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In This Bulletin

Sargassum Special Issue

Contact: WCWG Secretary

Ann Pienkowski

apienkowski@ukotcf.org

Sargassum Influx – Is there a sustainable solution?

Sargassum influx in Cayman. Photo: Cayman Compass

The large quantity of sargassum coming ashore in the Caribbean has been cause of concern for several years. UKOTCF, and especially WCWG, have received numerous communications about this. As secretary of WCWG, I have reported this problem and some of the various solutions which have been proposed, and tried. But I knew very little about sargassum, and as a trained scientist (albeit nearly 40 years ago since I last worked full-time professionally as a scientist!) I thought I should learn more. So when I was made aware of the 2 webinars on *Sargassum issues and solutions 2020* in July 2020, I signed up.

The webinars were organised by SOP (Stop Ocean Pollution) Technologies and focussed on South Florida, but it was noted that this is a regional issue which is here to stay, and experts from around the world need to share knowledge and research – learn from each other and apply what is best.

Here are the links to the webinars:

https://soptechint.com/blog/2020/7/17/sargassum-issues-and-solutions-webinar-2020-07-17

https://www.youtube.com/watch?v=8hm9occseiM

Webinar contributors are listed at the end.

This review tries to summarise the key things which I learnt from these and some follow-up, and which I thought might be of interest to others. The webinars contain references to the information for those who wish to find out more. Any errors in summarising this information are my own.

Illustrations are from the webinars, unless otherwise stated.

Background

***1.* S. fluitans*; 2.* S. natans**
***Webinar 2: Ligia Collado-Vides* et al**

There are 2 main species of pelagic sargassum, *S. fluitans* and *S. natans*. A lot of marine life relies on pelagic sargassum to survive, and it is not considered a problem when in the open sea. In fact, it is a critical ecosystem, providing shelter and food for marine organisms, such as fish and small turtles; and a natural mitigation for climate change due to CO^2 uptake. However, large quantities in shore and on beaches cause huge problems.

In 2011, large quantities of pelagic sargassum appeared on the shores of several Caribbean Islands, Florida, Mexico and West Africa. Since then, this has been a recurrent event, mainly from spring to autumn, with some piles of stranded sargassum reaching several metres high on the beaches, with dense floating rafts of the seaweed in bays and creeks.

Sargassum in East End, Tortola, BVI.
Martina J.
https://www.youtube.com/watch?v=ifVYK1aNTF4

Scientists are now convinced that these influxes to the Caribbean Sea and along the coast of West Africa are related to massive sargassum blooms occurring in the equatorial area of the Atlantic where the ocean currents rotate in what oceanographers call the North Equatorial Recirculation Region (NERR), an area which is not directly associated with the Sargasso Sea and is essentially a new 'source' region for sargassum.

From Hinds* et al *2016

Various theories as to why there is this huge increase in pelagic sargassum include warming of the sea-surface due to climate change and increased nutrient load in the sea, both from terrestrial run-off and red Sahara sand carried by winds.

Finding ways to clean up sargassum from coastal ecosystems has become a priority in the region because of its effect on tourism, fisheries and vulnerable ecosystems such as mangroves, seagrass beds and corals. Large quantities of sargassum on turtle nesting-beaches make it difficult for the females to dig nests and lay eggs, and make it very difficult for hatchling turtles to reach the sea.

Sargassum monitoring, Antigua
sargassummonitoring.com

Turtle hatchling struggling in sargassum on Cayman Brac.
Photo: Cayman DoE

Increased turbidity affects inshore environments.
Webinar 1: Valentina Caccia

As the sargassum inshore breaks down, it increases water turbidity, cutting out sunlight, and reduces the amount of dissolved oxygen, so having a detrimental effect on, for example, coral and seagrass beds.

Decaying sargassum, in reduced oxygen conditions in the piles, produces poisonous hydrogen sulphide gas, which smells awful and is harmful to most marine animals. Prolonged exposure to high concentrations of hydrogen sulphide gas can also cause human health problems (including nausea, headaches, skin-rash and even breathing difficulties) and can tarnish metals (coins, bathroom fittings, door knobs, even jewellery) as well as damage sensitive electronic appliances (TVs, computers, air-conditioning units).

East Coast, Barbados, September 2014. Photo: H. Oxenford

News report
https://local10.com

Cleaning up large quantities of sargassum is no easy or cheap task. In South Florida, the cost of keeping 15 miles of beach clear is about $9 million per year. There is no "one-size-fits-all" solution. And what can be done with the sargassum once it is removed?

Remote sensing via satellite is being used to identify sargassum rafts, and models are being created to predict their paths toward the coast. NOAA (National Oceanic and Atmospheric Administration [US]) and GEOSS (Global Earth Observation System of Systems' Platform) support free information sharing. However, offshore sargassum rafts do not necessarily reach shore; wind and current for example are critical. Knowing in advance where and when rafts will arrive on shore is critical for efficiently locating barriers or planning removal.

Webinar 2: Joaquin Trinanes

Much research is ongoing in the search for a sustainable solution to the problems caused by Sargassum influx. A sustainable solution in one location might not be sustainable in another. Sustainable solutions should address concerns about landfill, incineration, pollution, economic cost, the appropriateness of available technology, and environmental and social perspectives. Clearly environmental impact assessments, as well as economic and social impact assessments, are needed to ensure that actions do not cause ecological damage. The questions posed in this article are to highlight some of these issues.

Below is a summary of some of the actions tried, their advantages and disadvantages, and questions to be considered before use in any particular location.

Options for action

Doing nothing

Advantages: This is the most sustainable solution when sargassum washes ashore in small quantities or in inaccessible, non-tourist or non-critical locations. This is the simplest and least costly. It has the benefit of potentially nourishing beaches and stabilizing the shoreline. It will eventually be washed away. The large number of amphipods living in the washed-up seaweed are an important element in marine food webs, both for fish and shorebirds. In a recent study (Dr Joe Serafy, University of Miami-NOAA, webinar 2 presentation), amphipods in tide-wrack had an average density of 13,000 individuals per m^2 and about 400g per m^2. This density can remove nearly 1 kg of weed per m^2 per day, so could play a significant role in reducing the biomass of sargassum.

Disadvantages: During decomposition of large amounts of weed, there will be a smell and increased insects. Removal action is needed for individual sensitive and vulnerable sites. These sites need identifying and action

plans put into place before any influx.

Q. Have sites which can be left for nature to take its course been identified in a national or regional plan?

Leave to nature

Consider situation - leave or manage?

Manage appropriately

***Webinar 2: Ligia Collado-Vides* et al**

Removal from the shore

There are several different methods being used (see below), each with advantages and disadvantages. However, a major disadvantage of removal from the beach is that it makes it extremely difficult to use the collected sargassum, due to the resulting sand content.

Rake and Integration into the beach

This works only for sandy beaches, and is used mainly on tourist beaches.

Advantages: There is no sand loss and it helps stabilize the beach. Eliminates the problem of what to do with removed sargassum.

Disadvantages: Requires very expensive equipment and human resources. Heavy large equipment needs beach access and parking. Measures are required to protect nesting turtles. The sargassum is polluted with plastic and glass, which also gets chopped up, and is a hazard to people and animals using the beach. The integrated seaweed can incubate bacteria, and there are odour issues during decomposition. This technique "buries" the seaweed at a depth of about 15cm, and often looks unattractive. Only so much sargassum can be buried, so there is a further problem if there is a lot. The broken up sargassum gets washed back into the sea, increasing water turbidity and reducing the amount of dissolved oxygen, affecting coral reefs and seagrass beds.

Q. Are tourists happy with the beach after this action; is it economic?

Rake and Integrate method, Key Biscayne.
Webinar 1: Roland Samimy

Beach after Rake and Integrate method, Key Biscayne.
Webinar 1: Roland Samimy

Manual Removal – Hand Rake and Wheelbarrow

Advantages: This is the least damaging. It can be used on sites with difficult access. It is ecologically sensitive, able to take account of turtle nesting, and minimises sand loss and beach compaction. It is not confined to sandy beaches.

Disadvantages: It needs a large workforce, and is hard work. It is not feasible with very large sargassum influxes.

And what do you do with the removed sargassum?

Q. Is there funding to pay a large workforce, or can sufficient volunteers be mobilised on a regular basis? Is there a suitable site/method for disposing of the removed sargassum?

Hand rake and wheelbarrow removal, Bonaire. Photo: Dutch Caribbean Nature Alliance (DCNA)

Mechanical Removal

Advantages: The sargassum is removed from the beach.

Mechanical Removal
Webinar 1: Roland Samimy

Disadvantages: Requires very expensive equipment and human resources. Heavy large equipment needs beach access and parking. Measures are required to protect nesting turtles. About 15% of sand is removed with the sargassum, which can lead to serious beach erosion. The machinery compacts the sand, which is a problem on turtle nesting beaches as it makes it more difficult for the turtles to dig nests. And what do you do with the removed sargassum?

Q. Is this an ecologically and economically sustainable option? Is there a suitable site/method for disposing of the removed sargassum?

Removal from water nearshore

Advantages: It prevents the sargassum from reaching the shore, and the resultant difficulties and expense of removing it from the shore, as summarised above.

Disadvantages: It works only in calm shorelines and harbours. It requires specialised and expensive skimmers and barges. There may be a detrimental effect on the marine life which the sargassum raft supports. And what do you do with the removed sargassum?

Q. Is this an economically viable solution? Is there a suitable site/method for disposing of the removed sargassum?

Specialised barge for removing sargassum from water
Hinds* et al *2016

Deflection barriers

Deflection barrier
Webinar 2: Elastec, Duanne Bennish

There are now several different types of deflection barriers, which are being used to prevent the sargassum reaching the shore. Improved designs now allow marine life (such as turtles, fish, rays) to pass under them, and the barriers have sufficient height above water to prevent sargassum going over them. Their placement needs to be guided by information on currents, tides, winds, water depth etc, so previous local research is essential.

Advantages: They prevent the sargassum reaching the shore, so can protect sensitive habitats and harbours.

Disadvantages: They are expensive; it is essential that they are combined with boats or skimmers to remove sargassum from

the water, or the barriers are placed so that they direct the flow of the sargassum to a shore collection point. Anchoring can be a problem. They need frequent maintenance. And what do you do with the removed sargassum?

Q. Has research been conducted to determine the placement of the barriers? Is funding available for the installation, ongoing maintenance, and associated boats? Is there a suitable site/method for disposing of the removed sargassum

Air-bubble curtains

These have been used in the Florida Key canals and creeks. A flow of air-bubbles prevents the sargassum from entering the inlet.

Advantages: The inlets do not get blocked.

Disadvantages: An electricity source is required, installation and maintenance costs are high, and sargassum held back by the air-bubble curtain needs to be collected by skimmers. And what do you do with the removed sargassum?

Q. Is the necessary infrastructure (e.g. electricity supply) available, and can the installation and maintenance costs be met? Is there a suitable site/ method for disposing of the removed sargassum?

Air-bubble curtain
Monroe County Management Plan
http://ocean.floridamarine.org/FKNMS_WQPP/docs/canals/20190215/2018_canal_project_report.pdf

What can be done with the removed sargassum?

The cost and effort of removing sargassum, either from the water or the coast, is very high, so it would be excellent if an ecologically and economically sustainable use could be found for it. Various methods are in use, are under trial or being investigated.

The composition of the sargassum causes problems. It accumulates heavy metals and metalloids, including arsenic which is very toxic. So any use must take account of this. It is definitely not recommended that it be used for food. And some people have raised doubts about composting it, unless the levels of heavy metals and arsenic are checked for safety.

Here are some of the ways in which removed sargassum is being used or dealt with.

Landfill or dumping

The location for landfill or dumping must be very carefully chosen to avoid impacting the environment. The increased salinity can affect the micro-organisms that degrade solid waste, as well as altering the soil composition. Also the soil can be contaminated with heavy metals.

Q. Has a suitable site been identified which can deal with a large quantity of sargassum, and will not have an environmental impact? Have monitoring procedures been put in place?

Illegal dump in the Mexican Rain Forest
Webinar 1: Valentina Caccia

Composting

The salt may need to be removed, and if the sargassum has been collected from the beach, sand, plastic and glass need to be removed. It may need to be mixed with other organic matter (e.g. garden waste) for effective composting. High levels of heavy metals and arsenic are a problem, so this needs testing.

Q. Is there a sustainable and economic water-supply available to wash the salt from the sargassum? What will happen to the effluent from this process? Are there facilities for testing the sargassum for heavy metal contamination? Are there suitable storage/composting facilities? Is garden or agricultural waste available to mix with the sargassum for the composing process?

Sargassum Composting trials
Tumbler: A)No washing; B) Wash with fresh water; c)Sargassum + brown clippings; D) Sargassum + green clippings
Piles (composting on a larger scale) - washed vs unwashed.
Results not yet available
Webinar 2: Helena Solo-Gabriele

Use as a material for its cellulose content

Small-scale but successful ventures have used sargassum to make bricks, paper and the soles of shoes, particularly in Mexico.

Products containing sargassum
https://www.youtube.com/watch?v=wcix4sAYtrg

Q. Larger-scale use will require storage facilities, how practicable is this?

For energy production

For any of the options being considered, the sargassum has to be free of sand, so once it has reached the shore it is very difficult to use for energy production. Other constraints with use for energy production are the technicalities of moving the sargassum to the production site, and storage. The production of biofuels needs a regular stable supply with no peaks and troughs, so scale and reliability are key issues. No-one is currently using algae for biofuels on a commercial scale anywhere in the world, although some pilot projects are showing promise. But there are many technical, economic and scale problems.

Some of the processes require dry sargassum, and the drying process can use a lot of energy. Sun-drying is a

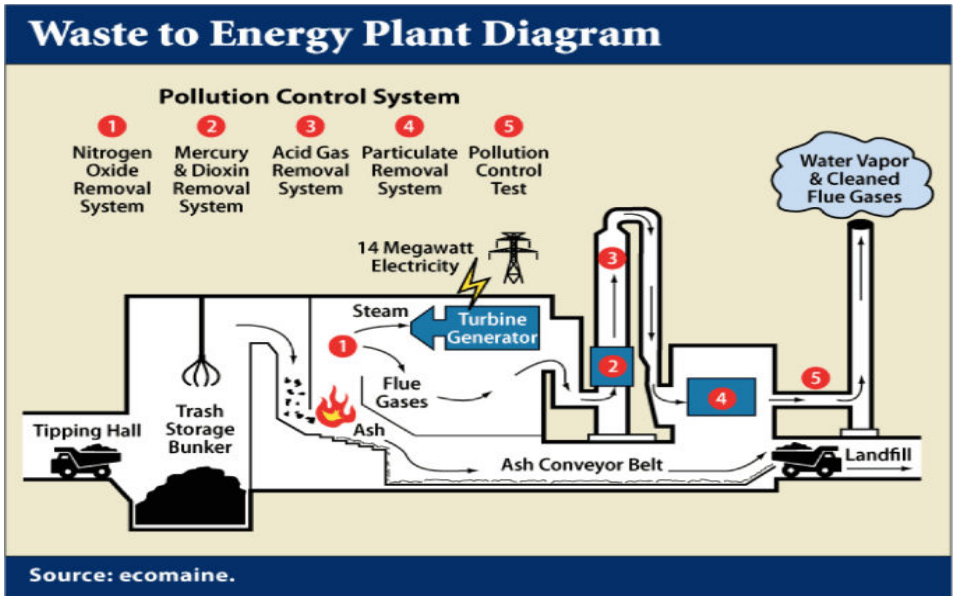
possibility, but is unreliable due to weather events, and not suitable for large quantities.

Sargassum has a very low calorific value, so the energy input and output has to be carefully analysed. Plastic and other contaminants need to be dealt with; for example burning plastics can produce toxic substances. Residual ash may contain heavy metals. The effluent from some of these processes is very corrosive.

For all these processes the problems of ensuring a regular supply of feedstock, and storage of feedstock need to be solved

Current research and investigations for energy production include:

Incineration: Q. How do you deal with probable toxic emissions and residues?

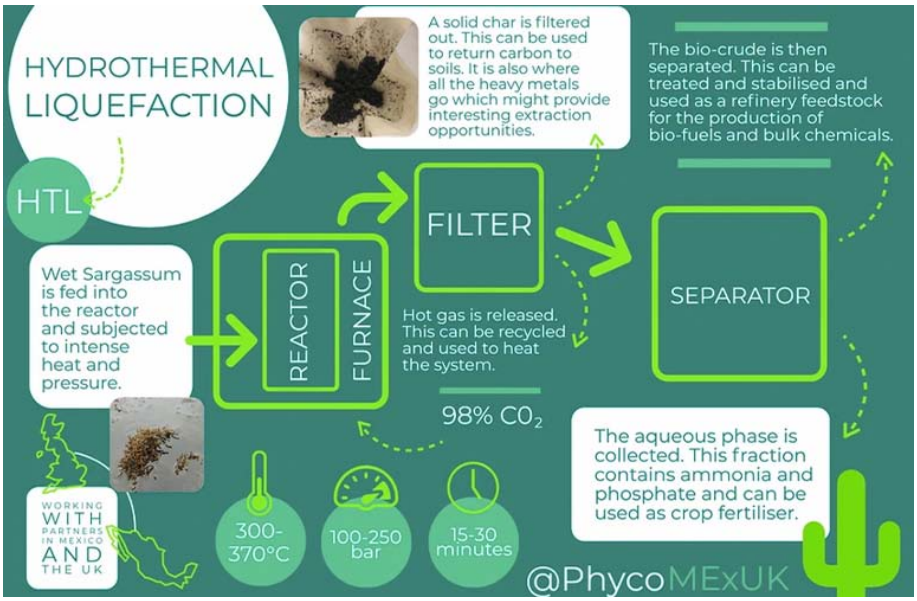


A typical waste-to-energy diagram

Biochar production: (Like charcoal production: dry organic material burnt without oxygen; can be used as a soil improver). Q. How do you deal with probable toxic emissions. Are levels of heavy metals in the biochar safe?

Biogas production (anaerobic digestion): This has been suggested as one of the most promising, particularly as the feedstock can be wet. However, Milledge, J. et al 2019 (see information source list) concluded that algal biomethane production processes are currently unprofitable and unsustainable.

Biodiesel Production and Hydrothermal Liquefaction: There are promising developments here by a team from the Universities of Exeter and Bath, working with partners in Mexico. But as the diagram shows, sophisticated technical infrastructure is required. Disposal of potentially corrosive by-products needs careful consideration.



All the above involve complicated technical and engineering infrastructure, and are not currently practicable on an economic scale. They would need rigorous environmental impact

Biodiesel Production and Hydrothermal Liquefaction

Jones, E et al, Saltwater based

investigations before any implementation. For those wishing to know more about these, an online browser search will find many research papers. If any interested readers would like to provide a readily understandable review and update of any of these processes, especially in relation to environmentally sustainable solutions, they would be most welcome, and could be reproduced in future WCWG eBulletins.

Many questions about the future sustainability of such processes could include:

Have the economics of this process been analysed, and found to be profitable, or at least cost-neutral?

Where would the infrastructure be located?

How would any washing, cleaning, decontamination be dealt with?

How would a regular supply of feedstock be provided (drying, storage, etc).

How will the waste products from the process be dealt with?

You can probably think of others!

Is there currently a sustainable solution to the sargassum influx problem?

After my research, I cannot say that there is. But please let me know if I have missed anything.

The best solution for a particular location or region needs to be determined on local factors – one size does not fit all and, as detailed above, all methods currently being used have ecological, economic and social problems. The least damaging, doing nothing, is not an option in all cases. Perhaps identifying the places where nature can be left to take care of itself, concentrating removal on the critical places, such as tourist beaches and harbours, is the best of a not very satisfactory situation. It is critical that the disposal site for any removed sargassum is carefully chosen, subject to an environmental impact assessment, and monitored. I came across one case where the sargassum was dumped illegally on the edge of Yucatan Peninsula jungle.

A sustainable technological waste-to-energy solution seems to be some way in the future, and may not be appropriate for small-island states or territories, which have limited natural and human resources, sensitive ecological areas, and are of high biodiversity value. In such situations where would the required infrastructure be located without causing ecological damage?

Sources of Information

July 17 webinar

Organisers

Dr Josefina Olascoaga, Professor (Physical Oceanographer) RSMAS (Rosenstiel School of Marine and Atmospheric Science), University of Miami

Emilio Lopez, Co-Founder & CEO SOP (Stop Ocean Pollution) Technologies

Dr Valentina Caccia, Restoration and Enhancement Section, DERM-RER (Regulation and Economic Resources, Division of Environmental Resource Management) Miami-Dade County

Speakers:

Eilieen Higgins, Miami-Dade County Commissioner

Mark Richard, Senior Region Manager, Parks, Recreation and Open Spaces Department, Miami-Dade County

Dr Roland Samimy, Chief Resilience and Sustainability Officer, Village of Key Biscayne

Rhonda Haag, Monroe County Office of Sustainability

Dr Valentina Caccia, Restoration and Enhancement Section, DERM-RER (Regulation and Economic Resources, Division of Environmental Resource Management) Miami-Dade County

July 24 Webinar

Speakers:

Dr Joaquin Trinances, University of Miami-NOAA (On Remote Sensing Monitoring)

Dr Maria Josefina Olascoaga, University of Miami (On Predicting Sargassum paths and landing)

Dr Helena Solo-Gabriele with Affeefa Aleema, University of Miami (On Bacteria)

Dr Joe Serafy, University of Miami-NOAA (On amphipods)

Dr Ligia Collado-Vides, Florida International University (On Biological Perspective of Sargassum landings in Miami Dade Beaches, and SARGNET Role and Advances)

Duanne Bennish, Elastec (On Sargassum Barriers)

Joel Gonzalez, Oceanographer, ASOCEAN Mexico (On Development of Sargassum Barriers)

Facilitators:

Dr Josefina Olascoaga, Professor (Physical Oceanographer) RSMAS (Rosenstiel School of Marine and Atmospheric Science), University of Miami

Emilio Lopez, Co-Founder & CEO SOP (Stop Ocean Pollution) Technologies

Dr Valentina Caccia, Restoration and Enhancement Section, DERM-RER (Regulation and Economic Resources, Division of Environmental Resource Management) Miami-Dade County

Webinar Discussion contributor:

Martin Sherman: Inventor of Seaweed Paddock a deep water Sargassum farm with biofuels as the end use. Their multidisciplinary team was funded by the USA's DOE ARPAe MARINER program. Contact at info@seavac.org

Other sources of information:

Hinds, C., Oxenford, H., Cumberbatch, J., Fardin, F., Doyle, E. &Cashman, A. (2016). Golden Tides: Management Best Practices for Influxes of Sargassum in the Caribbean with a Focus on Clean-up. Centre for Resource Management and Environmental Studies (CERMES), The University of the West Indies, Cave Hill Campus, Barbados.17 pp.

Making bricks, notebooks and shoes (Mexico):

https://www.youtube.com/watch?v=wcix4sAYtrg

A Brief Review of Anaerobic Digestion of Algae for Bioenergy John J. Milledge, Birthe V. Nielsen, Supattra Maneein and Patricia J. Harvey

Energies 2019, 12(6), 1166; **https://doi.org/10.3390/en12061166**

Summary

Algal biomass represents a potential green bioenergy source for the production of biomethane when processed using AD methods. However algal biomethane production processes are currently unprofitable and unsustainable unless considered as an adjunct to processes that aim for a circular economy such as wastewater treatment, reduction of eutrophication, or zero-waste objectives in algal biorefineries. Limitations include harvesting costs from water bodies, pre-treatment and seasonal variation in biomass composition and yield, as well as operational costs aimed at improving biomethane conversion yield. Wastewater treatment ponds are currently the most economic approach to the production of microalgal biofuel

fractionation and valorisation of macroalgae, Journal of Chemical Technology and Biotechnology. April 2020. **https://doi.org/10.1002/jctb.6443**

https://bioenergyinternational.com/research-development/40830

Summary

Macroalgae are gaining increasing interest as an important biomass feedstock. Yet when valorising marine biomass, the presence of salt can pose a substantial obstacle to the effectiveness of downstream biological and chemical processes, as well as the engineering infrastructure required. Accordingly, dewatering, washing and drying are often considered the first and crucial primary steps in processing marine biomass such macroalgae. The high costs of these processes can make further marine biorefinery commercialisation prohibitive. This investigation assesses simple pre-treatments for macroalgal biomass in saltwater, thereby reducing the freshwater footprint, and removing the need for an energy-intensive washing and drying stage.

Anaerobic Digestion Economic Feasibility Study: Generating energy from waste, sewage and sargassum seaweed in the OECS [31/01.17 In Grenada and St Lucia]

https://www.caribbean-council.org/caribbean-council-cpi-study-highlights-major-potential-waste-energy-technology-caribbean/

Summary

The available information on *Sargassum natans* and *fluitans*, the two species of primary concern across the Caribbean, is sparse. The small BMP (Biochemical Methane Potential) assessment carried out showed that 'old', beached Sargassum, when milled to a powder and digested, has a very low BMP. Therefore, it would not be possible to run an AD plant on Sargassum alone if the Sargassum was presented in the same way. More work needs to be done to understand how best to preserve the Sargassum and how quickly it should be used. Pre-treatment to break down the complex structural carbohydrates could improve the biogas yield.

Sargassum inundation, East Caicos, Turks and Caicos Islands
Kathleen McNary Wood
In some remote places, any clean-up is impracticable at present, and may not be desirable. But there can be significant detrimental effects on, eg turtle nesting beaches, coral reefs, seagrass beds and mangroves.