Michael Chapuis March 5th, 2019

BIO376 Blog Assignment

Anthropogenic Threat to Seagrass and Mitigation of Nitrogen Inputs

Often overlooked when compared to the attention garnered by coral reefs and coastal mangrove forests, seagrass meadows are critical marine ecosystems currently facing considerable anthropogenic stressors. Seagrass is composed of approximately 60 different species (Devault & Pascaline, 2013) and is found in tropical and temperate coastal waters around the world (Figure 1) (Duarte & Chiscano, 1999). Seagrasses are flowering plants that anchor their roots in sandy substrata and complete their entire lifecycle under the water surface unlike many aquatic flowering plants, which, at certain times, need to penetrate the water surface (Devault & Pascaline, 2013). While some species can be found at depths of up to 70 meters, the majority of the 19.9 billion tons of seagrass biomass (Devault & Pascaline, 2013) is found within 10 meters of the surface (Grech et al., 2012). Close proximity to the coast however, makes seagrass particularly sensitive to light inputs, eutrophication, and other anthropogenic disturbances.

The importance of seagrass to the marine ecosystem can be seen through its provision of food and habitant for a multitude of organisms, as well as its role in erosion control (Quiros, Croll, Tershy, Fortes & Raimondi, 2017). Its biochemical role, however, may be its most critical asset to the environment. Despite only occupying 0.15% of the marine surface, seagrass is responsible for 12% of net production in the oceans around the world (Duarte & Chiscano, 1999). Its ability to sequester 27 million tons of carbon on an annual basis makes it a critical carbon sink as well as a provider of carbon to deeper benthic environments (Devault & Pascaline, 2013).

Seagrass health has only become a topic of in-depth study relatively recently, and concerns over the health and resiliency of meadows are increasing as we learn more about their importance to the marine ecosystem. Seagrass meadows are now considered to be one of the most at-risk marine environments. At the global scale, 15% of seagrass species are under threat (Grech et al., 2012), and we are losing considerable swaths of this important habitat at a current rate of 7% per year (Jones, Cullen-Unsworth & Unsworth, 2018). Their relative lack of genetic diversity could potentially make them vulnerable to large-scale impacts if marine conditions become unsuitable (Devault & Pascaline, 2013).

At the 8th International Seagrass Biology Workshop, seagrass experts representing each bioregion in which seagrass is present all agreed that the primary anthropogenic threat to seagrass health, resiliency, and diversity is runoff from urban and agricultural land uses (Grech et al., 2012). While some types of fisheries, dredging and boating traffic also negatively impact seagrass to differing degrees, runoff from anthropogenic land use appears to be the most invasive.

Nitrate and ammonium inputs into coastal marine ecosystems is becoming an increasing concern as human population densities increase in coastal areas, producing increasing effluent and requiring more intense applications of fertilizers to maintain sufficient crop levels (Tyler, Moore & Locke, 2012). As fertilizers are progressively added to soil, leaching of excess nitrate and ammonium during natural precipitation and irrigation events flows into coastal waters (Tyler, Moore & Locke, 2012).

By using nitrogen stable isotope analysis, researchers were able to confirm the source of elevated nitrogen levels in the biomass of seagrass in the British Isles to be from agricultural land use (Jones, Cullen-Unsworth & Unsworth, 2018). The elevated levels of $\delta^{15}N$, indicative of agricultural inputs in the water, were shown to have considerable negative impacts on seagrass meadows. The biomass of seagrass was reduced due to shrinking aboveground leaf width and length, as well as belowground shoots (Jones, Cullen-Unsworth & Unsworth, 2018). Additionally, the studied nutrient inputs increased the risk of eutrophication of the water and an increasing in epiphytic microalgae, which accumulates on seagrass and reduces its ability to photosynthesize (Jones, Cullen-Unsworth & Unsworth, 2018). If epiphyte blooms become large enough, seagrass and biodiversity as a whole can diminish under the resulting hypoxic or anoxic conditions (Lapointe, Barile & Matzie, 2004). Inshore and offshore seagrass meadows are affected by increasing land-based nitrogen inputs, potentially endangering many populations (Lapointe, Barile & Matzie, 2004).

Given what we know, it seems likely that detrimental runoff is affecting all areas inhabited by seagrass, to differing degrees. This leaves humans with a considerable ecological predicament. Determining the best approach for mitigating the effects of environmental runoff is a complex issue given the diversity of land use, terrestrial and aquatic conditions, as well as differences in nutrient types and scales of input around the world.

One approach is to establish marine protected areas (MPA). While MPAs are important factors in the health of our marine environments, many anthropogenic stressors are sourced from terrestrial environments that subsequently affect marine ecosystems (Quiros, Croll, Tershy, Fortes & Raimondi, 2017). A 2017 study of the mitigating effects of MPAs showed that they had minimal protective value compared to addressing land use issues and protecting terrestrial zones adjacent to marine coasts (Quiros, Croll, Tershy, Fortes & Raimondi, 2017). It is unrealistic however, to entirely control coastal land use and development given their socioeconomic importance. How can we move toward seagrass protection while maintaining use of coastal land, given the evidence that these areas have considerable impact on marine habitats?

Reducing the amount of nitrogen input into coastal marine environments could dramatically reduce the negative repercussions of anthropogenic land uses (particularly agricultural use). A 2012 study on the denitrifying effects of three particular plant species showed promising results. The study focused on cutgrass (*Leersia oryzoides*), cattail (*Typha latifolia*), and bur-reed (*Sparganium americanum*) to demonstrate that these aquatic plants have the ability to efficiently reduce ammonium and nitrate from runoff waters when placed in agricultural drainage ditches (Tyler, Moore & Locke, 2012). When exposed to water enriched with ammonium and nitrate, then allowed to process the runoff, *T. latifolia* and *S. americanum* reduced ammonium content by approximately 59% and 33.7% respectively while *L. oryzoides*, *T. latifolia*, and *S. americanum* reduced nitrate levels by approximately 67%, 64%, and 29% respectively compared to unvegetated tests (Tyler, Moore & Locke, 2012).

The benefits of creating drainage ditches populated with appropriate aquatic plant species are numerous. The plants directly intake nitrogen loads into biomass, provide organic carbon to soil substrates thereby facilitating denitrification, as well as provide an environment well suited for microbes that take part in the denitrification process (Tyler, Moore & Locke, 2012). Further study is required to determine which plant species would be best suited to various regional conditions in order to have the greatest beneficial effect on the health of seagrass habitats around the world.

This method could prove useful given its relative ease of application, minimal space requirement relative to filtration ponds, and low economic burden (Quiros, Croll, Tershy, Fortes & Raimondi, 2017). Adaptations could be made to the scale and species of nitrogen reducing plants in drainage ditches in order to best suit the local climate and level of runoff risk.

The protection of seagrass along coastal regions around the world would help ensure its benefit as a significant primary producer, sanctuary for a range of aquatic species, as well as an aide in reducing coastal erosion and help ensure the economic viability of several industries that directly and indirectly depend on the presence of seagrass.

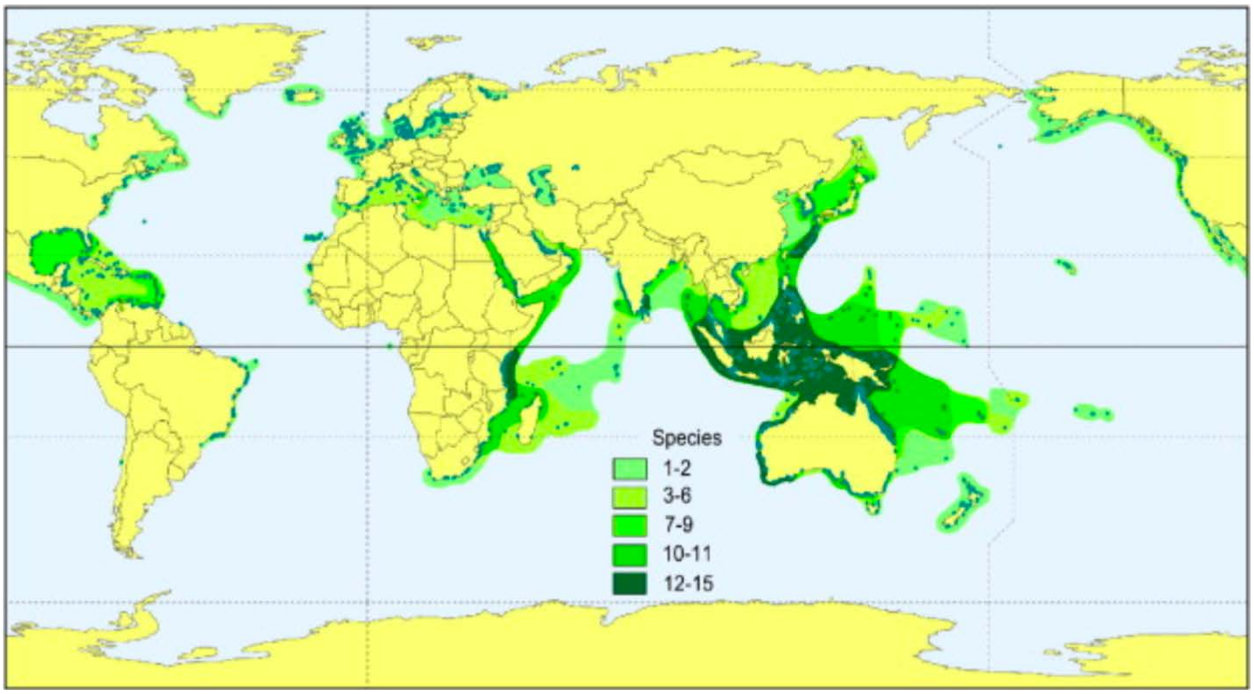

Figure 1. Coastal areas with noted seagrass populations indicated by green dots. Difference in shading indicates the number of species within that area. (Devault & Pascaline, 2013)

References

Devault, A.D., & Pascaline, H. (2013). Herbicide Impact on Seagrass Communities. *Herbicides - Current Research And Case Studies In Use*. doi: 10.5772/55973

Duarte, C., & Chiscano, C. (1999). Seagrass biomass and production: a reassessment. *Aquatic Botany*, *65*(1-4), 159-174. doi: 10.1016/s0304-3770(99)00038-8

Grech, A., Chartrand-Miller, K., Erftemeijer, P., Fonseca, M., McKenzie, L., & Rasheed, M. et al. (2012). A comparison of threats, vulnerabilities and management approaches in global seagrass bioregions. *Environmental Research Letters*, *7*(2), 024006. doi: 10.1088/1748-9326/7/2/024006

Jones, B., Cullen-Unsworth, L., & Unsworth, R. (2018). Tracking Nitrogen Source Using δ15N Reveals Human and Agricultural Drivers of Seagrass Degradation across the British Isles. *Frontiers In Plant Science*, *9*. doi: 10.3389/fpls.2018.00133

Lapointe, B., Barile, P., & Matzie, W. (2004). Anthropogenic nutrient enrichment of seagrass and coral reef communities in the Lower Florida Keys: discrimination of local versus regional nitrogen sources. *Journal Of Experimental Marine Biology And Ecology*, *308*(1), 23-58. doi: 10.1016/j.jembe.2004.01.019

Quiros, T., Croll, D., Tershy, B., Fortes, M., & Raimondi, P. (2017). Land use is a better predictor of tropical seagrass condition than marine protection. *Biological Conservation*, *209*, 454-463. doi: 10.1016/j.biocon.2017.03.011

Tyler, H., Moore, M., & Locke, M. (2012). Influence of Three Aquatic Macrophytes on Mitigation of Nitrogen Species from Agricultural Runoff. *Water, Air, & Soil Pollution*, *223*(6), 3227-3236. doi: 10.1007/s11270-012-1104-x