

Eighth Meeting of the Scientific and Technical Advisory Committee (STAC) to the Protocol Concerning Specially Protected Areas and Wildlife (SPA) in the Wider Caribbean Region

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**Sargassum White Paper - Sargassum Outbreak in the Caribbean:
Challenges, Opportunities and Regional Situation**

For reasons of economy and the environment, Delegates are kindly requested to bring their copies of the Working and Information documents to the Meeting, and not to request additional copies.

***Sargassum* Outbreak in the Caribbean: Challenges, Opportunities & Regional Situations**

by the SPAW Sub-Programme at the UN Environment CEP Secretariat

Conceptual background

Pelagic *Sargassum* is a type of brown alga or seaweed that can form large floating mats that are often referred to as “golden tides”. Field surveys and satellite maps indicate that *Sargassum* blossoms naturally in the Tropical South Atlantic and in the North Atlantic including the Sargasso Sea, over an area spanning 2 million square miles in the warm waters of the Atlantic Ocean. In the last few years, there have been several episodes of unusual quantities of two species of *Sargassum*, *S. natans* and *S. fluitans*, reaching the coasts of many of the islands of the Caribbean Sea, and countries in South, Central, and North America. What appears to have been an unprecedented quantity of pelagic *Sargassum* reached Caribbean islands in the spring of 2011¹. Anomalous amounts of *Sargassum* also reached the coasts of Sierra Leone and the Gulf of Guinea in June 2011. Satellite images now show unusually high amounts of *Sargassum* spreading throughout the tropical Atlantic and Caribbean Sea in 2018.

Scope and Methodology

This white paper is not an exhaustive review of current knowledge on *Sargassum*. Instead, this is a brief overview of the current situation that includes some novel quantitative data on the regional situation across the Wider Caribbean Region. A survey (see Appendix) was sent to the UN Environment CEP National Focal Points of the member states of the region, and results were coupled with additional research and satellite data. We thank the 49 respondents from 28 sovereign states and dependent territories for their participation in the survey, as their responses help us to better understand the status and needs of the region.

Causes of *Sargassum* Invasion

In 2013, satellite images showed that there was an area where *Sargassum* concentrated in the tropical North Atlantic over 600 km offshore from South America, to the north and west of the mouth of the Amazon River². There is no evidence that the *Sargassum* increases are in any way related to Amazon River outflow. Rather, the Amazon River plume is used as a tracer of the retroflection of the North Brazil Current³. Indeed, for about 18 months prior landing in 2013, back traces from the *Sargassum* sighting location were made using a high-resolution numerical ocean current model which pointed to waters near the North Equatorial Recirculation Region (NERR)⁴. *Sargassum* may aggregate in the NERR region and bloom there. Reports indicate that when the North Brazil Current Retroflection region

¹Gower, J. & King, S. (2011) Distribution of floating *Sargassum* in the Gulf of Mexico and the Atlantic Ocean mapped using MERIS. *International Journal of Remote Sensing*, 32, 1917–1929.

²Gower, J., Young, E. & King, S. (2013) Satellite images suggest a new *Sargassum* source region in 2011. *Remote Sensing Letters*, 4:8, 764-773.

³Muller-Karger, F., Richardson, P. & McGillicuddy, D. (1995) On the offshore dispersal of the Amazon's Plume in the North Atlantic. *Deep-Sea Research I*, 42:11/12, 2127-2137.

⁴Johnson, D.R., Franks, J.S., Ko, D.S., Moreno, P. & Sanchez-Rubio G. (2013) *Sargassum* Invasion of the Eastern Caribbean and West Africa 2011: Hypothesis. *Proceedings of the GFCI 2012 annual meeting*.

broke down prior to 2011, *Sargassum* was ‘flushed’ from the NERR in spring of 2011. More recent satellite images reveal increasing trends in *Sargassum* amount in both the tropical Atlantic and the Caribbean through 2018 (Figure 1). The currents that have resulted in the movement of more *Sargassum* into the Eastern Caribbean and Northwest African coastlines are not clear at this time.

Surface waters of the NERR are warm. Satellite data shows that the annual average temperature of surface water in the western tropical Atlantic including the Caribbean Sea increased over 0.75 degrees Centigrade between 1982 and 2018. Many organisms reproduce faster in warmer waters. However, it is unclear whether the increasing trend of *Sargassum* can be associated with the warming of the tropical North Atlantic Ocean.

There is no evidence that river discharge and nutrients from rivers has stimulated new growth of *Sargassum*. The tropical Atlantic has for ages received rich nutrient inputs from some of the largest rivers in the world, including the Amazon, Orinoco, and Congo Rivers. There is also upwelling in the equatorial regions of the Atlantic, and along tropical Africa and South America. The tropical Atlantic also receives dust from the Sahel in Northwest Africa which is rich in iron⁵. While these nutrients may enhance the growth of *Sargassum*, these inputs have not likely varied enough to be the primary cause for the *Sargassum* impacts on the greater Caribbean region in recent years.

To understand the causes of the inflow of *Sargassum* to the Caribbean Sea it will be necessary to conduct an in-depth study of the circulation of currents and winds as they have changed over many decades in the entire tropical Atlantic. It is also important to make detailed physiological studies of the different *Sargassum* species, and better understand the origin of each, i.e. where the stock originates.

Further, to understand the ecological role and impacts of changes in the *Sargassum* distribution and abundance, and the environmental conditions that drive these changes, it is useful to develop and track indicators of the biodiversity of the pelagic habitats of *Sargassum* and of the coastal areas where it lands (corals, beaches, wetlands).

It is important for these studies to engage in efforts to measure Essential Ocean Variables, such as those developed by the Intergovernmental Commission (IOC and IOCARIBE), and to develop and use Best Practices curated by the IOC’s IODE. Additional important partners in these efforts are UN Environment, the Ocean Biogeographic Information System (OBIS), and the Marine Biodiversity observation Network (MBON) <http://www.marinebon.org/about-mbon.html>.

Indeed, the exact conditions (chemical, physical, or biological drivers) responsible for the unusual bloom of seaweeds in the region remain unclear. Understanding the possible causes for the proliferation of the massive seaweeds in recent times requires further research, but the following (still untested) hypotheses have been advanced:

- Warming and changing of ocean temperature due to long-term cycles such as the Atlantic Meridional Oscillation or AMO, and/or global climate change
- Changes in ocean circulation

⁵Johnson, D.R., Franks, J.S., Ko, D.S., Moreno, P., Sanchez-Rubio G (2013) *Sargassum* Invasion of the Eastern Caribbean and West Africa 2011: Hypothesis. Proceedings of the GFCI 2012 annual meeting.

The following causes are the subject of substantial speculation, but whether they play a role is unclear and perhaps even unlikely:

- Increased land-based nutrients and pollutants (which include nitrogen-heavy fertilizers and sewage waters) washing into the ocean water.
- Flow of nutrients from the Congo River, Amazon River, and Northwest Africa iron-rich dust.
- Maritime traffic as a potential introduction vector.

In January 2018, unusually high amounts of *Sargassum* were observed in satellite imagery in both the Caribbean and the central West Atlantic, according to the *Sargassum Watch System* (SaWS)⁶ operated by the University of South Florida (USF)'s Optical Oceanography Lab (OOL). While the satellite records are only available through July 2000, the 2018 bloom represents a historical record.

Based on these observations and based on the connectivity analyses done by tracking surface currents and surface ocean winds, in early February 2018 SaWS generated and distributed the first 1-page *Sargassum* outlook bulletin for the Caribbean Sea⁷. SaWS predicted that 2018 would be a major bloom year for the Caribbean. The prediction was confirmed by various local reports around the Caribbean in later months.

Effects

Recent reports on the invasion of *Sargassum* in West Africa and the Caribbean suggest that since 2011, *Sargassum* has become a regional phenomenon. It negatively impacts aquatic resources, fisheries, waterway, shorelines and tourism. The unprecedented scale of the *Sargassum* invasion also led to emergency conditions in several Caribbean countries.

Ecological – Unfortunately, there is very little knowledge of the ecological impacts of invasive seaweeds on the ecosystem in general which needs to be assessed. The assumption, however, is that massive influx of *Sargassum* seaweed has resulted in potential disturbance of marine life living in the coastal zone (dead fish and sea turtles have been found when *Sargassum* washes onto the shore in massive quantities, showing the potential correlation), beach fouling, and coastal dead zones. The accumulation and decay of large amounts of *Sargassum* in the water can result in anoxia and the release of poisonous hydrogen sulphide, potentially causing the death of marine life⁸. Entanglement of foraging turtles in the *Sargassum* rafts, and blockage of turtle nesting sites by the seaweed that reaches the beach also represents a threat to turtle populations⁹. Moreover, the use of machinery to remove seaweed may impact beach habitats. The ecological effects in pelagic zones and in the High Seas, on the other hand, are not understood and may be positive (i.e., refugia for other organisms in the pelagic environment).

⁶Satellite-based *Sargassum* Watch-System (SaWS). University of South Florida, Optical Oceanography Laboratory College of Marine Science. Available at: <https://optics.marine.usf.edu/projects/saws.html>.

⁷Satellite-based *Sargassum* Watch-System (SaWS). University of South Florida, Optical Oceanography Laboratory College of Marine Science. Available at: <https://optics.marine.usf.edu/projects/saws.html>.

⁸Pfaff, M. (2015) Key scientific questions addressing environmental drivers and effects of periodic mass deposits of a brown seaweed (golden tides) along the Sierra Leone coast. Draft report for Oceans and Coastal Research, Directorate: Biodiversity and Coastal Research.

⁹Maurer, A., De Neef, E. & Stapleton, S. (2015) *Sargassum* accumulation may spell trouble for nesting sea turtles. *Frontiers in Ecology and the Environment*, 13:7, 394-395.

As mentioned above, it is important to develop indicators of biodiversity in partnership with UN Environment, GOOS/IOCARIBE, OBIS and MBON.

Socio-economic – Recent reports on the invasion of *Sargassum* in West Africa and the Caribbean suggest that there are conditions during which this becomes a regional phenomenon, negatively impacting aquatic resources, fisheries, waterway, shorelines and tourism. Massive *Sargassum* deposits on beaches have negative impacts on the socioeconomic aspects of livelihood (tourism, fishery industries etc.) of coastal communities. Some areas of the Caribbean have witnessed large declines in tourism, such as a 35% drop during this year's first semester in Mexico¹⁰. *Sargassum* blooms result in reduced access to fishing grounds and disrupted fishing operations¹¹. Fisheries and aquaculture may also be severely impacted by the mortality of fish and other marine life¹², resulting in reduced and/or altered fish catches¹³. There is a need to develop regional cooperation on ocean governance and ensure an ecologically friendly management (transformation and value-addition to animal feed and fertilizers etc.) intervention of the *Sargassum* seaweed.

Ecological Importance of *Sargassum*

Besides the ecological and socio-economic effects of the invasive seaweeds, *Sargassum* provides refuge for migratory species and serves as an important nursery habitat for a vast array of invertebrate and fish species that are closely associated with the ecosystem¹⁴. At least “127 species of fish and 145 invertebrate species have been associated with the presences of *Sargassum* algae”¹⁵. Of these species, 10 are known to be endemic to our ecosystem, including the *Sargassum* crab, *Sargassum* shrimp, *Sargassum* pipefish, *Sargassum* anemone, *Sargassum* slug, *Sargassum* snail, juvenile swordfish, triggerfish, filefish, driftfish, and sea turtle species.

Of all these marine vertebrate species, sea turtles appear to be the most threatened as they depend on *Sargassum* to provide structural complex habitat and also as refuge from predators, protection against threat from poaching, coastal development and fisheries bycatch. This implies that *Sargassum* plays an important role during the critical neonate cycle of sea turtle.

¹⁰Arellano, S. Sargazo provoca baja de 35% de turismo: alcaldesa electa en QRoo. Milenio, August 3rd 2018. Accessed September 20th 2018. Available at: <http://www.milenio.com/estados/sargazo-provoca-baja-35-turismo-alcaldesa-electa-qroo>.

¹¹Solarin, B., Bolaji, O. & Akinnibadage R. (2014) Impact of an invasive seaweed *Sargassum hystrix* var. *Fluitans* (Børgesen 1914) on the fisheries and other economic implications for the Nigerian coastal waters. IOSR Journal of Agriculture and Veterinary Science, 7:7, 01-06.

¹²Pfaff, M. (2015) Key scientific questions addressing environmental drivers and effects of periodic mass deposits of a brown seaweed (golden tides) along the Sierra Leone coast. Draft report for Oceans and Coastal Research, Directorate: Biodiversity and Coastal Research.

¹³Fogarty, P. (2018) *Sargassum*: The seaweed deluge hitting Caribbean shores. BBC News, August 6th 2018. Accessed September 20th 2018. Available at: <https://www.bbc.com/news/world-latin-america-45044513>.

¹⁴Wells, R.J.D. & Rooker, J.R. (2004). Spatial and Temporal Patterns of Habitat Use by Fishes Associated with *Sargassum* Mats in the Northwestern Gulf of Mexico. Bulletin of Marine Science, 74:1, 81-99.

¹⁵Laffoley, D, Howard, R., Angel, M. & Vats V. (2011) The protection and management of the Sargasso Sea: The golden floating rainforest of the Atlantic Ocean. Summary Science and Supporting Evidence Case. Sargasso Sea Alliance.

Regional Activities on the *Sargassum* Influx

Regarding this transatlantic issue, the Abidjan Convention collaborates with the Cartagena Convention, through its biodiversity Protocol and its SPAW-RAC (the Regional Activity Center for the implementation of the Protocol Concerning Specially Protected Areas and Wildlife of the Cartagena Convention). Since early 2015 the SPAW-RAC developed a regional cooperation and information platform with all interested countries and organizations for the enhancement of collaboration between different sectors and sharing of information and experiences through an on-line forum on which more than 200 members are registered and contribute to the exchanges.

The year 2015 was marked by many initiatives and the *Sargassum* influx was discussed in several scientific and management events in the Caribbean and in West Africa. The first *Sargassum* Caribbean Symposium hosted at the University of the West Indies in August (<http://www.sargassumat-cermes.com/>), the Gulf and Caribbean Fisheries Institute Annual meeting in Panama, the first Caribbean Sea Commission Symposium in Trinidad (both in November 2015). In March 2016, a *Sargassum* East Caribbean Conference was organized on Mosquito Island in the British Virgin Island, by the BVI Government, Virgin Unite, the Caribbean Council, the UK Foreign & Commonwealth Office and the Organisation of Eastern Caribbean States. This brought together various stakeholders from the Caribbean, Europe and Africa concerned by the issue. The need for coordination at a wider scale was highlighted, including for the development of best management practices and awareness.

More recently the Intergovernmental Oceanographic Commission (IOC of UNESCO) organized a Workshop on *Sargassum* and Oil Spills Monitoring Pilot Project for the Caribbean and Adjacent Regions in Mexico, D.F. May 2018 aiming to aggregate information from existing regional *Sargassum* identification/tracking/forecast systems and collaborate with regional interests to develop products and user interfaces for accessing information among others.

***Sargassum* on the 2nd United Nations Environment Assembly (UNEA-2) agenda and Caribbean Region**

In the context of the Post-2015 Sustainable Development Goals 13 (combating climate change and its impacts) and 14 (conserving and sustainably use of the oceans, seas and marine resources for sustainable development), and in the framework of the United Nations negotiations of a new global agreement for biodiversity in areas beyond national jurisdiction, the Abidjan and Cartagena Conventions are working with UN Environment/Global Programme of Action and affected member States to ensure that the *Sargassum* seaweed impact is discussed at the upcoming United Nations Environment Assembly UNEA-2 Side Event.

At the 2017 Oceans Conference, the Association of Caribbean States committed to controlling the *Sargassum* Seaweed in the Caribbean Sea through monitoring and exploration of commercial use.¹⁶

¹⁶The Ocean Conference. Available at: <https://oceanconference.un.org/commitments/?id=15536>.

UN Environment Caribbean Environment Programme and the Sargassum Issue

The contribution of SPAW – Regional Activity Centre (SPAW-RAC) to the Sargassum outbreaks:

The SPAW-RAC facilitated networking on different topics among countries and followed development and implementation of research projects:

- In November 2016, the SPAW-RAC hosted a technical session on the *Sargassum* influx at the 69th Gulf Caribbean Fisheries Institute (GCFI) annual meeting;
- The SPAW-RAC has been in contact with many project developers for collection and reuse of *Sargassum* and assists stakeholders by sharing the information on different methods, as well as encouraging more sustainable ones.
- The SPAW-RAC helped in the launch of an interactive platform of exchanges, with around 250 members to date. This “*Sargassum* on-line forum”¹⁷ provides easy access to information and experiences on management practices and research about the *Sargassum* influx.

The Caribbean Environment Programme’s (CEP) SPAW Protocol has partnered with University of South Florida (USF) and Texas A&MG (TAMUG) - it is recommended that a system to predict incoming *Sargassum* be developed with support of the Watch System from USF (see below) alongside TAMUG and other partners, as it is evident that residents need a system to forecast *Sargassum* blooms and beaching in both the long and short terms. A project is currently underway at TAMUG regarding short term forecasting of *Sargassum* landings with greater specificity of sites (beaches).

Long term research and forecasting system in place (University of South Florida University):

- In January 2018, unusually high amounts of *Sargassum* were caught in satellite imagery in both the Caribbean and the central West Atlantic.
- In February 2018 USF predicted that 2018 would be a major bloom year for the Caribbean.
- Several territories in the Gulf of Mexico and the Caribbean have already confirmed exceptionally high levels of seaweed for the year – e.g. Barbados, Trinidad (primarily east coast communities from Cumana to Guayaguayare), Antigua and Barbuda, and Martinique to name a few.
- Since February 2018 USF has generated and distributed monthly *Sargassum* outlook bulletins to update *Sargassum* situation in the Caribbean

In addition to near real-time satellite imagery for monitoring and monthly bulletins for forecasting, research is also underway at USF to study *Sargassum* biomass and nutrients and to understand the environmental conditions that favour *Sargassum* blooms and aggregations.

¹⁷Sargassum on-line forum. Available at: <http://www.car-spaw-rac.org/?Sargassum-on-line-forum.684>

Short term forecasting system in place:

The Sargassum Early Advisory System (SEAS) at Texas A&M combines high-resolution satellite imagery and surface currents and winds to make predictions of possible Sargassum inundation on beaches. Similar systems have been implemented for selected Caribbean countries. However, there is significant gap in connecting researchers developing *Sargassum* identification and forecasting methods with national and regional agencies challenged by dealing with the problem.

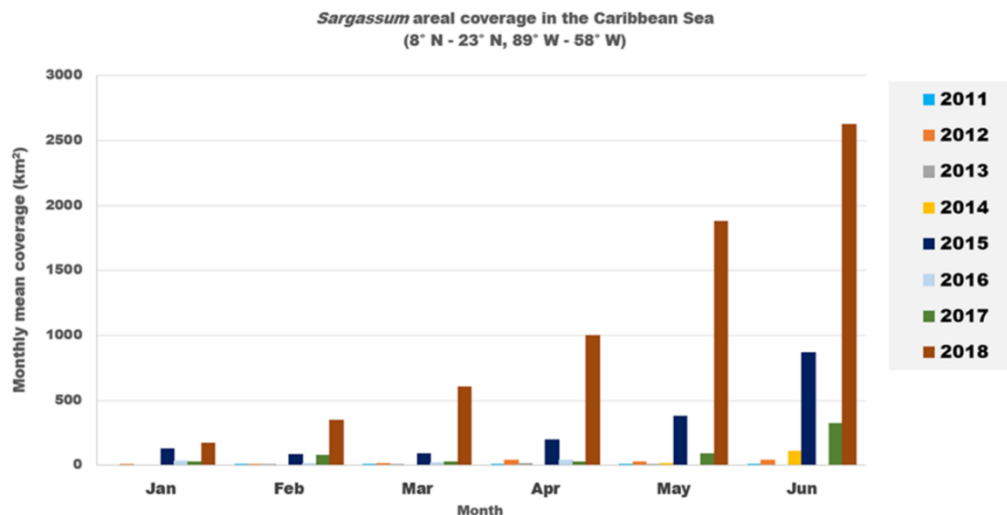


Figure 1 – Monthly mean *Sargassum* areal coverage in the Caribbean Sea, between 2011 and 2018. Source: University of South Florida Sargassum Watch System (SaWS, <https://optics.marine.usf.edu/projects/saws.html>)

Land-Based Sources of Pollution (LBS) Protocol support to *Sargassum* Research:

- The Protocol is currently working on the development of a Regional Nutrients Reduction Strategy under the CLME+ Project and cooperation with the Amazon Basin/N Brazil Shelf as nutrients may be a contributing factor. The development of this strategy will be discussed during the upcoming 4th LBS STAC in Panama next week;
- Cooperation with the Protocol's Oil Spills RAC and the NOAA/IOC UNESCO Project concerning early detection systems;
- UN Environment through its Global Programme of Action (GPA) has reached out to the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) to determine if they would be willing to include Sargassum relates issues in their work programme. This is following the side event which was held at UNEA in 2017 and as such it might be useful for Ministers of Environment within the region to raise this as issue at the UNEA 2018, and also during the CARICOM and LAC Ministers of Environment Meeting (ROLAC).

Strategy and Opportunities

To better cope with the complexity of the massive *Sargassum* landings, a multi-stakeholder strategy using the integrated approach is required at three levels:

1. Forecast

The study of historical records of all sorts, including satellite data and mariner's experiences, and long-term observation are critical to understand *Sargassum* distribution patterns. Long-term prediction is one of the main concerns to determine the perennial aspect of the phenomenon and to better guide annual preparation. Short-term prediction is key to alerting stakeholders about landings within a short period (of less than a week) to improve response and actions for the collection, transport and reuse of the *Sargassum*. Both short- and long-term predictions require careful analyses of historical (past 30 year) and ongoing patterns in surface and mid-depth ocean circulation, nutrients, water temperature, and wind patterns, and how these have changed.

2. Collection

Managing *Sargassum* on beaches and other coastal habitats is a financial challenge. Specific equipment and infrastructure are needed to collect, transport and store the seaweed. While most countries are collecting the massive amounts of seaweed once they reach the shore, using heavy machinery and manual work, there are a few initiatives in place to stop it off-shore, before it reaches land. This solution may prove more effective, less impactful and cheaper than in-shore collection, yet careful attention must be paid to avoid disrupting marine life communities living in the *Sargassum* rafts. Only two countries indicated their use of off-shore technologies such as floating barriers and pumping boats in the survey.

3. Reuse

To date, many tests have been done to recycle *Sargassum* for different purposes (fertilizer, chemical compounds, biofuel/biogas, etc.), and there is a need to sustainably manage it. However, commercialization of the products is limited, owing to the uncertain availability of *Sargassum* and its bio-absorbent properties (including for heavy metals such as Arsenic)¹⁸. Market studies and biochemical analyses are therefore necessary before any product development.

Some have already started capitalizing on this profitable, freely available resource. The government of Saint Lucia, like many others, had been burying the excess *Sargassum* to remove it from the shores. But Algas Organics, the first indigenous biotech company of the Caribbean, now claims the algae since it developed a technique to make a plant bio-stimulant out of *Sargassum* in 2015. This product can replace energy-intensive, polluting synthetic fertilizers, with a quality similar to top fertilizer brands. The demand for the plant tonic has been on the rise in the St. Lucian agricultural market and is reaching other islands such as Barbados. After building partnerships and receiving support from international organizations and the government, the company has built the first *Sargassum* processing facility of the

¹⁸Milledge, J& Harvey, P. (2016) Golden Tides: Problem or Golden Opportunity? The Valorisation of *Sargassum* from Beach Inundations. Journal of Marine Science and Engineering,4:60.

Caribbean, which now plans to expand their production, create more jobs in the community and invest in research to improve their *Sargassum*-based products¹⁹.

Although not at a commercial scale, other islands are also putting efforts into using these algae for their local benefit. *Sargassum* is being used for diverse and creative purposes; summarized in Figure 2. These include the use of the algae both after industrial treatment, as well as untreated. An additional simple and sustainable use, which is not listed in Figure 2, is the use of untreated *Sargassum* as a natural fertilizer for dune plant communities, proven to enhance their growth²⁰. This may nevertheless be limited to dune areas secluded from tourism, as the decaying *Sargassum* may be unattractive. It is important to note, however, that 5 territories (23%) out of the 22 that reported having a significant *Sargassum* issue in their coasts in our survey are not giving *Sargassum* any use (Figure 2). This is not only a missed opportunity, but also an additional environmental issue resulting from the polluting discard of algae in landfills.

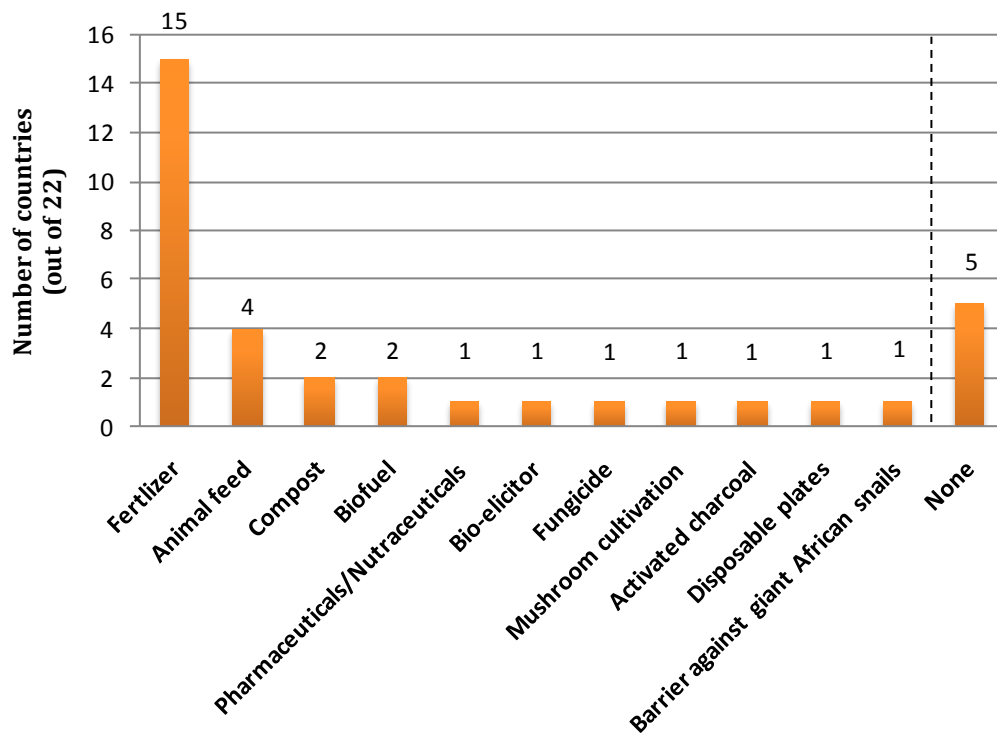


Figure 2 – Utilization of *Sargassum* across countries of the Wider Caribbean Region. Data based on survey responses from a total of 22 territories that reported having a significant *Sargassum* issue in their coasts.

¹⁹St. Lucia innovates to address *Sargassum* seaweed. St. Lucia Times, May 10th 2018. Accessed September 20th 2018. Available at: <https://stluciatimes.com/2018/05/10/saint-lucia-innovates-to-address-sargassum-seaweed/>.

²⁰William, A. & Feagin, R. (2010) *Sargassum* as a Natural Solution to Enhance Dune Plant Growth. Environmental Management, 46:5, 738-747.

Recommendations for a regional strategy:

- It is impossible to perform long-term (months to years) forecasting of *Sargassum* blooms without understanding what caused the blooms and annual fluctuations in previous years. A significant research gap exists in such understandings. Furthermore, because *Sargassum* blooms and invasions are not local, multi-lateral and multi-agency collaborations are required to understand the puzzling phenomenon in recent years.
- UN Environment CEP recommends conducting an in-depth regional assessment of socio-economic impacts and challenges to better comprehend the effective and sustainable management of *Sargassum*.
- Recommend the development of an early detection warning system at regional scale, including understanding historical patterns of algae abundance, ocean circulation, wind, temperature and nutrients for comparison against present conditions. As noted, cooperation is already ongoing among CEP, SPAW RAC, USF and Texas A & M and Intergovernmental Oceanographic Commission from UNESCO.
- Development of a ship-based monitoring protocol (observation and reporting of *Sargassum* rafts in the open sea by the maritime fleet including commercial boats) in the Atlantic Ocean.
- Support intensified remote sensing efforts with a variety of platforms and integrate physics, biogeochemical and biological observations.
- Continue to coordinate related initiatives at regional scale and using the integrated approach, continue to collaborate with regional organizations already involved with monitoring the seaweed.
- Enhance overall collaboration, coordination, and research at global, regional and national levels.

Country recommendations from the survey:

18 representatives from 14 territories provided additional insights into how the *Sargassum* influx should be addressed regionally. These recommendations are summarized below:

- Regional Plan for *Sargassum*: develop an early warning system, a communication strategy, emergency response plan and a research agenda. A regional workshop for sharing experiences and best practices to treat *Sargassum* landings and minimize them. Develop strategic national and regional partnerships with affected parties.
- Encourage and support countries to reduce ocean pollution from agriculture, land-use changes, and source pollution, which is responsible for algal overgrowth. Increase awareness of climate change link.
- Focus on research of possible uses of *Sargassum* and share knowledge on how to use *Sargassum* for farmers, livestock holders, and industry, as well as at the household level (e.g. home gardening). Promote education campaigns and trainings.
- Collection off-shore, placing barriers and containers in strategic spots identified by models compiling marine currents, crosscurrents and wind.
- Funding needed for clean ups and sharing non-costly methodologies to control *Sargassum*.

The contribution of the SPAW Protocol to the strategy:

1. 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.
2. Data: Ongoing cooperation with USF and Texas A&M University for *Sargassum* early prediction systems.
3. Planning and Policy: Emphasis on ecosystem-management approach, linked primarily via the CLME+ project.
4. Provide guidance to implement provisions of related and broader agreements.
5. 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).

Regional Situation

The following results were drawn from our survey study (see Appendix), with the participation of the UN Environment CEP National Focal Points:

The severity of the *Sargassum* outbreak varies markedly across the Wider Caribbean Region (Figure 3). The most gravely impacted nations include the Lesser Antilles, the Dominican Republic, Turks and Caicos, Florida (U.S.A.) and Southeast Mexico. The remaining countries of Central America, northern South America, Cuba, Haiti and the Bahamas are seeing minimal to no impacts from the influx.

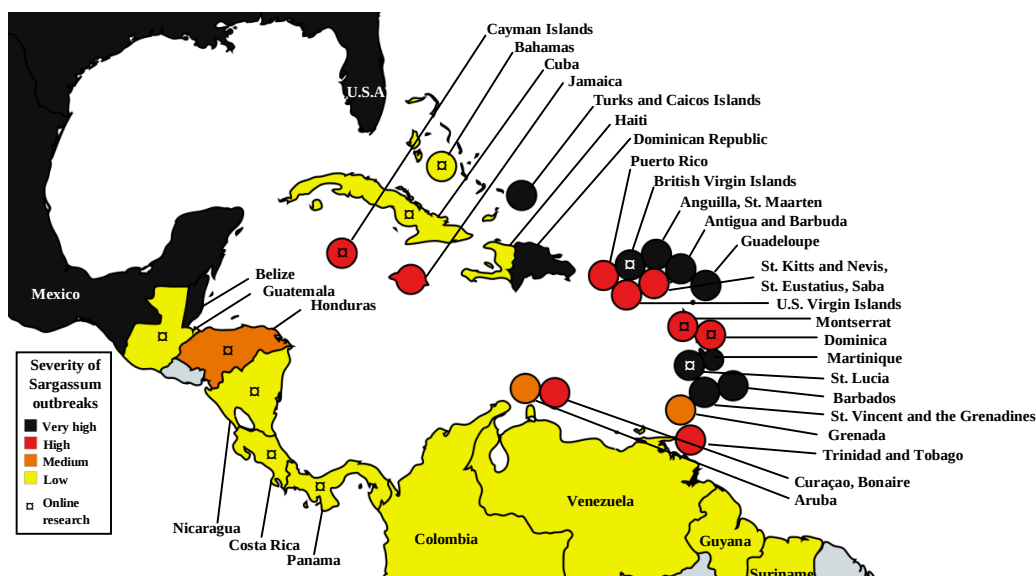


Figure 3 – Severity of the *Sargassum* influx per territory across the Wider Caribbean Region. Data based on survey responses of National Focal Points, except for the territories labeled ‘Online research’, whose data was drawn from satellite records and online websites.

Five major economic sectors have been impacted in varying frequencies across nations of the region. Tourism, ecology and fisheries have been impacted in between 75 and 86% of the 28 territories that responded to the survey (Figure 4.a.), including 6 countries that were only moderately affected by *Sargassum*. Human health was also affected in almost half of the countries, including one fatality that was indirectly associated to the *Sargassum* blooms. Two countries additionally noted negative impacts of the *Sargassum* in a reverse osmosis plant and in electric production plants located in bays and estuaries.

Among the ecological damages, beach fouling was most predominant (71%), but surprisingly, major issues such as coastal dead zones and washing of dead fish, turtles and other marine wildlife occurred in between 50 and 61% of the territories (Figure 4.b.). One country also reported the killing of young mangrove seedlings and Spartan grass as a result of the outbreak.

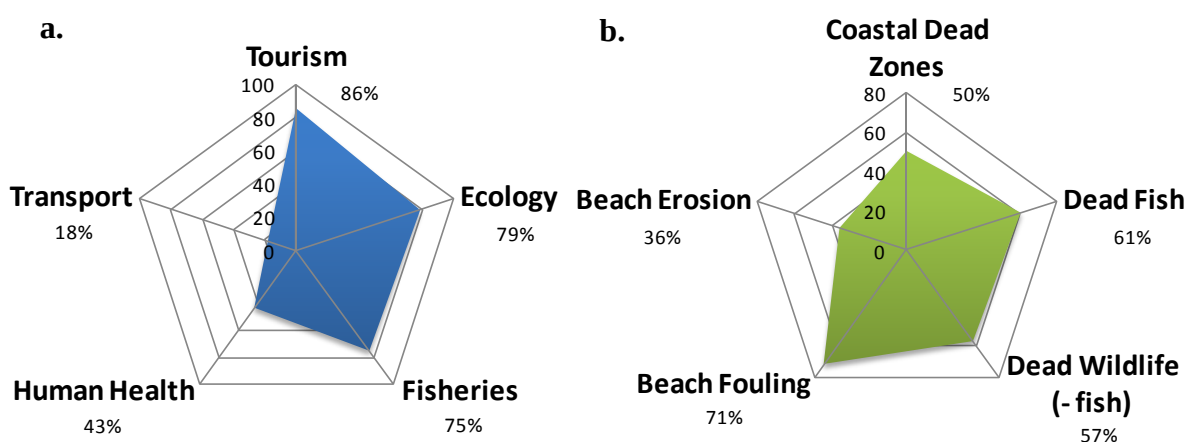


Figure 4 – Percentage of territories where different economic sectors have been affected by *Sargassum* (a.), and where different ecological issues have occurred as a result of the outbreaks (b.). Data based on survey responses of national Focal Points, from a total of 28 territories.

Out of the 19 territories that suffer a significant *Sargassum* issue and provided details about their tracking procedure in the survey, only 8 (42%) currently track the algae. Most of these territories do field surveys (7), yet some do it informally and not in standardized procedures. Only half of them (4) map *Sargassum* along their shorelines, and only 3 forecast algae landings through satellite monitoring (Figure 5).

Martinique has the most advanced tracking system of all the respondents, additionally including shoreline monitoring through satellite, airborne surveys, and a camera network, and permanently measures levels of toxic gases in the air. This data stresses the need for more and improved tracking systems across the Caribbean, in order to evaluate and minimize the impacts of *Sargassum*, and to prepare for approaching rafts. The territories that are most advanced in this technology, such as Martinique, may share their expertise and technology with nations that have less developed systems.

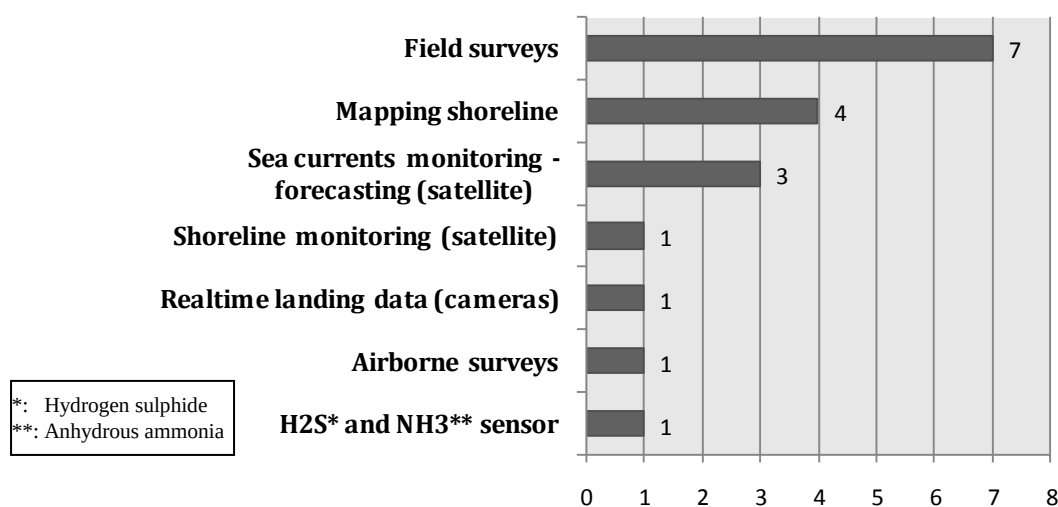


Figure 5 – Tracking procedures conducted in the 8 Caribbean territories that indicated a significant *Sargassum* issue in our survey, and that currently track the algae (out of a total of 19 territories).

It is important to acknowledge that in some instances, several respondents from the same territory provided different information. In most instances they added to each other, yet sometimes there were discrepancies. In these cases, the most frequent response was selected, or a decision was made in complement with online research and satellite data. This highlights the need to strengthen the regional information networks to ensure full awareness of national situations by focal points.

Conclusion

The unprecedented influx of *Sargassum* that reached the Caribbean islands repeatedly in 2011, 2015 and 2018 is a major threat to the economy, ecology and health of the Caribbean. Impacts are felt across the wider Caribbean region. This is an issue of regional importance. Numerous initiatives and action plans are arising at local and national levels, but there is a need to develop a regional plan where experiences, knowledge, best practices and technology may be shared and put into action to minimize further impacts. While some nations have very advanced systems for forecasting, tracking, preventing and managing the *Sargassum* influx, others have underdeveloped strategies and capacity. Strong partnerships are needed to protect the most vulnerable to this emergent threat. Further research and actions to reduce ocean pollution and climate change may be needed as well to minimize *Sargassum* overgrowth in the coming years.

Appendix

Find below the survey questionnaire that was sent to the UN Environment CEP National Focal Points of the Wider Caribbean Region, through which the regional data was collated. Spanish and French versions of the survey were also sent to the respective nations.

Regional status of the *Sargassum* seaweed invasion in the Caribbean

Country represented:

Respondent Name:

Email address:

1. Is *Sargassum* considered a national concern along the coasts of your country?

Yes/No

2. How severe do you estimate the *Sargassum* impact in your country?

Low/Medium/High/Very high/Don't know

3. Which sectors of the economy have been affected by the unusual *Sargassum* blooms during 2015 and 2018?

Tourism; Fisheries; Transport; Ecology/Biodiversity; Human health; Other:...

4. According to the media and/or institutional records, has ecological damage been reported as a consequence of *Sargassum* invasions?

Yes/No

5. Which of the following issues has been reported during the *Sargassum* episodes?

Coastal dead zones (hypoxic (low oxygen) conditions caused by the *sargassum* accumulation); Dead fish; Dead turtles, mammals, invertebrates or birds; Beach fouling; Beach erosion; Other:...

6. Has your country put in place measures to address *Sargassum* accumulated along its shores?

Yes/No

7. If yes, what tools have been used?

Heavy machinery; Manual; Other:...

8. Is there an effort in place to use *Sargassum* for any purposes?

Yes/No

9. If yes, how is it used?

Biofuel; Fertilizer; Animal feed; Pharmaceuticals/Nutraceuticals; Other:...

10. Does your country currently map and/or monitor coastal areas experiencing *Sargassum* accumulation?

Yes/No

11. If yes, kindly provide details on software/parameters:

12. Please add any additional comments on how the *Sargassum* influx can be addressed regionally: