

# ***Sargassum*: Impact on Tourism and Fisheries and Its Cascading Effects on Bonaire, Dutch Caribbean**

## ***Sargassum*: Impacto en Turismo y Pesca y su Efectos de Cascada en Bonaire, Caribe Holandés**

## ***Sargasse*: Impact sur le Tourisme et la Pêche, et Son Effet de Cascade, Bonaire, Antilles Néerlandaises**

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### **EXTENDED ABSTRACT**

Just north of Venezuela lies Bonaire, a small island approximately 12.16°N and 68.25°W. Tourism is the pillar of the economy. Although small to medium *Sargassum* landing events are not unusual, the frequency as well as the amount of *Sargassum* has increased in recent years throughout the Caribbean. There are two major lagoons on the east coast: Lagun and Lac Bay, the latter being a Ramsar site as well as an Important Bird Area. Lac Bay is a hotspot for tourism (windsurfing as well as beach recreation), is an important foraging area for green turtles and is an important nurseries for fish and invertebrates in the Dutch Caribbean.

The periodic influx of *Sargassum* has direct and indirect effect on the beaches, flora, and fauna of the bays. Due to the extractive manner of current removal methods, Lac bay may have less appeal for tourists as beaches become more and more eroded. When *Sargassum* piled up in the shallows, fish, conch, turtles, crabs, lobster, worms, and many infaunal creatures died. In areas where it was not removed immediately, it decomposed, causing further damage. Seagrass short shoots experienced sloughing and rhizomes completely died in some of the impacted areas. A total of 29 ha (11%) of seagrass was heavily affected. The foliage of mangroves in an area of 70 ha (30%) of mangrove area turned yellow but have since recovered. In the mangrove forest is a network of small creeks and lagoons that have an important nursery function.

A degraded habitat will have less nursery functions, food sources for flamingoes and diversity of other foraging animals.

The cascading effects of *Sargassum* landings are in altering the habitat. In 2010 the invasive seagrass *Halophila stipulacea* was found on Bonaire. Monitoring has shown a decrease in cover of the native species in favor of the invasive species; open spaces are more readily recolonized with the invasive species that offers inferior ecosystem services.

### **Introduction**

In recent years, a patch of *Sargassum* northeast of the coast of Brazil has increased in size and, along with changing current patterns, has caused *Sargassum* influxes on islands in the southern region of the Caribbean Sea. Bonaire's coastline was struck with unusually large amounts of *Sargassum* in March and July of 2018. Prevailing currents and winds for Bonaire are from the east, thus the east coast is mainly affected. The east coast is approximately 50 km long with mainly limestone cliffs. There are some sandy, rubble beaches in the north, two bays with seagrass beds and mangroves, and several medium to small inlets. Some of the small inlets feed into shallow ponds where one of the major flamingo breeding colonies of the region is, called Pekelmeer (170 ha). The other bays are Lagun (14.7 ha). Lac Bay (approx. 780 ha). Lac is, economically, the most important, for tourism (kayaking, windsurfing and general beach recreation) as well as fisheries. Pekelmeer and Lac Bay are also Ramsar sites.

### **Methodology**

During the *Sargassum* landing events, the impacted areas were mapped. We did this by wading through the water with a GPS, and using drone images combined with Google Earth. Mangrove growth was monitored along the channels in the mangroves by measuring the aerial roots monthly. The seagrass beds of Lac have been surveyed periodically since 1999, and have been closely monitored from 2010 on, for cover per species. Three native seagrasses occur here: *Thalassia testudinum*, *Syringodium filliforme* and *Halodule wrightii*. In 2010, the invasive species *Halophila stipulacea* was found.

### **Results**

The total mangrove area in Lac is 240 ha, of which 70 ha was affected. A difference in growth between two areas with and without *Sargassum* impact was noted. In the impacted areas, we noticed the leaves of the mangroves turning yellow shortly after *Sargassum* infiltrated and rotted, but this discoloration only lasted 2 - 3 months. Near the beaches, loss of seagrass beds happened because of the use of mechanical equipment, human trampling during removal, and through decomposing *Sargassum*. Seagrass beds close to the mangroves suffered mainly through heavy loads of decomposing *Sargassum*. After the *Sargassum* landings in March and July 2018, shallow seagrass beds near the mangroves (*Thalassia testudinum*) died and were replaced by floating algal masses. After several months, only dead remnants of the shoots were observed, without viable rhizome systems. The total area impacted was 29 ha, of which at least 4 ha has lost all living

*Thalassia* above and below the substrate. During the March event, large amounts of Sargassum entered the breeding area for the flamingoes in the south, the Pekelmeer. Afterwards, large numbers of undernourished flamingo chicks were brought to a bird rehabilitation facility, but study is needed to link the *Sargassum* influx to the state of the flamingo chicks and their food availability.

### Conclusions and Recommendations

Tourism will be affected. A study with the TEEB (The Economics of Ecosystems and Biodiversity) format puts a very high nature value for tourism in Lac Bay (Schep et al., 2013), especially in the Sorobon area: the prime area for beach recreation. During light *Sargassum* events, beaches can still be used, though appreciation will be lower given the constant cleaning of the beaches. When massive influxes occur beaches cannot be used and other water based activities are barely possible to not possible at all. Mechanical means have to be used and cause large amounts of beach erosion. The fishery suffers directly through mortalities during *Sargassum* events. Long-term effects are through loss and degradation of nursery areas (seagrass beds, network of channels and lagoons in mangrove forest). The nursery function of seagrass beds and adjacent mangrove forests has well been documented (eg Nagelkerken et al. 2002). The mangroves are impacted but so far have been able to recover.

*Sargassum* will have a cascading effect on seagrass communities and associated (fish) fauna. Recent studies in Lac Bay have shown that megaherbivores such as turtles influence the cover of seagrasses by the different species in the lagoons: after grazing on the preferred seagrass species – *Thalassia testudinum*, grazed patches are colonized rapidly by the invasive seagrass, *Halophila stipulacea*. After this year's *Sargassum* influxes, large areas of *Thalassia testudinum* were lost. In bare patches, masses of floating algae were found initially, later to be encroached by the invasive seagrass. *H. stipulacea* offers less ecosystem services in terms of carbon sequestration and sediment stabilization as its volume is less and its rhizome system less robust. Canopy height is also less and will provide less shelter for juvenile fish. Studies in 2014 (Becking et al. 2014), demonstrated a significant lower number of fish in turtle grass beds than in beds of *Halophila stipulacea*, 420 individuals in 20 5 m<sup>2</sup> plots versus 224, respectively. Species composition shifted also, with less fish diversity in beds of *Halophila*. Green turtles, having a preference for the native seagrass species, will probably also be affected since the nutritional value of the invasive species is lower.

Response to *Sargassum* is not yet optimal. For removal from beaches there are good guidelines, but the unpredictability of the events (even with an early alert system: <https://optics.marine.usf.edu/projects/SaWS.html>) make it challenging. The potential severity takes a toll on Bonaire's capacity. For preventing *Sargassum* entering the mangroves and accumulating on adjacent seagrass beds, an adequate response must still be developed. Trials have been run with booms. Placing booms strategically is an option. This way, *Sargassum* may be guided to a location where it may be removed, manually or mechanically (with a pump or conveyor belt). In order not to lose more important areas, an adequate system needs to be in place as soon as possible and we hope to learn from experience in the region. There is no question if *Sargassum* will hit again, but when, and then we need to be prepared.

KEYWORDS: *Sargassum*, tourism, fishery

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