

# Managing Sargassum Shoreline Inundations: A Toolbox



# Preface

Large mats of floating sargassum have been stranding along shorelines of the Caribbean and West Africa since 2011, resulting in substantial damage to coastal ecosystems and their valuable services. These inundations have resulted in significant costs to coastal livelihoods and national economies, affecting fisheries, tourism, recreation, human health and coastal businesses.

The SargAdapt Good Practice Guide Series has been launched to provide easy-to-read, straightforward, technical advice to Caribbean stakeholders facing this 'sargassum crisis'. This volume in the series provides a guide to help determine the most feasible and least damaging solution for the collection of sargassum in the nearshore or on the beach of any particular site.

Efforts to mitigate the immediate impacts of sargassum inundations along our shorelines have often resulted in further damage as a result of the use of inappropriate methods or equipment ill-suited for the purpose. Furthermore, sargassum clean-ups typically entail high economic costs in labour, equipment and transport that falls on both governments and the private sector. This guide recognizes the importance of sharing lessons learned to date in order to avoid repeating mistakes that have been made by others in the learning process. By spreading awareness of suitable equipment and best practices this guide is intended to help towards developing sustainable solutions to managing sargassum inundations.

*Note:* Every site has unique characteristics, and there is no 'one solution that fits all'. In addition, nations/territories have different regulations and permit requirements. The information and guidance given here is based on best available information in the public domain, consultations with practitioners and observations by the authors.

## How to Cite

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Photos taken by H.A. Oxenford unless otherwise indicated.

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Graphic design by Jeanelle Irvine



This volume of the SargAdapt Good Practice Series is supplemented by visual aids and webpages.

**Click any link icon to explore relevant online resources.**

# Introduction

**Sargassum Inundation =** Floating sargassum arriving in large amounts, overwhelming shorelines and bays as it piles up on beaches or is trapped in the nearshore.

Sargassum inundations can have significant negative impacts on coastal ecosystems, livelihoods, health and overall wellbeing. These events, which have been plaguing the Caribbean since 2011, are likely to continue into the future. It is clear, therefore, that we need to adapt and deal with these repeated sargassum inundation events by finding sustainable long-term solutions to minimise the environmental, social and economic damage they are causing.

Many mistakes have been made over the years in trying to cope with these unprecedented sargassum inundations. At the same time, important lessons were learned and these have been shared in a number of guides providing advice about the *Dos and Don'ts* of sargassum collection methods. However, such advice needs constant updating as more innovations are tested, new lessons are learned and new techniques and customised equipment emerge.

This toolbox for the management of sargassum inundations draws on previous publications [see below] and provides updated summaries of best advice available. It is intended for use by Caribbean stakeholders facing, or tasked with managing, sargassum inundations. Firstly, we present 7 key lessons for general guidance. We then examine available tools and methods for onshore and in-water collection of sargassum, providing guidance regarding their applicability in different situations.

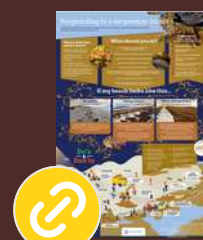
## Other Management Resources



**GCFI  
Sargassum  
Fact Sheet**  
(Doyle and  
Franks 2015)



**UWI-CERMES  
Sargassum  
Management  
Brief**  
(Hinds et al.  
2016)



**GCFI Best  
Practices  
Infographic  
Poster**  
(GCFI 2018)



**Prevention and  
Clean-up of  
Sargassum in  
the Dutch  
Caribbean**  
(DCNA 2019)



**Evaluation of  
Sargassum  
Collection  
Operations**  
(Chereau 2019)



**Technical and  
Management  
Guidelines for  
Sargassum**  
(Gov. of Mexico  
2021)

# Key Lessons

- 1 Apply adaptive management
- 2 When to collect and when to leave alone
- 3 Forecast and monitor sargassum arrivals
- 4 A customised toolbox is essential
- 5 Choose the right methods and equipment
- 6 Designate extraction and storage sites
- 7 Communicate!



# 1 Apply adaptive management

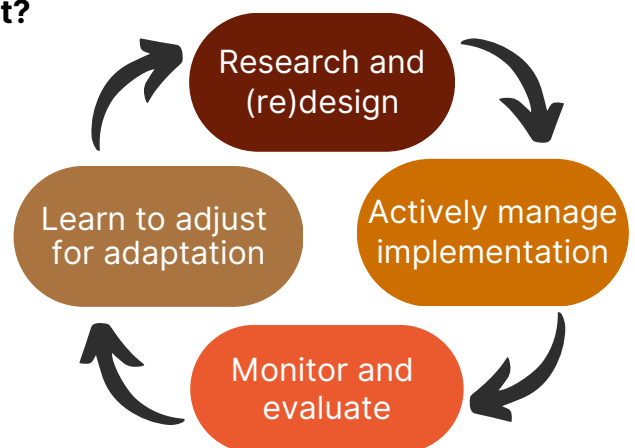


*Ad hoc* unplanned responses reacting to sargassum inundations waste resources, repeat mistakes, and frustrate or harm those most affected. Every country should have a Sargassum Adaptive Management Strategy (SAMS) and site-level management or operational plans.

A national-level strategy allows for addressing sargassum at any level of severity, both as a hazard and as an opportunity. The site-level plans fit into the national strategy and allow more specific responses tailored to prevailing, often changing, local conditions, including calling on national resources if needed.

## Why adaptive management?

Adaptation is a systematic way of trying different things (doing research) and learning from results to adjust and improve the next time around. There will be a risk that things don't go as planned, but there is no failure if the next test succeeds.



In the case of sargassum, with so many uncertainties, it is good practice to be adaptive as there is no “business-as-usual” yet.

Using lessons already learned from 'climate change adaptation' and 'disaster risk management' can assist a sargassum strategy. Removing sargassum, whether as a hazard or for commercial use, can be an enormous and recurring task that is expensive and time consuming. Good practice includes having a priority ranking of sites based on an assessment of exposure and vulnerability of assets to sargassum inundations to help guide where resources should be deployed.

If sites are properly profiled (e.g. by surveys, observations, drones) and mapped (e.g. in GIS), with the information made public, the government, communities and private sector can all be better informed. This facilitates the critical coordination and collaboration for tackling sargassum adaptively. People learn by working together on shared problems to find common solutions.

## ② When to collect and when to leave alone



Even at high priority sites (that is, locations where sargassum events impact the amenity value or economic activity present there), it is not necessary to collect or clear up after **all** sargassum beaching events.

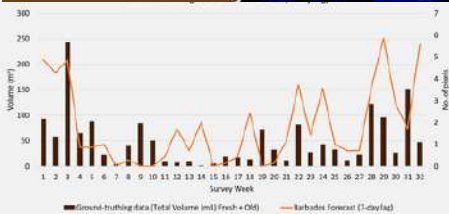
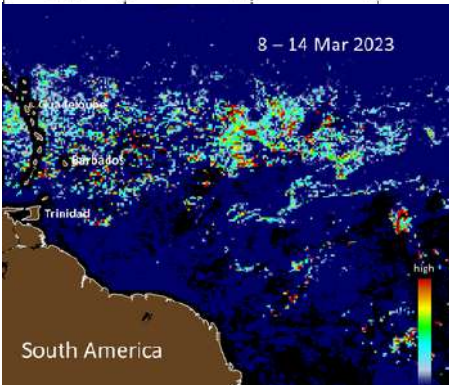
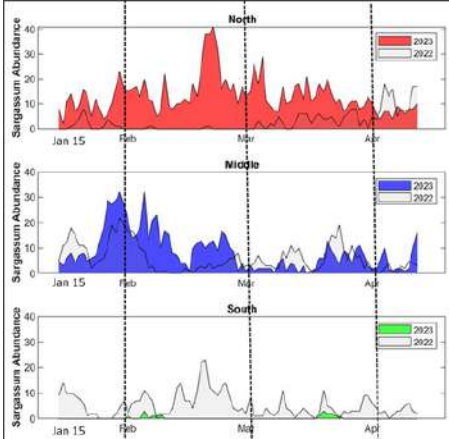
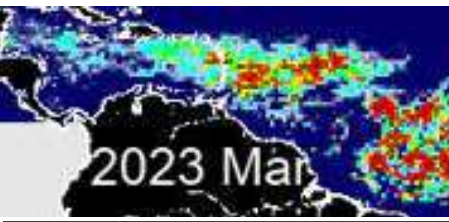
Small amounts of sargassum on the beach will do no harm and may even provide benefits to foraging shorebirds, ghost crabs and strand plants. Over-cleaning a beach is harmful to the environment.

Medium amounts of sargassum may also not require any intervention especially where the sargassum can dry out naturally, becoming dark and brittle and incorporated into the beach sand, or get washed back out to sea.

However, large inundations that result in sargassum piled a metre or more high along shorelines and/or trapped in the nearshore, especially in inlets, estuary and wetland areas, can result in rapid ecosystem damage, human health impacts and severe socio-economic consequences. In this situation, sargassum will need to be **cleared quickly** (within 24-72 hours) to prevent:

- **Decomposition and sinking of sargassum** in the nearshore that makes it impossible to collect and smothers marine habitats.
- **Anoxic decomposition** of wet sargassum along the shore that produces toxic hydrogen sulphide, ammonia and methane gases, which can cause health concerns like eye irritation and respiratory problems and add to greenhouse gases.
- **Formation of a sargassum brown tide** [*plume of brown poor-quality water spreading out from the shoreline*] that ruins the aesthetic beauty of coastal waters, often smells bad, and can result in death of nearby marine life.
- **Blocked access** to and from the sea.

# 3 Forecast and monitor sargassum arrivals



## When, where and how much?

These are essential questions to inform sargassum collection efforts, planning and investment, and for informing the public and affected businesses.

There are now several sargassum forecast products freely available, that vary in geographical scope (area covered), and resolution (days, months). Examples include:

- The Satellite-based Sargassum Watch System ([SaWS](#)) produces a monthly Outlook Bulletin providing Caribbean-wide coverage.
- CERMES [Sub-regional Sargassum Outlook Bulletin](#) provides a 3-month outlook for the Eastern Caribbean islands, published bi-monthly.
- Several countries also have their own customised forecasts (e.g. Jamaica, Mexico, Guadeloupe, etc.) including shorter-term or near real-time predictions of site-level beaching events.

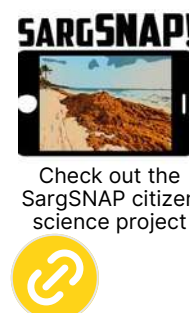
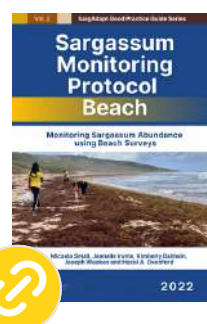
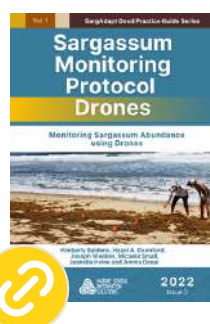
Commercial bespoke sargassum forecasts including medium-term and near real-time predictions are also available through the [CLS SamTool](#)

Monitoring the frequency and volume of stranding sargassum and/or volume of sargassum collected from shorelines is also critical at the national and regional level to:

- Help validate and improve forecasts
- Inform appropriate collection methods
- Understand the variability

Simple standard monitoring protocols using drones ([SMP-Drones](#)) or simple field methods alone ([SMP-Beach](#)) have been developed for easy sharing and comparison of data.

Special cameras or webcams installed on hotel roofs, and citizen science programmes (e.g. SargSNAP) are also being used for this purpose.



Check out the SargSNAP citizen science project



## 4

# A customised toolbox is essential

## Best practice will require site-specific solutions

A very important lesson is that there simply is no 'one solution that fits all' for either onshore or in-water collection of sargassum. Operational planning, including the selection of equipment, should consider the local context, site conditions that will affect how the operation is executed, and the risks or potential impacts of the operation at the site.

Firstly, it is likely that a combination of methods and equipment will be required for collection at any one site to deal with the different levels of incoming sargassum experienced over time.

Secondly, this 'toolbox' of suitable methods and equipment will certainly vary by site according to the different physical, environmental and socio-economic conditions and the institutional and legal arrangements at any given location.

Important physical considerations will be: prevailing winds and sea conditions; water depth; sea floor substrate (rock, rubble, sand, living); shoreline type (rocky, sandy, cliff, artificial); beach slope, length and width; site access; presence of infrastructure (jetties, breakwaters, moorings) etc.

Environmental considerations will include: presence and type of nearshore marine habitats (e.g. coral reefs, seagrass meadows, seaweed); shoreline vegetation (e.g. mangroves, dune vegetation, strand plants, trees); and wildlife using the area (e.g. shore birds, crabs and endangered species such as sea turtles, sharks, dolphins and manatees).

Socio-economic considerations will include: typical uses of beach and nearshore area (e.g. recreational or commercial activities) and adjacent land area (e.g. tourism, fisheries, residential, commercial, government facilities).

Additionally, institutional and legal considerations will include: the land ownership (e.g. ability to access a site); the local laws, regulations and permit requirements (e.g. governing collection of sargassum and operation of equipment on site); and the availability of labour, equipment and funding.



# 5 Choose the right methods and equipment



Choice of the right methods and equipment and operational procedures for collecting sargassum is very important, but has been difficult for many reasons including:

- Lack of prior experience in dealing with sargassum inundations.
- The need for specialised equipment, especially in-water.
- A dearth of reputable commercial manufacturers / suppliers of suitable equipment for in-water use (largely due to the fact that the necessary research, trials and development of different designs is still on-going).
- Very little unbiased guidance available on what is suitable and unsuitable.
- The relatively high costs involved in rental or purchase and maintenance of suitable equipment, especially for in-water collection.

Consequently, many mistakes have been made, resulting in environmental damage and/or a waste of precious resources in buying equipment not fit for purpose, or unsuitable for the site conditions, or operated inappropriately.

With time and experience now on our side, such errors can be minimized through the sharing of experiences across the Caribbean in what works and what doesn't!

In this guide, we have attempted to provide an unbiased summary of methods (onshore and in-water collection) and equipment that are likely to be appropriate under given conditions in the following 'toolbox' section.

Note that it is highly likely that a combination of equipment and methods will be needed, and ultimately the choice of which to use will be strongly influenced by logistical considerations at the site.

Good practice would include the development of a site-level '**operational plan**' that would map out exactly how the equipment is to be used for effective and efficient collection, transport and storage or disposal of sargassum, whilst minimizing environmental damage. Local stakeholder knowledge should be used to help inform the choice of appropriate methods and equipment and the development of the operational plan.

Given the new technology, especially for in-water collection, due diligence should be exercised (including obtaining advice from those with hands-on experience using something similar) before final purchase or rental of equipment and services.

# ⑥ Designate suitable extraction and storage sites



Collected sargassum is bulky and large accumulations are potentially toxic (high in trace metals such as arsenic, and capable of producing toxic gases if allowed to decompose without oxygen).

As such, you will need to identify appropriate disposal sites or storage sites, if it is to be used. This will require selection and preparation (e.g. lining with geomembranes to prevent escape of leachates) of suitable on-site temporary holding areas or permanent storage locations on or off-site.

A suitable beach access route, transfer equipment (e.g. grab, conveyor belt) or manpower for manual transfer, as well as transport will be required to remove sargassum from the collection site by land or sea.

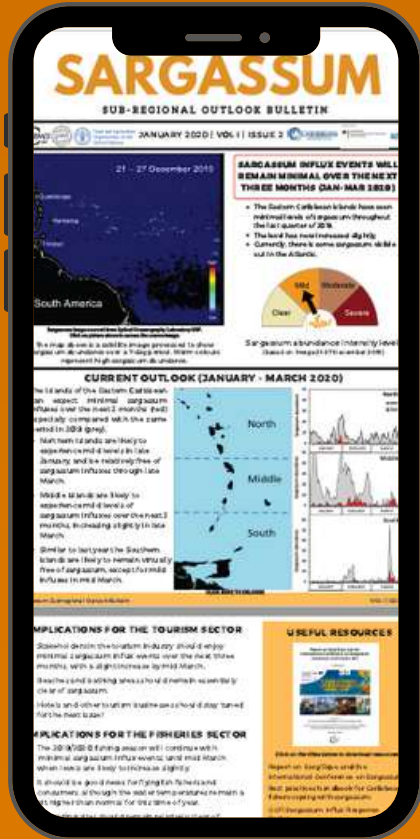
Storage / disposal sites must allow sargassum to dry out to prevent anaerobic decomposition and production of toxic and flammable hydrogen sulphide, ammonia and methane. These sites must also ensure that sargassum leachates do not contaminate the environment including the groundwater.

These will be important considerations for the site-specific plan.



Credit: Kim Baldwin

Aerial image, St. Lucia east coast, showing example of on-site sargassum storage at back of beach, where mechanical rake is off-loaded.



**Picking the right communication method is critical in ensuring that sargassum information reaches its intended audience.**

It is essential to keep policy makers, coastal stakeholders, visitors and the wider public informed with relevant, up-to-date, and easy-to-understand information about:

- Sargassum - what is it, where it comes from, why is it here, is it safe to touch, what can and can't it be used for?
- Forecasting - regional and local efforts at predicting when, where and how much sargassum will arrive.
- Existing sargassum management arrangements at either the local or national level (i.e. who is the lead agency responsible for sargassum removal? How can reports be made or partnerships be formed?).

A communication strategy needs to identify the most effective communication channel for each stakeholder group to ensure that the information reaches those in need of it.


This could include:

- Signage at beaches and coastal areas.
- Flyers/posters at hotels.
- Radio and TV announcements.
- Newspaper notices and articles.
- SMS alerts.
- Dedicated website or social media groups.

Knowledge is power; so, we expect that clean-up or collection initiatives will be most successful when stakeholders are informed and empowered, instead of being left frantic and misinformed.

Involving the general public in clean-up initiatives could bolster management efforts and even act as an opportunity for reputable information to be shared.

Private businesses could even be encouraged to 'Adopt a beach for sargassum clean-up'.

Incorporation of mobile and web applications (e.g., [Epicollect](#)) ) that facilitate citizen science could also be very effective.

# Toolbox



# Collection Method

Sargassum inundations can be managed through collection and removal or harvesting and use. Collection or harvesting of sargassum can be done using a variety of onshore and in-water methods.

Here, we consider the available methods and equipment, and the feasibility of implementation under a variety of conditions typical of Caribbean shorelines.

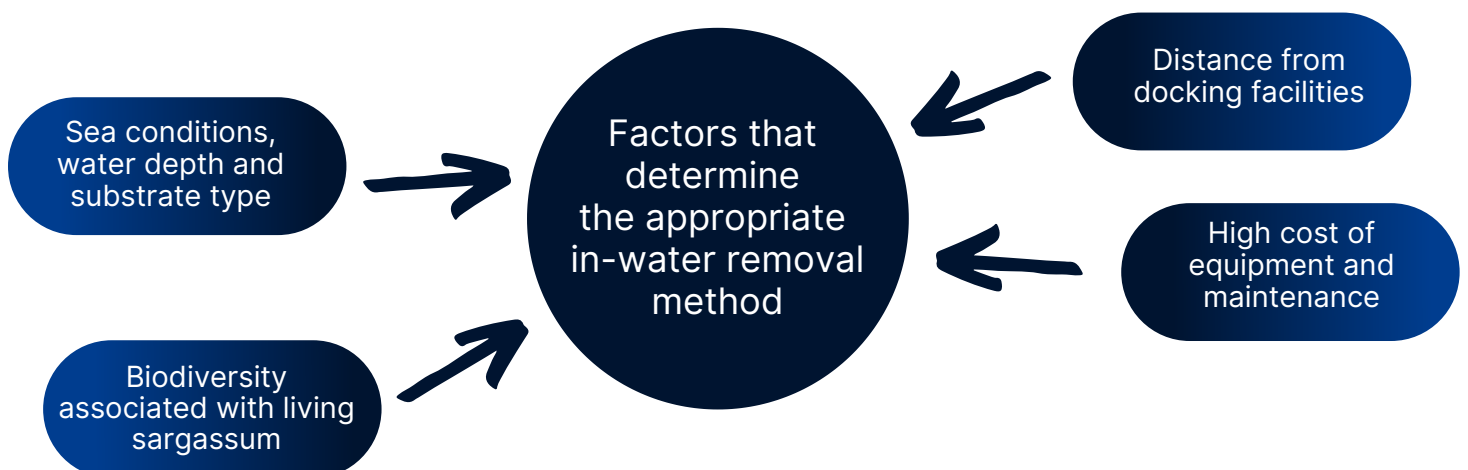
## 1 Onshore Collection

Whilst it is preferable to collect the sargassum before it reaches the shore, onshore collection is often the only feasible option.



## 2 In-water collection

Whilst it is preferable to collect the sargassum before it reaches the shore, in-water collection is technically much more complex and often not feasible.



# Onshore Collection: Manual



## 1 Hand tools

Manual onshore removal of sargassum using rakes/pitch forks and wheelbarrows/buckets is:

- The least environmentally damaging onshore method of sargassum removal (does not compress beach sand or damage turtle nesting sites, can selectively avoid strand vegetation, manually assist trapped wildlife).
- The least intrusive in terms of disturbing tourism and other beach users.
- The most versatile with regard to the physical conditions (it can be applied regardless of beach width and slope, sea conditions, site access, presence of infrastructure).
- The least expensive with regard to equipment (uses only relatively low-cost available technology).
- Suitable for volunteer stakeholder involvement to offset high labour costs.

## 2 Beach seine

Manual onshore removal of sargassum using a beach seine or other net operated by wading into the nearshore is **not recommended**. It takes a huge number of people, is very heavy and easily damages the net, and is potentially harmful to nearshore marine flora and fauna.

# Onshore Collection: Manual



<p><b>Suitable Conditions</b></p>	<ul style="list-style-type: none"> <li>• Low to medium inundation.</li> <li>• Low frequency of events.</li> <li>• High ecological sensitivity (e.g. turtle nesting beach, valuable strand vegetation).</li> </ul>
<p><b>Good Practice</b></p>	<ul style="list-style-type: none"> <li>• Sargassum should be collected when fresh because it is lighter and much easier to handle than when it compacts and starts to rot.</li> <li>• Health issues and damage to environment is reduced if collected fresh.</li> <li>• Fresh sargassum may have more potential for valorisation.</li> </ul>
<p><b>Unsuitable Conditions</b></p>	<ul style="list-style-type: none"> <li>• High volumes of beached sargassum.</li> <li>• Long inundation events with continuous high supply daily.</li> <li>• Wet sargassum decomposing at site producing high levels of toxic gases posing a health risk to manual labourers.</li> </ul>
<p><b>Cost Considerations</b></p>	<ul style="list-style-type: none"> <li>• Low technology equipment, likely available locally and easy to maintain.</li> <li>• Time consuming and labour intensive.</li> <li>• Suitable for involvement of volunteers.</li> <li>• Whether the storage area is on site or sargassum needs transportation off site.</li> </ul>



# Onshore Collection: Mechanised



Credit: Getty Images RF

Mechanised onshore removal of sargassum can be done using a variety of standard and/or customized machinery and heavy equipment and is:

- The best or perhaps the only option for removing large quantities of beached sargassum quickly and effectively.
- Potentially damaging to the beach due to incidental removal of strand vegetation and large amounts of sand which can lead to serious beach erosion, as well as deep rutting and compaction of the beach sand which can destroy turtle nests and the habitat of other beach dwelling fauna. Note that sand can sometimes be recovered from collected sargassum and returned to the beach, but doing so will also have associated costs.
- The most intrusive with regard to disturbing tourists and other beach users.
- Costly to purchase and maintain equipment, especially in such a harsh environment (wet, salty, sandy).
- Requires dedicated access to the beach.
- Not suitable for involving general public volunteers as the equipment requires trained operators.
- May require a permit to operate on the beach or not be allowed at all by local legislation.

**Note:** While the mechanised approach to onshore removal is appealing because of its quickness, it should only be used after the local context and environmental impact is considered.

# Onshore Collection: Mechanised



## 1 Mechanical rake

<p><b>Suitable Conditions</b></p>	<ul style="list-style-type: none"> <li>• Volume of sargassum is low - medium and inundations are frequent, making investment in the equipment worthwhile.</li> <li>• Long, wide, flat or gently sloping sand beach with no or little beach infrastructure.</li> </ul>
<p><b>Good Practice</b></p>	<ul style="list-style-type: none"> <li>• Operate when beach use is low (e.g. early or late in the day).</li> <li>• Most effective if used on falling or low tide and picking up fresh sargassum.</li> <li>• Utilise an on-site storage/drying area to retrieve sand for renourishing beach or for creation of small sand dunes.</li> <li>• Implement a strict maintenance schedule for equipment, including freshwater washing.</li> </ul>
<p><b>Unsuitable Conditions</b></p>	<ul style="list-style-type: none"> <li>• High levels of beached sargassum piled thicker than 30-40 cm deep. Will need to have the top layer removed first by other means.</li> <li>• Narrow or short or steeply sloping beaches or those comprising pebbles.</li> <li>• Beaches with high density of beach infrastructure or vegetation</li> </ul>
<p><b>Cost Considerations</b></p>	<ul style="list-style-type: none"> <li>• Cost for initial purchase of rake and tractor (latter may already be available) and ongoing maintenance in harsh environment (wet, salty, sandy).</li> <li>• Maybe available for hire.</li> <li>• Requires only one driver to operate machinery and capable of covering a large area.</li> <li>• Costs will increase if the sargassum must be removed from the site</li> </ul>

# Onshore Collection: Mechanised

## Choice of mechanical rakes

Mechanical beach rakes come in a variety of forms from towed rakes with automatic emptying mechanisms, to sit-on machines, to autonomous cleaners.

This equipment was designed for cleaning beach litter and has been tried and tested and used effectively for this purpose for decades.

Some designs have now been tested and effectively employed for clearing/collecting sargassum. A couple of examples of tractor-towed mechanical rakes that work well for sargassum are given here with links to the manufacturers.

**Barber surf rake**



**Unicorn Scarbat rake**



**Flozaga Gutern rake**



**Note:** None of the manufacturers have been sanctioned by the UWI, and are given here as examples only.

# Onshore Collection: Mechanised

## 2 Other mechanised equipment



**Note:** Employment of heavy machinery may not be allowed in certain places, or may be constrained by local permits and guidelines. We encourage extreme caution in its use on beaches.

### Suitable Conditions

- Incidental collection when excessive volumes of sargassum inundations make manual collection or use of mechanical rakes initially impractical.
- Where fast removal of huge accumulations is deemed essential (for environmental and health reasons).
- Shoreline sediment that can bear weight of heavy machinery.
- Available dedicated access for heavy equipment.

### Good Practice

- Reserve use of heavy equipment for exceptional circumstances.
- Always avoid use of heavy tracked vehicles on sandy beaches.
- Use vehicles with large pneumatic tyres to spread load.
- Use mechanical bucket or front scoop to remove only the top layer of sargassum to avoid beach damage and sand removal as much as possible. Consider removing remainder by mechanical or manual rakes.
- Deploy environmental monitor to oversee operation.

### Unsuitable Conditions

- Narrow beach, rocky shoreline or presence of dense beach infrastructure.
- Shoreline with no vehicular access.
- Ecologically sensitive beach (e.g. turtle nesting, strand vegetation preventing erosion).

### Cost Considerations

- Cost of equipment to purchase and continuously maintain, noting that it may already be available and used for other purposes.
- Likely available for hire.
- Requires trained machine operators.

# Onshore Collection: Mechanised

## Choice of mechanised equipment

There is a wide choice of mechanised equipment generally used in construction and agriculture. These range from small, relatively light and versatile bobcats, to much heavier excavators, front-end loaders and bulldozers, and are available from multiple manufacturers.

All of these have been used for clearing sargassum, although none have been specifically designed for this purpose. A few examples are given here.



### Things to note:

- Great care must be taken in the operation of equipment to avoid removing sand by never digging down to sand level - leave thin layer of sargassum on surface to be cleared by manual or mechanical rake.
- Avoid using heavy tracked machinery on sandy beaches. Experience has shown that this results in damaging compaction and beach erosion.
- A perforated/screening bucket or claw attachment are recommended to minimize sand removal.
- Use front scoop of wheeled bulldozer to take off top layer of sargassum only.
- Erosion can be somewhat offset by separating sand from the collected material and returning it to the beach.
- Equipment maintenance (including post-use freshwater wash down) will be critical in these conditions



# In-water Collection

Where possible, it is generally agreed that in-water collection close to shore is often preferable to beach collection. This approach can help to avoid many of the negative impacts of sargassum inundations and will also provide higher quality sargassum for potential uses.



Credit: Makeda Corbin & Kristie Alleyne

The potential loss of biodiversity associated with floating sargassum rafts when collected at sea is a concern. However, experience shows that **mobile fauna** (e.g. fish and juvenile turtles), that use the rafts for shelter and/or as a foraging ground, scatter when disturbed by the noise of collection vessels or abandon the rafts as they approach the shore and are therefore not captured with the sargassum.

In contrast, the **clinging fauna** (e.g. small crabs, shrimps, isopods, frogfish, turtle hatchlings) stay with the rafts and perish when the sargassum beaches.

Recent research in the Caribbean has determined that the species composition of the clinging fauna does not change with distance from shore (tested up to 1.5 km from shore). This indicates that distance from shore (0 - 1.5 km) for operation of sargassum collection vessels and equipment makes little difference with regard to species biodiversity loss.

However, special care should still be taken, especially off sea turtle nesting beaches during the nesting season, as **turtle hatchlings** leaving the beach will hide and remain in the sargassum and can be captured. In this situation, observers should be used to pick out and release any captured hatchlings immediately.



Credit: Amy Cox

# In-water Collection

## In-water collection/management requires:

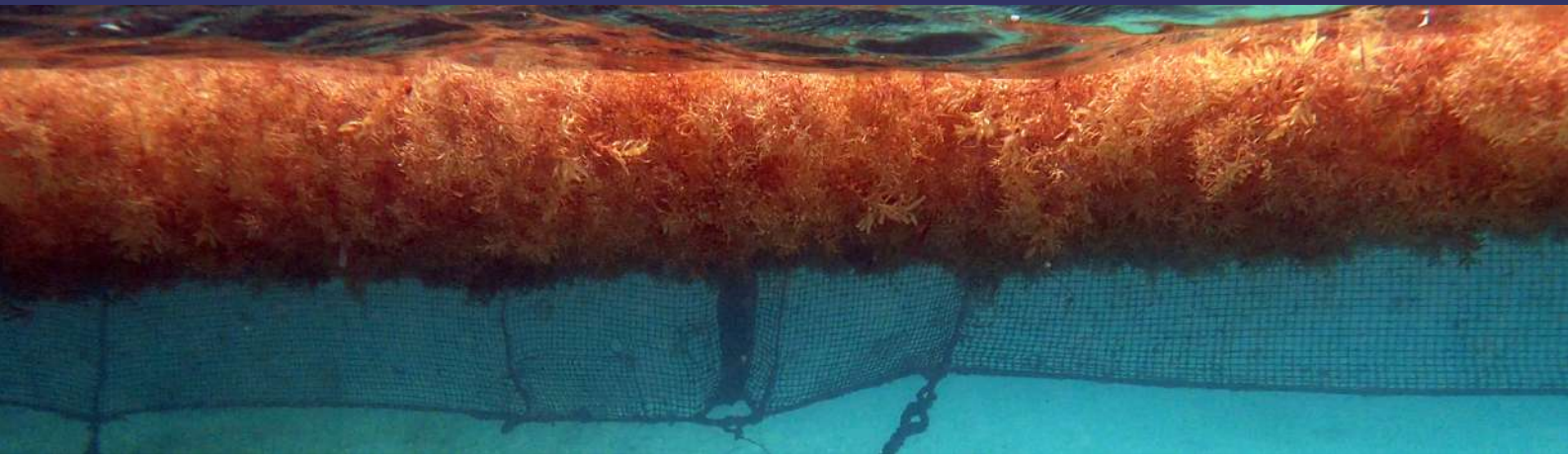
- Some kind of **barrier** to accumulate sargassum for collection and prevent it coming ashore or to deflect it to a suitable extraction point.
- A **harvest boat** to collect the consolidated sargassum rafts.



Credit: Mar Alive

**Note:** Effective implementation of in-water collection methods *strongly* depends on managers being aware of the variability of sea conditions at the site. Local knowledge counts!

# In-water Collection: Nearshore barrier



<p><b>Suitable Conditions</b></p>	<ul style="list-style-type: none"> <li>• Relatively calm sea conditions (e.g. lagoon protected by offshore barrier reef, semi-enclosed bay).</li> <li>• Shallow water with suitable anchoring substrate (e.g. sand, rock).</li> <li>• Accessible by sea and relatively close to safe harbour/docking facilities.</li> <li>• If being used for deflection, a constant current almost parallel to barrier to ensure sargassum moves along the barrier in the intended direction.</li> </ul>
<p><b>Good Practices</b></p>	<ul style="list-style-type: none"> <li>• Define optimal barrier orientation and anchoring points based on local geomorphic and hydrodynamic conditions - use research and local knowledge!</li> <li>• Ensure ample anchoring points, preferably with Halas-type moorings drilled into seafloor to avoid damage to living substrates from anchor chains or drag.</li> <li>• Clear barrier frequently to avoid build up of large amounts of sargassum to avoid it over-topping or breaking the barrier, and to prevent decomposition and sinking of sargassum resulting in smothering of benthic habitats and formation of a 'brown tide'.</li> <li>• Keep barrier and netting (skirt) clean of settling organisms to maintain water flow and extend life of barrier, by frequent cleaning.</li> <li>• Consider openings for boat traffic and nesting turtles and use observers to assist escape of turtle hatchlings.</li> <li>• Consider barrier removal during periods of low or no sargassum inundation.</li> <li>• Consider sufficient storage space for periods when the barriers are dismantled prior to storms or low sargassum periods.</li> </ul>
<p><b>Unsuitable Conditions</b></p>	<ul style="list-style-type: none"> <li>• Prevailing rough sea conditions with high or breaking waves.</li> <li>• Deep water and sensitive substrates for anchoring (e.g. coral reef).</li> <li>• Not easily accessible from sea or far from docking facilities.</li> </ul>
<p><b>Cost Considerations</b></p>	<ul style="list-style-type: none"> <li>• Cost of purchase and technical installation of barrier.</li> <li>• Continuous maintenance, which may include customised cleaning equipment.</li> <li>• Unlikely to be for hire, but full service contracts offered by some suppliers.</li> <li>• Purpose built harvest boat and transport vessels likely needed to continuously remove sargassum from containment barrier (see next section).</li> <li>• Skilled vessel operator(s).</li> </ul>



# In-water Collection: Nearshore barrier

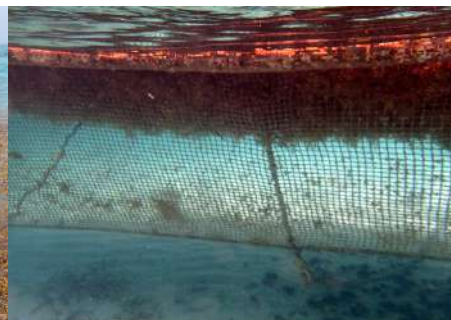
## Choice of nearshore barriers

Sargassum retention or deflection barriers need to be purpose-built. Initial use of oil-booms and marine construction silt barriers for this purpose were found to be ineffective.

Over the years, there have been numerous designs developed and tested (with many failures), and there is now a wide choice of barrier designs that have proven to be effective for sargassum management under a range of conditions. These vary widely in their construction, durability and versatility. Depending on supplier, barriers may be sold in standard lengths for customer installation, or can be purchased with a full service option including customised site design, mooring installation and maintenance.

A few examples are given here.

### **AlgeaNova custom-designs**



Vessel that straddles barrier for onsite repair and cleaning.

### **DESMI mesh boom**



### **Okeanis**



### **Elastec beach bouncer**



### **Important design features:**

- Above surface 'fence' to prevent over-topping.
- Multiple detachable segments for easy deployment and removal (also allows shoreside repair or replacement of damaged pieces).
- Underwater sturdy net 'skirt' to allow water flow but not entrap wildlife.
- Multiple anchors to withstand weight.

**Note:** None of the manufacturers have been sanctioned by the UWI, and are given here as examples only.

# In-water Collection: Harvest Boat



Credit: Ocean Cleaner

Harvest boats are most effective when used in tandem with a containment boom, to aggregate the material and reduce the surface area to be cleaned.

They typically have a catamaran hull for stability, speed efficiency and space.

They use a conveyor belt to pick up the sargassum as the vessel moves forwards.

Sargassum is temporarily stored onboard in a hopper or large bags and/or offloaded directly to another vessel or shore facility.

<p><b>Suitable Conditions</b></p>	<ul style="list-style-type: none"> <li>• Relatively calm sea.</li> <li>• Easily accessed from safe harbour/docking facilities.</li> <li>• Must have other vessel(s), dock or beach facility for frequent unloading.</li> </ul>
<p><b>Good Practices</b></p>	<ul style="list-style-type: none"> <li>• Ideally used in tandem with a containment boom allowing for aggregation of sargassum for easier collection.</li> <li>• Have observer(s) watching the conveyor system to pick out and release any turtle hatchlings and other larger marine organisms.</li> </ul>
<p><b>Unsuitable Conditions</b></p>	<ul style="list-style-type: none"> <li>• Rough seas or open ocean.</li> <li>• No transport vessels available or onshore offloading facility nearby.</li> </ul>
<p><b>Cost Considerations</b></p>	<ul style="list-style-type: none"> <li>• Cost of purchase of purpose-built vessel(s), unlikely to be available for hire.</li> <li>• Running and maintenance costs in marine environment usually high.</li> <li>• Skilled operators, but could use volunteer observers.</li> <li>• Costs could be ameliorated if sargassum sold/used for valorisation.</li> </ul>

# In-water Collection: Harvest Boat

## Choice of nearshore barriers

Like sargassum barriers, harvest/collection boats have had to be purpose built. Initial use of fishing vessels and nets, or algal harvesters designed for lakes and inland waterways were found to be completely inadequate.

Over the last decade there have been numerous designs developed and tested (again with many failures and lessons learnt), and there is now a choice of vessel designs that have proven to be effective for sargassum collection in coastal waters. However, research and development of improved designs is still ongoing and not all designs are commercially available as yet. Due diligence will be extremely important in selecting an appropriate vessel and accessories, especially in the Eastern Caribbean islands where there is very limited experience with use of harvest vessels.

A few examples are given here.

### **The Ocean Cleaner boats**



A Sargaboat collecting sargassum



Unloading onto a Sargatrailer transport vessel

### **Mar Alive**



Credit: Mar Alive

### **AlgeaNova**



Credit: AlgeaNova

### **Sargazo Solutions - Dakatso**



Credit: Sargazo Solutions

### **Important design features:**

- Adequate power and highly maneuverable to operate with heavy loads, around barriers, in high winds, strong currents, waves, and to dock safely with transport vessels or at shore facilities.
- Highly stable to operate safely with heavy load, including multiple crew members and wave conditions.
- Harvest capacity to meet expected sargassum volumes and efficient mechanism for transfer of collected sargassum to transport vessel or docking facility.
- Harvesting conveyor belt accessible to observers for removal of wildlife.
- High visibility from helm position.

**Note:** None of the manufacturers have been sanctioned by the UWI, and are given here as examples only.

# In-water Collection: Harvest Boat

## Choice of harvest boats

### STMI Sargator-2 vessels



Sargator-2 harvest boat simultaneously collecting and off-loading to coupled transport vessel. Outfitted for two transport vessels and recent tests show a collection capacity of 100 tons per hour

Sargator-2 transport vessel taking load to shore

### Things to avoid:

- Small narrow vessels are likely to be unstable in choppy seas and with heavy loads.
- Paddle wheel propulsion is unlikely to provide the power or maneuverability required for safe operation under most conditions.
- Unloading mechanism that does not easily couple with transport vessel or off-loading facility.
- Vessels designed for freshwater use.



**Note:** None of the manufacturers have been sanctioned by the UWI, and are given here as examples only.

# Removal, Transport and Storage

Once collected, sargassum will need to be dried and stored on site or transported to an alternative storage site.

<p><b>Suitable Conditions</b></p>	<ul style="list-style-type: none"> <li>• Vehicular access.</li> <li>• Planned storage area.</li> </ul>
<p><b>Good Practices</b></p>	<ul style="list-style-type: none"> <li>• Use a single dedicated access route to minimise damage to beach.</li> <li>• Close areas of the beach to the public whilst operating heavy equipment to ensure the safety of beach users.</li> <li>• If sargassum has been collected from the beach, dry and separate the sand before removal wherever feasible.</li> <li>• Sand can be effectively separated from sargassum using specialised shaker conveyor belts or tumblers.</li> <li>• Never operate heavy equipment over turtle nesting areas.</li> <li>• Avoid using machinery with metal caterpillar tracks on beaches.</li> <li>• Make provision for frequent maintenance and wash-down of the equipment after use.</li> <li>• Lifting sargassum piles from the beach with grabs or perforated buckets removes less sand than solid buckets or scoops.</li> <li>• Storage site should allow sargassum to be spread out to dry, and should not be near drinking water supply as leachates from decomposing sargassum are likely to be high in arsenic and possibly other elements that are damaging to the environment.</li> <li>• Hydrogen sulphide and methane meters could be installed around storage site to monitor air quality.</li> </ul>
<p><b>Unsuitable Conditions</b></p>	<ul style="list-style-type: none"> <li>• No vehicular access</li> <li>• Private or easily eroded vehicular access may also be unsuitable or need management.</li> </ul>
<p><b>Cost Considerations</b></p>	<ul style="list-style-type: none"> <li>• Cost of equipment purchase, hire or haulage contracts, noting that equipment may already be available and used for other purposes.</li> <li>• Running and maintenance costs of equipment handling heavy, salty, sandy, wet cargo. Will require frequent wash-down with freshwater.</li> <li>• Skilled operators for equipment, volunteers could help with manual loading of trucks or conveyor belts.</li> </ul>

# Removal and Transport

## Choice of equipment

Collected sargassum can be removed and transported with a variety of equipment commonly used in construction and agriculture, often with custom-built accessories. A few examples are given here.



Pitch forks and small trailer



Credit: Getty Images RF

Backhoe and large truck



Credit: Nation

Caterpillar excavator operating at roadside to load trucks



Credit: Nation

Sugar cane grabs have been used successfully for lifting sargassum



Credit: Ian Cox

Custom conveyor belt for lifting and loading sargassum directly from boat to truck

# Matrix for choosing appropriate method/equipment

(Adapted from Chereau et al. 2019)

Condition	Description of condition	Manual onshore collection	Mechanised onshore collection	Nearshore barriers	Custom-built harvest boats	Leave alone
<b>Biomass of sargassum</b>	Small to medium biomass	Green	Red	Red	Red	Green
	High biomass	Red	Green	Green	Green	Red
<b>Accessibility</b>	No vehicle access point	Green	Red	Green	Green	Green
	Vehicular access	Green	Green	Green	Green	Green
	Rough sea / far from docking facilities	Green	Green	Red	Red	Green
	Relatively calm / near to docking facilities	Green	Green	Green	Green	Green
<b>Beach morphology</b>	Wide beach (shallow and calm)	Green	Green	Green	Green	Green
	Wide beach (deep nearshore)	Green	Green	Red	Green	Green
	Narrow / short beach (shallow and calm)	Green	Red	Green	Green	Green
	Narrow/short beach (deep nearshore)	Green	Red	Red	Green	Green
<b>Ecological sensitivity</b>	Low ecological sensitivity	Green	Green	Green	Green	Green
	Medium-high ecological sensitivity	Green	Red	Green	Green	Green
<b>Beach structures</b>	High density of beach groynes / other structures	Green	Red	Green	Green	Green
<b>Available resources</b>	Low finance	Green	Red	Red	Red	Green
	Adequate finance	Green	Green	Green	Green	Green
	Limited labour	Red	Green	Green	Green	Green
	Adequate labour	Green	Green	Green	Green	Green

**Key:** Red squares - collection method not recommended; Green squares - suitable collection method

# Acknowledgements

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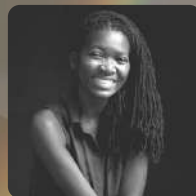


From  
the People of Japan

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