Comparative spatiotemporal analysis of accumulated pelagic *Sargassum* landings using community science data

Análisis espacio-temporal comparativo de las arribazones de Sargazo pelágico acumuladas utilizando datos científicos comunitarios

Analyse spatio-temporelle comparative des débarquements cumulés de Sargasses pélagiques à l'aide de données scientifiques communautaires

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EXTENDED ABSTRACT

The regional impact of pelagic *Sargassum* landings occurring periodically since 2011 requires large-scale visualization and monitoring efforts to forecast their arrival. These influxes originate at the Great Atlantic *Sargassum* Belt (GASB), localized at the North Equatorial Recirculation Region (NERR) and are transported via windage and water currents towards the tropical Atlantic (Wang et al. 2019, Johns et al., 2020). Efforts to monitor *Sargassum* are largely focused on satellite imagery; however, nearshore areas are not included or have low resolution. Community science initiatives and databases compensate for the shortcomings of satellite imagery by ground-truthing the models at various sites (Arellano-Verdejo and Lazcano-Hernandez 2020, Iporac et al., 2020).

This study aims to compare *Sargassum* accumulation levels and species composition over time and location using datasets from the "*Sargassum Watch*" community science initiative (Iporac et al. 2020). The inter-annual and intra-annual variability on *Sargassum* accumulation levels over the last two years were hypothesized to be synonymous with the forecasted imagery models from the *Sargassum* Watch System (SaWS) of the University of South Florida (https://optics.marine.usf.edu/projects/SaWS.html). Using Dr. Von D. Mizell-Eula Johnson State Park (MJ State Park), FL and Boddentown, Grand Cayman (GC) as comparable sites with differing latitudes, we also hypothesized GC to have greater accumulation levels than FL; GC in the Caribbean may be more susceptible to higher *Sargassum* accumulations than more northward Florida. Finally, the variability of *Sargassum* morphotype composition was hypothesized to be equally represented between the two sampling areas as well as within the last two years.

Data collection from *Sargassum Watch* was conducted since 2019 via collaborations with sea turtle monitoring groups in Broward County, Florida, and Grand Cayman. The Broward Sea Turtle Conservation Program (BCSTCP) collected daily observations from April to October each year at MJ State Park. The Sea Turtle Monitoring Programme in Grand Cayman collected weekly observations from June-August of 2020, though they did not collect in 2019. Data collected from Mostyn's Beach and Pease's Bay was compiled to represent the Boddentown area of south Grand Cayman, with the most recent version of the data collected up to August 2020.

Volunteers used the Epicollect5 app to take three photos of their site in a panoramic fashion and one photo containing all of the *Sargassum* morphotypes within their vicinity. All observations were geolocated and timestamped prior to upload onto the database. Data downloaded was checked for location accuracy from the GPS coordinates and associated site photos.

Accumulation photos were classified on a modified scale from 0-5, where 0 = little to no *Sargassum,* and 5 = very high accumulation of *Sargassum* (Collado-Vides et al. 2018). To prevent personal biases affecting the classification of accumulation levels, at least two peers examined the same observation to determine the most accurate accumulation level. Species photos were identified to morphotype level based on Schell et al. (2015) and marked for presence or absence per photo.

A two-way ANOVA was used to test for inter-annual and intra-annual differences in average accumulation levels in MJ State Park between years and months within each year. Significant differences were then outlined using a Tukey HSD post-hoc pairwise comparison test. Another two-way ANOVA model with Tukey HSD test was conducted to test for spatiotemporal differences in *Sargassum* accumulations between MJ State Park, FL and Boddentown, GC during the 2020 *Sargassum* season. Presence-absence data of morphotypes were used to calculate relative frequency of each morphotype present per month, calculated as the number of observations of each morphotype found per total number of observations per month

Significant differences were found in *Sargassum* accumulations at MJ State Park between years, months within years, and months between years ($p < 0.001$). Interannual comparisons showed 2019 having higher accumulation levels in earlier months (April-May) than similar months in 2020, though accumulations did not differ from June-August between years. In

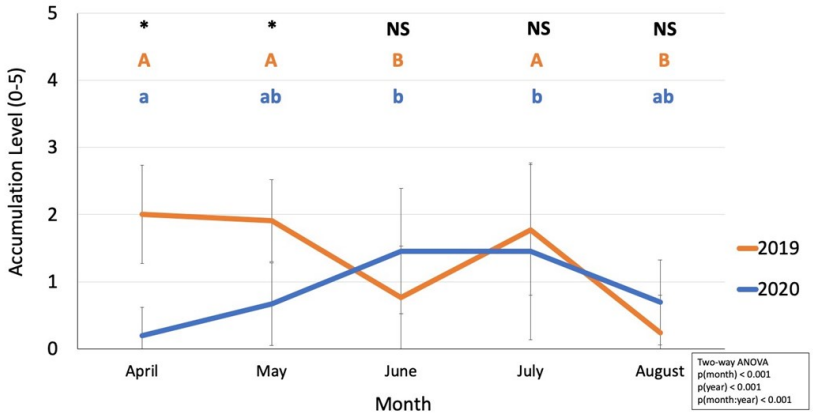

Figure 1. Inter-annual and intra-annual comparison of Sargassum accumulations at Mizell-Johnson State Park, Broward County, FL, USA. Black-texted post-hoc result denote comparisons between years during the same month. Blue- and orange-text post-hoc results denote comparisons between months within each year **(p < 0.05).** .

2019, April, May, and July had higher average accumulations than in June and August. In 2020, June and July had higher accumulation levels than April, though May and August were similar to all other months (figure 1).

Significant differences were found between locations and months during the 2020 season ($p < 0.001$), though no interaction effect was detected ($p = 0.09$). GC showed higher accumulation levels in June than Broward, though accumulations did not differ between locations from June-August. Within GC, June's accumulations were higher than in August, while July differed from neither month (figure 2).

When comparing the morphotype composition found at MJ State Park between the years of 2019 and 2020, the most common morphotype present was *S. fluitans* III, followed by lower relative frequencies of *S. natans* I and *S. natans* VIII, though the order of relative frequency varies. A similar pattern was found when comparing relative frequencies between GC and FL during the 2020 *Sargassum* season. Overall, there was not a consistent pattern in the relative frequencies of *Sargassum* morphotypes found between locations and sampling times (figure 3).

The variation found in average accumulation levels of MJ State Park showed to contrast with satellite imagery forecasts posted by the SaWS outlook bulletins. From comparisons of accumulation levels in 2019, accumulation levels decreased from May to June and increased again from June to July. The SaWS bulletin predicted higher accumulations off the east coast of Florida during those time periods (Wang 2019). Similar differences were found during 2020 where SaWS forecasted an unusual decrease in *Sargassum* biomass from June to July 2020 (Hu 2020); though data showed similar accumulation levels from June to July, and those months having the highest levels of 2020, those accumulations were best classified as little to low accumulation (between levels 1 and 2). However, the higher accumulations in GC compared to FL during the 2020 *Sargassum* season was consistent with satellite models, as areas in the Caribbean are more susceptible to *Sargassum* accumulations than northward Florida. The consistent commonality of *S. fluitans* III contrasted with previous abundance-based studies showing differences in morphotype dominance based on sampling time and location (Olszak et al., 2019, García-Sánchez et al. 2020).

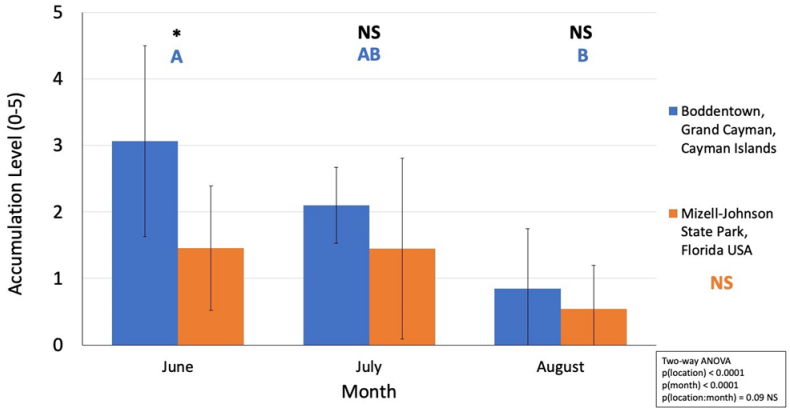

Figure 2. Inter-annual and intra-annual comparison of Sargassum accumulations at Mizell-Johnson State Park, Broward County, FL, USA. Black-texted post-hoc result denote comparisons between years during the same month. Blue- and orange-text post-hoc results denote comparisons between months within each year **(p < 0.05).** .

Community science data is best used to complement other methods of monitoring and forecasting *Sargassum* landings, including satellite imagery or standardized *in situ* quadrats or drones. Data collected by volunteers can be heavily influenced by the local geography of the sampled area, sampling frequency, and the quality of the images collected. The sheer amount of data collected needs more efficient processing methods, and the sample size among locations are not equally distributed across the tropical Atlantic. This analysis hopes to showcase the potential of community science initiatives as a valid and robust method of data collection to monitor *Sargassum* landings.

KEYWORDS: *Sargassum*, citizen science, community science, monitoring, macroalgae

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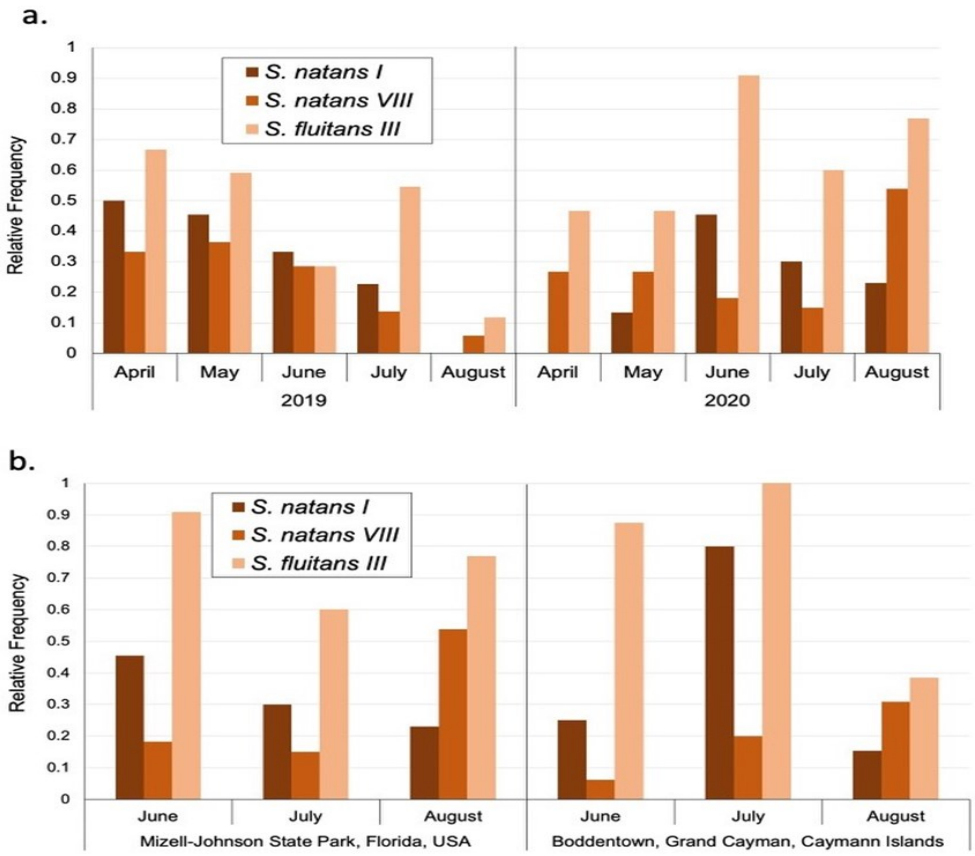

Figure 3. (a.) Comparison of relative frequencies of Sargassum species composition between sampling times (months and years) in Mizell-Johnson State park. (b.) Comparison of relative frequencies of Sargassum species composition between geographic localities during the 2020 Sargassum season.