ALGAL TURF PRODUCTION ON THE GREAT WICOMICO RIVER, VA, USA:

DIVERSITY AND BIOCHEMISTRY OF AN ALGAL TURF SCRUBBER (ATS™)

H. Dail Laughinghouse IV[1, 2], Walter H. Adey[1], John Miller[3]

[1]Department of Botany, National Museum of Natural History, Smithsonian Institution, Washington, DC, USA (hdliv@hotmail.com);

[2]MEES Program, College of Computer, Mathematical and Natural Sciences, University of Maryland, College Park, MD, USA;

[3]Department of Chemistry, Western Michigan University, Kalamazoo, MI, USA

Statoil

*funding

Introduction

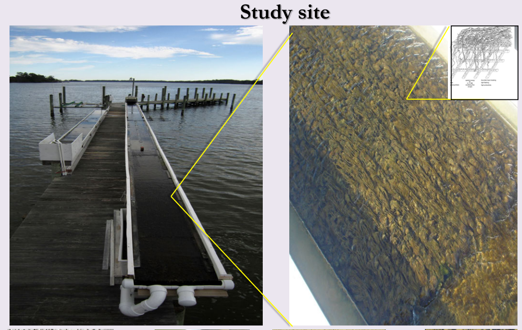
3 acre ATS system in Florida: used for phosphorus and nitrogen reduction on a eutrophic stream

7 acre Tilapia production system in south Texas

The algal turf scrubber (ATS) is an ecologically engineered system that develops natural periphytic algae (algal turf). ATS units are typically used to remove nutrients (especially nitrogen and phosphorus) and to inject oxygen into degraded waters. They have also been used in aquaculture production systems, and to remove heavy metals and break down toxic organics in industrially degraded waters. Larger ATS systems have been in constant operation for two decades and range from 0.1 to 3 hectares in size. In the ATS, algae grow attached to screens in shallow troughs over which pulsed, flowing water is passed. Algae in ATS systems are harvested on a weekly basis to remove the nutrients. The algal biomass can be used in a variety of by-products; both butanol and ethanol production, as well as fertilizer efficacy have been demonstrated.

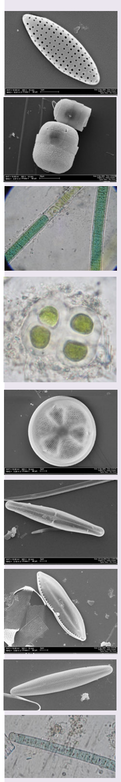
In this study, two two-foot wide experimental ATS systems, one 50 ft. the other 80 ft. long, constructed of fiberglass, were studied from summer 2009 to summer 2011. These units were used on a mesohaline river to examine the role of substrate type and CO_2 introduction on algal species composition, biomass production, and biochemistry, preparatory to developing an amelioration system for the Chesapeake watershed. A total of 45 samples over 25 dates were taken on either floway. Partial results are presented here on algal abundance and dynamics, biomass data, nutrient data, and biochemical by-products.

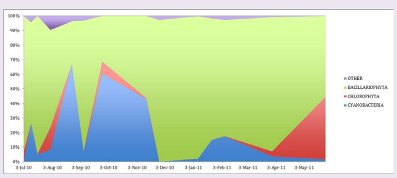
Study site



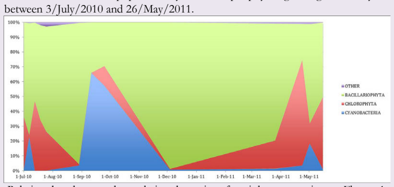
Water for the ATS™ experimental systems (shown on the upper left) came from the Great Wicomico River; a small tributary located on the northwestern shore of the Chesapeake Bay. Under that image are images of the algal turf growing on 2D and 3D screens

Results

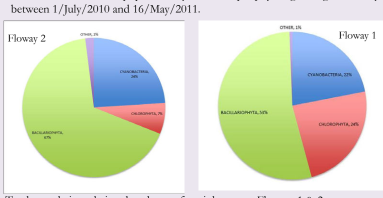




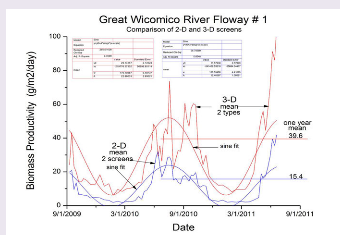
Relative abundance and population dynamics of periphyton growing on Floway 2 between 3/July/2010 and 26/May/2011.



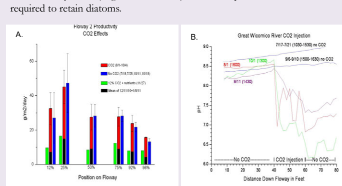
Relative abundance and population dynamics of periphyton growing on Floway 1 between 1/July/2010 and 16/May/2011.



Total cumulative relative abundance of periphyton on Floways 1 & 2.

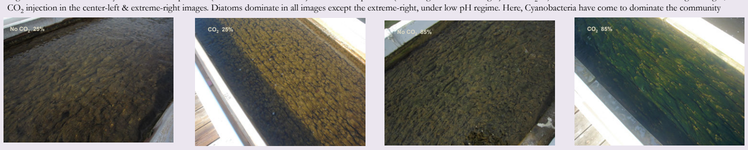


Algal biomass productivity using two substrate screen types. Flat-lying plastic screens work well in green algal dominated systems. In diatom-dominated systems (large water bodies) more complex 3-D substrates are required to retain diatoms.



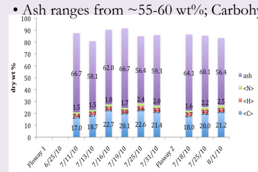
A) Algal biomass production at positions down Floway # 2, as a function of CO2 introduction regime. Note the black bars represent winter runs without CO2 injection. B) pH down Floway # 2, under manual operation, during the first few months of operation. Note that CO2 was injected at 40-50 feet and again at 60 feet (75%). In the fourth quarter of the floway, after injection ceased, the pH began to recover rapidly due to algal photosynthesis. The rise rates are greater, under the same solar regime than on the upper part of the floway, where less carbon was available.

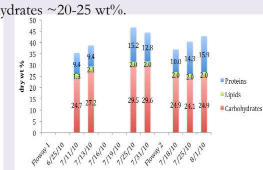
Algal communities on Floway # 2 at the 25% position (extreme left & center left) and the 85% position (center right & extreme right). No CO_2 injection in the extreme left & center-right images; full CO_2 injection in the center-left & extreme-right images. Diatoms dominate in all images except the extreme-right, under low pH regime. Here, Cyanobacteria have come to dominate the community

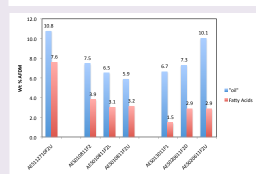


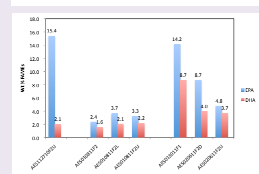
*Funding for Travel: Northeast Algal Society (NEAS) & ENST-UMD

- *Oil* is measured gravimetrically and consists of solvent-extractable materials;
- *Fatty acids* are components of the *oil* that are fatty-acid based, and are chemically analyzed as their methyl esters or *FAMEs*;
- *Oil* and *Fatty acids* are plotted relative to the ash-free dry mass;
- EPA and DHA are plotted relative to the total fatty acid-based fraction (as FAMEs);
- Ash ranges from ~55-60 wt%; Carbohydrates ~20-25 wt%.









The graphs above provide different biochemical composition of the algal biomass on the respective dates.

Conclusions

ATS systems operating on degraded water bodies, that are naturally-seeded with ambient algae, can be both highly productive and diverse.

Scale-up has been demonstrated and large river-scale amelioration, with resultant by-products is possible.

We have seen interesting results in our algal assemblages and are currently trying to understand what drives these successions. Bacillariophyta and Cyanobacteria dominate our units. Significant seasonal changes occur. Species of *Grammatophora* and *Thalassionema* are dominant in the colder months, while *Berkeleya rutilans* and *Melosira nummuloides* dominate in warmer weather. *Ulva intestinalis and Ulothrix* spp. increase in spring.

Lower pH increases the growth of *Lyngbya* cf. *salina*.

PUFAs increase in winter, however overall biomass decreases.