OCEAN SCIENCE

Seaweed, seaweed everywhere

Floating *Sargassum* seaweed species are spreading in the Atlantic Ocean

By **James Gower**[1] *and* **Stephanie King**[2]

Thanks to the gas vesicles that give the *Sargassum* genus its name, the open-ocean seaweed species *S. natans* and *S. fluitans* float freely in the ocean. On page 83 of this issue, Wang *et al.* (*1*) report that patches and lines of these seaweeds have grown and spread through the Caribbean and across the north equatorial Atlantic to the west coast of Africa and the Gulf of Guinea, forming what the authors call the great Atlantic *Sargassum* belt. Other species of *Sargassum*, such as *S. muticum* (*2*) and *S. horneri* (*3*), have also increased their range recently but are rooted and are probably being spread through shellfish shipments and ship ballast water. It is the freely floating species that are providing the major changes noted by Wang *et al.*

Sargassum **seaweeds have washed up on an ocean beach in Playa del Carmen, Mexico, in May 2019.**

PHOTO: VICTOR RUIZ/AP PHOTO

Greek and Roman classical authors reported strange seaweeds in the Atlantic beyond the Strait of Gibraltar, but Columbus was the first to give definite reports of *Sargassum*, during his voyage to the Americas (*4*–*6*). Later, Jules Verne, in his novel *20,000 Leagues Under the Sea*, gave Captain Nemo a submarine for exploring the world's oceans, partly to enable him to cross the Sargasso Sea, the area of the North Atlantic gyre where *Sargassum* tends to accumulate. *Sargassum* does not pose a problem to modern shipping, but dense mats would have affected sailing vessels when wind speeds were low; furthermore, it would have suggested dangerously shallow waters to sailors who lacked charts, were unsure of their position, and were used to seeing seaweed only near shore.

S. natans and *S. fluitans* are highly visible to optical sensors on modern satellites, thanks to the high infrared reflectance of the chlorophyll a pigment that is present in all photosynthesizing plants. For plants floating on the ocean, this gives high contrast, seen against the low infrared reflectance of seawater. Furthermore, this pigment has low reflectance at visible wavelengths and high reflectance in the infrared, separated by a sharp increase (a red edge) at a wavelength of ~700 nm. This allows imaging instruments with suitable spectral bands to discriminate between floating plant life and clouds, haze, foam, or reflected sunglint, which lack this red edge. However, patches of *Sargassum* are often much smaller than the spatial resolution (300 to 1000 m) of ocean-monitoring satellite imagers. The satellites therefore probably miss many smaller patches but can detect larger accumulations well enough to map the major concentrations of *Sargassum*.

When first observed by satellite, *Sargassum* in the Gulf of Mexico during the "high *Sargassum* year" of 2005 formed patches and sinuous lines across the northern parts of the Gulf (*7*). Studies by satellite of its movement in the years 2002 to 2010 (*8*) showed an annual pattern in which it grew in spring in the western Gulf of Mexico, moved east into the eastern Gulf and Loop Current, then into the Atlantic Gulf Stream and Sargasso Sea in the fall. This picture was consistent with the distributions reported from earlier ship observations (*2*–*4*, *9*–*11*), although the Gulf of Mexico was not previously seen as an area with substantial *Sargassum* growth. Before 2011, satellite data showed no sign of major quantities of *Sargassum* in the Caribbean or equatorial Atlantic.

This picture changed dramatically in 2011 (*12*), when large amounts of *Sargassum* were observed in the Caribbean and equatorial Atlantic. Since then, this great Atlantic *Sargassum* belt has continued to grow in density and areal extent, albeit with considerable interannual variation and with an unexplained annual cycle, as shown by Wang *et al.* Where it has drifted ashore in large amounts, especially on Caribbean beaches (see the photo), *Sargassum* can have a substantial negative impact on tourism. On the other hand, floating *Sargassum* at sea is an important habitat for many marine species, and the overall long-term impact on tourism is not clear. The recent change in distribution suggests an important, but so far undetermined, change in the marine environment. As Wang *et al.* suggest, increased nutrients from coastal upwelling and from the Amazon River may be a cause of this change.

Sargassum species are easy to track from space. Other marine species of plants or animals that have low spectral contrast, do not form extended patches, or live at depth below the water surface could also vary widely in spatial distribution, without this being as evident. Also, floating marine garbage, especially plastics, is known to accumulate in similar patterns but has thus far proved impossible to see by satellite. This is largely explained by the lack of infrared contrast and of the red edge of chlorophyll a.

Observers in the Caribbean, Brazil, and Africa have called the *Sargassum* influx since 2011 unprecedented (*12*). However, there is no easy way of determining past distributions, and it remains unclear whether similar changes in *Sargassum* distribution have occurred before, although DNA techniques may one day give an answer. In the future, the *Sargassum* distribution may shrink back to its traditional territory, centered on the Sargasso Sea, or it may spread into other oceans. In either case, present satellite sensors are well suited to watch. ■

[1]*Fisheries and Oceans Canada, North Saanich, BC, Canada.* [2]*Sea This Consulting, Nanaimo, BC, Canada. Email: jim.gower@dfo-mpo.gc.ca*

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