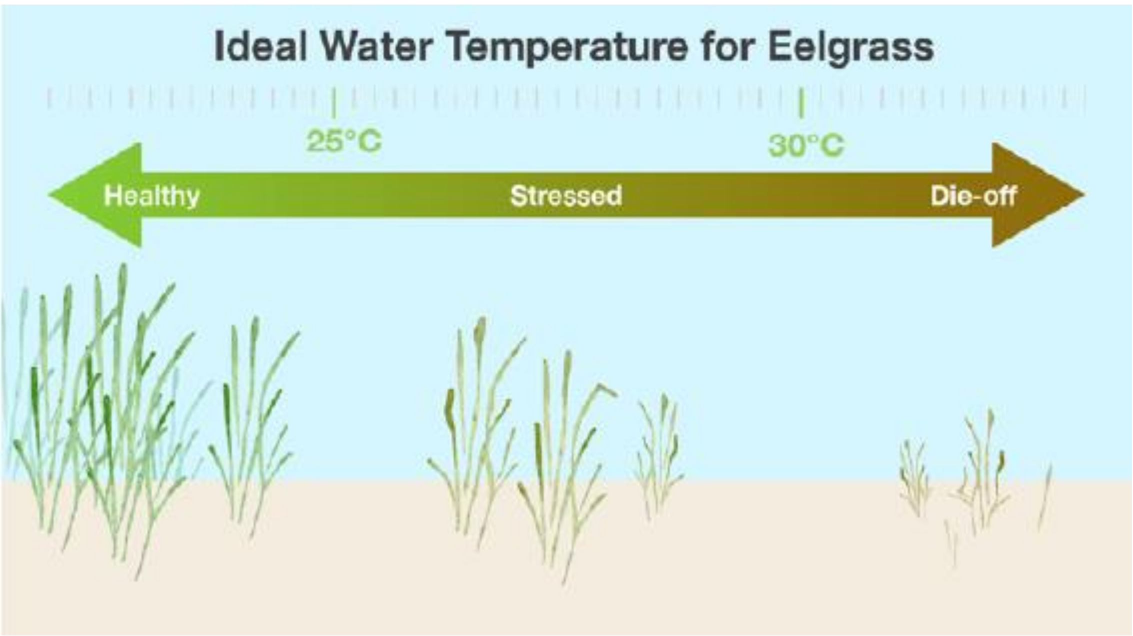
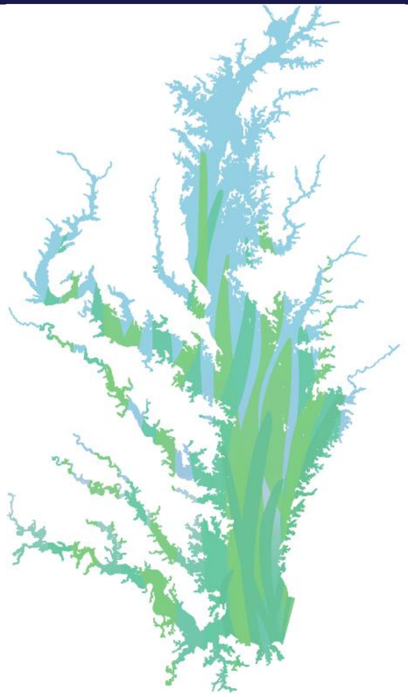
Water Temperature Effects on Submerged Aquatic Vegetation in Chesapeake Bay





J. Brooke Landry
SAV Element Lead
Chair, Chesapeake Bay Program's SAV Workgroup

SAV Session Goals

- State of the Science
- Data Gaps
- Current research
- Management Implications

Chesapeake Bay SAV:
The six most common species

Wild Celery (*Vallisneria americana*)

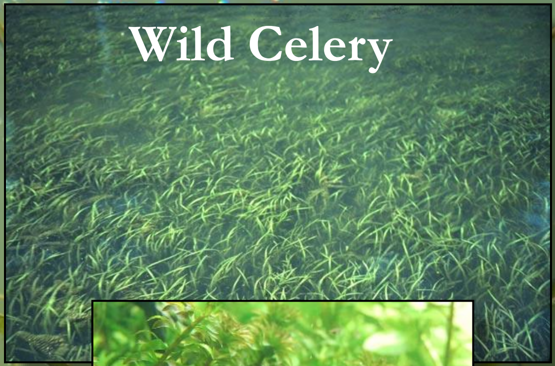
Hydrilla (*Hydrilla verticillata*)

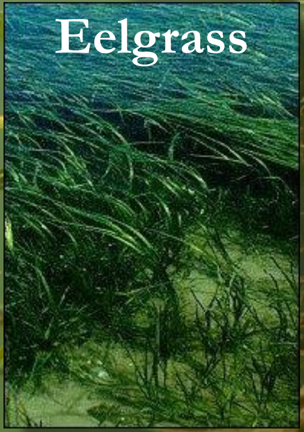
Redhead Grass (*Potamogeton perfoliatus)*

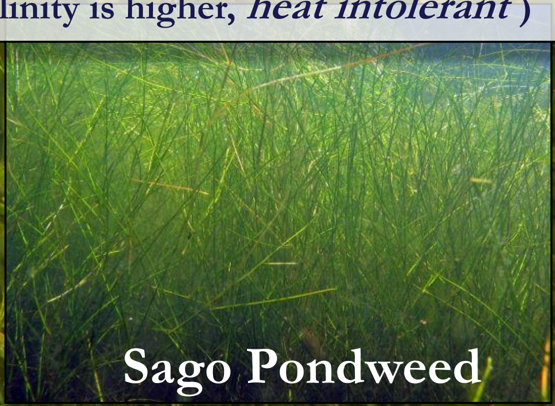
Sago Pondweed (*Stuckenia pectinata)*

Widgeon Grass (*Ruppia maritima*) (the most widespread)

Eelgrass (*Zostera marina)* (the only "true" seagrass species, can tolerate salinities as low as 10 ppt, but is dominant in the lower reaches of the bay where salinity is higher, *heat intolerant*)







Chesapeake Bay SAV:
Other species commonly observed in the Bay

1. *Potamogeton crispus* (Curly pondweed)
2. *Potamogeton pusillus* (Slender pondweed)
3. *Zannichellia palustris* (Horned pondweed)
4. *Elodea canadensis* (Canadian waterweed)
5. *Ceratophyllum demersum* (Coontail)
6. *Heteranthera dubia* (Water stargrass)
7. *Najas guadalupensis* (Southern naiad)
8. *Najas gracillima* (Slender waternymph)
9. *Najas minor* (Brittle naiad)
10. *Myriophyllum spicatum* (Eurasian watermilfoil)

Chesapeake Bay Salinity Zones and SAV Distribution

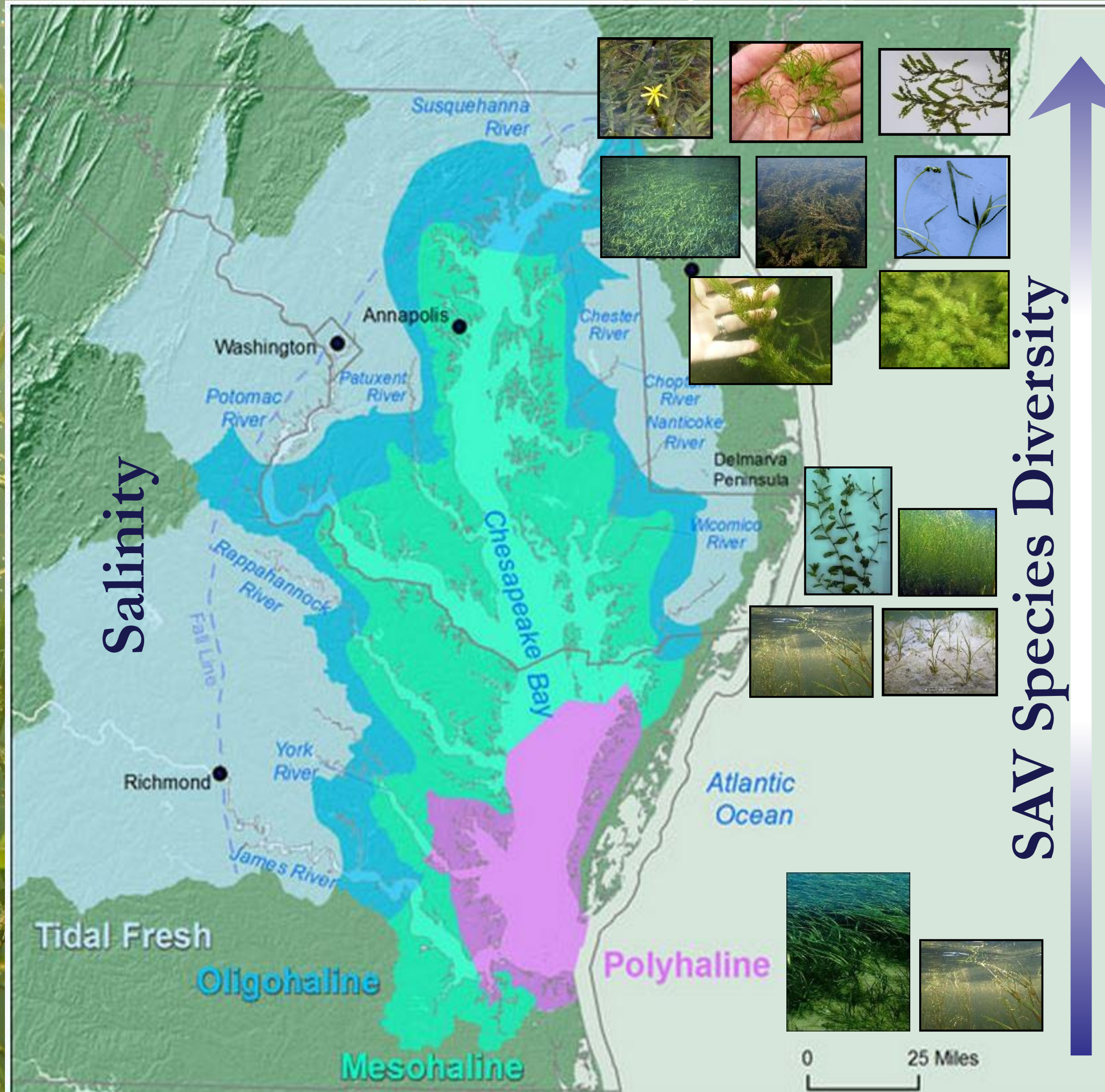
<u>Tidal Fresh</u>
0-0.5 ppt

<u>Oligohaline</u>
0.5-5 ppt

<u>Mesohaline</u>
5-18 ppt

<u>Polyhaline</u>
18-30 ppt

(The open ocean is 30+ ppt, on average about 35 ppt)



Map of Chesapeake Bay and its tributaries with Salinity Zones (Tidal Fresh, Oligohaline, Meshohaline, and Polyhaline)

Chesapeake Bay SAV Communities: Fresh, Brackish, Salty

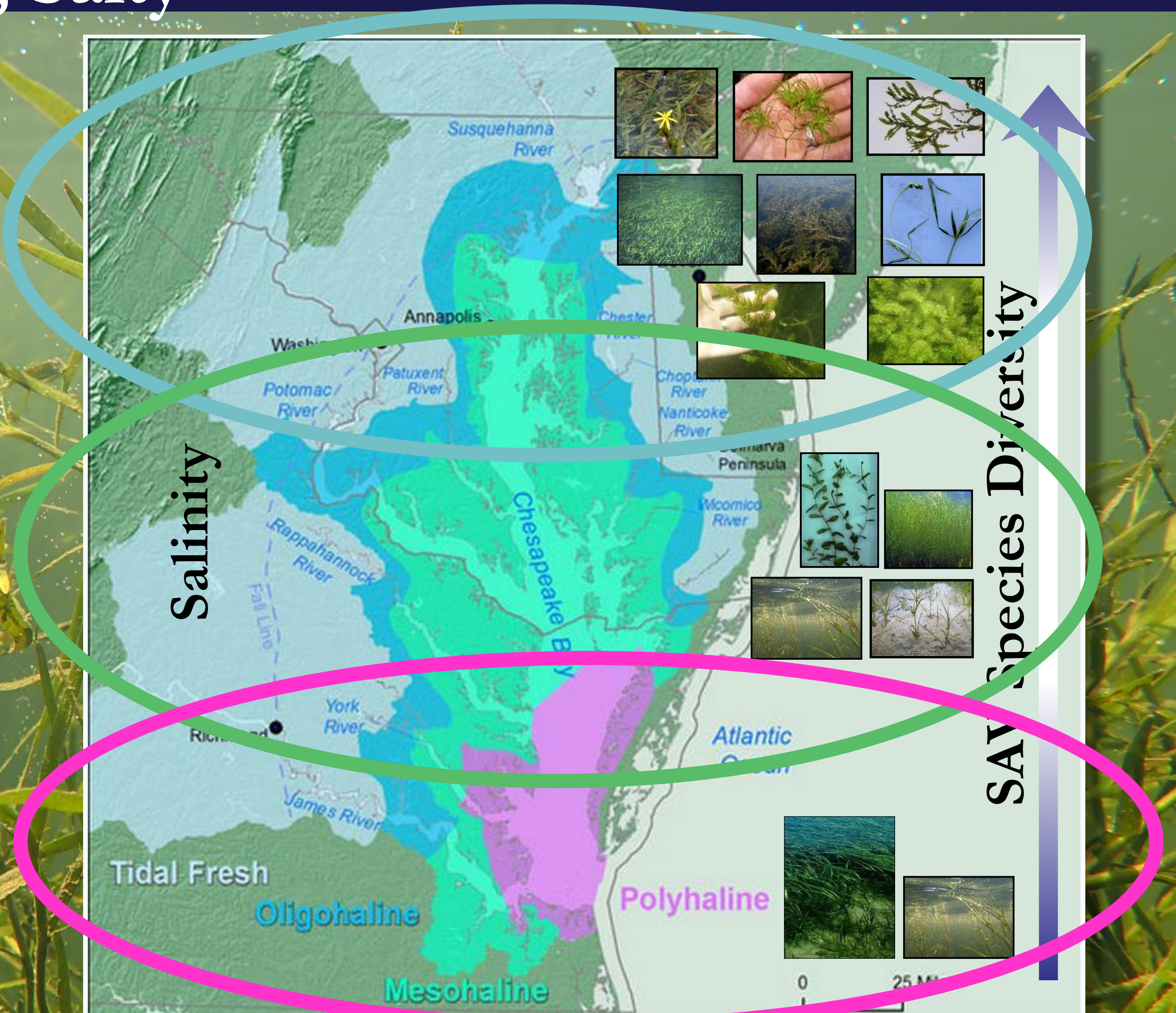
<u>Tidal Fresh</u>
0-0.5 ppt

<u>Oligohaline</u>
0.5-5 ppt

<u>Mesohaline</u>
5-18 ppt

<u>Polyhaline</u>
18-30 ppt

(The open ocean is 30+ ppt, on average about 35 ppt)



Map of Chesapeake Bay and its tributaries with Salinity Zones (Tidal Fresh, Oligohaline, Meshohaline, and Polyhaline)

Chesapeake Bay Climate Change: Direct SAV Impacts

By the end of the century, the Chesapeake region will be subject to a

-mean temperature increase of 2-6°C,
-0.7-1.6m of sea-level rise, and a
-50-160% increase in CO_2 concentrations

Chesapeake Bay Climate Change: Direct SAV Impacts

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These will directly affect SAV physiology, productivity, health, reproduction, and survival.

Chesapeake Bay Climate Change: Direct SAV Impacts - CO_2 Fertilization Effect

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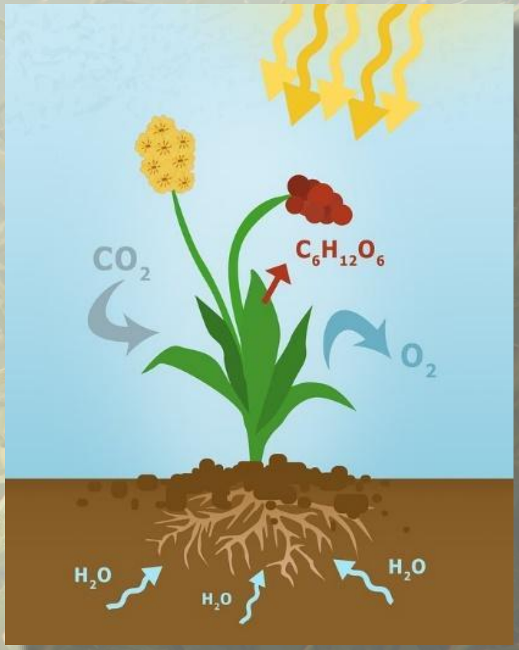


Chesapeake Bay Climate Change: Rising Temperature Impacts

Warming of the Chesapeake Bay will not occur uniformly.

The greatest and most inconsistent warming will almost certainly occur in shallow waters (SAV habitat) as well as in areas affected by urbanization.


Photo: Baltimore Magazine

Chesapeake Bay Climate Change: Rising Temperature Impacts on SAV

Most Bay species are considered to be "temperate" species, with an optimal growth temperature range of 11.5° C to 26° C.

In general, increasing temperatures alter

-rates of photosynthesis and respiration,

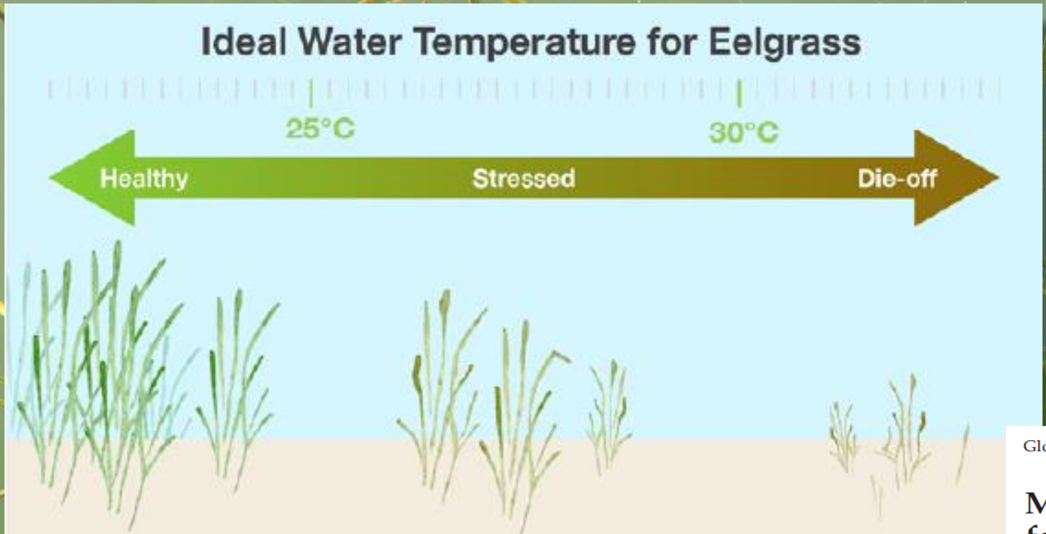
-interfere with germination triggers and life-cycles,

-trigger disease outbreaks and algal blooms,

-cause increased SAV mortality

The ability of SAV to tolerate warming will be species-specific.

Chesapeake Bay Climate Change: Eelgrass (Salty)



-optimal water temp is ~10-20° C

-optimal seedling growth range: 16-17° C

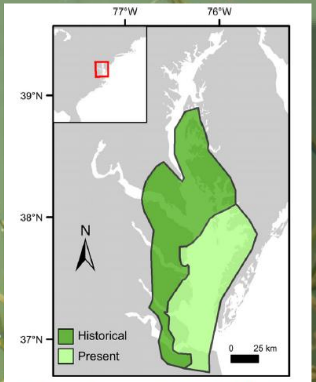
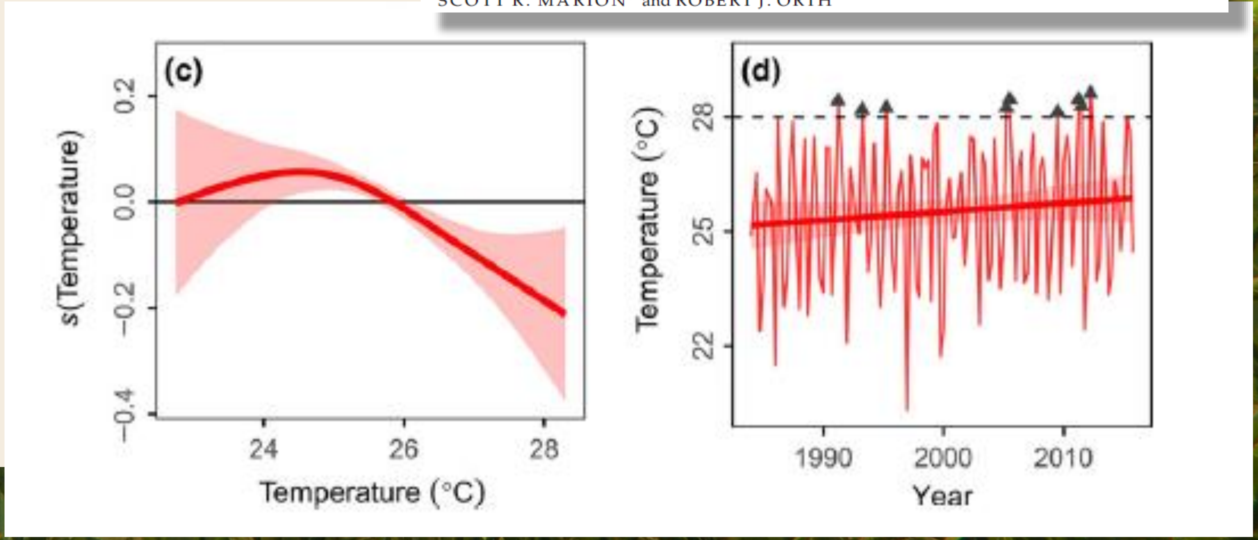


Fig. 1 Current (light green) and historical distribution (dark green) of eelgrass in Chesapeake Bay. Historical distribution is prior to 1971, immediately preceding Tropical Storm Agnes.

Global Change Biology (2017), doi: 10.1111/gcb.13623

Multiple stressors threaten the imperiled coastal foundation species eelgrass (*Zostera marina*) in Chesapeake Bay, USA

JONATHAN S. LEFCHECK[1], DAVID J. WILCOX[1], REBECCA R. MURPHY[2], SCOTT R. MARION[3] and ROBERT J. ORTH[1]



Chesapeake Bay Climate Change: Widgeongrass (Brackish)

Ruppia maritima tolerates a wider range of temperature and salinity conditions than eelgrass

- Rm tolerates temps from 7-40°C
- Ideal growth conditions range from 20 to 25° C
- Optimal seed germination occurs at 15-20°C
- Lethal temp is 45°C

Ruppia's very wide temperature tolerance may make it a "winner" in a warmer climate, replacing eelgrass in much of the lower Bay, but it is not absolutely heat-proof.

Chesapeake Bay Climate Change: Brackish SAV

1. Sago pondweed (*Stuckenia pectinata*):
   - -23 to 30^{O}C for early growth
   - -can tolerate 35^{O}C

2. Redhead grass (*Potamogeton perfoliatus*)

-Needs more research

3. Horned pondweed (*Zannicellia palustris*)*

-Needs more research

*(*Zann* has a very broad salinity tolerance and is a cool water/early season plant. Likely temperature sensitive.)

Chesapeake Bay Climate Change: Freshwater SAV, general

-Freshwater SAV response to increasing water temps will likely be species-specific, and may vary even for locally-adapted “biotypes” of a single species.

-Some species will likely exhibit earlier germination and increased productivity, while others do not. This will be due to their response to the CO_2 fertilization effect.

Chesapeake Bay Climate Change: Freshwater Species, some specifics

-Myriophyllum spicatum: optimal photosynthesis between 30 to 35^{O}C

-Potamogeton crispus: net photosynthesis is highest around 30^{O} C

-*Elodea canadensis* has a range of 27 to 35^{O} C

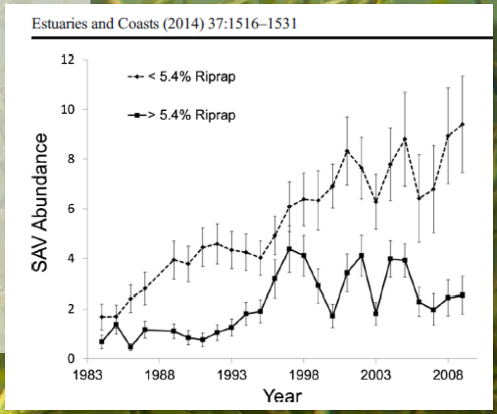
What about the rest?

Chesapeake Bay Climate Change: Freshwater Species, the upside

Unlike marine seagrass beds that are often monotypic, freshwater beds often consist of a diversity of SAV species with different niche requirements. These differences provide some insurance against changes in the environment - as one species declines due to unfavorable conditions, another may compensate and increase in abundance.

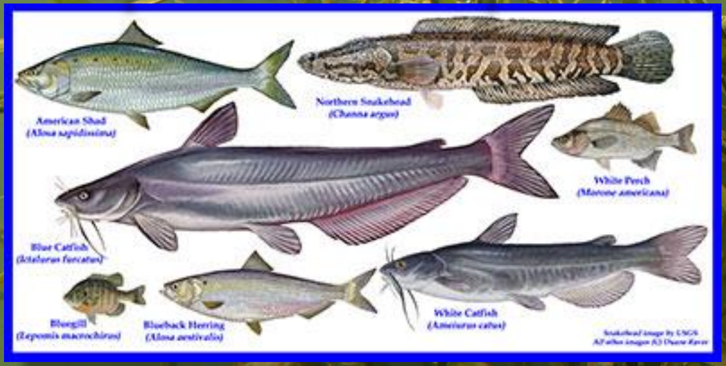
Chesapeake Bay Climate Change: Indirect SAV Impacts and Complicating Factors

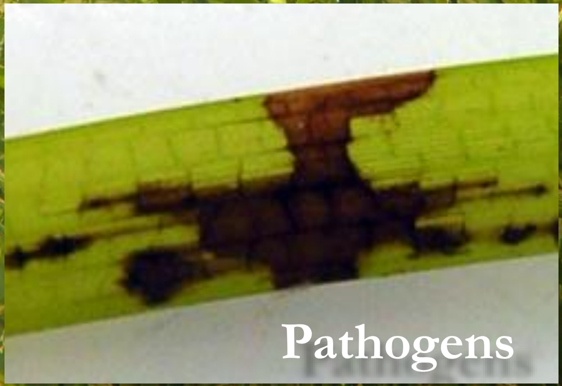
-changes in rainfall and the frequency and intensity of storms,
-increased eutrophication,
-proliferation of epiphytes,
-increased shoreline armoring,
-higher sediment sulfide levels,
-invasive species,



-expanding Lyngbya and other filamentous BGs
-pathogens (ie. *Labyrinthula spp.*)

Aquatic Invasive Species





Chesapeake Bay Climate Change: Current Research

1. STAR/SAV Workgroup GIT Funded Project 2021

Modeling climate impacts on submerged aquatic vegetation (SAV) in Chesapeake Bay

1. **Will address the role of climate stressors on Chesapeake Bay SAV.**
2. **Will model interactions between nutrient loading and climate stressors and determine tipping points.**
3. **Will include a detailed report of model outcomes and potential SAV recovery trajectories under various climate change scenarios.**

STRESSORS:

- **reduced oxygen concentrations,**
- **increased runoff**
- **warming temperatures,**
- **sea-level rise,**
- **greater precipitation,**
- **reduced water clarity**

Chesapeake Bay Climate Change: Current Research

2. *Causes of benthic cyanobacteria overgrowth in submersed aquatic vegetation (SAV) beds in Chesapeake Bay: Potential consequences for ecosystem resilience*

-Joint proposal from UMCES, DNR, and SMCM

-This project will look at the causes and impacts of the spread of Lyngbya and other filamentous cyanobacteria and macroalgae on the recovery potential of SAV communities throughout the Bay's freshwater.

Lyngbya

What is it?

Lyngbya is a genus of freshwater cyanobacteria that grows in strands that clump together and form mats. During the summer, some species of *Lyngbya* have been found in the northern Chesapeake Bay covering SAV beds and caught in fishing gear. *Lyngbya* occurs naturally, but under certain conditions may "bloom".

Is *Lyngbya* harmful to SAV?

Lyngbya may overgrow SAV beds, blocking sunlight and inhibiting photosynthesis. *Lyngbya* also competes with SAV for nutrients.

Chesapeake Bay Climate Change: Management Implications for SAV

- The loss of eelgrass in the lower bay may impact our ability to meet the Bay-wide SAV goal as well as tributary-specific goals.

- Widgeongrass may fill the niche, but differences in timing and bed structure may impact the animals that rely on eelgrass (such as blue crabs).

- Much of our recovery has been fueled by recovery of freshwater SAV. Freshwater SAV may not be as negatively impacted as the salty and brackish species, indicating that we may need to consider more regionally focused management actions for these communities.