Productivity and Nutrition of *Sargassum:* A Comparative Ecophysiological Study of Benthic and Pelagic Species in Florida

La Productividad y la Nutrición de *Sargassum* : Un Estudio Comparativo de Ecofisiológico Bentónicas y Pelágicas en Florida

Productivité et Nutrition de *Sargassum* : Une Étude Comparative des Écophysiologique Benthiques et Pélagiques en Floride

BRIAN E. LAPOINTE[1] and ALISON FEIBEL[2]
[1]*Florida Atlantic University - Harbor Branch, 5600 US 1 North, Ft. Pierce, Florida 34946 USA.* blapoin1@fau.edu
[2]*Gulf of Maine Research Institute, 350 Commercial Street, Portland, Maine 04101 USA.* alison.feibel@gmail.com

EXTENDED ABSTRACT

Introduction

Since the 1970s, benthic macroalgae have increased in abundance on Caribbean coral reefs in response to expanding human activities and land-based nutrient pollution. Several species of benthic and pelagic *Sargassum* have responded to the increased nutrient subsidies. For example, extensive meadows of *Sargassum hystrix* and *Sargassum polyceratium* have replaced hermatypic corals on fringing reefs along the north coast of Jamaica (Lapointe 1997, Lapointe et al. 2011) and southwest Martinique (Littler et al. 1992). In 2011, unprecedented high-biomass strandings of pelagic *Sargassum* began to impact coastal waters throughout the Caribbean, resulting in fish kills, dead zones, human health issues, and economic impacts to the regional tourist-based economies (Hu et al. 2016).

Biogeochemical studies along offshore gradients, combined with experimental nutrient enrichment studies, indicate that elevated nitrogen (N) and phosphorus (P) availability from expanding human activities is a major factor supporting enhanced productivity, growth and reproduction of both benthic and pelagic *Sargassum* (Lapointe, 1995, Lapointe, 1997, Lapointe et al., 2011, Lapointe et al., 2014). Pelagic species could also be responding to nutrient enrichment in upstream waters in the Gulf of Mexico: tissue carbon:nitrogen:phosphorus (C:N:P) data indicate that high N:P discharges from the Mississippi and Atchafalaya rivers contributed to blooms of pelagic *Sargassum* in the Gulf of Mexico that occurred from 2011 through 2015 (Lapointe et al., 2015).

This study compared the tissue nutrient content of three benthic *Sargassum* species (*Sargassum pteropleuron*, *Sargassum polyceratium*, and *Sargassum filipendula*) and two pelagic species (*Sargassum fluitans* and *Sargassum natans*) in Florida. We hypothesized that the benthic species would have a higher tissue nutrient content than the pelagic species due to their closer proximity to land-based nutrient pollution. Additionally, the pelagic species would have higher tissue nutrient content and productivity compared to baseline data (Lapointe et al. 2014) due to increasing anthropogenic nutrient loading.

Methods

Sargassum plants were collected at four different locations between February 2015 and April 2016. The species and locations included *S. filipendula* in the Indian River Lagoon (IRL) in east-central Florida; *S. polyceratium* at West Content Key, *S. pteropleuron* at Munson Island, and *S. natans* and *S. fluitans* at Looe Key, three sites located in the lower Florida Keys. During each sampling, macroalgal tissue was collected to determine the stable C ($^{\delta 13}$C) and N ($^{\delta 15}$N) isotopes and elemental C:N:P contents. Composite samples consisted of ~8 - 12 apical thalli, cleaned of epiphytes/epizoa, briefly rinsed (< 5 s) in deionized water, and dried in a Fisher Scientific Isotemp® oven at 65°C for 48 hours. The dried macroalgae was ground using a Thompson Scientific Wiley Mini-Mill® or mortar and pestle, and stored in plastic screw top vials. Samples were analyzed at the University of Georgia Analytical Chemistry Lab for $^{\delta 13}$C and $^{\delta 15}$N analysis and tissue % C, % N, and % P. Additional tissue was collected for net productivity measurements using traditional "light-dark" bottle methods (Lapointe 1995) with a YSI ProODO optical oxygen meter. A handheld YSI- Model 1030 was used to measure temperature, salinity, specific conductivity, and pH and a YSI ProODO was used to measure dissolved oxygen at each site.

Results and Discussion

The tissue C:N:P content and net productivity of the benthic and pelagic species were not significantly different in this study, indicating that the pelagic species were receiving levels of nutrient availability comparable to that of the nearshore benthic species. However, the pelagic species in our studies at Looe Key exhibited significantly higher N:P ratios and net productivity compared to the baseline data from Looe Key in 1986, suggesting a shift towards stronger N enrichment and P-limitation and increased overall productivity and growth of these pelagic species. The % P and N:P ratio, but not % N, were significantly different for *S. natans* ($p < 0.01$) and *S. fluitans* ($p < 0.001$) in the 1986 baseline studies (Lapointe et al. 2014) vs. this study in 2015 - 2016. For both pelagic species, the % P was higher in the 1986 studies, whereas the N:P ratio was higher in the current study. These data suggest that the N:P ratio of pelagic *Sargassum* has increased not only in the GOM (Lapointe et al. 2015), but also in the downstream waters of the lower Florida Keys over the past three decades. This finding is not surprising, as the N-loading of major river discharges into the GOM and coastal

waters of south Florida are increasing as a result of expanding urban and agricultural activities (Lapointe et al. 2015). Notably, the higher N:P ratio in the pelagic species correlated with a significantly higher net productivity of *S. fluitans* in the current study vs. baseline values from 1986 when N:P ratios were lower (Lapointe et al. 2014).

These results, although limited in their temporal and spatial extent, support the hypothesis that the recent mass strandings of *Sargassum* in the GOM, North Atlantic basin, and Caribbean Sea reflect decadal trends of increasing anthropogenic nutrient inputs that enhance productivity of pelagic *Sargassum*. Additional research is needed to expand the geographic scope of this work to see if these results apply to the broad distribution of pelagic *Sargassum* throughout the North Atlantic basin and Caribbean Sea.

KEYWORDS: *Sargassum*, benthic, pelagic, productivity, nitrogen, phosphorus

LITERATURE CITED

Hu, C., B. Murch, B. Barnes, M. Wang, J. P. Maréchal, J. Franks, B. Lapointe, D. Goodwin, J. Schell, and A. Siuda. (2006) *Sargassum* Watch Warns of Incoming Seaweed. *Eos.* **97,** doi:10.1029/2016EOO58355, published on 02 September 2016.

Lapointe, B.E., L.W. Herren, A. Feibel, and C. Hu. 2015. Evidence of nitrogen-fueled blooms of pelagic *Sargassum* in the Gulf of Mexico. *Proceedings of the Gulf and Caribbean Fisheries Institute* **68**:419-420.

Lapointe, B.E., L.E. West, T.T. Sutton, and C. Hu. 2014. Ryther revisited: nutrient excretions by fishes enhance productivity of pelagic *Sargassum* in the western North Atlantic Ocean. *Journal of Experimental Marine Biology and Ecology* **458**:46-56.

Lapointe, B.E., K. Thacker, C. Hanson, and L. Getten. 2011. Sewage pollution in Negril, Jamaica: effects on nutrition and ecology of coral reef macroalgae. *Chinese Journal of Oceanology and Limnology* **29(4):**775-789.

Lapointe, B.E. 1997. Nutrient thresholds for bottom-up control of macroalgal blooms on coral reefs in Jamaica and southeast Florida. *Limnology and Oceanograpy* **42**:1119-1131.

Lapointe, B.E. 1995. A comparison of nutrient-limited productivity in *Sargassum natans* from neritic vs. oceanic waters of the western North Atlantic Ocean. *Limnology and Oceanography* **40**:625-633.

Littler, M.M., D.S. Littler, and B.E. Lapointe. 1992. Modification of benthic community structure by cultural eutrophication: The southwest coast of Martinique. *Proceedings of the 7th International Coral Reef Symposium* **1**:335-34.