Despite an increasing number of Caribbean countries hosting or having access to a formal policy brief to support management of *Sargassum* influxes, there are equally a number without a publicly accessible overarching strategy, and across strategies the lack of evidence to support decision-making is lamented.

3.2 Geopolitics of management strategies

Over twenty countries were identified to have developed some form of *Sargassum* management strategy at the state level, and the majority of these are either based on a template from another country or institution, or the product of overseas national governments. This section briefly summarises the political and social characteristics underlying the policies discussed above, including language, sovereignty, population size, development, and regional organisational membership.

The majority of identified briefs are written in English for countries for which English is at least one of the nationally recognised languages. The only exceptions were the French Republic research reports (Ministère des Outre-Mer, Ministère de l'Environnement, de l'Énergie et de la Mer, and Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt 2016; Agence de l'Environnement et de la Maîtrise de l'Énergie (ADEME) 2019). Both French and Dutch reports have been released on the state of *Sargassum* in the Caribbean, but there is no comparable United Kingdom document. Countries with both very large populations in the region and those with smaller populations do not have a *Sargassum* policy; for example, no briefs were identified for Suriname (population over 500,000) but also not for Anguilla (population of around fifteen thousand) nor Turks and Caicos (population of around forty thousand). All ODA receiving countries, other than Suriname and Montserrat, have some form of *Sargassum* plan – although multiple were not easily accessible (e.g. no formal policy found for Haiti and the Dominican Republic). Despite the CRFM releasing a framework protocol for member states, Barbados, Suriname, Montserrat, Anguilla, the Bahamas and Turks and Caicos (CRFM members) were all found to be lacking a *Sargassum* management strategy. Of these, Barbados, Suriname, Anguilla and Turks and Caicos were identified in the UNEP white paper on *Sargassum* as experiencing very high impacts (2018).

3.3 Problem framing

Strategies on managing the *Sargassum* influxes lament the dearth of evidence on which to base their strategic decision-making. Regional collaboration and investment in research is highlighted as a priority by Martinique, St Maarten, and Trinidad and Tobago, and developing and improving the monitoring of *Sargassum* at sea is identified in almost all national policies. This absence of knowledge is often acknowledged regarding adaptation, but is equally frequently raised in strategies as a limitation in understanding the nature of the *Sargassum* influxes.

Table 2. Problem framing of Sargassum near and onshore

Country	Problem framing <i>Benefit framing</i>	Problem location	Problem regularity	Problem causes
Antigua and Barbuda	Hazard to economy, health and tourism	Beaches and coastline	Recurring (not specific how frequent)	N/A
Aruba (NL)	Biodiversity, economic and social hazard <i>Possible opportunity as a resource</i>	Beaches	Recurring (multiple years)	Anthropogenic (climate change, nutrients)
Bonaire (NL)	Biodiversity impacts (fish and seagrass die-offs, damage to mangroves), economy, health and tourism threat	Coastline (Sand/rubble beaches, mangrove lagoons)	Regular (almost annual)	Anthropogenic (climate change, nutrients)
Cayman Islands (UK)	Not specifically framed as a problem	Beaches	Unclear if regular annual event	Ocean currents from Atlantic
Curaçao (NL)	Aesthetics (smell), biodiversity (problem for turtles), social and economic problem when in excessive amounts	Shoreline, in water	Recurring (multiple years)	Anthropogenic (climate change, nutrients)
Dominica	Hazard needing management <i>Resource to exploit</i>	Beaches and shorelines	Recurring (but not as consistent or great in quantity as other islands)	Anthropogenic (warming ocean temperatures, increased quantities of nitrogen and phosphorus)
Grenada	Framed as a climate change impacts issue, affecting: biodiversity, fisheries, property damage, residents and tourism <i>Dune and beach stabilisation</i>	Beaches, coasts, in water	<i>Not stated</i>	Anthropogenic (warming ocean temperatures, increased nutrients)
Guadeloupe (Fr)	Health, tourism (reduction in revenue), property damage	Shore, bay, ports	Recurring (multiple years, irregular)	Wind and surface currents, nutrients (from rivers or Sahara)
Guyane (Fr)	Health, tourism (reduction in revenue), property damage	Shore, bay, ports	Recurring (multiple years, irregular)	Wind and surface currents, nutrients (from rivers or Sahara)
Jamaica	Aesthetics, biodiversity (reefs, benthic mangroves and seagrasses), fisherfolk livelihoods (equipment, access to resources, launch sites), health, infrastructure (power plant cooling water intakes), local community access to shorelines, tourism <i>Beach nourishment</i>	Shore, beaches and bays	Recurring (multiple years, irregular)	High ocean temperatures, nutrients, ocean currents
Martinique (Fr)	Aesthetic (smell), biodiversity (destruction and disturbance of ecosystems), health (toxicity), economic (penalizing tourism, fishing activities and aquaculture) <i>Less/no problems at sea</i>	Shore, bay, ports	Recurring (multiple years, irregular)	Wind and surface currents, nutrients (from rivers or Sahara)
Saba (NL)	Limited impact	<i>Not stated</i>	<i>Not stated</i>	Anthropogenic (climate change, nutrient load)
St Eustatius (NL)	Biodiversity impacts (turtle nesting) <i>Positive biodiversity impacts</i>	Beaches	One-off (2015)	Anthropogenic (climate change, nutrient load)
St Kitts and Nevis	Framed as a climate change issues, with impacts: economic, disease, impeding	Beaches, bays	Recurring (unpredictable)	Sargasso Sea, Atlantic Ocean

Country	Problem framing <i>Benefit framing</i>	Problem location	Problem regularity	Problem causes
	development of sea moss industry, and tourism			
St Lucia	Boating, changes fish catch species, affects fishing, property damage, swimming, tourism	Beaches, coasts, in water	Regular (almost annual)	Ocean temperatures
St Maarten (NL)	Biodiversity (sea turtles), aesthetics, health impacts, fish die-off in a pond, concerns for swimmers' safety	Wetlands, in water	Recurring (multiple years)	Anthropogenic (climate change, nutrient load)
St Martin (France)	Aesthetics (smell), economic (costs to businesses including hotels and restaurants), health complains, tourism	Beaches	Recurring (multiple years)	Wind and surface currents, nutrients (from rivers or Sahara)
St Vincent and the Grenadines	Biodiversity (concerns for nesting turtles), fishing industry (hindrance to equipment they use), property damage, tourism (prevents beach use, yacht deterrent, smells/sickness),	Beaches (mostly east beaches), coasts, in water	Recurring (not specific how frequent)	Fukushima and Japan tsunami, high water temperatures and nutrient load
Trinidad and Tobago	Beach use, biodiversity (sea floor and marine habitats, turtles, dead fish), fishing industry (hindrance to launching boats and accessing resources), health (toxicity)	Beaches, coasts, in water	Recurring (not specific how frequent)	Ocean temperatures, ocean circulation, nutrient load (from land based sources)
Countries with a policy, but that have not been viewed by the research team: Belize, Dominican Republic, Haiti, Puerto Rico, and US Virgin Islands Countries not known to have policies: Anguilla, Bahamas, Barbados, Bermuda, British Virgin Islands, Guyana, Montserrat (UK), Suriname, and Turks and Caicos				

Strategies almost without exception establish the offshore ecosystem significance of *Sargassum*.

Sargassum has a keystone role in the Sargasso Sea as the holopelagic foundation for the ecosystem, providing habitat for endemic, young and other species, including invertebrates, fish and turtles (Wells and Rooker 2004; Witherington, Hiram, and Hardy 2012; Inter-American Convention for the Protection and Conservation of Sea turtles (IAC) and Sargasso Sea Alliance (SSA) 2014). Nevertheless, even in the Sargasso Sea the history, origins, life cycle and geography of *Sargassum* remain poorly understood (Ardron et al. 2011). Whilst its offshore, distant life cycle is acknowledged to be of ecological importance and is even subject to harvesting restrictions, for example through the Fishery Management Plan for Pelagic *Sargassum* Habitat of the South Atlantic Region (South Atlantic Fishery Management Council 2002). Bermuda largely frames *Sargassum* as a positive arrival to its shores, providing forage matter and habitat for fauna, critical services for dune formation and stabilisation, and supporting traditional uses of it as a fertiliser (Department of Environmental and Natural

Resources n.d.). However, generally *Sargassum* is framed as more problematic when experienced closer to the shoreline, especially in large quantities.

Beaches and the shoreline are the most frequently identified location of problematic *Sargassum*.

While in Aruba, St Eustatius and the Cayman Islands, beaches are identified as the exclusive physical area of *Sargassum* impact, other strategies identify at least one other location, including bays, wetlands, and near-shore in water. The direct impacts of *Sargassum* are also located further inland from the shore, as a result of the smell of the rotting algae onshore. Offshore, negative impacts are described to affect swimmers and recreational users of bays, as well as fisherfolk in terms of fish catch species, and use of equipment including boating and fishing tackle.

Impacts described as problematic include health, economic, social, biodiversity and ecological, tourism, property damage, fishing and aquaculture, beach access, swimming, boating toxicity, and olfactory effects of *Sargassum* on the nearshore and offshore. Of these, negative impacts on tourism, biodiversity, health and fisheries are most commonly listed. For example, in Bonaire the main impacts of *Sargassum* have been experienced dominantly on beaches falling under Stinapa National Park management, and not in more popular tourist areas; thus some of the main immediate threats are biodiversity related. Whilst some positive impacts are recorded, including for biodiversity, hazards, and opportunities as a resource, these are generally less frequently raised in strategies than other negative impacts including social, aesthetics, property damage and economic factors. In Bermuda, for example, harvesting of *Sargassum* from the beaches is highlighted as a traditional use of the biological material, and in the British Virgin Islands the statement to parliament examined here identifies the role of *Sargassum* in beach accretion of biodiversity; nevertheless, in the British Virgin Islands, a series of management actions are suggested to reduce negative impacts of the influxes.

Regularity of the *Sargassum* influxes differs by Caribbean region, country and within-country, but an underlying commonality is the unpredictability of events – both by year, and within *Sargassum* seasons by timing of influxes. The UNEP SPAW White Paper on the *Sargassum* Outbreak in the Caribbean (2018) drew on a regional survey (sent to the UN Environment CEP National Focal Points of the Wider Caribbean Region) to inform an assessment of the severity of the influx by country; of the Caribbean islands the majority were identified to be experience high or very high severity. Of the islands, only Cuba, the Bahamas, Aruba and Haiti were experiencing medium or low severity influxes. There is no consistent method by which events are recorded reported in any of the strategies, and thus not only do the strategies describe the irregularity and unpredictability of severe years and severe stranding events, but the record of past events and their severity is poor.

As was highlighted above, scientific uncertainty underpins most of the conclusions drawn about *Sargassum*. Regarding the proposed causes of the influxes, the uncertainty is equally significant. The St Vincent and the Grenadines management plan describes a local perception that *Sargassum* was first experienced after the tsunami and Fukushima nuclear disaster in 2011. Most strategies, however, list anthropogenic causes underlying the influxes now experienced in the Caribbean, specifically, climate change driven changing ocean temperatures and currents, and increased nutrient loads. The nature of the changed currents and the causes of the increased nutrient loads are, again, uncertain. For example, proposed origins of the nutrient loads include Saharan dust as well as river estuaries. Strategies generally no longer describe the Sargasso Sea as being the origins of the *Sargassum* influxes.

4. Management options

This section examines the adaptation options proposed by the existing management strategies.

Clean-up of *Sargassum* onshore is the most frequently proposed approach, mentioned in all

strategies excepting the draft protocol for Grenada. The adaptations are summarised in Table 3, and are discussed below.

Table 3. Management actions identified in existing strategies and protocols

Country	Goal of policy document	Recommended adaptations	Adaptation responsibility (stakeholders)
Antigua and Barbuda	To develop a sustainable approach to <i>Sargassum</i> seaweed management and seek viable alternatives for the use of <i>Sargassum</i> in Antigua and Barbuda.	Clean-up (removal of <i>Sargassum</i> at sea; reduction of <i>Sargassum</i> arriving on the beach), reuse (economic and beneficial uses for <i>Sargassum</i>)	Department of the Environment Ministry of Health, Wellness and the Environment Contractors
Cayman Islands (UK)	<i>No explicit aim</i> Guide to good practice on removal of <i>Sargassum</i> from beaches	Clean-up (by rake at low-tide; for mechanised clean-up consultation with DOE is required), do nothing (preferred option), reuse (as fertiliser is possible)	<i>Not explicitly listed</i> Department of Environment
Dominica	To address the negative impacts of the <i>Sargassum</i> influx while taking advantage of the various positive opportunities it presents	Clean-up (rake and bury), governance (action committee, five-year review), partnership, public engagement (beach signage), research (data collection), reuse (fertilizer or export)	Fisheries Division Ministry of Tourism Ministry of Planning and Economic Development UEWI Ministry of Agriculture Ministry of Environment, Climate Resilience, Disaster Management and Urban Renewal Tourism (private) Karlino Territory Agriculture (private)
Dutch Caribbean (Aruba, Bonaire, Curaçao, Saba, St Eustatius, St Maarten)	<i>No explicit aim</i> Highlight the urgency of the <i>Sargassum</i> problem, assist stakeholders, present range of solutions, short and long-term mitigation strategies, promote stakeholder engagement.	Clean-up (best practice, disposal, onshore, near-shore, at sea not recommended, manual and mechanised), early warning system (regional systems), forecasting, governance (national coordinating body), partnership (local partnerships, community engagement, communication channels, national and regional), prevention (containment booms), public engagement and stakeholder participation	<i>Not explicitly listed</i>
Grenada	<i>No explicit aim</i>	Avoidance (avoid contact with equipment and people), Governance (establishment of management structure), public engagement (public education and awareness initiatives for the public), partnership (and collaboration), reuse (commercialisation, organic compost, commercial products, feed),	Fisheries Division Agronomy Division National Solid Waste Management Authority Environmental Division Affected municipalities Grenada Hotel and Tourism Association

Country	Goal of policy document	Recommended adaptations	Adaptation responsibility (stakeholders)
French Caribbean (Guadeloupe, Guyana, Martinique, St Martin)	To make operational recommendations to organize the collection process, storage, treatment and valuation of <i>Sargassum</i> algae from a management perspective on the long term	Clean-up and disposal (manual, mechanical, onshore, nearshore, treatment – within three days), forecasting, governance (integrate <i>Sargassum</i> into existing risk management plans at multiple authority levels), monitoring, research, reuse (agriculture)	Agence de l'environnement et de la maîtrise de l'énergie (ADEME) Agence Nationale de Sécurité Sanitaire de l'alimentation, de l'environnement et du travail (ANSES) Agence régionale de santé (ARS) Centre d'étude et de valorisation des algues (CEVA) Chambre consulaire interprofessionnelle des îles de Guadeloupe (CCIIG) Chambre consulaire interprofessionnelle de Saint-Martin (CCISM)
Jamaica	To define measures to respond to the abnormal accumulation of <i>Sargassum</i> on the Island's shoreline through national public sensitization, community mobilization and clean-up activities.	Clean-up (shoreline), communication (media and information dissemination), governance (clear designation of responsibilities), monitoring (resource assessments, surveys, data collection centre), partnership (national committee), public engagement (information exchange with fishing and other interest groups, communities), research	National Environment and Planning Agency National Solid Waste Management Authority Fisheries Division Ministry of Local Government and Local Community Development/Local Parish Councils Office of Disaster Preparedness and Emergency Management Ministry of Tourism and Entertainment UWI Scientific Research Council Rural Agricultural Development Authority
St Kitts and Nevis	To ensure the protection and conservation of coastal resources, and the sustainability of marine resources	Clean-up (guidelines, onshore), governance (structure to regulate fishing activities around <i>Sargassum</i> , sustainable marine resource management), monitoring, partnership (committee), public engagement (educate and sensitize the public), research (distribution, production and ecology), reuse (fertilizer and fish feed)	Department of Environment Department of Marine Resources Department of Fisheries Department of Physical Planning, Natural Resources and Environment Ministry of Tourism St Kitts Ministry of Tourism Nevis Hotel and Tourism Association St Kitts Tourism Authority
St Lucia	To address the <i>Sargassum</i> influx on St Lucia's beaches and within the bays and harbours	Clean-up (onshore and offshore), communication, , economic opportunities and community employment generation, forecasting, partnership (regional protocol), public engagement (education and awareness, participation), research, reuse (development and innovation for reuse, beach building and nourishment, organic fertilizer, peat moss,	Department of Fisheries Fishers and residents of coastal communities Tourism Officials Hotel Owners

Country	Goal of policy document	Recommended adaptations	Adaptation responsibility (stakeholders)
		agricultural uses, pharmaceuticals and chemicals, food, medicine)	
St Vincent and the Grenadines	<i>No explicit aim</i> Disseminate information on the <i>Sargassum</i> influx and to promote the adaptation of best management practices in dealing with the issue	Clean-up (onshore and offshore, work plan, best management practices advice), governance (national task force), monitoring and reporting of events (and evaluation), preparedness (identification of sites prone to accumulation before events), public engagement (public education and awareness)	Ministry of Agriculture Rural Transformation, Forestry and Fisheries and Industry Ministry of Transport, Works, Urban Development and Local Government National Parks Rivers and Beaches Authority Ministry of Health, Wellness and the Environment Ministry of Housing
Trinidad and Tobago	<i>No explicit aim</i> Key goals: public awareness, efficient knowledge exchange, collaboration among the various agencies and sectors and research and development of <i>Sargassum</i> products	Clean-up (coordinate clean-up and disposal/reuse, onshore), communication (communication strategy), early warning system (remote sensing, ground truthing, oceanographic modelling), emergency response teams, monitoring, partnership (national coordination), research	Regional Corporations Tobago House of Assembly Tourism Development Company Ministry of Local Government and Rural Development Ministry of Planning and Development Ministry of Finance Ministry of Community Development Institute of Marine Affairs Fisheries Division, Ministry of Agriculture, Lands and Fisheries Office of Disaster Preparedness and Management Civil Society Organisation Hotel Association
<p>Dutch Caribbean and French Caribbean are both grouped here because no independent brief or recommendations were identified (Ministère des Outre-Mer, Ministère de l'Environnement, de l'Énergie et de la Mer, and Ministère de l'Agriculture, de l'Agroalimentaire et de le Forêt 2016; Dutch Caribbean Nature Alliance 2019)</p> <p>Countries with a policy, but that have not been viewed by the research team: Belize, Dominican Republic, Haiti, Puerto Rico, Trinidad and Tobago, US Virgin Islands</p> <p>Countries not known to have policies: Anguilla, Bahamas, Barbados, Bermuda, British Virgin Islands, Guyana, Montserrat (UK), Suriname, Turks and Caicos</p>			

4.1 Conserve it

Preceding the influx of *Sargassum* experienced in 2011 and ensuing years, the species now perceived as problematic near the shore were largely the subject of marine resource conservation discourse. As a marine resource, there are multiple international and regional conventions by which the species could be governed. Its treatment as a living marine resource, under United Nations Convention for the Law of the Sea (UNCLOS), is put into practice by the United States National

Oceanic and Atmospheric Administration and their development of a fisheries management plan for the habitat (UN General Assembly 1982; South Atlantic Fishery Management Council 2002). Both the Cartagena Convention (Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region) and more specifically the SPAW protocol (Specially Protected Areas and Wildlife) are Caribbean regional instruments including articles on the protection and preservation of coastal and marine biodiversity, ecosystems and habits; thus *Sargassum* is also subject to the regional agencies' overseeing these protocols. Conservation of *Sargassum* remains ongoing, such as through the efforts of the Sargasso Sea Commission to afford the Sargasso Sea protections through non-legal agreements such as the Hamilton Declaration 2018; but much of that work is focused on *Sargassum* far from the shoreline. Furthermore, most management strategies do reiterate the importance of *Sargassum* to ecosystems at sea. It is when it is at the nearshore in vast quantities that it becomes to be experienced as more problematic. There are multiple regional and international legal and organisational frameworks to support management of *Sargassum* as a marine resource to conserve.

4.2 Ignore and avoid it

Few policies exclusively advised leaving *Sargassum* in nearshore water and on beaches without some form of direct physical intervention. Bermuda, for which no formal policy was obtained, and which is the only land territory recognised within the Sargasso Sea, has a longstanding history with *Sargassum* on its nearshore and coastline, and for the most part either utilises the species as a traditional resource or leaves it on the beach to support stabilisation (Department of Environmental and Natural Resources n.d.). Similarly, Aruba Disaster Response Agency recommended in 2018 to leave *Sargassum* onshore when present on the North Coast (the more affected area), and only to

intervene with beach evacuations should it reach tourist-based beaches.¹ The policy draft of Grenada similarly advised avoidance by swimmers and diversion around in-water *Sargassum* by fisherfolk and other water users, including their equipment. Nevertheless, most countries facing *Sargassum* influxes are experiencing it not only in less-utilised waters and coastlines, but also in areas where leaving it to break down in situ is not perceived as a viable dominant strategy.

4.3 Prevent and clean it up

Despite the dominance of clean-up in management briefs, the damage that poorly conducted clean-up efforts may cause are widely cited. Thus, there are multiple distinctions across proposed clean-up approaches: offshore and/or onshore, mechanised and/or manual, disposal practices, speed of clean-up. Several strategies discourage mechanised clean-up, mostly because of observed damage to the beach and contribution to beach erosion (Antigua and Barbuda, Jamaica, St Lucia, and Trinidad and Tobago). Nevertheless, the sheer quantities being identified for clean-up meant that few policies have explicitly banned mechanised management; albeit that in most countries official permitting is required for mechanised clean-up activities to be conducted legally. All policies (barring Grenada) identify onshore clean-up as a management approach; not all policies identify offshore clean-up as an option. Nevertheless, the use of containment booms and other approaches to prevent onshore arrival and collect *Sargassum* from the nearshore are increasingly observed (e.g. Belize, Bonaire, Curaçao, Dominican Republic, Saba, and St Eustatius) (Persbureau Curacao 2018; Leposa 2019; Whittaker 2019; Rijkswaterstaat 2020).² Only the French Republic has explicitly set a target time within which they aim to clear *Sargassum*, advocating for *Sargassum* to be cleared within

¹ 'Enorme Sargassum Velden Opnieuw Aangetroffen Aan de Noordkust van Aruba'. n.d. Accessed 18 June 2020. https://www.overheid.aw/actueel/nieuws_46856/item/enorme-sargassum-velden-opnieuw-aangetroffen-aan-de-noordkust-van-aruba_41650.html#titel41650.

² Also, 'Oil-Control Material for Saba and St. Eustatius'. 2018. Saba-News.Com. 4 October 2018. <https://www.saba-news.com/oil-control-material-for-saba-and-st-eustatius/>.

three days of arrival on the beach. This, to prevent the toxicity observed on Martinique and the French Antilles, as well as other shores.

4.4 Reuse it

The opportunity to use *Sargassum* collected from the shore or nearshore is present in most policies, with common suggested purposes being compost, fertiliser, and agricultural uses in general. In some management briefs, such as that of St Lucia, an extensive range of economic opportunities deriving from *Sargassum* reuse are proposed, including: organic fertiliser for farming, cooperative for processing, community mobilisation to process as peat mass, beach building and nourishment, agricultural uses such as soil enhancement, pharmaceuticals, food based uses, alginate extraction for industrial exploitation, and use in bioremediation of polluted water.

5. Conclusion

In summary, we this article contains an analysis of existing regional and national frameworks for the management of this Sargassum seaweed, and created creating a synthesis of best practice and challenges in this management area. We achieved this through an analysis of the formal and informal literature on contemporary management of Sargassum at the national and regional scale in the Caribbean. Clean-up and prevention dominate adaptation strategies, although there is also continued recognition of the ecological value of Sargassum offshore and even at the nearshore. Few policies exclusively recommend ignoring Sargassum on the nearshore or onshore, and increasingly reuse is being researched and used as an adaptation option. We recommend the framing of Sargassum as a threat or opportunity offshore, near shore on onshore be more explicitly discussed by future management strategies, to support identification and use of appropriate adaptation frameworks to guide management planning.

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