Dominance of Cladophora Oxygen Demand at Night-time in Wequetequock Cove

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Motivation and Objective

- **Motivation:** Water quality measurements effectuated by CUSH from 2008 to present reveal that oxygen concentrations in Wequetequock Cove (Stonington) are extremely low in summer mornings, which is detrimental to the organisms living there.
- **Objective:** Quantify the inputs and outputs of oxygen therein in order to determine where the O_2 is going at night

Methods

We measured the following in the fall of 2015 and again in the fall 2016:

- Respiration rates of small animals that live in the water column of the cove
- Dark sediment respiration rates, *i.e.*, O_2 uptake into surface sediments due to decomposition by sediment bacteria
- Dark microbe respiration rates in water collected in the cove
- Dark respiration rates of Cladophora mats collected in the cove

We calculated:

- Gas transfer rates (based on Wanninkohf, 1992): The oxygen replenishment to the cove based based on our measured (data logging anemometer) night-time average wind speed for the cove

Photosynthesis and Respiration

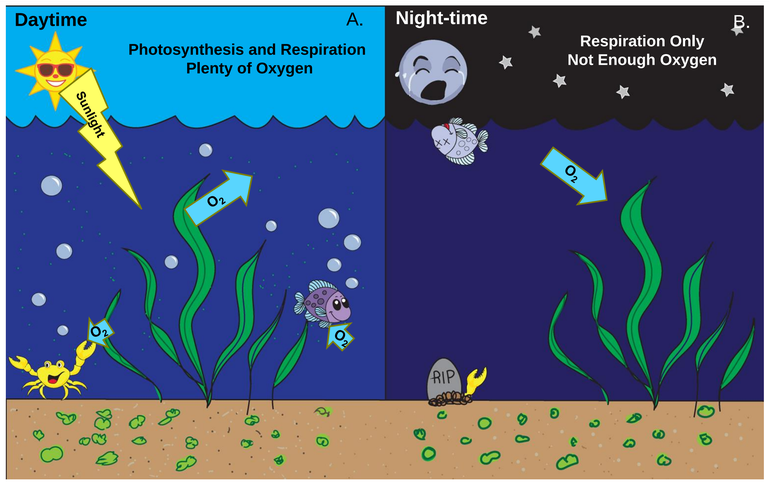

Figure 1. (A) In the daytime in Wequetequock Cove aquatic plants and some microbes use light to create oxygen by photosynthesis. During this time there is plenty of oxygen for the animals to use for respiration. **(B)** At night-time the only process that occurs is respiration (oxygen consumption), there is not enough oxygen for all the plants and in the water column. Oxgyen is consumed by animals, by Cladophora, by microbes in the water and by microbes in sediment.

References

Wanninkhof, Rik. "Relationship between Wind Speed and Gas Exchange over the Ocean." *J. Geophys. Res. Journal of Geophysical Research* 97.C5 (1992): 7373

Results

- Water column respiration rates were on the order of 103.3± 3 mmol O_2 m^{-2} d^{-1} (mean ± range; **Fig. 2**), accounting for 8% of the total measured oxygen demand (**Fig. 3**).
- Small animals in the water column were estimated to respire at a rate of 320 mg $O_2/m^{-2}d^{-1}$, approximately 25% of total oxygen demand.
- Oxygen uptake rates by sediment were on the order of 64 ± 7 mmol O_2 m^{-2} d^{-1}, 5% of total oxygen demand.
- Cladophora mats in the dark consumed oxygen at an average rate of 798 mmol O_2 m^{-2} d^{-1}, accounting for 62% of the oxygen demand in Wequetequock Cove.
- The only input of oxygen to cove waters at night is through gas transfer from the atmosphere (**Fig. 2**), which increases as a function of wind speed
- Wind speeds are low at night (averaging 1 mile per hour in summer months), and thus can introduce 11.2 ± 3 mmol O_2 m^{-2} $night^{-1}$, and can only replenish .9% of the required oxygen
- Over 8 hours of night time, the total measured oxygen demand would amount to **6.6 mg L^{-1}** of dissolved O_2.
- At the start of the night oxygen concentrations are **~ 7 mg L^{-1}**.
- Based on our measured rates, oxygen concentrations will drop to **0.4 mg L^{-1}** at night, though direct measurements by CUSH evidence complete oxygen loss in some summer mornings.

Night-time Oxygen Demand

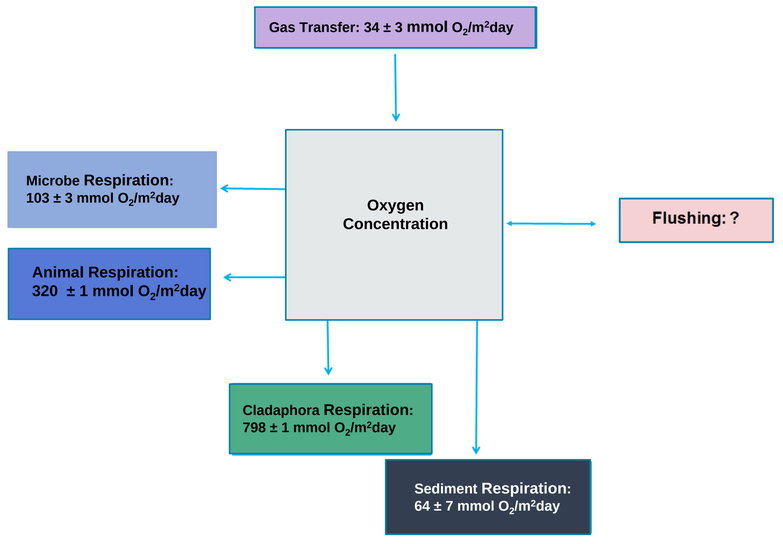

Figure 2. Night-time oxygen demand of Wequetequock Cove: At night, because there is no photosynthesis, the only input is gas transfer from the atmosphere. This input increase with wind speed. Microbes, animals, Cladophora mats, and microbes in sediment all decrease consume oxygen, causing concentrations to decrease thoughout the night. The oxygen input for flushing by tides and currents is not determined.

Oxygen Consumption at Night

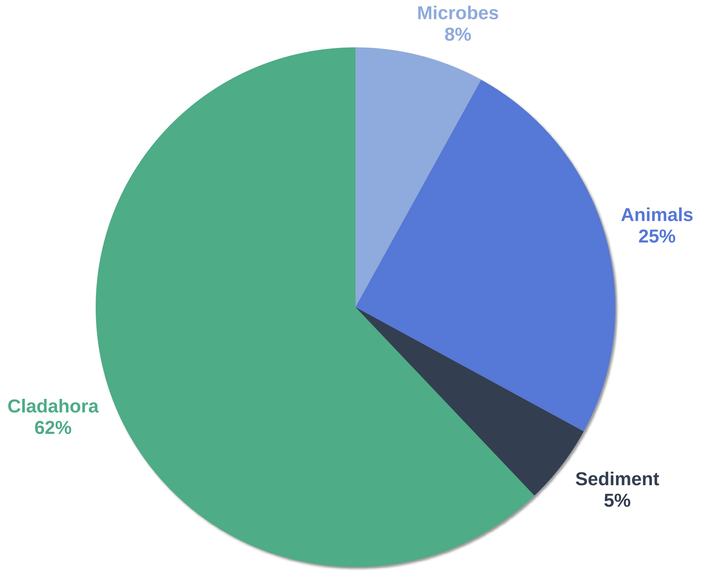

Figure 3. Night-time oxygen consumption in Wequetequock Cove. Cladophora accounts for 62% of the night-time oxygen consumption. The remaining 38% is from bacteria in the sediment, microbes, and animals in the water above.

Conclusion

- Cladophora mats consume the majority of dissolved oxygen at night-time in Wequetequock Cove.
- Water column microbes, sediment microbes and animals together account for less oxygen consumption.
- The only input of oxygen to cove waters at night is through gas transfer from the atmosphere, which is insufficient to replenish oxygen
- Oxygen concentrations in the morning is deleteriously for animals that can't "swim away" to the outside of the cove
- If there were no Cladophora, oxygen concentration would, on average, only decrease to **4.6 mg L^{-1}** at night, a sufficient concentration for animals

Recommendations

- In order to keep the oxygen concentrations above 4 mg L^{-1}, the density of Cladophora mass would need to derease by ≥ 85%
- The probable cause(s) of Cladophora invasion may include:
  - -Excess nutrients from the watershed
  - -Warmer summertime temperatures
  - -Longer summer seasons (shorter winters)
- Further efforts to mitigate the spread of Cladophora in and around Wequetequock Cove and in southern New England are necessary to maintain healthy coastal habitats
- A reduction in the inputs of nutrients from the watershed is the most viable long-term mitigation strategy, at this junction