

SARGASSUM WHITE PAPER

Turning the crisis into an opportunity

2021

CREDITS AND ACKNOWLEDGEMENTS

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Front page photo credit: Tony Rath – Drone photograph of a vast mat of sargassum near Silk Cayes, Belize, 4 Sept 2018



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TABLE OF CONTENTS

1. Problem Statement	4
2. Purpose and Scope of Paper	6
3. Sargassum Background and Impacts	7
3.1 Pelagic Sargassum: Benefits	9
3.2 Sargassum Influx Events: Causes	10
3.3 Impacts of Sargassum Influx Events	11
3.3.1 Biophysical Impacts	12
3.3.2 Socioeconomic Impacts	13
3.4 Sargassum Coastal Influx Events – Hazard or Opportunity?	14
4. Caribbean Regional situation	17
5. Caribbean Sargassum Stakeholders	20
6. Strategy Framework	23
7. Interventions and Management Strategies	25
8. Gap Analysis and Recommendations	29
8.1 Forecasting	29
8.2 Harvesting/collection and use	30
8.3 Policy and Coordination	32
9. Contribution of the Cartagena Convention to the strategy	33
10. General Recommendations	35
11. Conclusion	36
12. Selected Reading	37
13. Appendices	43
13.1 Appendix I: Forecasting Initiatives	43
13.2 Appendix II: Monitoring Initiatives	45
13.3 Appendix III: Projects, Programmes and Initiatives	47
13.4 Appendix IV: Sargassum management plans and strategies in the Caribbean	54



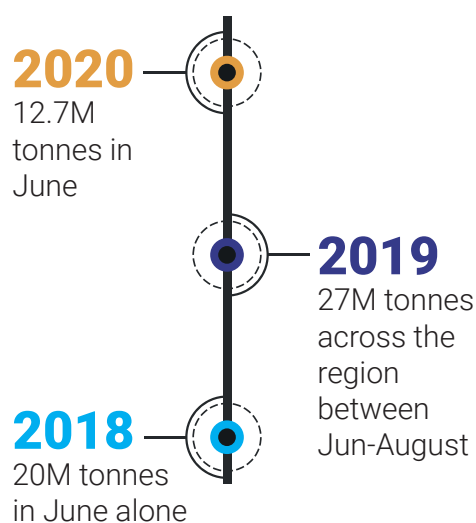
Photo credit: Hayden Billingsy

1

PROBLEM STATEMENT

Since 2011, Caribbean coastlines have been subject to unprecedented, massive, episodic influxes of floating sargassum seaweed. While 2020 was relatively mild in terms of sargassum volumes, and a global pandemic became the overarching worry, 2018 was record breaking in terms of sargassum volumes reaching Caribbean shores and 2019 was also significant.

Floating sargassum should not be construed as negative in and of itself – it is beneficial at sea, mainly as a unique pelagic habitat. However, the mass stranding of sargassum on coastlines has significant negative impacts (biophysical and socio-economic), particularly on coastal communities and livelihoods, public health, tourism and fisheries. This issue therefore represents an emerging hazard for a region that is already subject to numerous hazards. Indeed, various countries in the Caribbean have declared national states of emergency with respect to sargassum influxes (Desrochers *et al.* 2020).

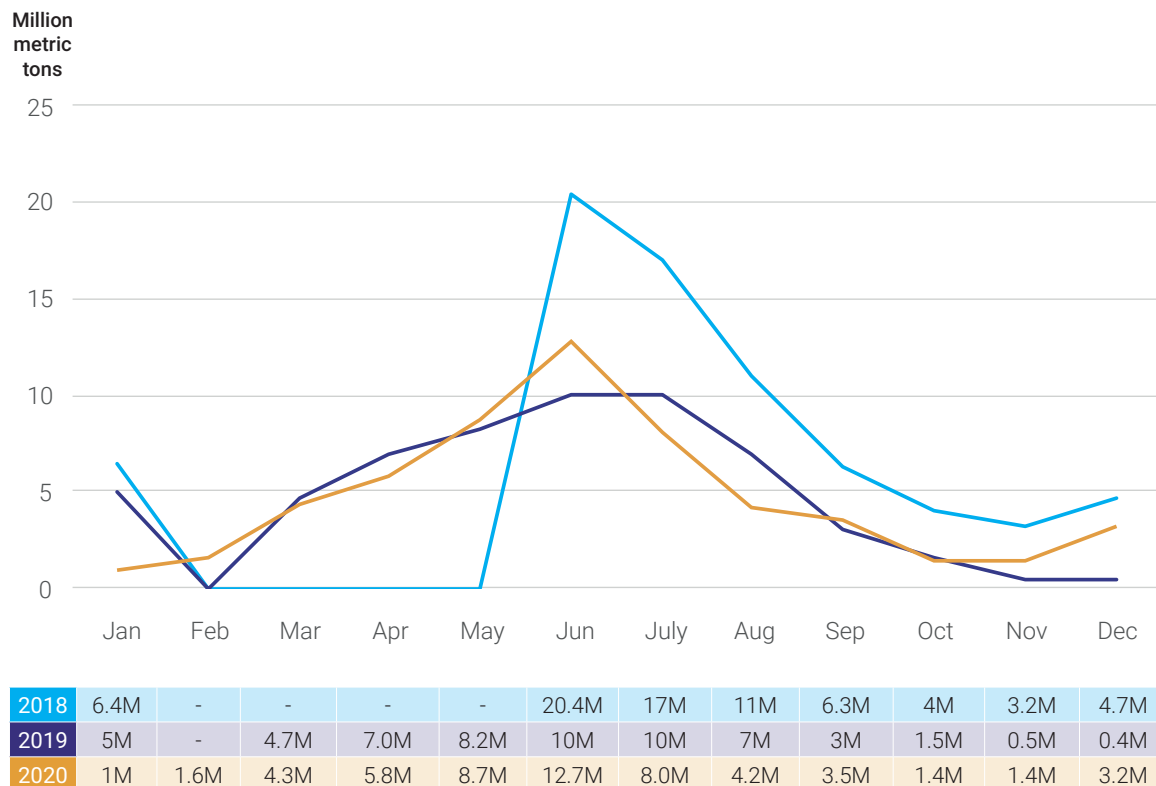


Initially, there was significant uncertainty as to the causes and expectations of recurrence of this new issue, and therefore also on the best response for impacted territories. Subsequently, in the ten (10) years since the first inundation episodes, it is generally accepted that the influxes are part

of a 'new normal,' and significant progress has been made in understanding this phenomenon and developing response strategies. Nonetheless, this is a still relatively new issue, and significant gaps remain in information and understanding, as well as effectiveness of response strategies. Significant seasonal and international variations in the influx timing and magnitude hinder accurate predictions, and periods of time when the issue is *'out of sight, out of mind'* amidst myriad other issues (now including a global pandemic) can derail momentum. Furthermore, the challenges are compounded by the general complexity of Caribbean regional ocean governance. While there is general consensus that part of the response should consider influxes an economic opportunity as much as a threat, there remain many issues to be resolved before that is realised.

The issue is however not confined to the Caribbean, but it extends across the Tropical Atlantic, including equatorial Brazil as well as coastal West Africa from Sierra Leone through the Gulf of Guinea. Sargassum influxes are very much a multi-regional transboundary issue, demanding coordination and collaboration within and across impacted regions.

FIGURE 1: Estimated total amount (million metric tons) of sargassum in the tropical Atlantic (2018 – 2020)



Source: USF Outlook Bulletin



Photo credit: Hayden Billingsy

2

PURPOSE AND SCOPE OF PAPER

The overall purpose of this white paper is to compile background information for a strategic status update and critical situational analysis that informs and elicits feedback from key regional stakeholders. It will also form the basis for development of a draft Concept Note for a UNEP Cartagena Convention-led project targeting key issues identified. The paper is not an exhaustive review of all available knowledge on the issue. It focuses on influxes in the Caribbean, with reference to other impacted regions as appropriate.

This paper is a living document intended to be regularly updated so that it remains current and relevant. This most recent update is the first revision following the original version presented during the Eighth Meeting of the Scientific and Technical Advisory Committee (STAC-8) to the Protocol Concerning Specially Protected Areas and Wildlife (SPA) in the Wider Caribbean Region held in Panama City, 5–7 December 2018.

The original white paper drew upon desktop research and the results of a survey disseminated to UNEP CEP National Focal points in 2018. This update relies entirely on desktop research and review of recent literature. It includes information on new initiatives, proposes a strategy framework and concludes with a section that lists useful resources.

This paper also builds on immense interest on this topic, with over 2,500 registrations to the 4 webinars hosted by UNEP in 2020. This was a joint effort between the GPA Global Partnership on Nutrient Management, UNEP's Science Division, the Cartagena and Abidjan Convention Secretariats of the Regional Seas Programmes, and UNESCO-IOC Harmful Algal Blooms Programme.

The target audience of this paper is diverse, potentially including researchers, policy makers, impacted sectors, and parties interested in sargassum as a commodity, and therefore encompassing both technical and nontechnical readers. Hence, the paper deliberately uses simplified technical language while making reference to technical sources for those interested in further reading.



Photo credit: Hayden Billings

3

SARGASSUM BACKGROUND AND IMPACTS

Sargassum is a genus or family of brown *macroalgae* or seaweed that includes over 300 species distributed across the world in both temperate and tropical oceans. Many species are *pelagic*, forming large floating rafts or mats, but most have a benthic (bottom-attached) phase of their life cycle.

A few species, thought only to occur in the Atlantic, are '*holopelagic*,' meaning that they spend their entire life cycle afloat, transported by ocean currents with influence from surface winds. While individuals of these species may occasionally float alone, they more often tangle together to form communities of many individuals, which can take the form of large mats or rafts, or sometimes long lines called windrows. These species are thought to reproduce only vegetatively through growth and fragmentation. Knowledge of growth and mortality rates is limited, although it is known that it can increase its biomass very quickly under the right conditions, and that growth rates are affected by nutrients, salinity and temperature (Desrochers et al. 2020).

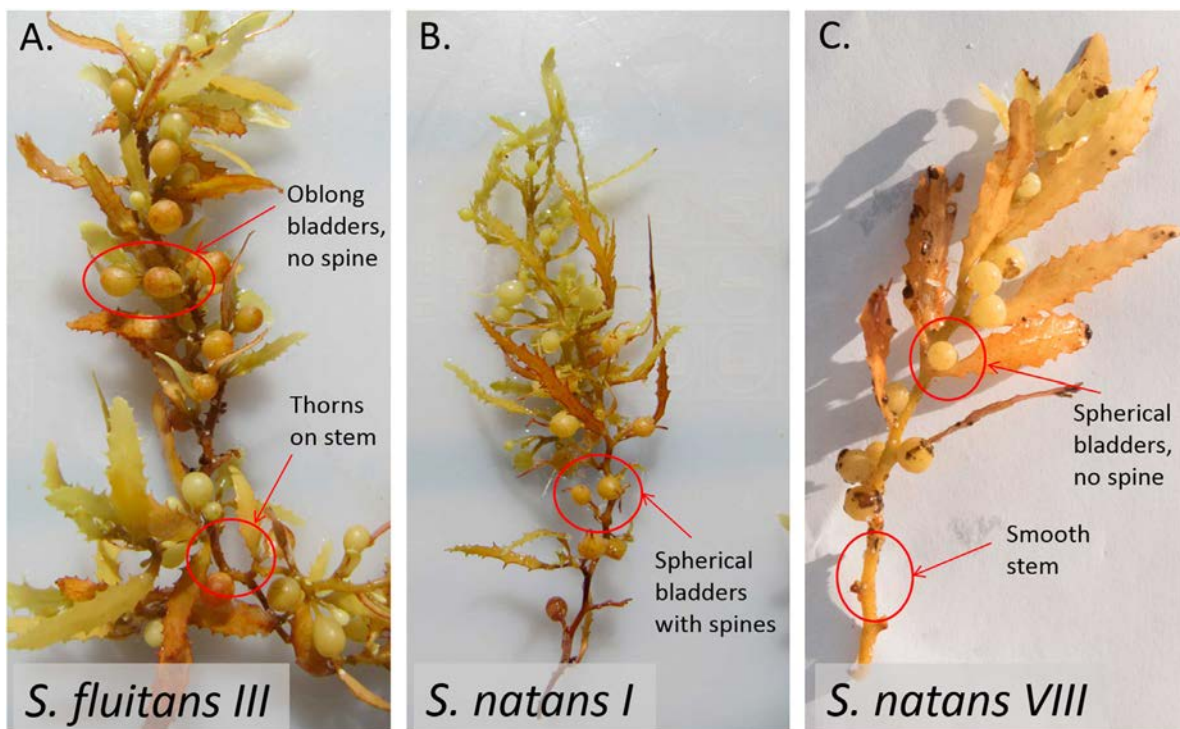
Holopelagic sargassum occurs naturally in the North Atlantic, where massive quantities contained by circulating currents form the Sargasso Sea. It is also common in the Gulf of Mexico where it blooms in the spring and supplies the Sargasso Sea population via the Gulf Stream current, and it has been known to occur occasionally in the Caribbean (Wang et al. 2019). Research into the causes of the recent massive influxes of sargassum in the Caribbean and West Africa has led to the identification of a new 'consolidation region' in the Tropical Atlantic, between the Gulf of Guinea and the north coast of Brazil that is generally agreed to be the source of the influxes to the Caribbean and West Africa.

FIGURE 2: Schematic illustrating new sargassum source region



Source: Adapted from Oxenford, H. A. 2020

The influxes to the Caribbean have been found to consist predominantly of two species of holopelagic sargassum, *S. natans* and *S. fluitans*. There are various morphotypes of these species and some debate as to whether there may be third additional distinct species. (Desrochers et al. 2020)



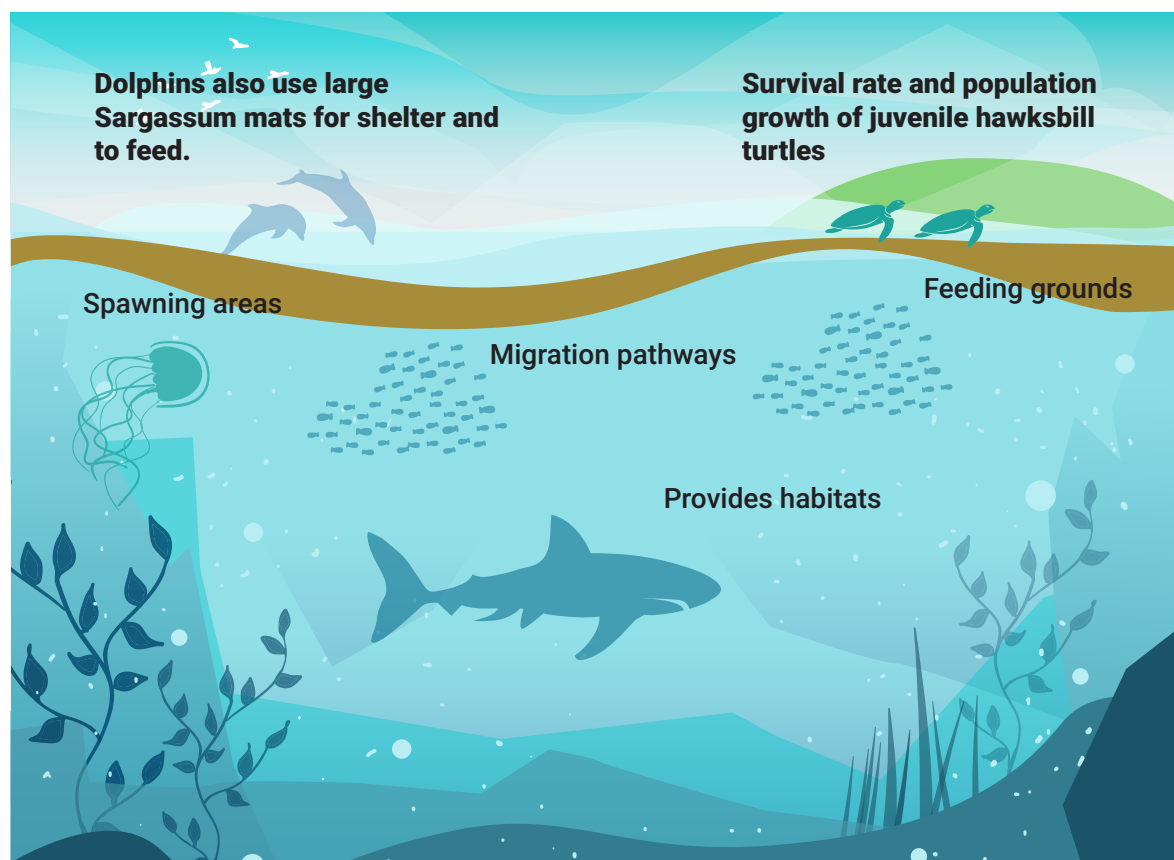
Source: DOI: 10.7717/peerj.7814/fig-1

3.1 Pelagic Sargassum: Benefits

Holopelagic sargassum in the open ocean is generally beneficial. The Sargasso Sea in the North Atlantic, named for the seaweed, is formed by circulating currents around the North-Atlantic sub-tropical gyre supporting a large community/ population of holopelagic sargassum that is the basis for a unique open-ocean ecosystem sometimes referred to as a 'golden floating rainforest.' According to the Sargasso Sea Commission, the '*Sargasso Sea provides habitats, spawning areas, migration pathways and feeding grounds to a diverse assortment of flora and fauna, including endemic, endangered, and commercially important species.*' Similar benefits obtain from free-floating sargassum are common in the Gulf of Mexico.

Pelagic Sargassum in the Tropical Atlantic, though relatively new in such quantities, does have some positive impacts in terms of habitat for marine species. Hawksbill turtles, in particular, are said to be benefiting from increased large Sargassum mats. In Jamaica, scientists have observed an increase in survival rate and population growth of juvenile hawksbill turtles during times of Sargassum infestation. The large sargassum mats provide shelter and food, and thus greater chances of survival. Dolphins also use large Sargassum mats for shelter and to feed on fish.¹

FIGURE 3: Sargassum benefits

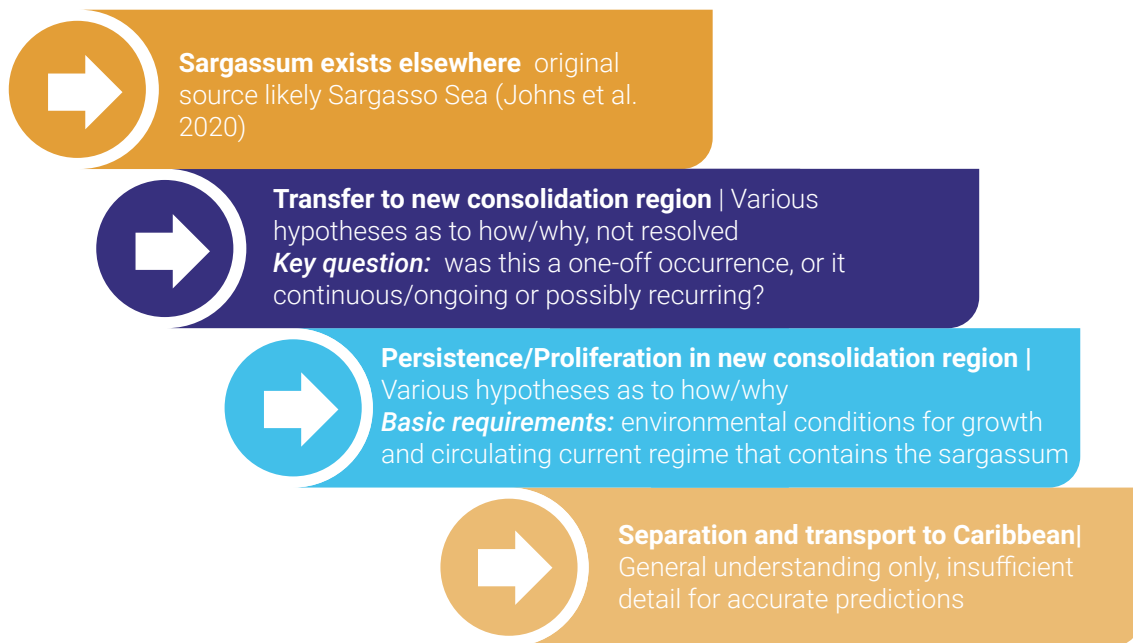


¹ The Gleaner. Sun, Sea and Sargassum. Available at: <http://jamaica-gleaner.com/article/news/20190707/sun-sea-and-sargassum>

3.2 Sargassum Influx Events: Causes

Identifying the causes of the sargassum influxes is fundamental and critical to any future effort to mitigate the issue, as well as efforts to predict the influxes that would support planning adaptive response and management measures. This is therefore an active area of research. This phenomenon does not stem from a single or simple cause, but rather from complex combination of causal factors that may be visualised as causal pathway or set of causal mechanisms. A key step in understanding this causal pathway was identifying the new consolidation region that is the source of these influxes. The existence of this was confirmed through remote sensing since 2013 (Gower, Young and King 2013). With this knowledge, it is possible to frame an outline causal pathway as follows:

FIGURE 4: Causal Pathway



Within the framework of this causal pathway, there remains much that is uncertain or unknown about the details of processes and mechanisms. There is much debate, with numerous hypotheses advanced, as to the establishment of the new consolidation region, i.e. how/why sargassum was transferred there, and how/why it persists/proliferates there.

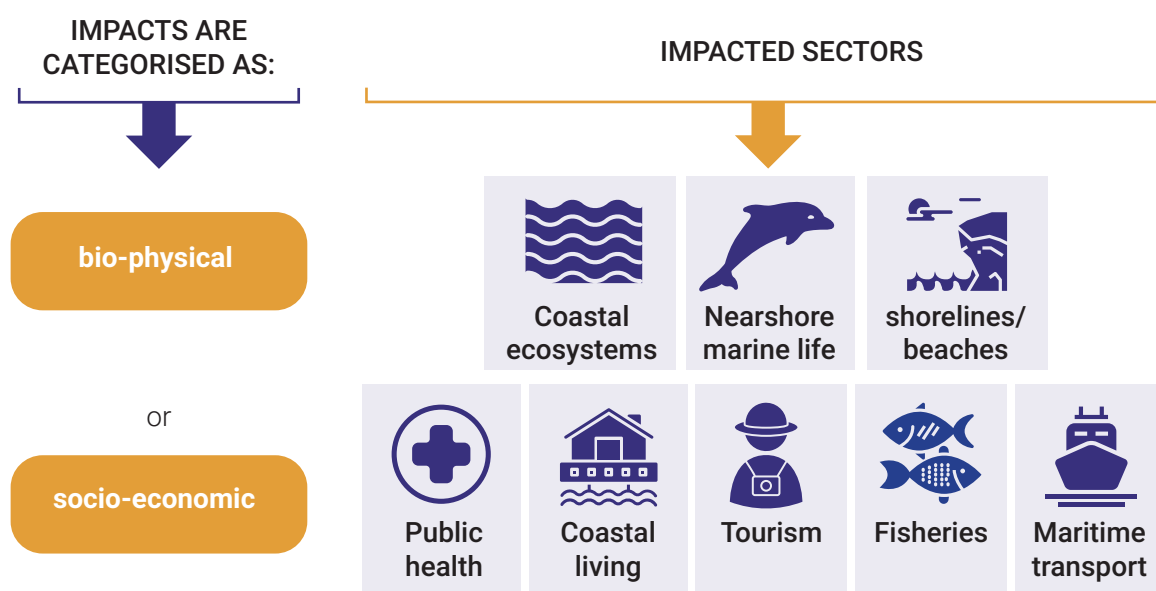
The immediate proximal factors involved are likely linked to broader underlying issues like general ocean eutrophication (land-based nutrient pollution) and climate change (Table 2). Given the existence of the new consolidation region, there is also general agreement that sargassum influxes may be expected to continue as part of the 'new normal' until/unless mitigation may be achieved, i.e. the issue is unlikely to resolve itself without intervention.

TABLE 1: Proximal Factors and supporting empirical evidence

Causal Pathway	Factors	Empirical evidence
Sargassum exists elsewhere	Wind anomaly	Gower, Young and King 2013 Johns et al. 2020
Transfer to new consolidation region	North Equatorial Current North Equatorial Counter Current	Putman et al. 2020 Johnson et al. 2020 Wang et al. 2019
Persistence/ Proliferation in new consolidation region	Nutrient enrichment African biomass Sea surface temperatures	Fulton et al. 2014; LaPointe 1995, 2019; LaPointe et al. 2014 Barkley et al. 2019 Djakouré et al. 2017
Separation and transport to Caribbean	North Brazil/Guiana Current North Brazil Current Rings North Equatorial Counter Current North and South Equatorial Currents	Lumpkin and Garzoli 2005 Gower et al. 2013 Franks et al. 2016 Putman et al. 2018 Putman et al. 2020

3.3 Impacts of Sargassum Influx Events

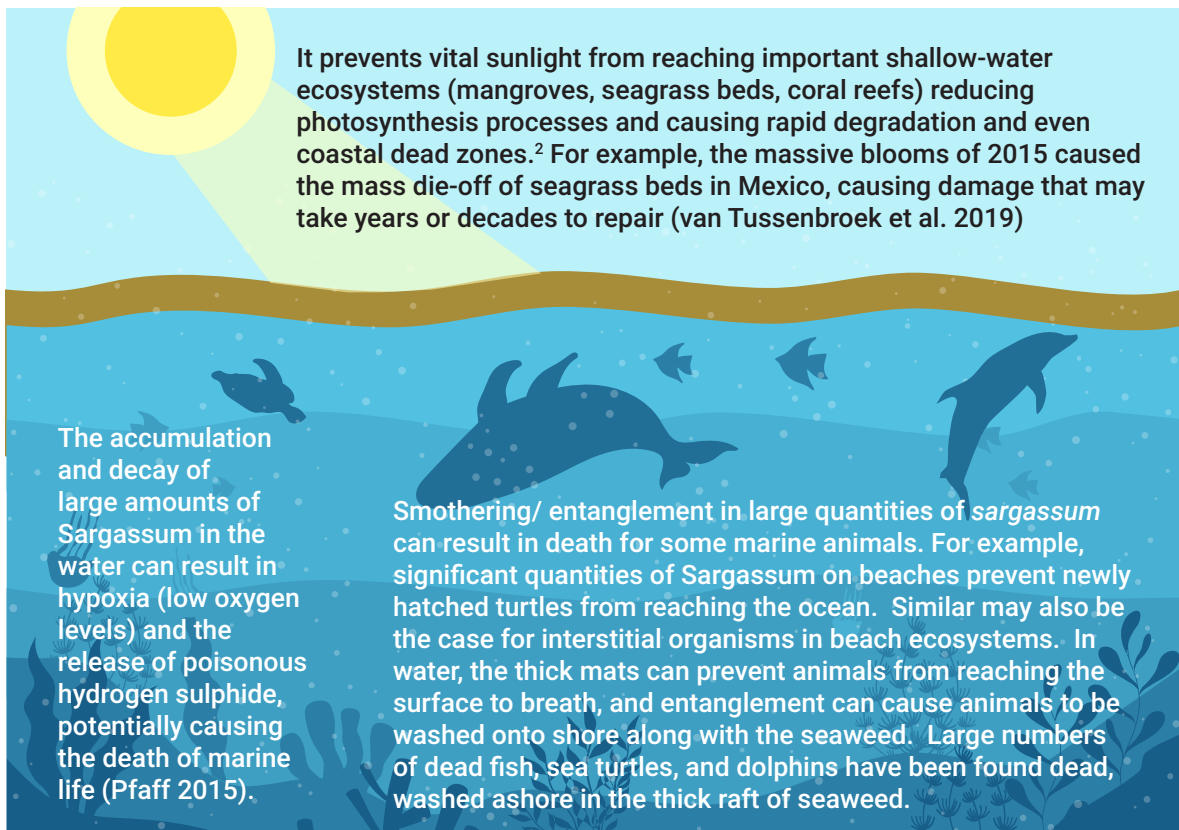
This section outlines the impacts of sargassum influxes in general, with some specific examples.



It should be understood that the types and severity of impacts and feasibility of responses all vary spatially across the Caribbean according to several factors, including: coastline position (level of exposure to sargassum influxes), geomorphology and coastal dynamics of the impacted coastline, and presence/absence/proximity of vulnerable resources, activities and operations along the impacted coastline. This is discussed further in Section 7.

3.3.1 Biophysical Impacts

Stranding on coastlines negatively impacts the sargassum itself (a potentially beneficial habitat at sea) as it dies and subsequently decays. Also in that process, the sustained presence of large quantities of decaying biomass negatively impacts coastal and nearshore marine life through a number of mechanisms:



A secondary, avoidable negative impact of the influxes relates to the use of heavy machinery to remove massive Sargassum landings, which impacts beach habitats and tend to worsen the environmental harm. The use of heavy machinery causes compaction of beaches and kills organisms that live in the sand, such as ghost crabs and other sea creatures that keep a beach healthy by creating hundreds of holes that keep the beach ventilated. Driving with heavy equipment will not only crush them, but also kills any potential sea turtles' nests.³ Another impact is the removal of vast quantities of sand, resulting in unintentional sand mining, and ends up affecting the entire beach ecosystem.

Sargassum washing ashore can in some cases yield a positive impact, wherein the seaweed aids in stabilising the beach. This benefit is likely lost with large quantities that overwhelm a beach or bay, and would often be offset by major negative impacts depending on the resources present and uses of the beach.

² Hakai Magazine. The Eastern Caribbean is Swamped by a Surge of Seaweed. Available at: <https://www.hakaimagazine.com/news/the-eastern-caribbean-is-swamped-by-a-surge-of-seaweed/>

³ The Gleaner. Sun, Sea and Sargassum. Available at: <http://jamaica-gleaner.com/article/news/20190707/sun-sea-and-sargassum>.

3.3.2 Socioeconomic Impacts



Sargassum influxes negatively impact human well-being, activities, and livelihoods as well as major sectors of Caribbean Economies. Key sectors impacted include: coastal living and livelihoods, marine transport/ navigation, public health, fisheries and tourism. These impacts are inter-related, with many stemming from one of the key drivers of biophysical impacts – the decay of the sargassum biomass.

The production of hydrogen sulphide negatively impacts air quality, results in very unpleasant odours, and prolonged exposure is unhealthy, especially for persons with underlying respiratory conditions. This is detrimental for coastal residents and beach users, whether local or visitors. Beach users who live elsewhere have the option to avoid impacted locations, while residents may be unable to avoid prolonged exposure.

Large quantities of sargassum also spoil the aesthetic appeal of Caribbean beaches, and inhibit access to nearshore waters. Both issues affect residents, local beach users and tourists, while the latter particularly impacts those whose livelihoods rely on the sea, such as fishers who may need to access the water to access their equipment and/or livelihood.

Specific sectoral impacts are outlined in Table 3 below, with specific examples where available.

TABLE 2: Sectoral impacts and examples

	<p>IMPACT There have been reports of respiratory problems, nausea, headaches and irritation of the eyes believed to be caused by exposure to high concentrations of hydrogen sulphide in the air. Furthermore, direct contact with Sargassum may cause skin rashes and/or irritation, not likely from the seaweed itself but because of some tiny organisms that live in the Sargassum (Resiere et al. 2018).</p> <p>Example(s) Reports in St. Lucia suggest that both residents and tourists have experienced higher incidences of respiratory problems since the sargassum influxes began. Other complaints include nausea, headaches, and skin rashes⁴.</p>
	<p>IMPACT Residents are unable to obtain relief from poor air quality, health impacts, and unpleasant odours by simply avoiding the area. Beach use that may have been a part of their lives will also be negatively impacted. It has also been reported that decomposing Sargassum causes corrosion of electrical appliances and equipment in the near vicinity (Mendez-Tejeda and Rosado Jiménez 2019).</p> <p>Example(s) In the Dominican Republic, coastal residents have reported that sargassum causes the corrosion of metal infrastructure and boats, which is likely associated with the effects of hydrogen sulphide. These effects dissipate as exposure decreases.</p>

⁴ <https://eos.org/articles/saint-lucia-works-to-release-itself-from-sargassums-stranglehold>



Tourism

IMPACT

Spoiled aesthetics, unpleasant odours, difficult access to the beach/sea, and potential health risks all diminish or destroy the 'sun-sand-and sea' appeal of Caribbean tourism. As a result, some areas of the Caribbean have witnessed large declines in tourism. This has significant impacts on the overall national economy, as well as direct impacts on those across income levels who make their livelihoods through tourism. Waterfront hotels may incur costs of beach clean-ups to alleviate the issue on their frontage (see below). Watersports operators would be directly impacted both through reduced visitor numbers and similar access issues as fishers (below).

Example(s)

Mexico experienced 35% drop in tourism during the first quarter of 2018 attributed to sargassum influxes.



Fisheries

IMPACT

Sargassum blooms also result in reduced access to fishing grounds and disrupted fishing operations when, in worst case scenarios, fisheries cannot take their boats out to sea (Solarin et al. 2014). Fisheries and aquaculture may also be severely impacted by the mortality of fish and other marine life (Pfaff 2015), resulting in reduced and/or altered fish catches (Fogarty 2018).

Example(s)

In Barbados, the arrival of massive amounts of Sargassum have coincided with a dramatic decrease in flyingfish landings from 981 tons in 2014, to 278 tons in 2015. This represented a 72 percent decline in one of the island's most important fisheries (Oxenford et al. 2019).



Maritime Shipping/Navigation

IMPACT

Ships and boats may find it difficult to navigate through thick mats of sargassum which affects the engines.

Example(s)

Transatlantic sailors have reported that thicker clumps of sargassum slowed down their boats significantly. The biggest problem is caused by seaweed snagging on spade rudders and bulb keels creating drag.⁵



Direct costs

IMPACT

In addition to economic and livelihoods losses as outlined above, especially tourism and fisheries, there are direct costs associated with alleviation measures such as beach cleaning. Depending on the location, these direct costs may be borne by government or hotels or both.

Example(s)

Mexico has spent USD\$17 million to remove Sargassum from over 1,000 km (621 miles) of Mexican beaches through 2019. From May to August 2019, 69,606.1 tons of Sargassum was collected and 13,527 people were employed to clean up beaches.

⁵ <https://www.yachtingworld.com/sailing-across-atlantic/sargassum-weed-increasing-problem-transatlantic-sailors-125971>

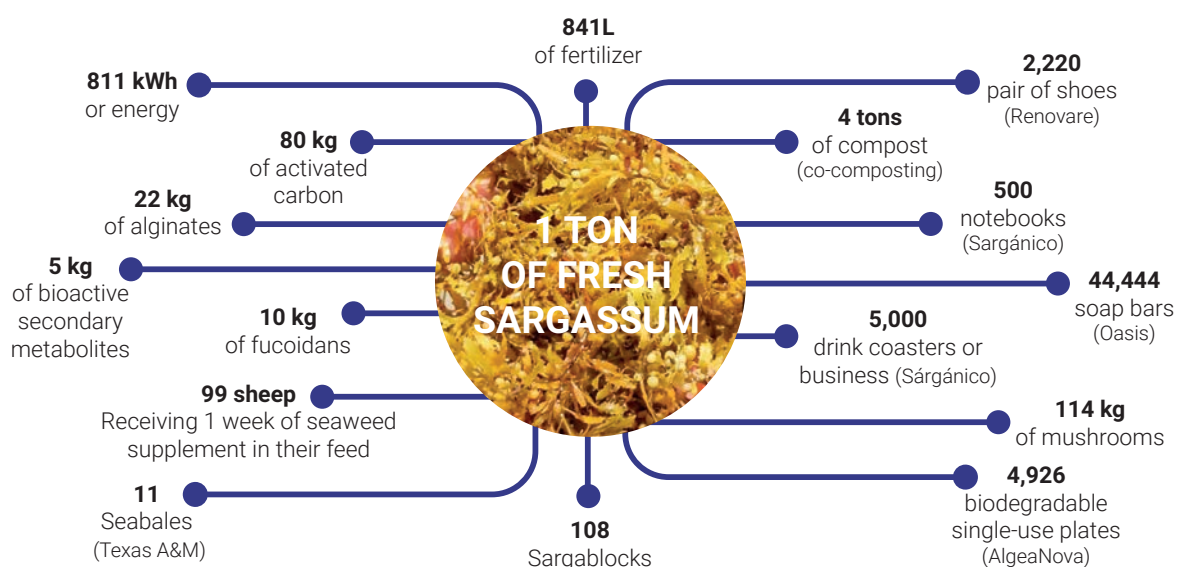
3.4 Sargassum Coastal Influx Events – Hazard or Opportunity?

It is important to make a clear distinction between floating sargassum on the high seas and floating sargassum that has been transported to and stranded in nearshore coastal areas in large quantities. The former is generally beneficial as outlined above. It is the latter that generates the significant negative impacts prompting this paper. When stranded in coastal areas, the sargassum itself dies, and many of the negative impacts originate with its decay. Given the scale and extent of the negative impacts these influx events may be characterized as a recurring hazard. The unprecedented scale of the Sargassum influxes also led to declaration of emergency conditions in several Caribbean countries e.g. Tobago in 2015, Barbados in 2018, and Mexico in 2019 (Chavez et al. 2020).

Sargassum has also been identified as a potential resource that may be commoditised. There is potential for a variety of uses including agriculture, bioenergy, bioplastics, bioremediation and purification, construction and cosmetic among others (Desrochers et al. 2020). As such, its transport in large quantities by natural processes to the Caribbean may represent an opportunity for economic development. At the same time, the Sargasso Sea Commission has identified the future harvesting of sargassum as a potential threat to the Sargasso Sea⁶. Harvesting Sargassum in the tropical Atlantic that would otherwise be stranded with the attendant negative impacts to supply that demand may have the co-benefit of helping to mitigate that risk to the Sargasso Sea.

This is however contingent on several factors that remain uncertain or unresolved on both the supply and demand sides. These include the capacity and costs required to efficiently harvest, store and transport sargassum for processing, as well as requirements for or preclusions from various potential end uses, e.g. some end uses may achieve a better yield with only certain types of sargassum, some processes may require fresh versus dried sargassum, or the presence of heavy metal or contaminants may preclude its use for certain applications. Another factor is the relative product yields based on a specific volume of fresh sargassum (Figure 5). Countries

FIGURE 5: Relative product yields that could potentially be produced from one metric ton (1000 kg) of fresh sargassum



Source: Adapted from Desrochers et al. 2020

⁶ <http://www.sargassoseacommission.org/about-the-sargasso-sea>

may want to explore uses that require larger volumes of sargassum and simple processing techniques to support cost-recovery initiatives.

On the last point, there are concerns regarding potential health implications with the consumption or utilization of Sargassum as fertilizer because of the potential harmful contents and the possibility that some crops may take up the contents of the seaweed. The French Research laboratory Institut Technique Tropical (IT²), along with the Agency of the Environment and Energy (ADEME) have produced an extensive study to warn about the utilization of sargassum as a soil fertilizer for two main reasons: the high risk of salinization of soils as well as the relative low results (based on cucumber, lettuce, sweet potato, bananas and sugar cane exploitations). Further research in this area is important to define the exact toxins and concentration levels to determine potential safe utilization purposes.

At this stage, while efforts to explore the potential opportunity are underway, the reality is that sargassum influxes remain more of a hazard than a benefit until key issues are resolved.



Photo credit: Ulises Jauregui



Photo credit: Hayden Billingsy

4

CARIBBEAN REGIONAL SITUATION

The Wider Caribbean Region (WCR) is geopolitically diverse and complex (Mahon et. al. 2013, Debels et al. 2017); indeed it is the most diverse and complex among the Regional Seas Programmes. There are numerous political entities, vast differences in size, and varying levels of development (Debels et al. 2017). The region contains numerous small island developing states (SIDS), with the well-known associated sustainable development challenges – the WCR contains the largest number of SIDS of any region globally, and by extension the largest number in any of the Regional Seas Programmes. While there are many commonalities and valid generalisations, the region is less homogenous and more variable than many realise. This has implications for both how sargassum impacts countries and territories of the region, as well as the suitability of responses.



Source: The CLME+Project

There are numerous ways to categorise the countries and territories in this complex region. For the purposes of this discussion, consider two broad categories/subsets outlined in Table 3. Note these are broad generalisations to make certain key points, and there will be some exceptions.

TABLE 3: Categorisation of countries and territories in the Caribbean

Category	The Island Chain (The Lesser Antilles, Greater Antilles and the outlying Lucayan Archipelago, i.e. the Bahamas plus Turks and Caicos)	Continental landmass of South and Central America
Type of land mass/ position	Fragmented land mass that forms the ‘front line’ or outer boundary of the Caribbean Sea, with various inter-island channels through which water flows along with all that it conveys including Sargassum	Continuous continental landmass that forms the southern and western borders of the Caribbean Sea
Exposure	More exposed to high energy sea conditions directly off the Atlantic	Less exposed to high energy sea conditions, sheltered by the outer barrier of the island chain
Development	Mostly SIDS, along with small island overseas territories of developed countries (US, UK, France and the Netherlands) that share some similar small island challenges	Continental countries, mostly classified as developing, albeit at varying levels, and including three (3) small countries categorised as SIDS based on shared challenges
Language	Mostly English speaking, with several exceptions (French, Dutch and Spanish)	Largely Spanish speaking with few exceptions

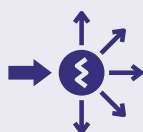
The impacts of sargassum influxes are outlined in general in Section 3. However, it is important to understand that impacts are not uniform across the region, or even across each territory. This heterogeneity also has implications for management and response strategies, in particular collection/ harvesting logistics. Key examples are outlined below:



The impacts of sargassum stranding and the suitability of the responses are influenced by coastline morphology and dynamics (shape, orientation, physical features, processes like waves/currents). A key distinction is that long beaches on continental landmasses will receive larger quantities of sargassum in a continuous stretch, whereas small beaches on a small island will receive smaller, fragmented amounts of sargassum. On islands where there are numerous pocket beaches, such as Barbados and Antigua, this fragmentation of the sargassum ‘supply’ is even more pronounced.



Specific coastlines, typically those that are windward/ Atlantic facing are impacted the most. For the islands of the Eastern Caribbean in particular, this is typically the most rugged and exposed coastline, with the most difficult sea conditions, often remote from urban centres and sometimes with difficult access.



Secondary impacts of sargassum influxes depend on the assets/ resources present at that coastline, e.g. tourism impacts are limited if that is not an important tourism site, similarly impacts on coral reefs / seagrasses are not relevant if those systems are not present at that site.



Capacity to respond varies significantly as well. SIDS and less developed countries already struggle to mobilise resources to address environmental issues and hazards.

Consequently, a blanket approach for the region is not suitable, as approaches and technologies that work well in one location may nor may not be transferrable to another. Critical analysis of the specific situation is required to identify and prioritise specific impacts, determine the appropriate course of action, and efficiently allocate resources. A hazard exposure and vulnerability assessment framework is outlined in Section 8 as a recommended approach for each territory.

While it is agreed that sargassum influxes represent a major transboundary issue requiring regional cooperation, it is also understood that regional ocean governance arrangements are complex, reflecting the overall complexity of the region as described above. Key issues such as weakness in regional natural resources governance, limited human capacity and financial resources, and external dependency have been identified as root causes of environmental degradation in the WCR (Mahon et. al 2013). It should be expected that associated challenges will also manifest in efforts to coordinate sargassum response regionally. Management and governance at the regional level for sargassum influxes are discussed/ described in detail in Section 6.

As things stand, there is significant variability in the uptake and various technologies in predicting, monitoring, collecting/harvesting, or sargassum and little in the way of consistent application across monitoring programmes. “Regional” projects are often targeted at a specific groups of beneficiary countries rather than the region as a whole. The multiple languages in the region can lead to language barriers that hinder transboundary collaboration, as cited by a recent paper on coral reef restoration (Bayraktarov, et al. 2020). Fortunately, numerous collaborations on sargassum issues have cut-across language barriers (e.g. Sarg’COOP, Appendix III), and some key publications including this white paper will be produced in English, Spanish and French.



Photo credit: Gary Marshall

5

CARIBBEAN SARGASSUM STAKEHOLDERS

Since the impacts of sargassum influxes are multi-sectoral, there is correspondingly a wide range of stakeholders. Stakeholder dynamics, interrelationships and interests are also often complex, again reflecting the general regional circumstances and governance arrangements as above. In order to identify stakeholders at the regional level with reasonable representation across sectors and interests, a stakeholder map has been developed (Table 4). The map is structured around three broad categories, namely:

- Stakeholders responding to sargassum influxes as a hazard requiring management, mitigation or adaptation;
- Stakeholders responding to sargassum as a resource/ commodity/ opportunity; and
- Stakeholders with broad interests in sargassum both in terms of both hazard management and potential opportunity.

Each of these broad categories is further sub-divided into sectors, e.g. tourism, fisheries etc., and stakeholder organisations in each category/sector are identified across the public and private sector as well as the NGO/CSO community. Several actors working at the marine science-policy interface in the Caribbean are featured in the stakeholder map. Of notable mention is the UNEP-CEP's Specially Protected Areas and Wildlife (SPA)W- Regional Activity Centre's (RAC) role in engaging regional stakeholders and facilitating networking opportunities related to sargassum management and research. Many of these initiatives and partners are featured in the regional sargassum activities illustration (Section 6) and in the appendices. Section 8 outlines the contribution of the SPAW protocol to the regional sargassum management strategy in more detail.

TABLE 4: Regional Sectoral Stakeholder Map

Broad interests in sargassum both in terms of hazard management/adaptation as well as a potential opportunity	Sector/ Category	CARICOM/ CARIFORUM	Other Inter-governmental	Private Sector	NGO/CSO/ "Third Sector"
Broad interests in sargassum both in terms of hazard management/adaptation as well as a potential opportunity	Sargassum Research/ R&D	University of the West Indies University of Guyana		Several private companies in R&D e.g. Punta Cana Foundation, Dominican Republic to be listed	Greater Antilles: DR - Universidad Autónoma de Santo Domingo CIBIMA; PR - Universidad de Puerto Rico French Caribbean - Université des Antilles Central America: UNAM (Mexico); University of Belize Environmental Research Institute USA Universities: FIU, USF, USM International Atomic Energy Agency
	Metocean	Caribbean Meteorological Organisation (CMO) Caribbean Institute for Meteorology and Hydrology (CIMH)	US National Oceanographic and Atmospheric Association (NOAA)		
	Caribbean Sea Management		Caribbean Sea Commission of the Association of Caribbean States UNEP-Caribbean Environment Programme (Regional Seas Programme) IOC Sub-Commission for the Caribbean and Adjacent Regions (IOCARIBE)		
	Economic Considerations		Economic Commission for Latin America and the Caribbean (UNECLAC)		
Stakeholders responding to sargassum as a risk or hazard requiring management, mitigation or adaptation	Funding / Investment	Caribbean Development Bank (CDB) Caribbean Tourism Organisation (CTO)	IDB, World Bank, UNEP, UNDP, FAO, Sida, KfW, USAID, Interegg Europe	Caribbean Hotel & Tourism Association	The Nature Conservancy (TNC)
	Tourism				
	Fisheries	Caribbean Regional Fisheries Mechanism (CRFM)	FAO/WECAFC	Caribbean Network of Fisheries Organisations (CNFO)	Gulf and Caribbean Fisheries Institute (GCFI)

Stakeholders responding to sargassum as a risk or hazard requiring management, mitigation or adaptation	Sector/ Category	CARICOM/ CARIFORUM	Other Inter-governmental	Private Sector	NGO/CSO/ "Third Sector"
Stakeholders responding to sargassum as a risk or hazard requiring management, mitigation or adaptation	Agriculture (terrestrial, i.e. not fisheries)	Caribbean Agricultural Development Institute (CARDI)	Food and Agriculture Organisation (FAO)		
	Public health	Caribbean Public Health Agency (CARPHA)	Pan American Health Organisation (PAHO)		
	Coastal ecosystems management/ conservation		UNEP-Caribbean Environment Programme (Regional Seas Programme), CLME+ Interim Coordination Mechanism (ICM)		Caribbean Natural Resources Institute (CANARI) The Nature Conservancy (TNC) Waitt Institute
	Marine pollution				Caribbean Water and Wastewater Association
	(Solid) Waste management		THE BASEL CONVENTION REGIONAL CENTRE-CARIBBEAN		
	Climate Change	Caribbean Community Climate Change Centre (CCCCC)			
	Port services/ maritime transport		International Maritime Organization (IMO)	Port Management Association of the Caribbean Caribbean Shipping Association	
	Marine Protected Areas management Marine surveillance/ patrol		CampAM, BioPAMA		
	Emergency management/ Response	Caribbean Disaster Emergency Management Agency (CDEMA)	Regional Security System Caribbean Catastrophe Risk Insurance Facility (CCRIF)		
	Small business/ SME affairs	Caribbean Export Development Agency		Regional network of Small Business Development Centres (SBDCs)	
Stakeholders responding to sargassum as resource/ commodity/ opportunity	Energy (renewable)	Caribbean Center for Renewable Energy and Energy Efficiency (CCREEE)		The Caribbean Electric Utility Services Corporation (CARILEC)	
	Harvesting - nearshore (national) vs offshore regional cooperation	TBD	TBD	TBD	TBD
	Uses - post harvest production	TBD	TBD	Algas organics	TBD
	Mitigation, cleanup, barriers (collection vessels, booms etc)	Fragmented - various national operations		Numerous e.g. AlgaeNova, EnergyAlgae	TBD



Photo credit: Hayden Billingsy

6

STRATEGY FRAMEWORK

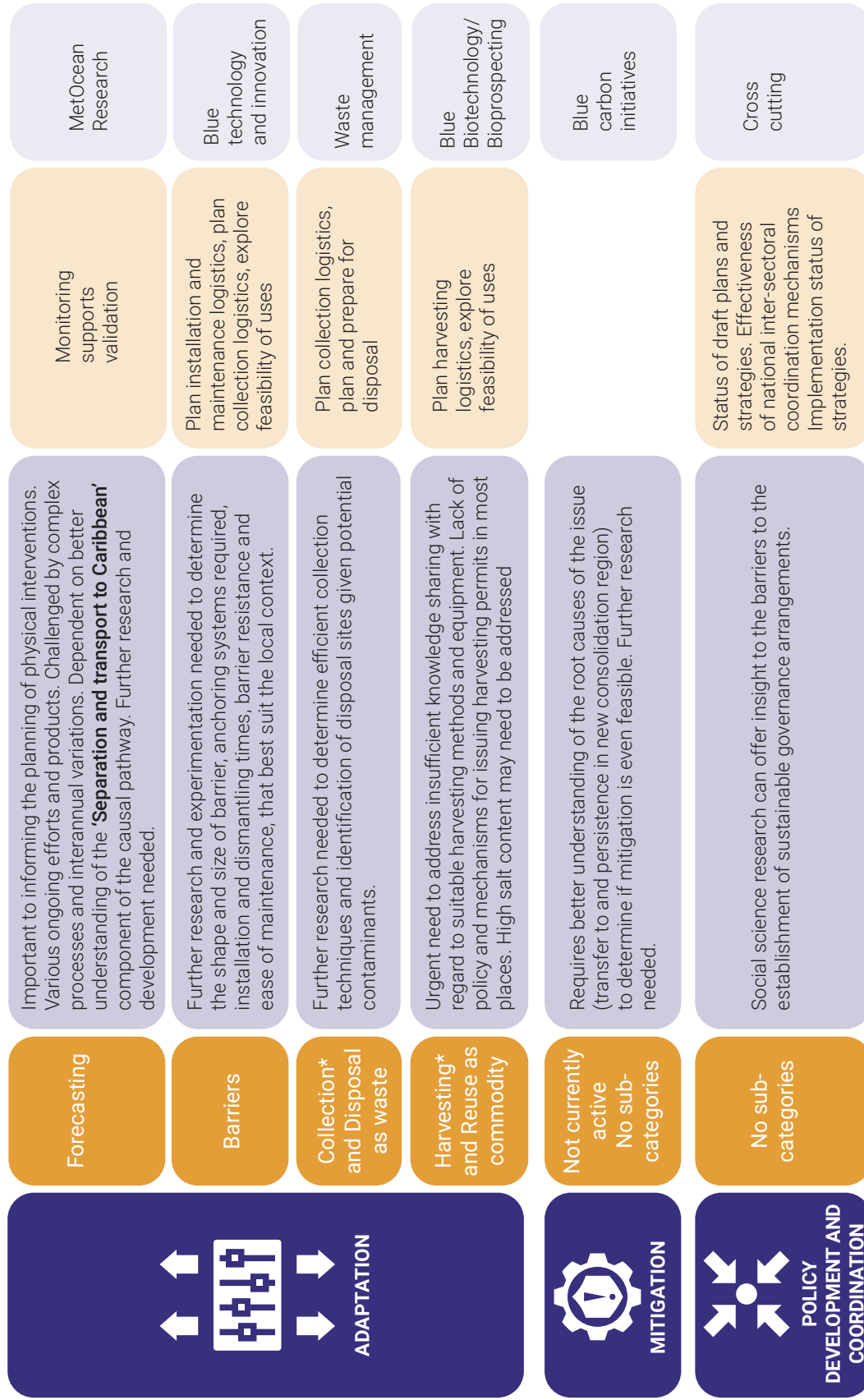
The range of possible interventions and management strategies may be broadly categorised as either adaptation or mitigation (meaning mitigation of the sargassum issue as distinct from climate change mitigation). Adaptation responses may be further categorised as efforts in forecasting, collection, disposal, or harvesting and reuse. Mitigation options are not well developed and require additional information on the root causes of the issue for further advancement. Policy development and coordination is also critical, and this will enable both adaptive and mitigative interventions. This strategy framework, presented in Table 5, will be used to identify gaps in coverage and make specific recommendations.

Some types of interventions are dependent on understanding the causal pathways/ and mechanisms of this issue. Efforts in mitigation and prediction have differing needs out of the causal analysis (Section 3.2). In the context of the causal framework, key questions in exploring mitigation include: *'how/ why does sargassum proliferate in the new consolidation region?' (leading to 'can it be stopped/ reduced?'), and 'was the incident that transferred sargassum to the new source region a one-time occurrence, or is there some means of recurrence or exchange between the new consolidation region and the original source?'* (the latter would stymie mitigation). Prediction is more considered with the process by which sargassum detaches from the main consolidation region and is transported to the Caribbean.

A key activity required as part or in support of these interventions is monitoring and quantifying sargassum influxes. This is needed to help validate forecasts, plan collection/harvesting logistics, plan and prepare for disposal, and explore use/ commoditisation opportunities.

Some of the adaptation intervention categories have clear links with Blue Economy development, and should be explored further in that context and in coordination with various regional blue economy initiatives.

FIGURE 6: | Strategy framework



* Note that 'collection' and 'harvesting' here overlap significantly, the difference is in the next step, whether disposal or putting the material to use.



7

Photo credit: Hayden Billingy

INTERVENTIONS AND MANAGEMENT STRATEGIES

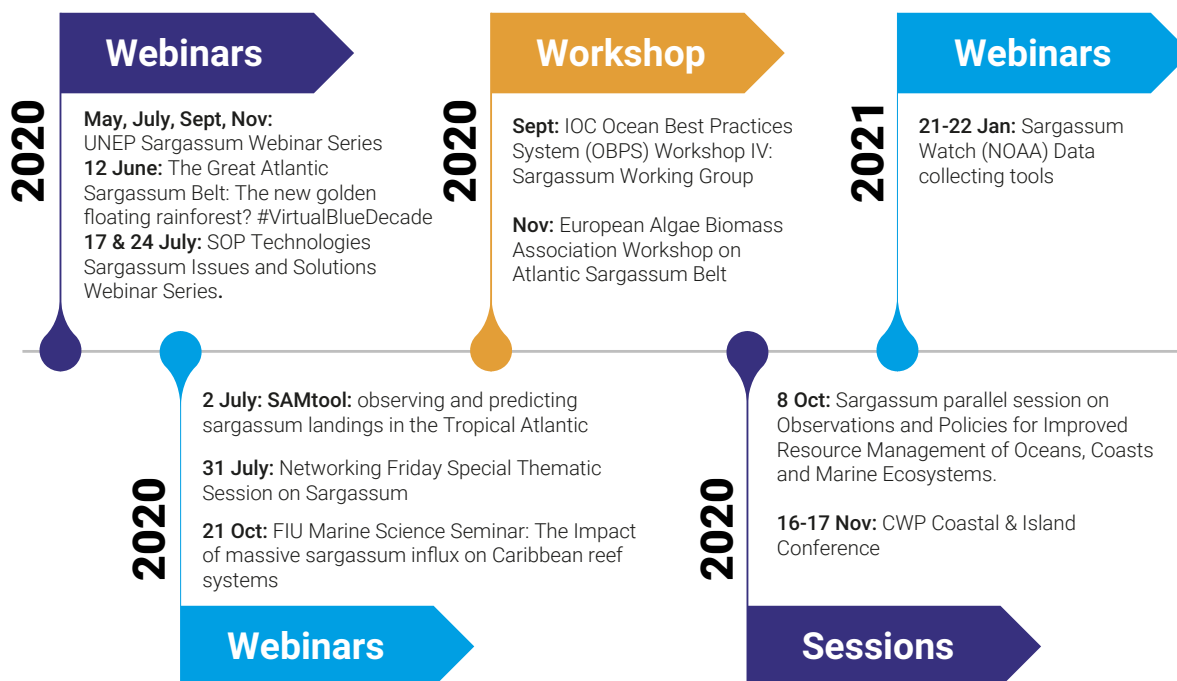
This section provides a review of existing and ongoing interventions and management strategies, including regional sargassum activities (meetings, symposia, workshops, conferences, grass roots activities etc), formal projects, programmes and initiatives, and governance arrangements. The presentation of this review is organised along the same lines as the overall strategy framework outlined in the previous section, in order to elucidate gaps in coverage and support subsequent recommendations.

Figure 7 below illustrates notable regional sargassum activities from 2015-2021.

Other activities not highlighted in the figure include the creation of numerous sargassum Facebook groups to promote information exchange, beach clean ups organised by community groups and art advocacy initiatives to inspire solutions.

FIGURE 7: Regional sargassum activities timeline (2015-2021)





For more information: <https://sargassumhub.org/events/>

Both the science and the management of this entirely new phenomenon were relatively slow to get going and are still 'playing catch-up' in what has now become a fast-moving and dynamic area of research and development. Some strides have been made albeit rather slowly in the development of forecasting and monitoring initiatives. We outline the most noteworthy in **Appendix I** and **II**. **Appendix III** highlights 27 ongoing projects, programmes and initiatives that are being implemented in the Caribbean region and in West Africa in some cases.

Several countries in the Caribbean region have established or are in the process of setting up multi-agency/multi-sectoral Taskforces or National Committees to provide support and coordination in addressing sargassum influxes. However, in many cases, the ability of these Taskforces/Committees to function has been limited by funding. In addition, draft sargassum management plans or strategies (**Appendix IV**) that have been or are being developed for some countries lack approval from cabinet or other competent authorities and resources to support implementation.

The plans are primarily a practical action, or operational plan, or an adaptive management strategy meant to be a framework for frequently updated content. Short, medium and long-term strategies are included with local strategies tailored to country and stranding site contexts. Special emphasis is placed on the importance of multi-level planning and management through intersectoral collaboration (Cox et al. 2019). National inter-sectoral coordination mechanisms (NICS) such as ocean governance committees (OGC) or fisheries advisory committees (FAC) are recommended for overseeing the implementation of the plans – as opposed to new sargassum-dedicated committees. These mechanisms can also provide a governance structure with a view of building resilience through adaptive capacity.

As part of the Climate Change Adaptation in the Eastern Caribbean Fisheries Sector (CC4FISH) project (Appendix III), CERMES, FAO and other regional partners are collaborating on several sargassum related initiatives including the development of draft national sargassum plans for four countries (Grenada, St. Kitts and Nevis, St. Lucia and St. Vincent and the Grenadines) in the Eastern Caribbean. These drafts build upon national level activities implemented under CC4FISH and other initiatives that seek to address sargassum influx events as a hazard and an opportunity. Principles of disaster risk management are being employed to address the threat aspect, while strategies for encouraging investment in innovation and entrepreneurship are provided to take advantage of the opportunity. Developing uses will require consideration by governments to update policies and regulations to allow expansion of sargassum enterprises. For example, governments will need to permit feed-in tariffs to allow the sale of electricity onto the grid and support companies in getting the necessary accreditation.

The plans are primarily a practical action, or operational plan, or an adaptive management strategy meant to be a framework for frequently updated content. Short, medium and long-term strategies are included with local strategies tailored to country and stranding site contexts. Special emphasis is placed on the importance of multi-level planning and management through intersectoral collaboration (Cox et al. 2019). National inter-sectoral coordination mechanisms (NICS) such as ocean governance committees (OGC) or fisheries advisory committees (FAC) are recommended for overseeing the implementation of the plans – as opposed to new sargassum-dedicated committees. These mechanisms can also provide a governance structure with a view of building resilience through adaptive capacity.

It has been recommended that these plans would be best placed as an annex to updated fisheries management plans (where applicable) and be operationalised as a set of webpages and links rather than remaining a static document unless it is regularly updated (every quarter, for example). Sargassum research, management and uses are all very dynamic; information is soon outdated or contested, but typically both with high uncertainty.



Photo credit: Hayden Billingy

8

GAP ANALYSIS AND RECOMMENDATIONS

The review of background information and ongoing interventions presented above was used to make an assessment of remaining gaps – in information and understanding, and in response. The gaps identified are outlined here, and then used to make recommendations. This section is organised to follow the strategy framework (Section 6).

8.1 Forecasting

Forecasting efforts, though much progress has been made, still provide only relatively low precision. Influxes do not follow a regular pattern, there are significant interannual variations. Key constraints to be addressed include:



limited optical satellite coverage in the cloud-covered sargassum source regions;



relatively low satellite image resolution and optical 'noise' (e.g. sun glint, Sahara dust, atmospheric moisture);



lack of information on the growth and mortality rates of floating sargassum as it travels through different environments;



lack of validation of regional wind induced slippage added in the predictive models versus actual movement of sargassum mats in situ; and



lack of consistent national and site-level monitoring of sargassum strandings, especially the quantity (as volume or weight) and the location, constrains the ability to validate predictive models.

Addressing the gaps in forecasting will require costly high precision imagery and radar that could help in observing movements of sargassum nearshore and support local predictions of strandings. This imagery can also address the uncertainty in the accuracy of open ocean current models over long-distance paths through this complex and dynamic ocean region. Research collaborations with meteorologists and radar specialists may offer an opportunity to explore this recommendation.

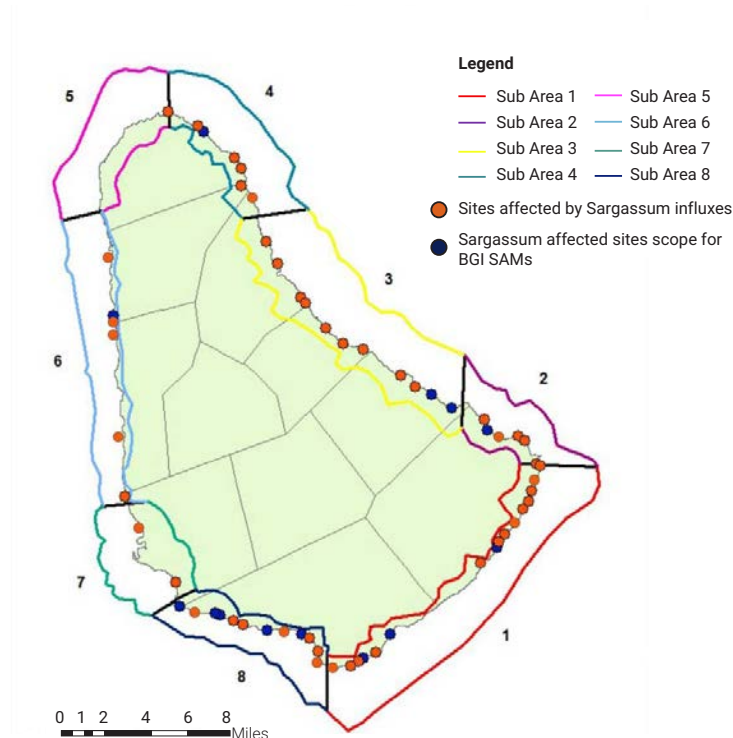
8.2 Harvesting/collection and use

With regard to the variation across the region outlined in Section 4, effective adaptive planning requires additional resolution at the level of the specific territories being affected. There is a need to acknowledge variation in impacts and systematically identify specific impacts and their spatial distribution, along with capacity and logistics within country/territory into order to effectively direct interventions to priority locations.

In order to evaluate country specific dimensions to sargassum impacts and responses, a coordinated programme of consistent spatially explicit hazard exposure and vulnerability assessments at the national level is recommended. This, or the information needed to support it, may exist to varying degrees in some locations. This would involve the following:

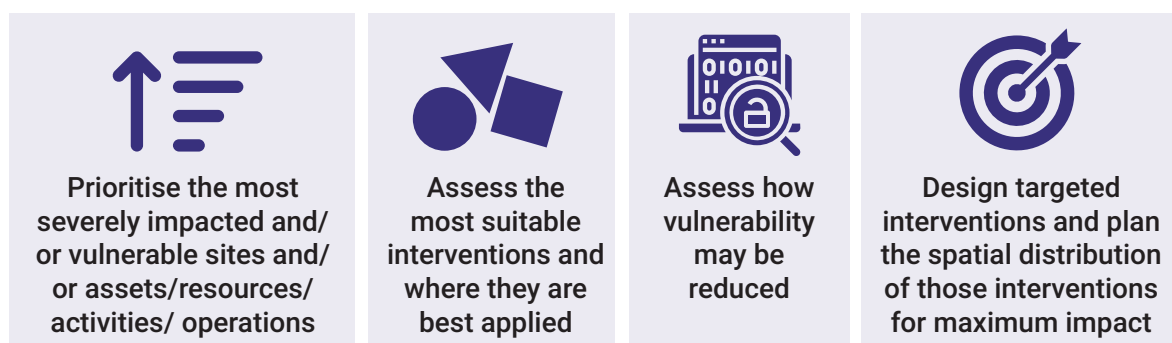
1. Mapping the spatial distribution of sargassum influxes (exposure)
2. Assessing exposed sites, mapping/ identifying the assets/ resources / activities / resources within/ near the exposure zones and identifying the specific impacts at the site
3. Assessing the vulnerability of the impacted assets/ resources / activities/ operations

FIGURE 8: Spatial Distribution of sargassum affected locations within the Barbados Integrated Coastal Zone Management (ICZM) sub areas



Source: CERMES and MMABE 2021

This assessment would be used to:



Interventions thus far focus on adaptation to intermittent sargassum influxes as a hazard, because direct mitigation of the issue is currently not possible. This in turn is because the root causes (transfer to and persistence in the new consolidation region, Section 3.2) are not well enough understood to effectively target them. This requires further research and development that would require substantial human and financial resources and the establishment of a regional governance framework given the fact that these root causes are transboundary issues.

A key question as part of this would be, was the transfer a one-off occurrence, or was there a continuous, possibly recurring process of transfer (one-way) or even exchange (two-ways)?

While there has been and continues to be work looking at the feasibility and marketability of sargassum uses and products, making the shift from hazard to opportunity requires more attention to potential value chains. This would involve assessing the locations where sargassum is available for collection, volumes available (including the inherent variability), the logistics of harvesting both in-water and onshore, the logistics of transfer to storage and/or use/production site, and finally the distribution of products to end users, and the costs and resources needed at each step. Such an analysis is needed for effective business planning at a scale significant enough to remove enough sargassum to begin to reduce the negative impacts. End use requirements – such as specific types of sargassum, fresh versus dry, absence of additional materials that may be mixed with sargassum - also need to be considered in the value chain to promote efficient production.



The potential commoditisation of sargassum also raises issues around ownership and rights to the 'resource.' There is some research into this issue, but beyond research, policy development work is required to address this, recognising that similar to other natural resources, this may be handled differently in different countries/ territories in the context of existing policy/legal frameworks.

The Caribbean is in the process of exploring the concept of the Blue Economy and developing strategies at the regional and national levels for Blue Economy development. There are opportunities for sargassum innovations to be considered as blue growth initiatives which can be integrated into blue economy strategic frameworks and road maps. This can support economic diversification and resilience to reduce economic vulnerability and reliance on a small number of sectors.

8.3 Policy and Coordination

No regional governance framework specific to the pelagic sargassum phenomenon exists to guide appropriate responses in the Caribbean. There is a lack of policy and management plans/strategies to deal with strandings, and many of those that exist have not been officially endorsed or implemented. In addition, there is also a lack of regulations to support harvesting, transport and production standard. This has led to a poor environment for encouraging investment in large-scale solutions.

The general lack of governance arrangements (policies, management plans and regulations), applicable to sargassum harvesting and use, needs to be addressed. Government policies and programmes need to present a more attractive and enabling environment that fosters innovation and supports the expansion of existing enterprises and the development of new industries. Protocols and standards need to be developed to prevent environmental damage and ensure the safety of products for consumptive or contact uses.

There are significant deficiencies in coordination and integration that relate to underlying deficiencies in regional ocean governance as outlined previously (Section 4). The response to sargassum influxes is a dynamic arena - there is no shortage of initiatives. This has reached the point of almost being problematic, creating information overload and difficulty in tracking related work. Too often, new initiatives are pursued rather than linking or building on existing ones.



For this reason, it is recommended that the CLME+ Strategic Action Programme (SAP) Interim Coordination Mechanism (ICM) should be leveraged to promote interactive governance of the sargassum issue in the region. The objectives of the ICM align with the recommendations outlined in previous sections that aim to enhance regional coordination and collaboration and support oversight.

Beyond the Caribbean, the need for transatlantic collaboration, including impacted countries/territories from both the Caribbean and West Africa has been highlighted in numerous meetings, conferences and webinars. While there are some collaborations that have begun, this remains an area in need of strengthening.



Photo credit: Hayden Billingy

9

CONTRIBUTION OF THE CARTAGENA CONVENTION TO THE STRATEGY



COOPERATION: Facilitate regional cooperation and guide national action to protect and sustainably manage ecosystems and species of national and regional concern: that may be affected by the Sargassum influx. This can be achieved through the CLME+ Strategic Action Programme (SAP) Interim Coordination Mechanism.



DATA: Ongoing cooperation with the IOCARIBE Oil Spills and Sargassum EWS, USF, Texas A&M University, CONABIO, NOAA-AOML, USM and UWI-CERMES for Sargassum early prediction systems.



PLANNING AND POLICY: Emphasis on ecosystem-management approach, linked primarily via the EBM Italian Project, the CLME+ project and UN Decades on Ecosystem Restoration and Ocean Science.



Provide guidance to implement provisions of related and broader agreements.



CAPACITY BUILDING AND OUTREACH: Emphasis on capacity building, public education and awareness, community participation, scientific information specifically through the Sargasso Forum and Parties participation in the Scientific and Technical Advisory Committee (STAC).



Active Working Group on Sargassum to advise regional decision makers by preparing Scientific and Technical Advisory Committee (STAC) documents to be endorsed politically at the COP.



Link with the Abidjan Convention to coordinate a Transatlantic action.



ONE UN approach aiming to build synergies and promote coordination and efficient use of resources.



10

GENERAL RECOMMENDATIONS

The use of the term 'sargassum influx' is recommended when addressing the challenges and impacts posed by large landings of sargassum. This terminology adequately reflects massive inundations and avoids erroneously characterising the genus *Sargassum* itself as an undesirable group of species.

The CEP Secretariat should increase collaboration and joint programming between the SPAW and LBS Protocols, particularly in the context of the SPAW Sargassum Working Group. The Secretariat is well positioned to promote regional cooperation on ocean governance and ensure ecologically friendly management interventions given the ecological and socio-economic implications of sargassum influxes for the entire area under the Cartagena Convention (UNEP-CEP 2019).

The SPAW Protocol should develop further cooperation with relevant organisations and initiatives in order to minimise duplication and enhance SPAW programme delivery. Collaboration with the Abidjan Convention (West Africa) and others such as the GEO-BluePlanet (Sargassum Information Hub) and Florida International University (SargNet) is encouraged with the objective of consolidating a common platform for Sargassum management in the Wider Caribbean and West Africa.

The CLME+ Strategic Action Programme (SAP) Interim Coordination Mechanism (ICM) should be leveraged to promote interactive governance of the sargassum issue in the region.



Photo credit: Morgan Lewis

11

CONCLUSION

Significant progress has been made in the last 10 years since sargassum influxes first emerged in the region. However, responses to addressing the issue have generally been reactive rather than proactive resulting in environmental degradation, inefficient use of resources and poor governance. There also has been significant research and business interest in exploiting sargassum as a commodity, or exploiting those desperate to be rid of sargassum. The arena is now very dynamic with the entry of many players with varying, sometimes competing interests. There are numerous projects and initiatives at national, multi-country and sub-regional levels that are sometimes very similar in nature, yet no formal attempt has been made to explore opportunities for promoting synergies to avoid unnecessary duplication.

This complexity is consistent with and reflective of the complexity and character of the region, but adds to the challenge of mounting a coherent response. With so much going on, while coordination and collaboration are much spoken of, there are inevitably fragmentation, disconnects and gaps. Effort and resources are not being applied efficiently or optimally. This situation has needed a systematic and strategic big picture review to consider what is being done, identify gaps and devise a strategy to better coordinate and apply effort and resources, fill gaps, recover costs, and promote synergies between existing initiatives. This white paper update seeks to begin that process through the provision of recommendations that will be validated through regional stakeholder input. Next steps include the development of a concept note to operationalise this strategy in an effort to reduce vulnerability and increase resilience to this issue, while seeking to explore emerging opportunity potential.

12

SELECTED READING

The documents listed below have either been cited in the preceding text of this white paper or provide additional information on many aspects of the sargassum issue. The list is not exhaustive.

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13

APPENDICES

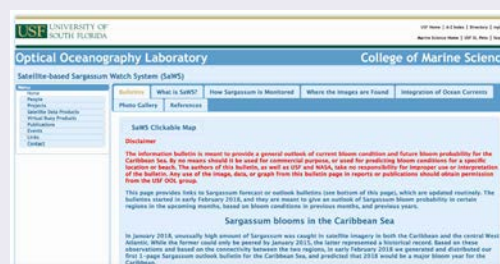
13.1. Appendix I: Forecasting Initiatives

SARGASSUM WATCH SYSTEM (SaWS)

Description: A portal developed by the Optical Oceanography Laboratory, USF. It provides open access to processed satellite images showing sargassum, and outlooks of sargassum blooms monthly for the entire Gulf of Mexico, Caribbean and the Tropical Atlantic.

Organisation/Agency: University of South Florida (USF)

Useful link: <https://optics.marine.usf.edu/projects/saws.html>



SARGASSUM EARLY ADVISORY SYSTEM (SEAS)

Description: Inactive experimental platform that provided visual processing of Landsat 8 images to draw the outline of the sargassum mats near the coasts, in about 30 small areas in the Gulf of Mexico and the Caribbean. Bulletins were also issued when the platform was operational.

Organisation/Agency: University of Texas A&M at Galveston (TAMUG)

Useful link: <http://seas-forecast.com>



SARGASSUM SUB-REGIONAL OUTLOOK BULLETIN

Description: Bi-monthly outlook bulletin presenting 3-month sargassum influx forecasts and implications to socio-economic sectors. Useful resources, recent publications and info on sargassum uses are also included.

Organisation/Agency: Centre for Resource Management and Environmental Studies (UWI-CERMES), University of Southern Mississippi (USM).

Useful link: <https://www.cavehill.uwi.edu/cermes/projects/sargassum/outlook-bulletin.aspx>



The development of this information product has benefited from the generous support of the Food and Agriculture (FAO) / Global Environment Fund (GEF) project 'Climate Change Adaptation in the Eastern Caribbean Fisheries Sector' (CC4FISH), and the Caribbean Biodiversity Fund (CBF) project 'Adapting to a new reality: managing responses to influxes of sargassum seaweed in the Eastern Caribbean (SargAdapt)', co-financed by the International Climate Initiative (IKI) of the German Federal Ministry for Environment, Nature Conservation, and Nuclear Safety through KfW.

SARGASSUM SURVEILLANCE BULLETIN FOR GUADELOUPE

Description: Weekly sargassum outlook bulletin for local authorities and government departments. Bulletins present a simple cartography of the coasts concerned, with a risk index in 4 colors, a forecast confidence index (linked to cloud cover), a forecast for the next 4 days, a trend over 2 weeks, over 2 months.

Organisation/Agency: Météo France, CLS and Nova Blue Environment (NBE)

Useful link: <http://bit.ly/MFWklyBulletin>



SAMTOOL

Description: Web-based sargassum detection and monitoring visualization platform. SAMTool allows the visualization of diverse information on a 30-day sliding time scale: cloud cover, daily sargassum identification layers, a weekly synthesis, drift predictions as well as area statistics, and detection level statistics (NFAI analysis).

Organisation/Agency: CLS

Useful link: <https://datastore.cls.fr/products/sargassum/>



SARGASSUM ALERT SYSTEM (SATSUM)

Description: Web-based maritime/coastal information and analysis system. SATSum is a sargassum monitoring and detection platform. There is also a site that presents sargassum observations on beaches with a density level, based on citizen observations.

Organisation/Agency: CONABIO (*Comisión Nacional para el Conocimiento y Uso de la Biodiversidad /National Commission for the Knowledge and Use of Biodiversity*)

Useful link: <https://simar.conabio.gob.mx>



EXPERIMENTAL WEEKLY SARGASSUM INUNDATION REPORT (SIR V1.2)

Description: Experimental Sargassum Inundation Reports (SIR) provide an overview of the risk of sargassum coastal inundation in the Caribbean and Gulf of Mexico regions. Risk is classified into three categories: low (blue), medium (orange) and high (red). In black are areas with not enough data.

Organisation/Agency: NOAA

Useful link: https://www.aoml.noaa.gov/phod/sargassum_inundation_report/

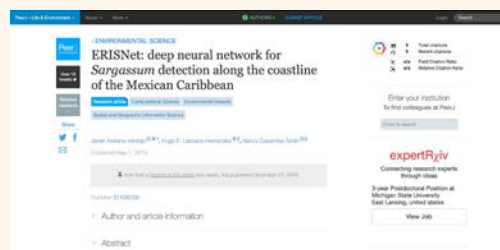


ERISNET

Description: Satellite detection platform using Artificial Intelligence to support sargassum detection along the coastline of the Mexican Caribbean.

Organisation/Agency: CONACYT (National Council for Science and Technology)

Useful link: <https://peerj.com/articles/6842/>



13.2. Appendix II: Monitoring Initiatives

SARGASSUM WATCH ON EPICOLLECT 5

Description: Citizen science project coordinated by MMRL-FIU. Platform allows submissions of reports accompanied by photos.

Organisation/Agency: Marine Macroalgae Research Lab at the Florida International University (MMRL-FIU)

Useful link: <https://five.epicollect.net/project/sargassum-watch>

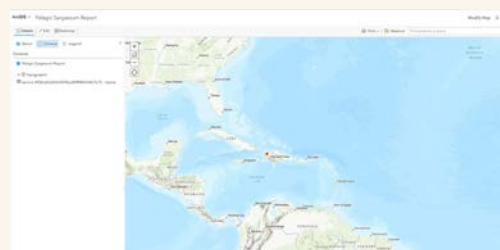


CARIBBEAN PELAGIC SARGASSUM REPORT

Description: Reporting website created with the core objective of creating a publicly available database that could be used to validate satellite and forecast products.

Organisation/Agency: CoastWatch Caribbean and Gulf of Mexico region node at NOAA/AOML

Useful link: <https://www.arcgis.com/home/item.html?id=e60a66e557a1483e-8427fe9c28157592>

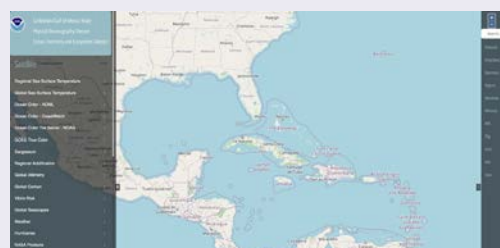


OCEANVIEWER

Description: GeoServer platform that allows users to view satellite data including processed satellite images produced by USF, and in situ observations

Organisation/Agency: NOAA/AOML

Useful link: <https://cwcgom.aoml.noaa.gov/cgom/OceanViewer/>

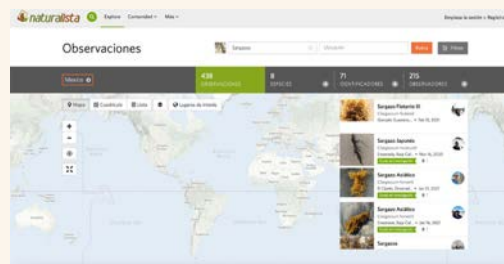


CONABIO'S MEXICAN ATLANTIC MONITORING PROJECT ON THE 'NATURALISTA' PLATFORM

Description: Citizen science platform that allows observations and close up and/or panoramic photographs of sargassum to be submitted and visualised.

Organisation/Agency: CONABIO

Useful link: https://www.naturalista.mx/observations?taxon_id=130178



UNIVERSITY OF SOUTHERN MISSISSIPPI (USM) REPORTING SITE

Description: This website serves as a data collection centre to accommodate reports of large quantities of pelagic sargassum observed within the region.

Organisation/Agency: USM

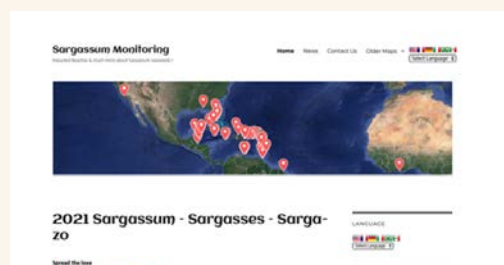
Useful link: <https://gcrl.usm.edu/sargassum/sargassum.observation.form.php>



SARGASSUM MONITORING WEBSITE

Description: Website that features maps created by reports of sargassum strandings using social media posts with the hashtag #sargassum. Photos/videos are provided for each impacted location.

Useful link: <http://sargassummonitoring.com>

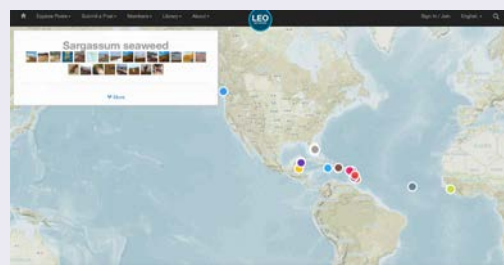


LOCAL ENVIRONMENTAL OBSERVER (LEO) NETWORK SARGASSUM REPORTING SITE

Description: Reporting site that allows the LEO network of local observers and topic experts to record observations of sargassum strandings.

Organisation/Agency: LEO Network

Useful link: <http://bit.ly/LEONetwork>



SARGASSUM SIGHTINGS FORM

Description: Reporting form that allows users to submit sargassum strandings using the KoBo Toolbox platform

Organisation/Agency: UNEP-CEP

Useful link: <https://ee.kobotoolbox.org/x/uEYhY0n7>

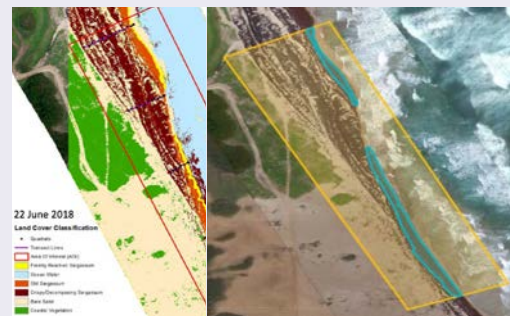


THE SARGADAPT DRONE MONITORING PROTOCOL

Description: This Protocol aims to develop the use of recreational drones, with UAS software & spatial analyses, to map, classify, & quantify the abundance of stranded sargassum. Field studies in Barbados have yielded successful results. Future work involves refinement and replication in other countries. Read more [here](#)

Organisation/Agency: UWI-CERMES, Marine Spatial Information Solutions, DroneDeploy's Drones for Good initiative, Center for Geospatial Analytics at North Carolina State University (NCSSU) Capstone Community Partnerships Program

Useful link: <https://www.cavehill.uwi.edu/cermes/projects/sargassum/sargadapt.aspx>



12.3 Appendix III: Projects, Programmes and Initiatives

SARGASSUM HUB

Description: Website that integrates information from multiple sources. Items featured include monitoring systems, in-situ observations, bulletins issued and best practices for management & use.

Organisation/Agency: Geoplanet, IOCaribe, Atlantos, Air Centre

Year Established: 2015

Useful link: <https://sargassumhub.org>



SARGNET

Description: A listserv and online network of sargassum stakeholders hosted by Florida International University (FIU).

Organisation/Agency: FIU

Year Established: 2019

Useful link: <https://listserv.fiu.edu/cgi-bin/wa?SUBED1=SARGNET&A=1>



SPAW-RAC/UNEP-CEP SARGASSUM ON-LINE FORUM

Description: Online forum that provides easy access to relevant documents on awareness, management and research about the Sargassum influx, as well as direct exchanges between stakeholders to share their experiences.

Organisation/Agency: UNEP-CEP

Year Established: 2015

Useful link: <https://www.car-spaw-rac.org/?Sargassum-on-line-forum>



CARIBBEAN COOPERATION PROGRAMME AGAINST SARGASSUM (SARG'COOP)

Description: The Caribbean cooperation programme for the monitoring of sargassum seaweed' is bringing together regional partners to share knowledge and expertise and foster collaboration across language barriers.

Organisation/Agency: Regional Council of Guadeloupe

Year Established: 2019



SARGADAPT (Adapting to a new reality: Managing responses to influxes of sargassum seaweed in the Eastern Caribbean as ecosystem hazards and opportunities)

Description: The ultimate goal of SargAdapt is to reduce the impacts of and improve adaptation to sargassum influxes in the Eastern Caribbean with emphasis on converting a climate-linked ecosystem hazard into an asset that supports opportunities for socio-economic development.

Organisation/Agency: UWI-CERMES, Caribbean Natural Resources Institute (CANARI)

Year Established: 2019 - 2022

Useful link: <https://www.cavehill.uwi.edu/cermes/projects/sargassum/sargadapt.aspx>



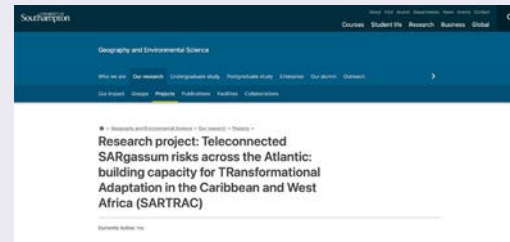
SARTRAC (Teleconnected SARgassum risks across the Atlantic: building capacity for TRansformational adaptation in the Caribbean and West Africa)

Description: SARTRAC identifies new transformational developmental opportunities that build resilience equitably, for people affected by changing biomes/ ecosystems in developing countries.

Organisation/Agency: University of Southampton, UWI-CERMES, University of Ghana, University of York

Year Established: 2019 - 2022

Useful link: <https://www.southampton.ac.uk/geography/research/projects/teleconnected-sargassum.page>



Climate Change Adaptation in the Eastern Caribbean Fisheries Sector (CC4FISH) Sargassum Subproject

Description: This sub-project aims to increase resilience and reduce vulnerability to climate change impacts including sargassum influx events in the Eastern Caribbean fisheries sector.

Organisation/Agency: FAO, UWI-CERMES, USM

Year Established: 2017-2021

Useful link: <http://www.fao.org/in-action/climate-change-adaptation-eastern-caribbean-fisheries/en/>



SASAMS (SATellite SARgassum Monitoring System)

Description: This project aims to develop a near real-time service for monitoring pelagic sargassum seaweed beaching, initially aimed at Mexico's Caribbean Coast.

Organisation/Agency: University of Nottingham, Specto Natura Ltd, Triple Line Consulting Ltd. CONABIO, UNAM, CentroGeo, Planet Inc.

Year Established: 2020

Useful link: <http://www.sasams.org>



SARGASSUM PRODUCTS FOR CLIMATE RESILIENCE IN THE CARIBBEAN

Description: The overall aim of the project is to mitigate the environmental and economic impacts of Sargassum seaweed influxes in affected Caribbean countries through the creation of inclusive value chains for Sargassum seaweed.

Organisation/Agency: CRFM, Plant and Food Research, New Zealand Crown Research Institute

Year Established: 2020 - 2023

Useful link: http://www.crfm.int/index.php?option=com_k2&view=item&id=667:sargassum-products-for-climate-resilience-in-the-caribbean&Itemid=175



ACTIVATED CARBON: A SUCCESSFUL MULTI-LATERAL AND MULTI-NATIONAL RESEARCH PROJECT

Description: This research project is investigating different activation methods and different pyrolysis temperatures (600 – 900°C) to obtain activated carbon using sargassum.

Organisation/Agency: Université des Antilles (Guadeloupe) (COVACHIMM2E laboratory), Instituto Tecnológico de Santo Domingo (INTEC) (Dominican Republic), Institut National de la Recherche Agronomique (INRA) (Guadeloupe & Nancy, France), Queen Mary University (UK), Instituto Superior de Tecnologías y Ciencias Aplicadas (InSTEC) (Cuba), Centre Inter-universitaire de Recherche et d'Ingénierie des Matériaux (CIRIMAT) (Toulouse, France), Université d'État d'Haïti (Haïti), Université Quisqueya, NBC (French Guiana), TECMALAB (Dominican Republic), NUM SMO Technologies (NST) and Phytobokaz (Guadeloupe)

Year Established: 2019

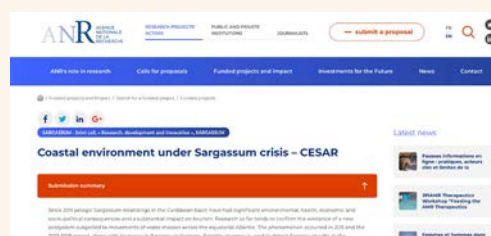
CESAR (Coastal environment under sargassum crisis)

Description: This projects seeks to develop tools and methods to manage sargassum influxes in the Caribbean, particularly in the French West Indies.

Organisation/Agency: Coordinator and collaborators can be found [here](#)

Year Established: 2017

Useful link: <https://anr.fr/Project-ANR-19-SARG-0005>



CORSAIR (Atmospheric and marine corrosions)

Description: The main aim of this project to investigate the corrosion rate of exposure sites and modelling the phenomenon of corrosion and its natural inhibitory solution. It also seeks to characterize of biofilms and compile legal tools

Organisation/Agency: Coordinator and collaborators can be found [here](#)

Year Established: 2019

Useful link: <https://www.slideshare.net/CRGuadeloupe/corsair-c-roos-l3ma-universit-des-antilles>



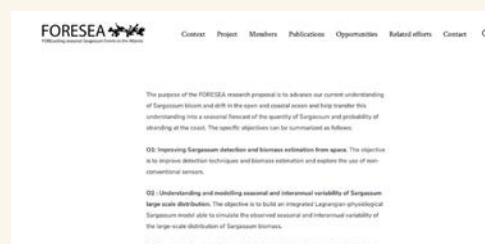
FORESEA (Forecasting of sargassum stranding in the Tropical Atlantic)

Description: The purpose of the FORESEA research proposal is to advance the current understanding of Sargassum bloom and drift in the open and coastal ocean and help transfer this understanding into a seasonal forecast of the quantity of Sargassum and probability of stranding at the coast.

Organisation/Agency: Coordinator and collaborators can be found [here](#)

Year Established: 2019

Useful link: <https://sargassum-foresea.cnrs.fr/la-recherche/>



PYROSAR (Valorisation of sargassum by pyrolysis-application for food safety)

Description: This project aims to optimize the production of biochar and activated carbon from sargassum at laboratory and industrial scale using the solar microwave process of NST

Organisation/Agency: Coordinator and collaborators can be found [here](#)

Year Established: 2019

Useful link: <https://www.regionguadeloupe.fr/actualites-et-agendas/toute-lactualite/detail/actualites/presentation-des-resultats-de-lappel-a-projet-sargasse/#>



SARG AS CLD (Environmental impacts of sargassum leachate due to arsenic and chlordecone: quantification)

Description: The initiative seeks to improve knowledge on sargassum contamination by arsenic (marine origin) and chlordecone (terrestrial origin).

Organisation/Agency: Coordinator and collaborators can be found [here](#)

Year Established: 2019

Useful link: <https://www.regionguadeloupe.fr/actualites-et-agendas/toute-lactualite/detail/actualites/presentation-des-resultats-de-lappel-a-projet-sargasse/#>

SARGACARE (Human health effects of chronic exposure to gaseous fumes from decomposing brown algae in the French West Indies)

Description: Goal: Conduct a detailed study of the clinical, biological, functional and socio-anthropological consequences of gaseous emissions produced by decomposing sargassum

Organisation/Agency: Coordinator and collaborators can be found [here](#)

Year Established: 2019

Useful link: <https://www.regionguadeloupe.fr/actualites-et-agendas/toute-lactualite/detail/actualites/presentation-des-resultats-de-lappel-a-projet-sargasse/#>

SARGASSUM ORIGINS (Identity and origins of pelagic sargassum)

Description: This project aims to identify sargassum species growing in the North Atlantic (co-occurrence) by studying the connectivity of sargassum at the Atlantic scale.

Organisation/Agency: Coordinator and collaborators can be found [here](#)

Year Established: 2019

Useful link: <https://www.regionguadeloupe.fr/actualites-et-agendas/toute-lactualite/detail/actualites/presentation-des-resultats-de-lappel-a-projet-sargasse/#>

SARGOOD (Holistic approach to sargassum valorisation)

Description: The project will conduct an assessment of the sargassum life cycle and develop innovative materials and technologies.

Organisation/Agency: Coordinator and collaborators can be found [here](#)

Year Established: 2019

Useful link: <https://www.regionguadeloupe.fr/actualites-et-agendas/toute-lactualite/detail/actualites/presentation-des-resultats-de-lappel-a-projet-sargasse/#>

SARGSCREEN (Pharmaco-toxicological screening of molecules extracted from Caribbean sargassum: highlighting their impact on certain pathologies widespread in the Caribbean)

Description: The project aims to detect pharmacological potential of sargassum extracts against pathologies spread over the Caribbean.

Organisation/Agency: Coordinator and collaborators can be found [here](#)

Year Established: 2019

Useful link: https://www.regionguadeloupe.fr/actualites-et-agendas/toute-lactualite/detail/actualites/presentation-des-resultats-de-lappel-a-projet-sargasse/#_

SARTRIB (Tribological and electrochemical valorisation of sargassum)

Description: Aim: Valorisation of vacuum pyrolysis by-products of sargassum: electrodes for lithium batteries and new generation of lubricant.

Organisation/Agency: Coordinator and collaborators can be found [here](#)

Year Established: 2019

Useful link: https://www.regionguadeloupe.fr/actualites-et-agendas/toute-lactualite/detail/actualites/presentation-des-resultats-de-lappel-a-projet-sargasse/#_

SAVE (Sargassum agricultural valorisation and energy production)

Description: This project seeks to identify non-destructive sargassum harvest methods and develop a social and environmental approach to integrating the treatment of sargassum and local bio wastes.

Organisation/Agency: Coordinator and collaborators can be found [here](#)

Year Established: 2019

Useful link: https://www.regionguadeloupe.fr/actualites-et-agendas/toute-lactualite/detail/actualites/presentation-des-resultats-de-lappel-a-projet-sargasse/#_

SAVE-C (Study of holopelagic sargassum responsible of massive beachings: valorisation and ecology on Caribbean Coasts)

Description: This project aims to better understand the diversity and the functioning of pelagic sargassum, from the drifting rafts until their beaching

Organisation/Agency: Coordinator and collaborators can be found [here](#)

Year Established: 2019

Useful link: https://www.regionguadeloupe.fr/actualites-et-agendas/toute-lactualite/detail/actualites/presentation-des-resultats-de-lappel-a-projet-sargasse/#_

DEVELOPING A SUSTAINABLE SARGASSUM VALUE CHAIN

Description: Research project seeking to identify sustainable business opportunities utilizing sargassum seaweed that could lead to the development of a sustainable sargassum value chain, easy to replicate and scaled- up in other areas or countries

Organisation/Agency: Polytechnic University in Quintana Roo (UPQRoo)

Year Established: 2019

SOS (Sargassum Ocean Sequestration) of Carbon

Description: This project supports the production of a specialized machine used as an alternative way to manage pelagic sargassum strandings. The machine pumps sargassum to a critical depth where it becomes negatively buoyant. Also exploring carbon credit or carbon trading opportunities.

Organisation/Agency: Massachusetts Institute of Technology (MIT)

Year Established: 2019

Useful link: <https://soscarbon.com>



ENERGYALGAE

Description: Multi-sectoral and multi-national initiative developing sustainable sargassum uses with a focus on bioenergy.

Organisation/Agency: AlgaeNova, Grupo Puntacana, University APEC (UNAPEC), Y.A. MAOF Holdings & Management Ltd.

Year Established: 2019

Useful link: <https://www.energy-algae.com>



CLOSING THE CIRCLE PROGRAMME

Description: Exploring challenges and advancing potential solutions to marine debris, Sargassum threats and marine spatial planning in Small Island Developing States with a particular focus on the Eastern Caribbean region.

Organisation/Agency: World Maritime University

Year Established: 2020

Useful link: <https://closing-the-circle.wmu.se>



SARGASSUM PODCAST

Description: A podcast hosted by marine educators and scientists with a range of expertise in Sargassum and Coastal Communities. The podcasts interviews a variety of stakeholders about how they experience Sargassum, a floating algae that has caused severe problems when beaching in the wider Caribbean and West Africa.

Organisation/Agency: Marine conservation without borders

Year Established: 2021

For more info: www.marinefrontiers.org/sargassum

To listen and subscribe to the podcast go to <https://anchor.fm/sargassum-podcast> (audio only) or [https://youtube.com/playlist?list=PLJmthP9YWdLQbvb7dJz271d1RUvUam3Z5\(vi-deo\)](https://youtube.com/playlist?list=PLJmthP9YWdLQbvb7dJz271d1RUvUam3Z5(vi-deo)).

You can also listen to it on:

Spotify: <https://open.spotify.com/show/3Y4oa8F6DtpyC4l-7w09NSr>

Breaker: <https://www.breaker.audio/the-sargassum-podcast>

Google podcast: <https://podcasts.google.com/feed/aHR-0cHM6Ly9hbmNob3luZm0vcy80NmE1ZjU3OC9wb2RjYXN0L3Jzcw==>

Pocket cast: <https://pca.st/kv0u4fda>

Radio Public: <https://radiopublic.com/the-sargassum-podcast-Gmb7qN>

13.4 Appendix IV: Sargassum management plans and strategies in the Caribbean

Country/ Territory	Document type	Plan/Strategy title	Publication year
Antigua and Barbuda	Request for Expression of Interest	Request for Expression of Interest for the Supply of Equipment and Machinery for Aquatic Sargassum seaweed removal in Antigua and Barbuda	2018
Bahamas	None found	N/A	N/A
Barbados	Management plan Management strategy	Barbados Sargassum Management Plan Barbados Sargassum Adaptive Management Strategy	2019 2021
Belize	None found	N/A	N/A
Dominica	Strategic preparedness plan	Strategic Sargassum Preparedness Plan	2019
Dominican Republic	None found	N/A	N/A
Grenada	Model protocol Management strategy	Protocol for the management of the extreme accumulations of sargassum on the coast of Grenada Grenada Sargassum Adaptive Management Strategy	2017 2021
Guyana	None found	N/A (supposed to be modifying CRFM protocol)	N/A
Haiti	None found	N/A	N/A
Jamaica	Strategic preparedness plan	National Response Strategy: The Sargassum Threat	2015
Puerto Rico	None found	N/A (Protocol for the management of extreme accumulation of Sargassum on the coasts of Puerto Rico)	N/A
St Kitts and Nevis	Management brief Management strategy	Plan for the Management of the Accumulations of Sargassum on the Coastal and Marine Ecosystem St. Kitts and Nevis Sargassum Adaptive Management Strategy	2017 2021
St. Lucia	Management brief Management strategy	Saint Lucia National Strategy for the Management of Sargassum Influxes on Beaches, Bays and Small Harbours St. Lucia Sargassum Adaptive Management Strategy	2017 2021

Country/ Territory	Document type	Plan/Strategy title	Publication year
St Vincent and the Grenadines	Management brief Management strategy	The Management of Extreme Accumulations of Sargassum on the Coasts of St. Vincent and the Grenadines St. Vincent and the Grenadines Sargassum Adaptive Management Strategy	2017 2021
Suriname	None found	N/A	N/A
Trinidad and Tobago	Management brief	National sargassum response plan Draft Tobago Emergency Response Plan	2016 2016
Turks and Caicos	None found	N/A	N/A
US Virgin Islands	None found	N/A	N/A
Anguilla (UK)	Management plan	Draft Sargassum management plan	2015
British Virgin Islands (UK)	Statements to parliament	Statement by Deputy Premier and Minister for Natural Resources and Labour Dr. The Honourable Kedrick D Pickering "Sargassum Seaweed Phenomenon"	2015
Bermuda (UK)	None found	N/A	N/A
Cayman Islands (UK)	None found	N/A	N/A
Montserrat (UK)	None found	N/A	N/A
Aruba (NL)	Management brief (NL)	Prevention and clean-up of Sargassum in the Dutch Caribbean	2019
Bonaire (NL)			
Curaçao (NL)			
Saba (NL)			
St Eustatius (NL)			
St Maarten (NL)			
Guadeloupe (Fr)	Report and recommendations (FRA)	Le phénomène d'échouage des sargasses dans les Antilles et en Guyane	2016
Guyane (French Guiana) (Fr)			
Martinique (Fr)			
St Martin (Fr)			

