Literature Review for UCFR

Turnover times

* Cladophora turnover times are a year or longer (Bergey 1995, citing Whitton 1970, Entwisle1989, Power 1992) and diatom algal mat turnover times are a few days (citing oemke and Burton 1986)

Controls on Cladophora

* Water velocity effects cladophora architecture with more branching in low velocity more breakage in high (Bergey 1995)
* Cladophora is most ubiquitous macroalga in freshwaters. It is grazer resistant (Dodds 1992)
* In CF, cladophora tends to be in places with higher water velocities potentially due to resource limitation. Too much flow however causes sloughing (Flynn 2020) (connects well to the idea of space limitation/nutrient limitation in Davis 2012)
* Cladophora threshold for limited growth is 5C (Flynn 2014)
* Cladophora may follow the ‘inefficient food web model’ because of grazer resistance which is where more productivity means more biomass, while diatom mats would follow the efficient model where more productivity doesn’t change biomass. The examples of these models are in Marks 2003, but applied to a nutrient gradient instead of different algal groups.
* Cladophora only observed in the Eel river where there is a large increase in N (Power 2009)
* The functional performance of cladophora changes at different growth stages (Power 2009)

Food web controls

* Cladophora is grazer resistant (Dodds 1992)
* Grazers at high densities removed 75% of epiphytes on cladophora (Dodds 1991)
* Cladophora is a habitat for midges but the preferentially graze the epiphytes, which helps the cladophora grow. (Furey 2012)
* Late stage cladophora is better for midges because it has more epiphytes aka better food quality (Power 2009)
* Grazing increases the abundance of filamentous and decreases abundance of non filamentous green algae (Lamberti 1989)
* Grazing lowers total biomass resulting in higher biomass-specific production rates but not higher system level GPP (Lamberti 1989, 1983)
* Different algal taxa have different strategies, diatoms seem to be more resistant to digestion while filamentous algae more resistant to ingestion (Peterson 2002)
* Invertebrate diversity is higher when there is less filamentous algae. It responds to algal architecture not biomass (Tonkin 2014)
* Grazers remove on average 59% of periphyton biomass across systems (Hillerbrand 2009)
* A mismatch between primary production rates and algal biomass is strong evidence of top-down control (Vadeboncoeur 2021)

Controls on productivity/biomass

* Algal diversity
  + More diverse algal communities take up and store more nitrate and have higher biomass (Cardinale 2011)
* Carying capacity
  + When few exogenous factors limit productivity, GPP/biomass may be limited by carrying capacity, self shading, and within-mat DIC limitation in the SF of the Humboldt (Davis, 2012)
  + Density dependent competition limits algal growth when nutrients and light aren’t limiting in experimental channels (Stevenson 1991)
* Nutrients
  + Both N and P limit biomass in rivers, threshold for eutrophic is >70 mg/m2 average chl and > 200 gm/m2 max chl (Dodds, 2016)
  + Nutrient thresholds for UCFR and other rivers to prevent eutrophication (350 ug/L N and 30 ug/L p (Dodds, 1997)
  + In UCFR cladophora is N deficient and epiphyts are P deficient indicating they don’t compete. (Dods 1991)
  + Some degree of nutrient reduction in the UCFR (cladophora dominated) has not translated into algal biomass decreases while it has in the lower clark fork which is diatom dominated (Suplee 2012). Maybe cladophora in particular is not responsive to nutrient reduction.
  + More N means more algal biomass. There is little effect of N:P ratio on total biomass but it does change the algal assemblage (Stelzer 2001)
  + Filamentous mats may increase residence time of water enough to allow for recycling of nutrients (Mulholland 1994)
* Drought/low flow
  + During summer dry period algal assemblage shifts to more filamentous if nutrients are high, but not if low (Suren 2003)

Models of productivity/biomass or relationships between

* Metabolic theory can be used to predict GPP relying on linear scaling of GPP with biomass (Demars 2023)
* GPP can be predicted as a function of chlorophyll, but temperature has an effect on this relationship, particularly in stream periphyton (Morin 1999)
* Stream productivity:chlorophyll ratio decreases with more biomass likely due to self-shading and shift toward more filamentous algae (Morin 1999)
* Across a group of desert and dam tailwater autotrophic rivers, standing stock of algae and GPP are negatively correlated (in the table in Davis 2012) Maybe this is because of what type of algae are most productive (my speculation)
* Autotrophic biomass is positively correlated with productivity although they found no relationship with specific autotrophic groups (filamentous, epilithic) (Bernot 2010)

Clark fork patterns

* Green up after spring flood with peak biomass in the summer (Flynn, 2014)
* Snowmelt causes enhanced primary production in the UCFR but the magnitude of the peak flood sets the max filamentous biomass (Valett 2023)
* During the late season, succession from filamentous greens to epilithic cyannos when N gets low and water is warm (Valett 2023)

Other

* We can probably measure biomass from drones (Flynn 2014)
* Algal biomass controlled daily O2 fluctioations (Sabater 2000)