



1990—Peter Kotanen acquaints Berkeley ecologists with Bob's research at La Perouse Bay

1991—Bob on fellowship at Bodega Bay, holds a workshop on plant-grazer interactions, initiates collaborations with John Maron and Don Strong and others on feedbacks (via nitrogen loading) from strong or weak lupin cohorts to N. California coastal prairies.



1992--Dinner on a Berkeley porch with Bob & Sue, Gary Polis, and Lauri and Tarja Oksanen

1995--Visit to University of Toronto, reception at Sue and Bob's house the same week that Canadians impounded a Spanish fishing vessel to save turbot!



1998—Excursion with Bob and Rudi Drent's in the Netherlands, Bob describes landscape as "dripping with nitrogen".

Canadian Arctic- irreversible feedbacks as goose grubbing converts marsh to salinized mudflat....



La Perouse Bay (Jefferies et al. 1999)

Blue-water

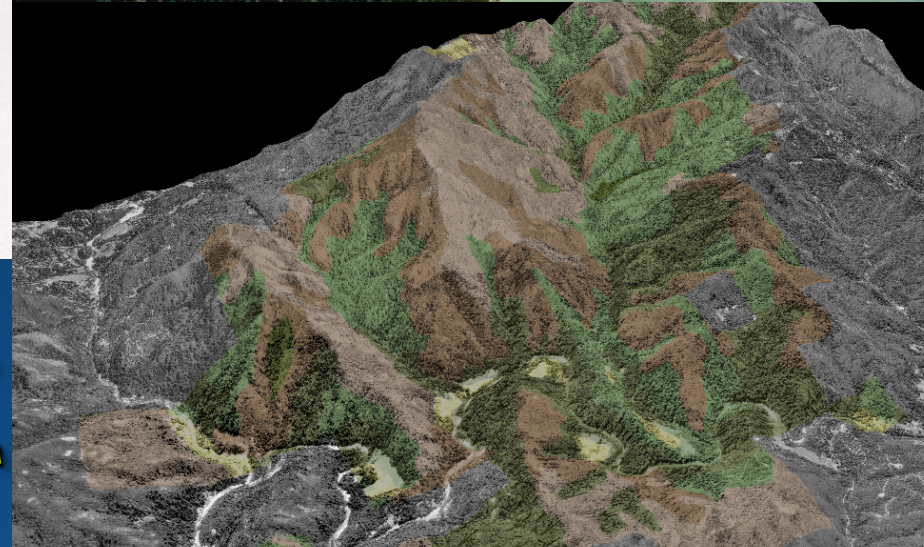
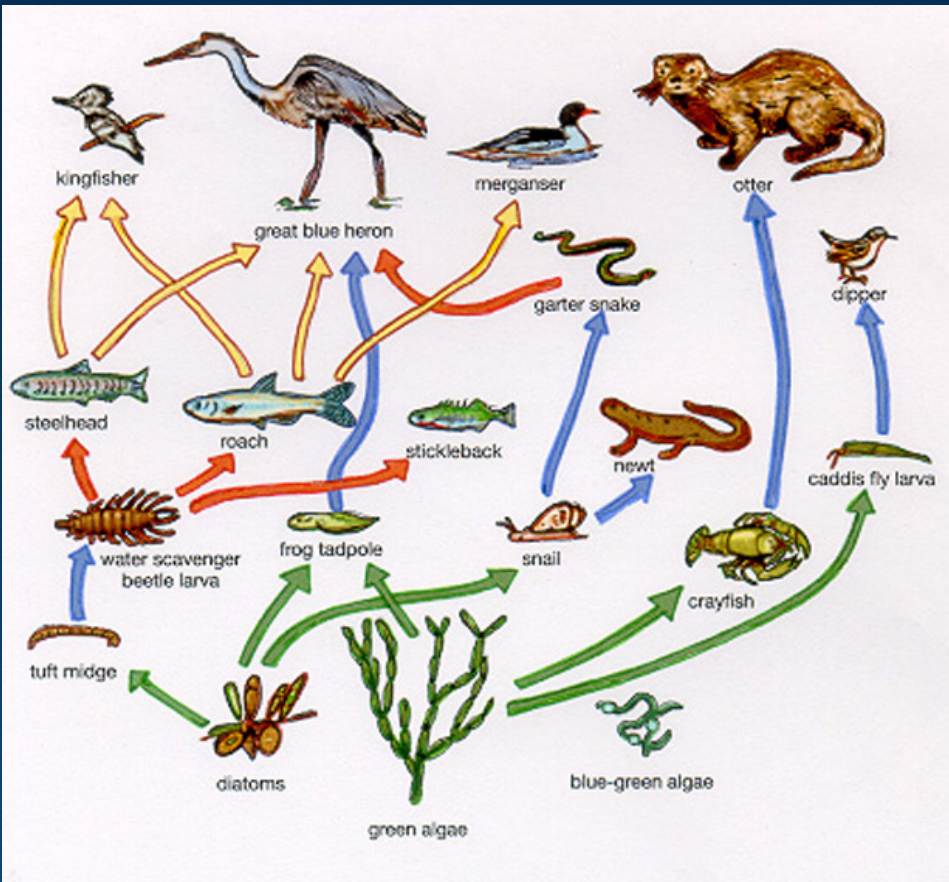
Green-graminoid vegetation

Red—had veg in 1973,
mudflat in 1993)

“your work continues to be such an inspiration, because you deal with rather enormous and significant spatial and temporal scales, yet manage to keep a tight rein on the elucidation of mechanism...”

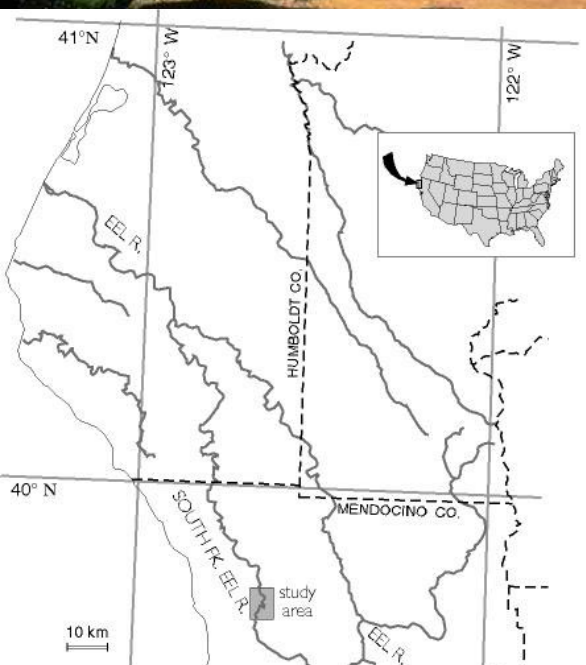


Algal-mediated linkages of river, terrestrial, and marine ecosystems



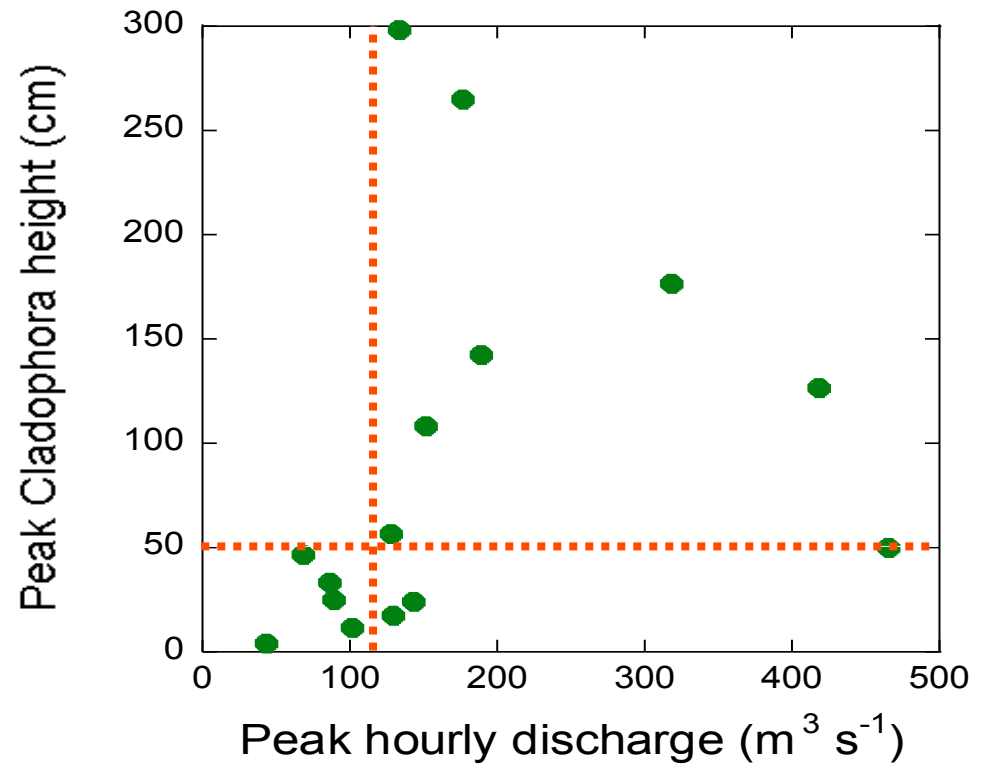
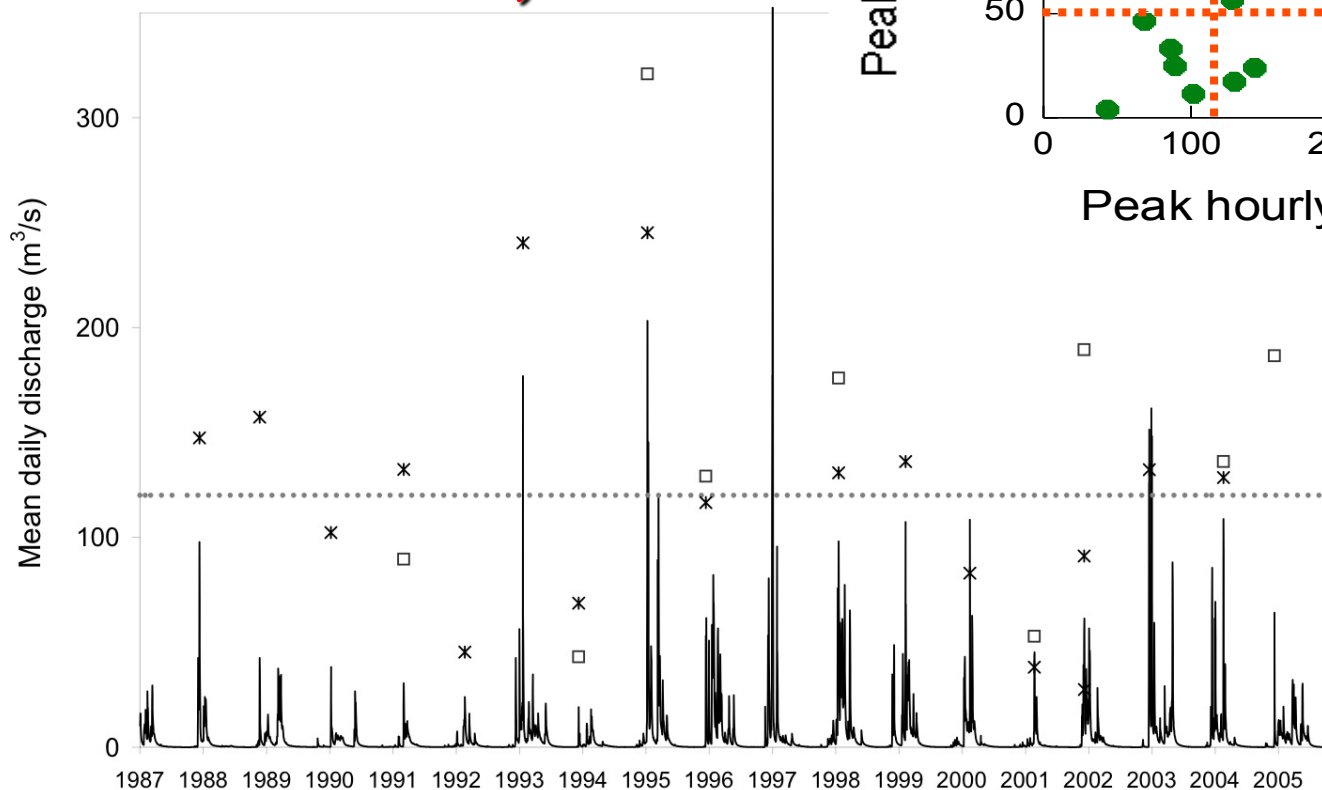
Mary Power, Charlene Ng, Jack Sculley, Paula Furey, Jill Welter, Miki Hondzo, Jacques Finlay, Rex Lowe, Collin Bode
Inez Fung, Jim Bishop, Zack Powell, Bill Dietrich

S. Fork Eel R. Mediterranean hydrograph



How much annual algal production?

Big algae years follow winters with bed-scouring floods (> bankfull, exceeding 1.5 y recurrence interval)

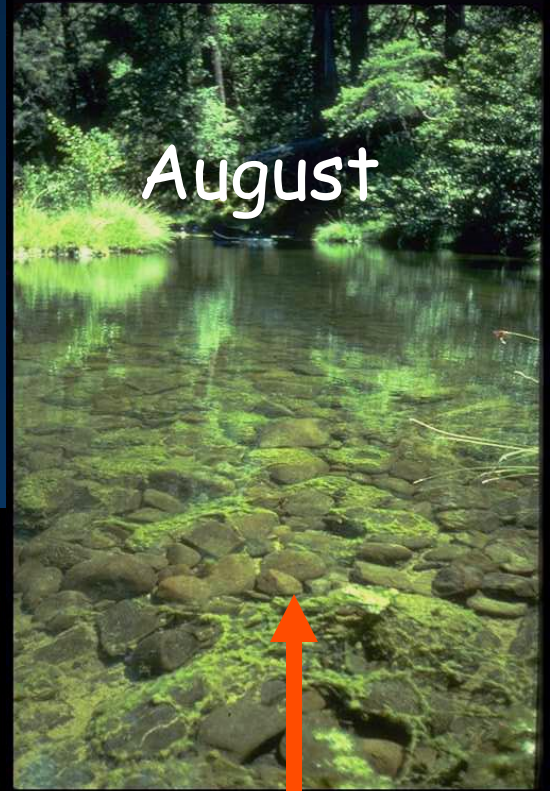


March



*Cladophora
glomerata*

August

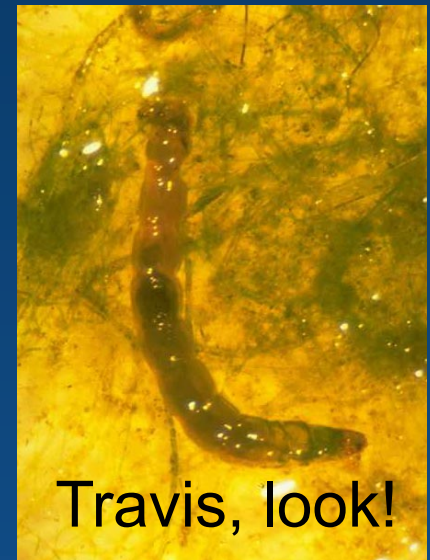
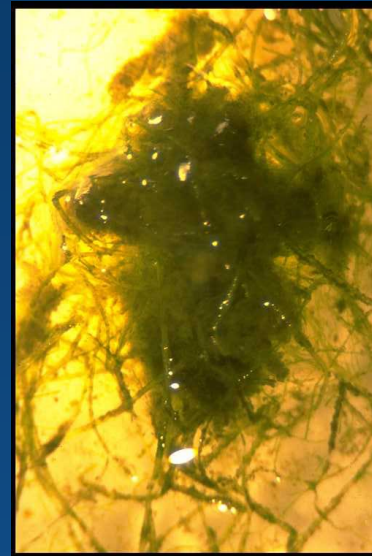


July



June



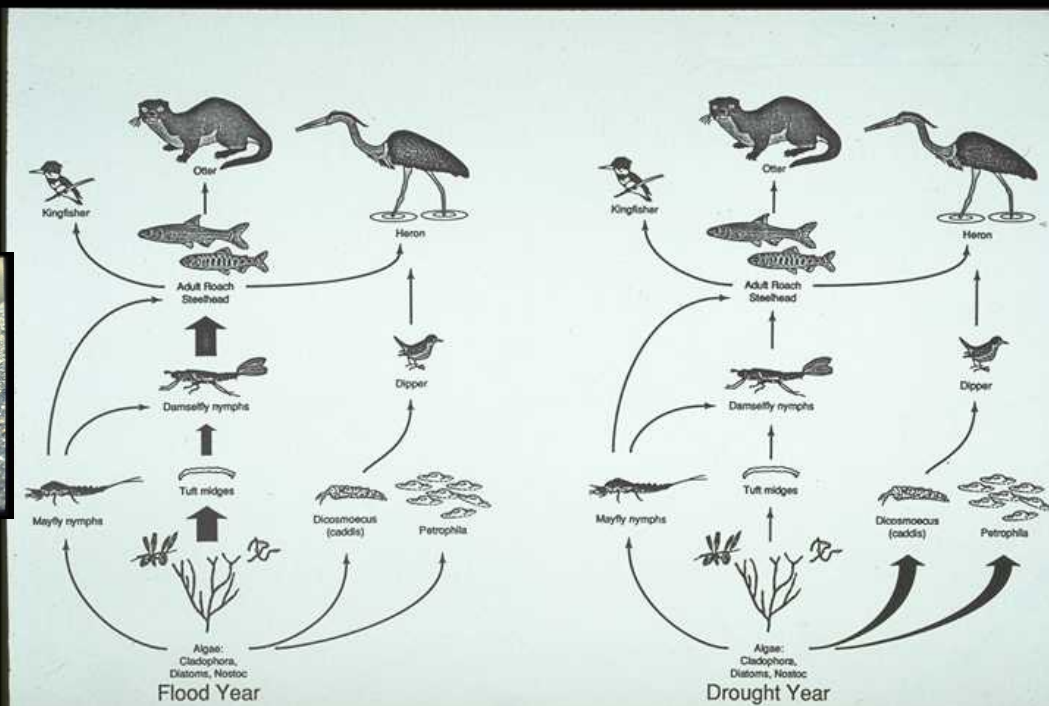


Role of midges?

Winter scour favors vulnerable grazers, linking fish to algae



Flood:
Edible grazers



Drought:
Inedible grazers

1989-flood (4 levels)
1990-drought (2 levels)
1991-drought (2 levels)
1993-flood, spring spate
(3 levels)
1997-flood (4 levels)



Enclosures, fish



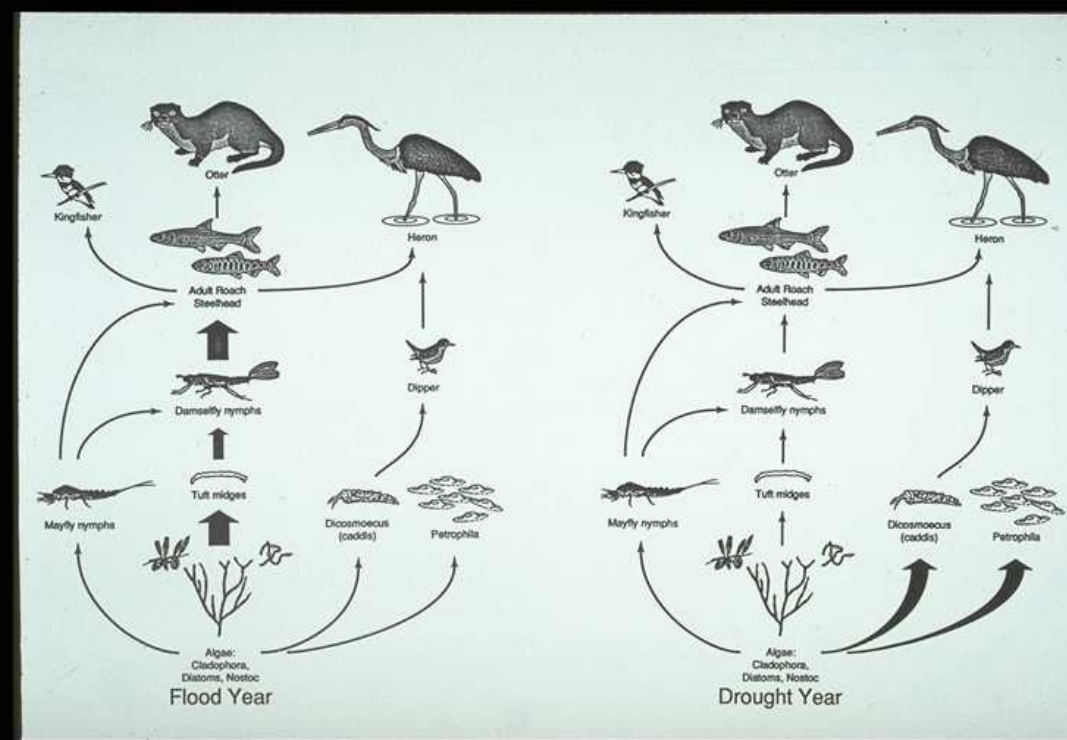
Power 1990 Science
Wootton et al. 1996 Science
008 Ec



Exclosures, no fish



1989-flood (4 levels)
 1990-drought (2 levels)
 1991-drought (2 levels)
 1993-flood, spring spate (3 levels)
 1997-flood (4 levels)



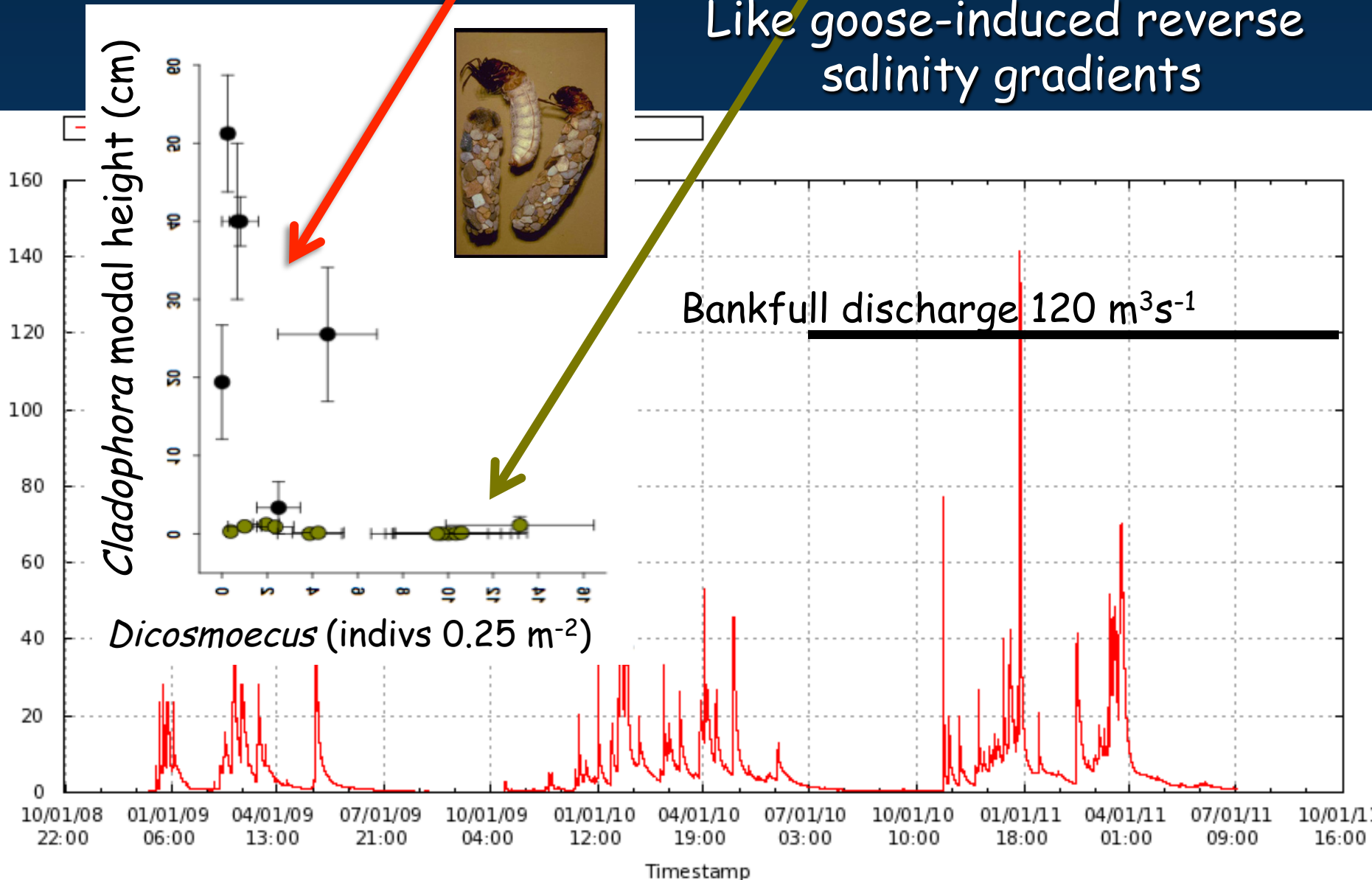
Power 1990 Science
 Wootton et al. 1996 Science
 2008 Ec

Enclosures, fish

Exclosures, no fish

Winter 2010: 17 km² tributary scours ; 130 km² S. Fk. Eel does not, reversing light limitation of *Cladophora* biomass

Like goose-induced reverse salinity gradients





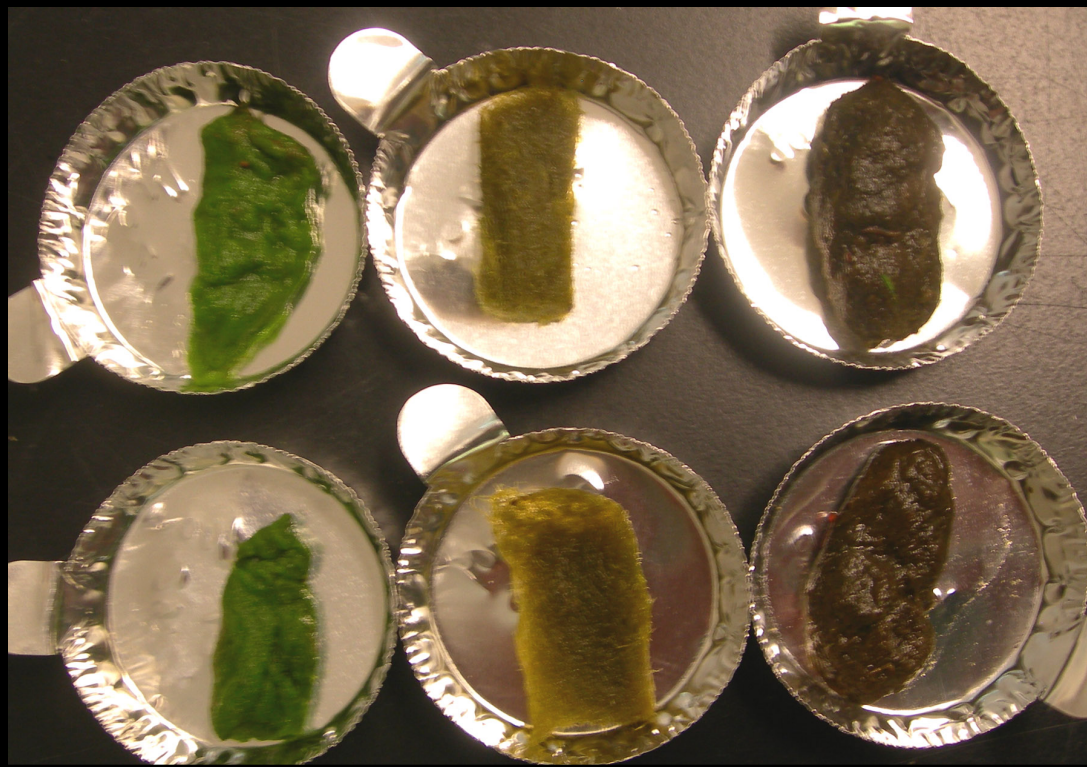
Rex Lowe



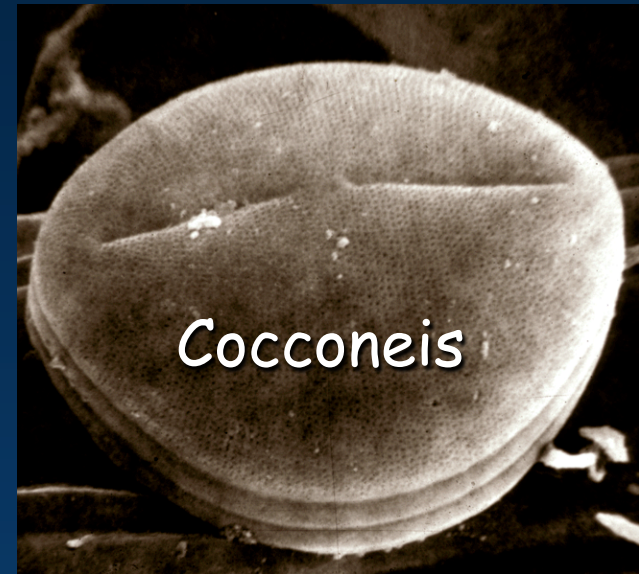
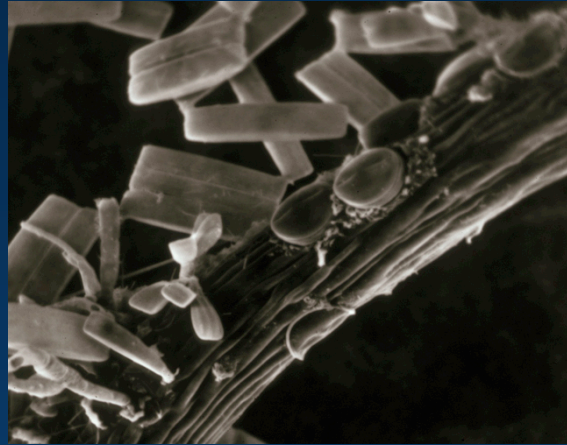
Cladophora:
branched
filamentous
green
macroalga

DA > 100 km²: *Cladophora* proliferates,
increasing ecological surface area
2000 to 200,000 x

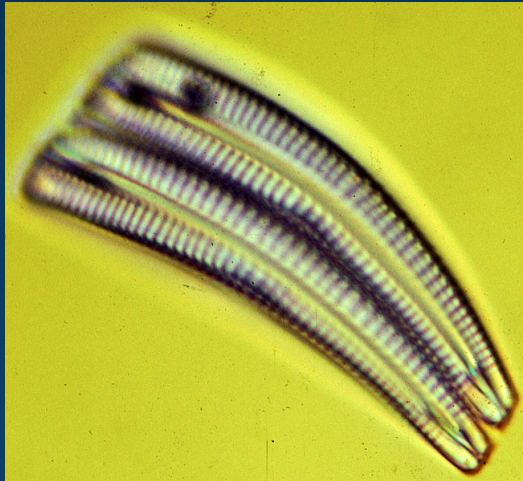




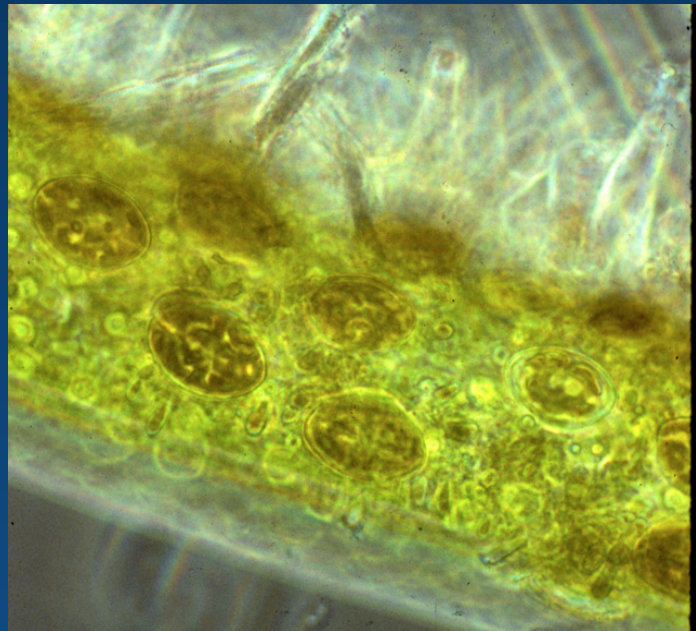
Epiphytes on yellow Cladophora



Cocconeis

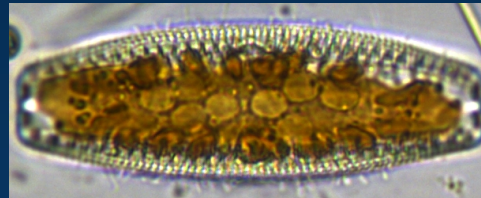


Rhoicosphenia

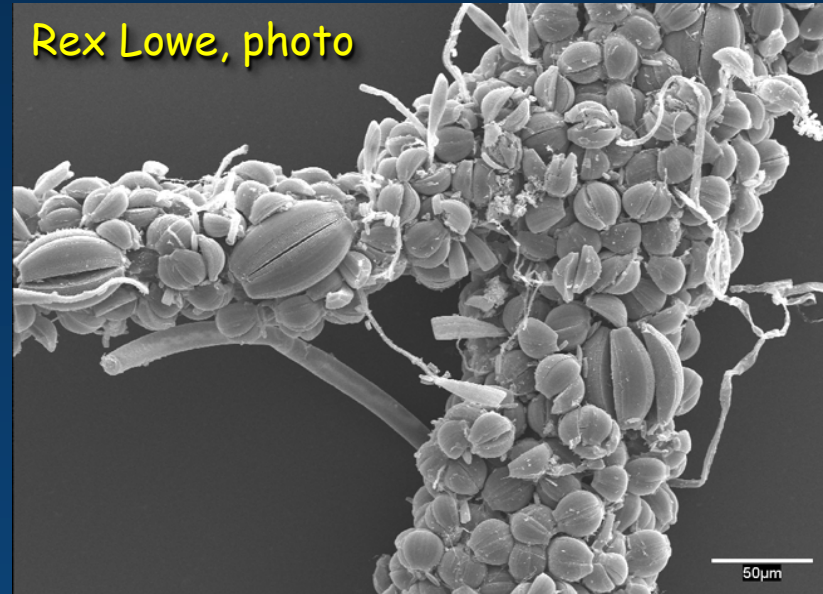


Gomphonema

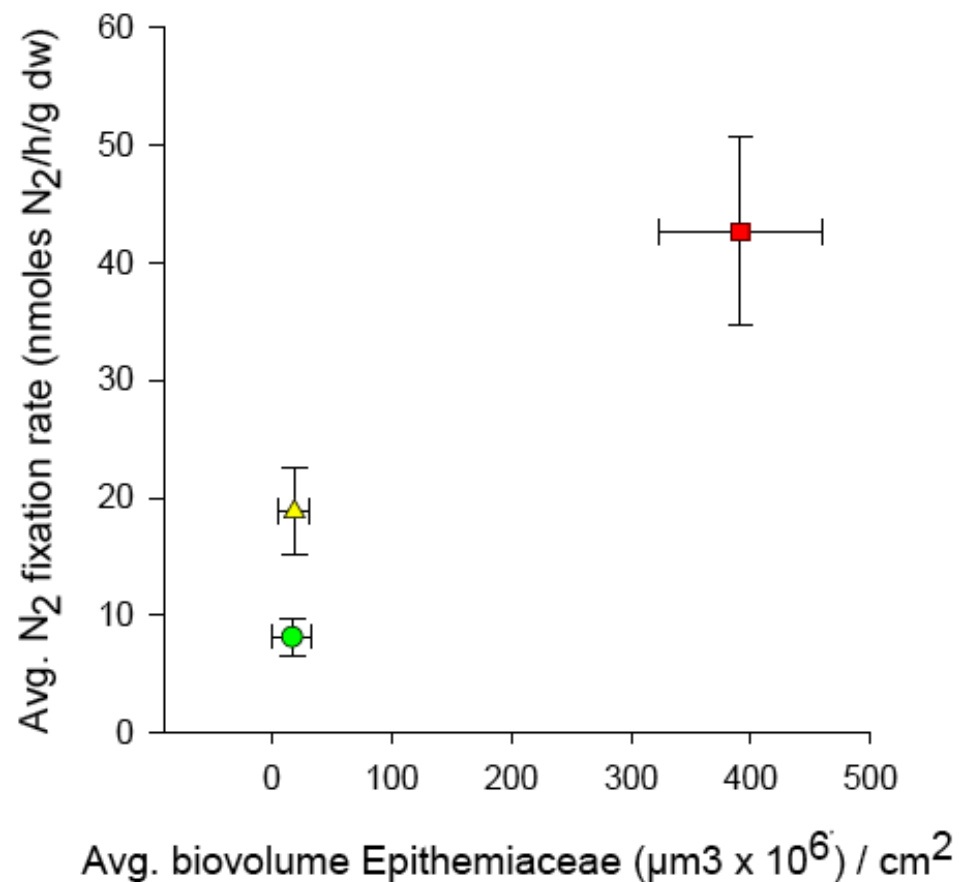
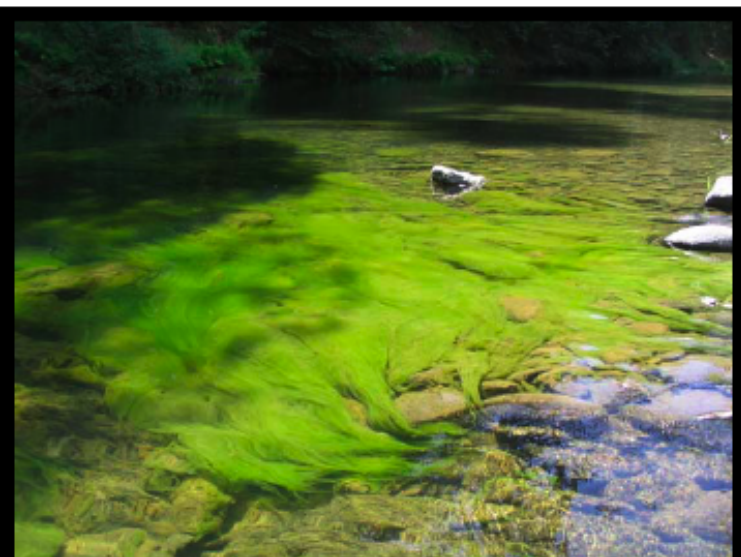
Rusty Cladophora: *Epithemia turgida*, *E. sorex*



Rex Lowe, photo

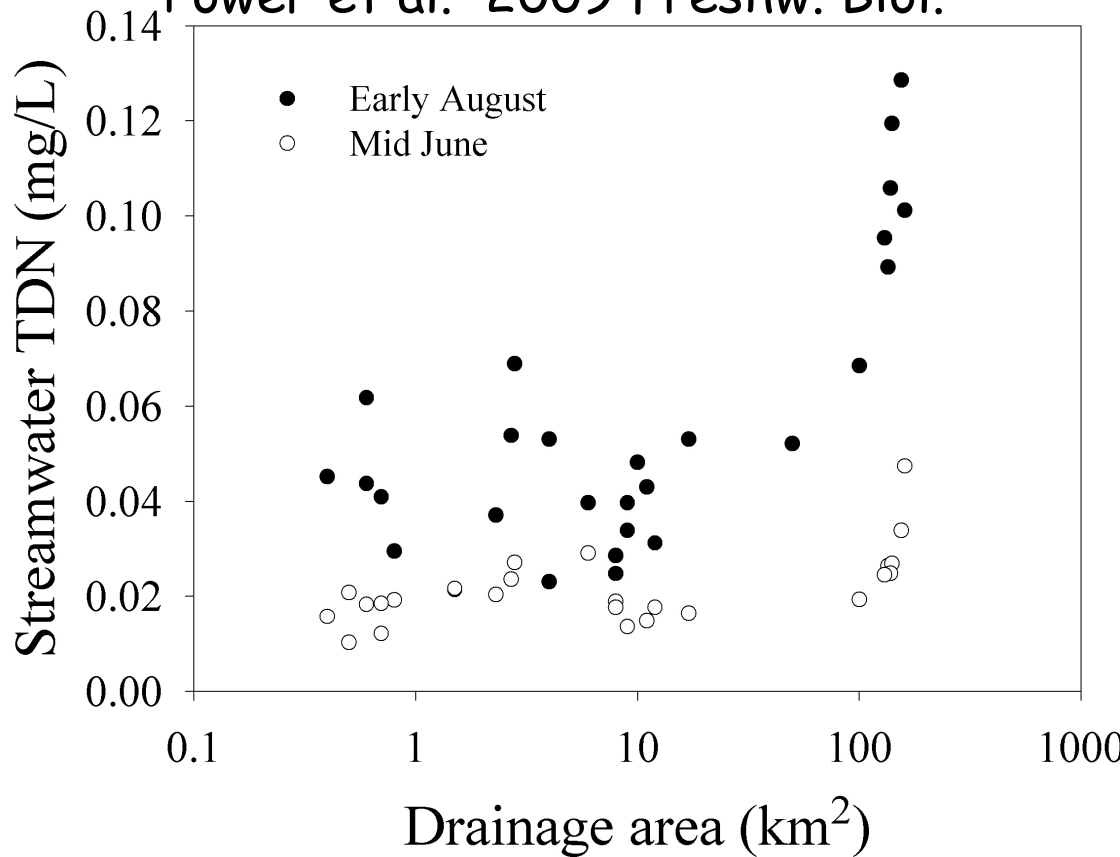


Algal Mat Colors and Nitrogen Fixation Rates

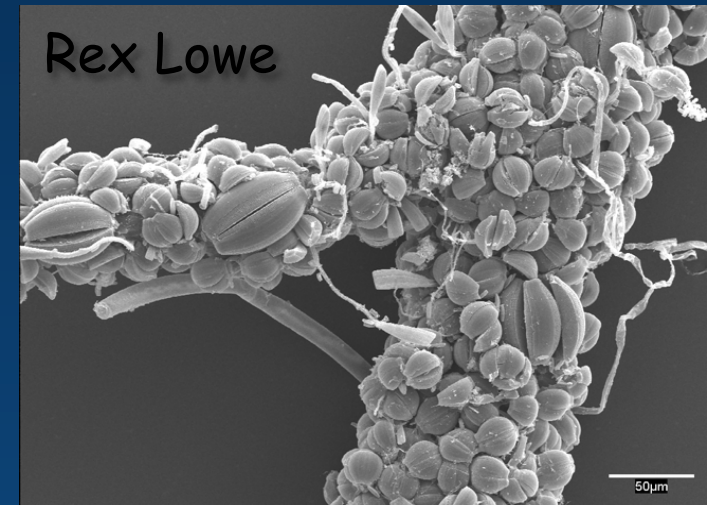


Welter, Bratt, Furey, Power, unpub

Power et al. 2009 Freshw. Biol.



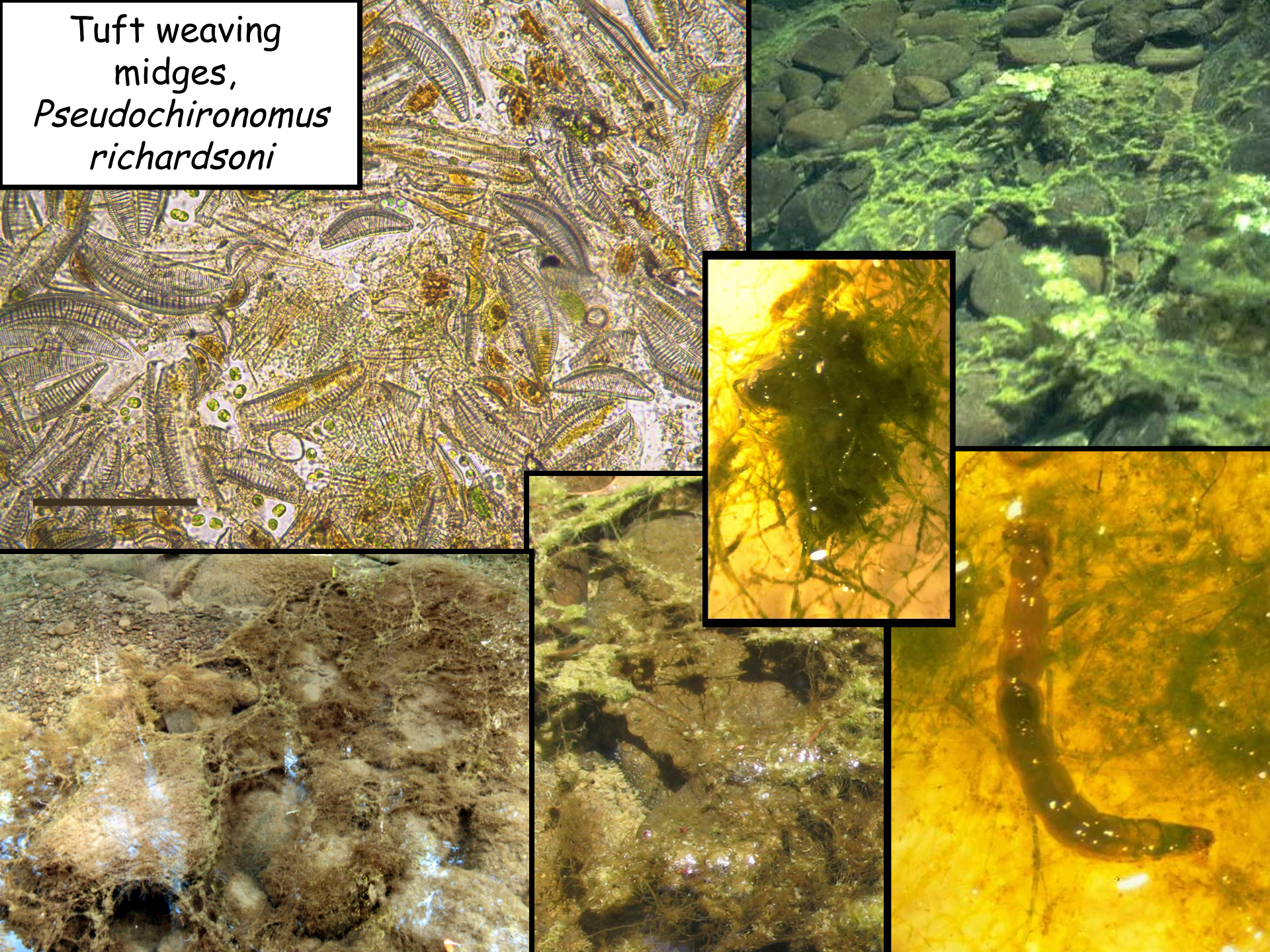
100 km²
threshold
for N₂
fixation

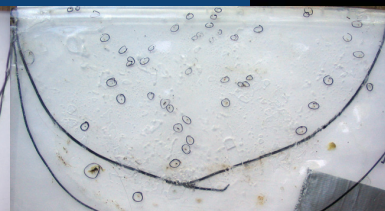


Charlene Ng



Tuft weaving
midges,
Pseudochironomus
richardsoni

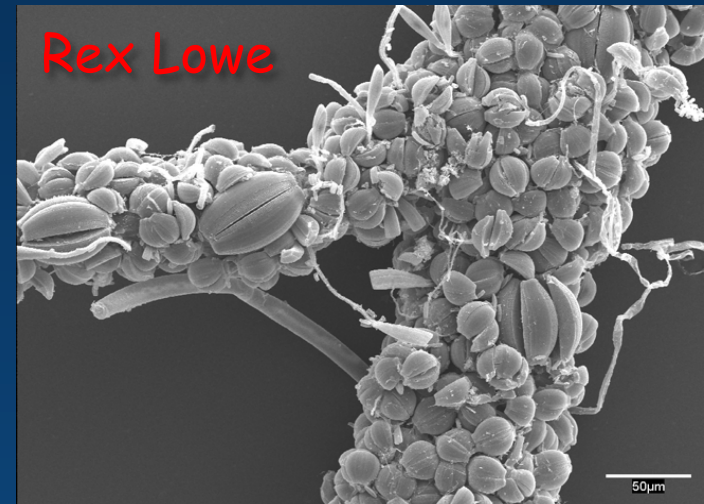




Oedogonium Green Clad. Yellow Clad. Rusty Clad.



**Insect
emergence
increases 25x
from *Epithemia*-
covered mats**



Charlene Ng





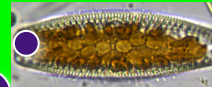
**Insect
emergence**

Terrestrial
food web

Stranding

River food
web: long or
short food
chains?

Algae
(C, N)



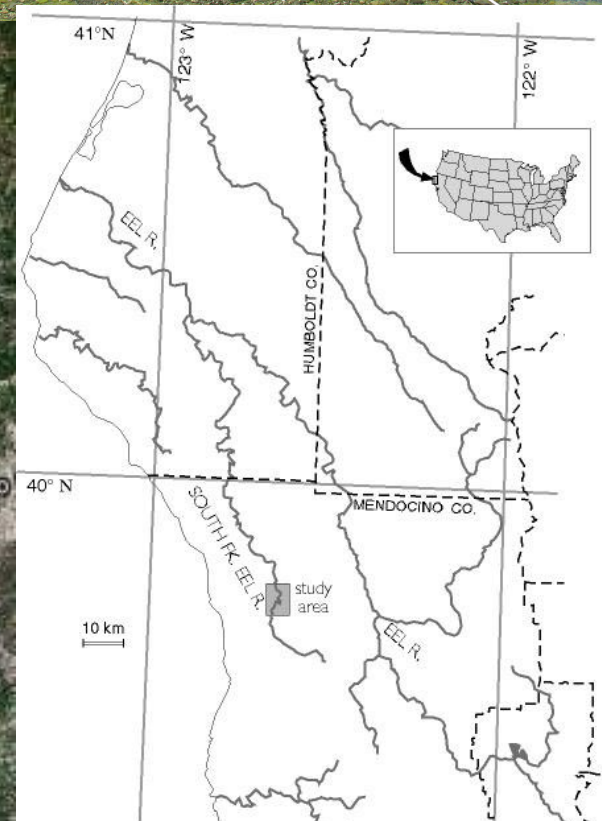
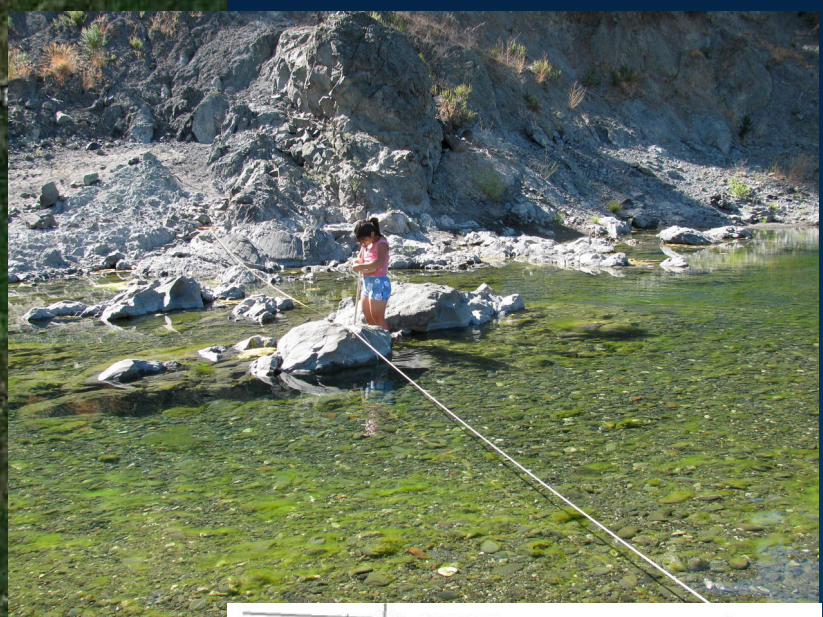
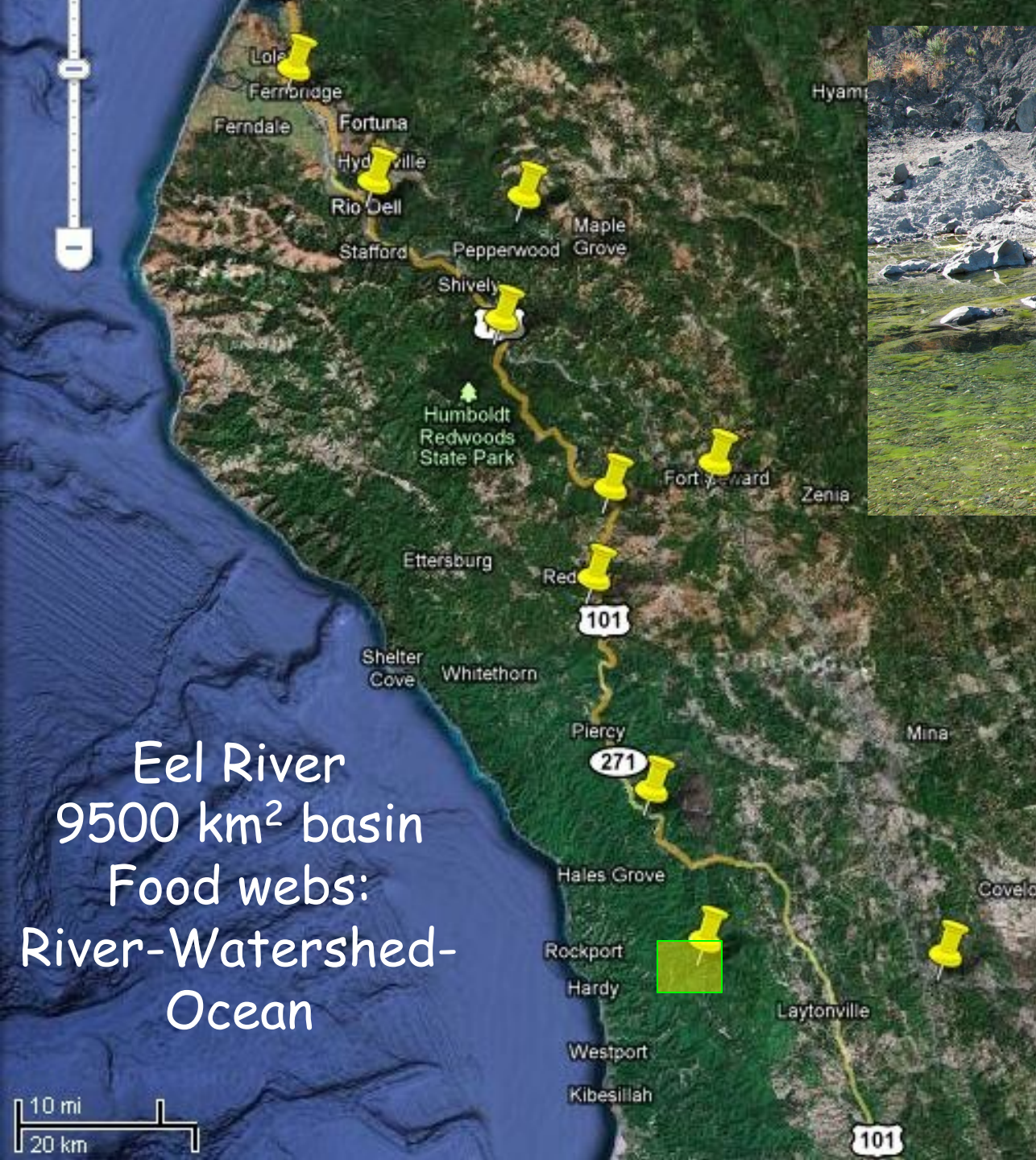
Near shore
marine
food web

Intertidal
food web

Deep
ocean
burial

N_2
 CH_3

CO_2



Eel River
9500 km² basin
Food webs:
River-Watershed-
Ocean





Charlene Ng





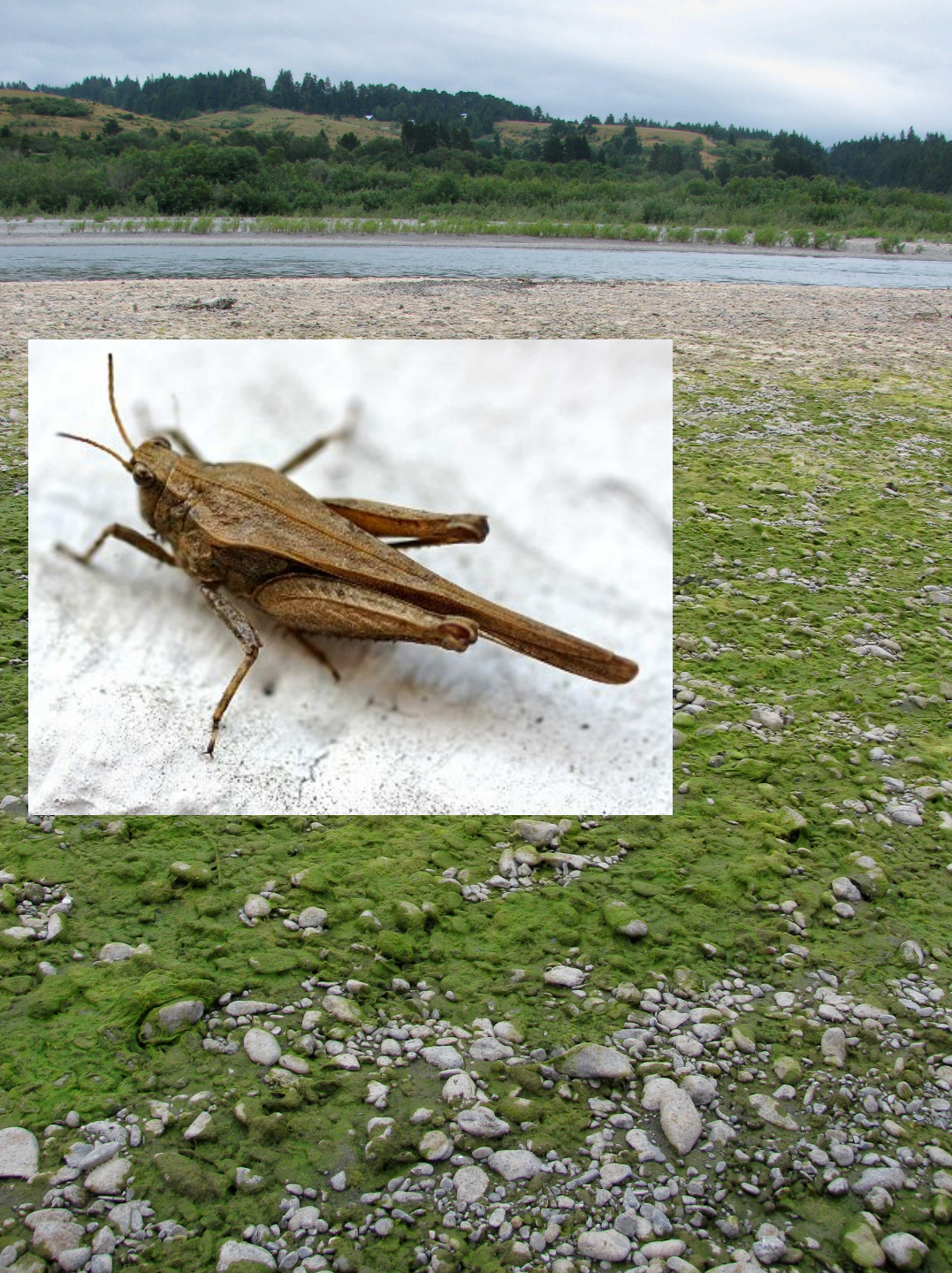


Intertidal Cafeteria trials









Stranded *Cladophora*

Bastow et al. 2002 *Oecologia*



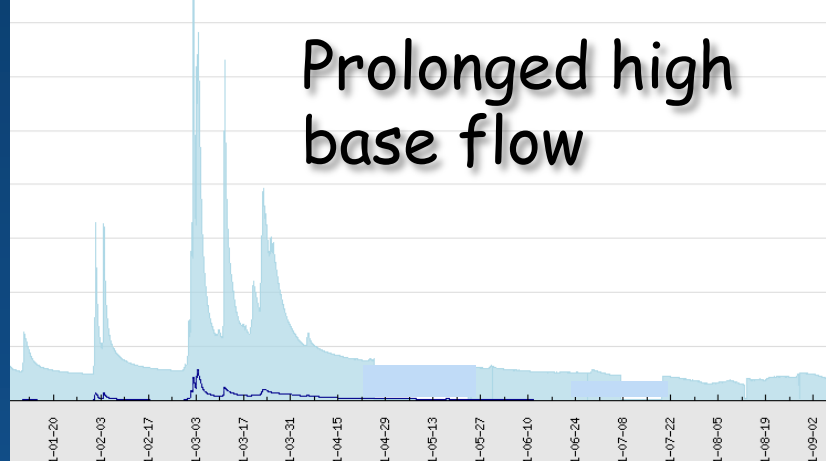
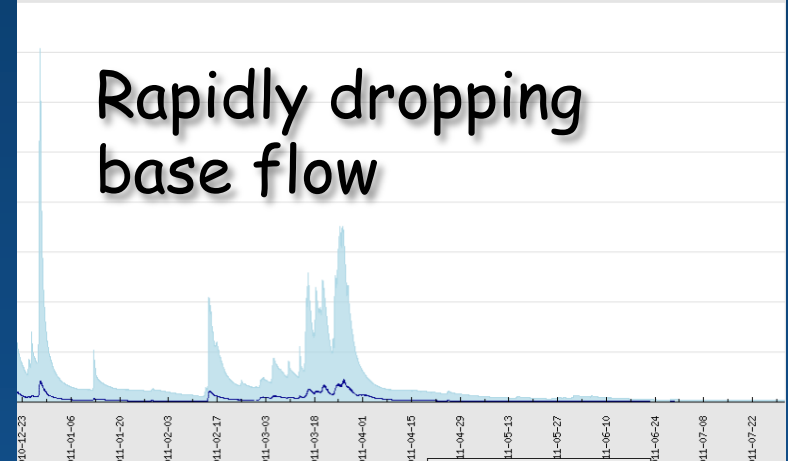
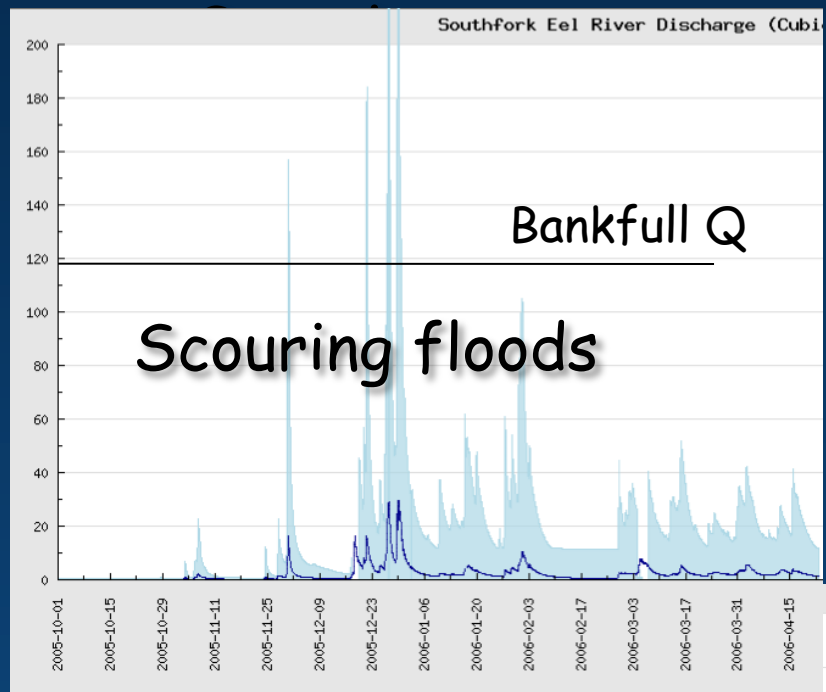
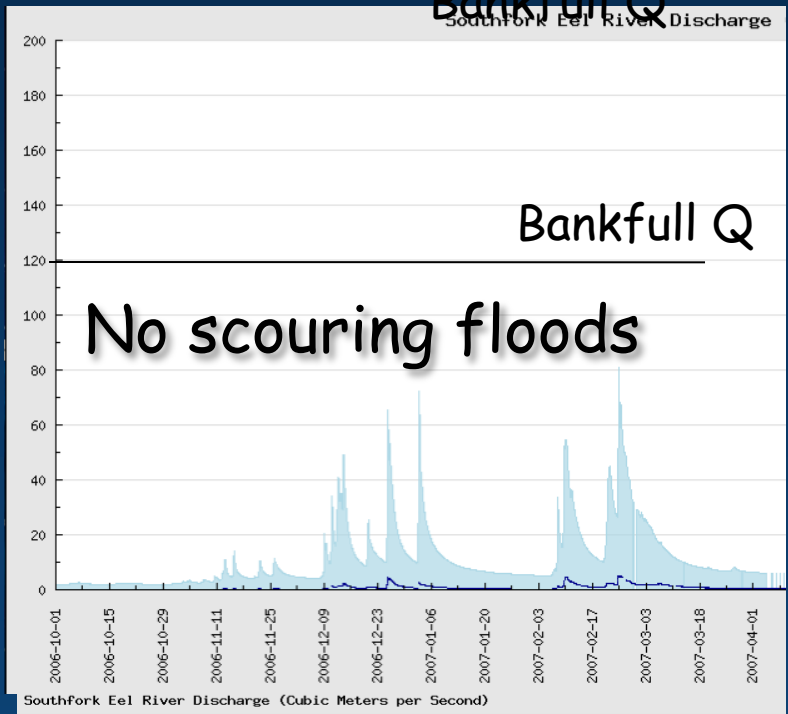
Interannual Flow Variation* in Mediterranean Rivers:

Drought

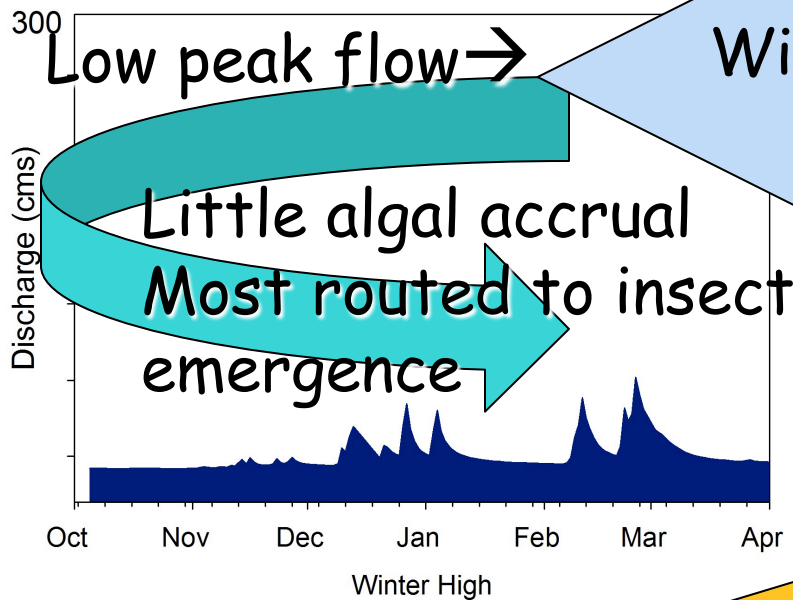
‘Normal’ rains

winter

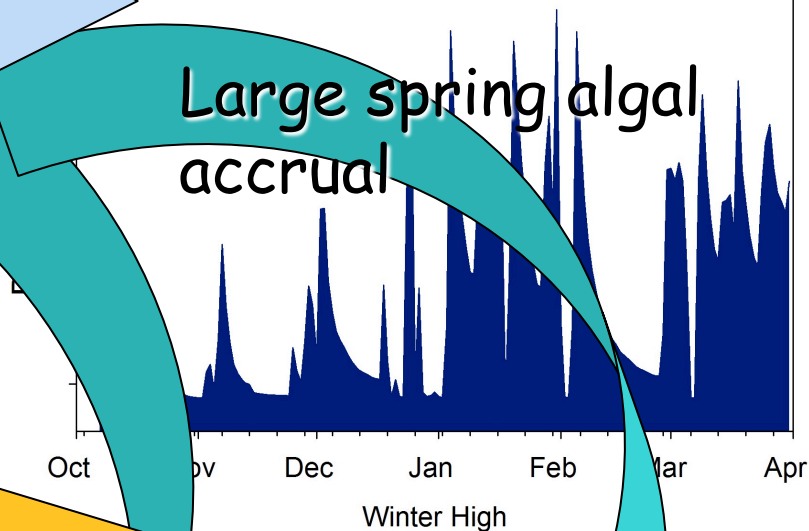
summer



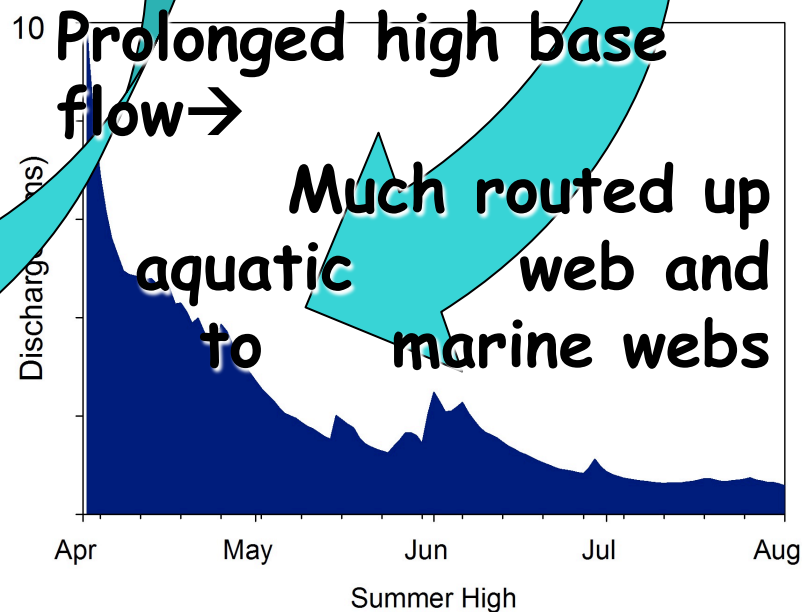
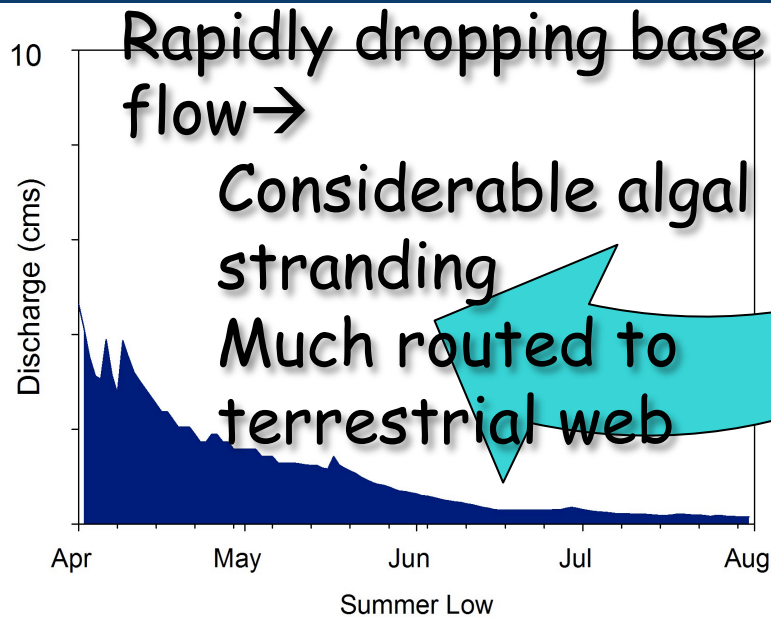
Winter?



High (<bankfull) flow →



Summer?



Winter?

High (<bankfull) flow→

Large spring algal
accrual

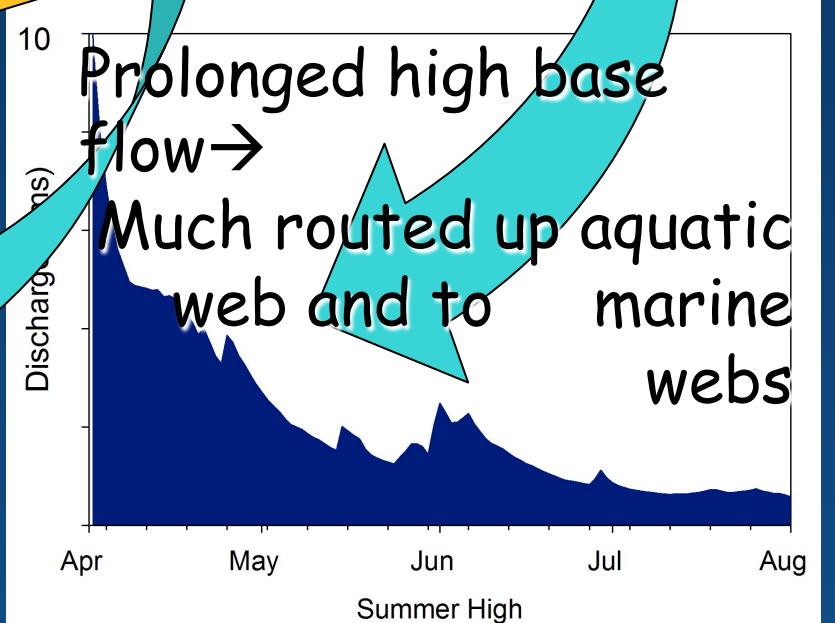
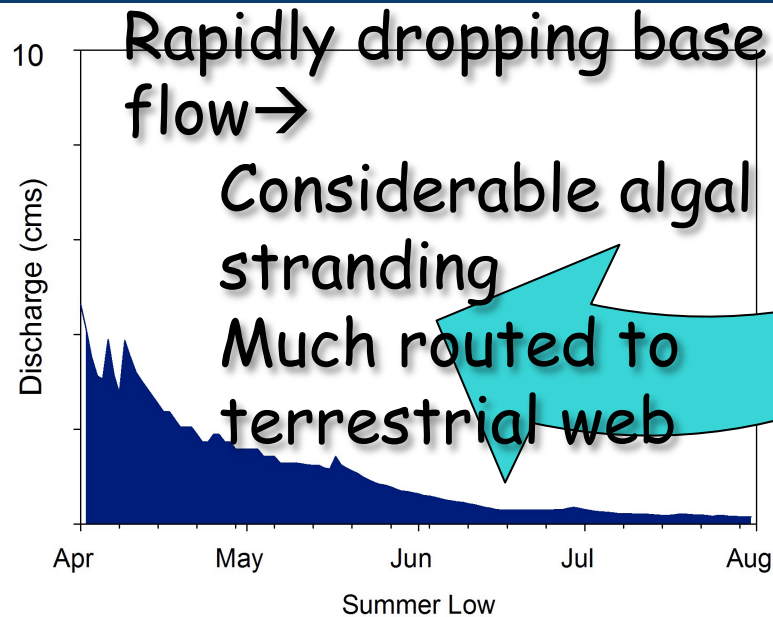
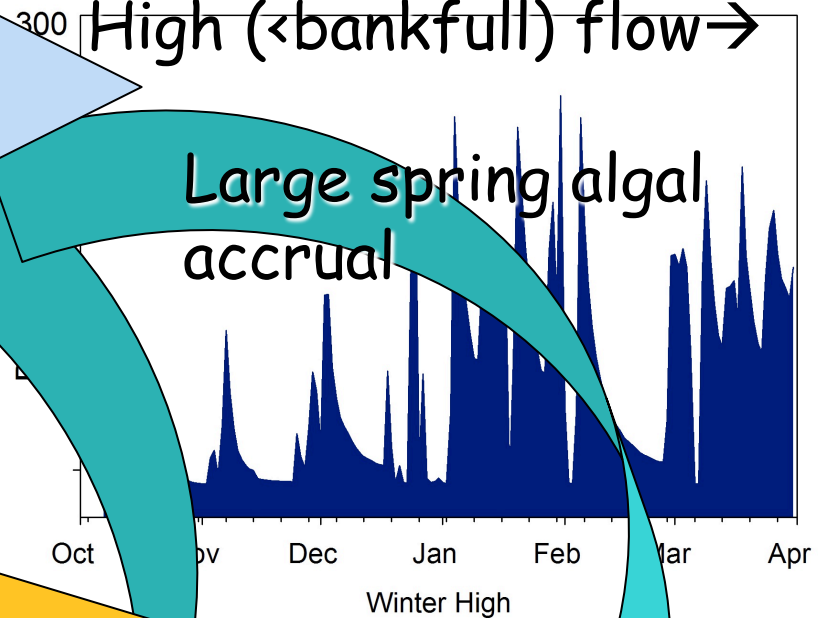
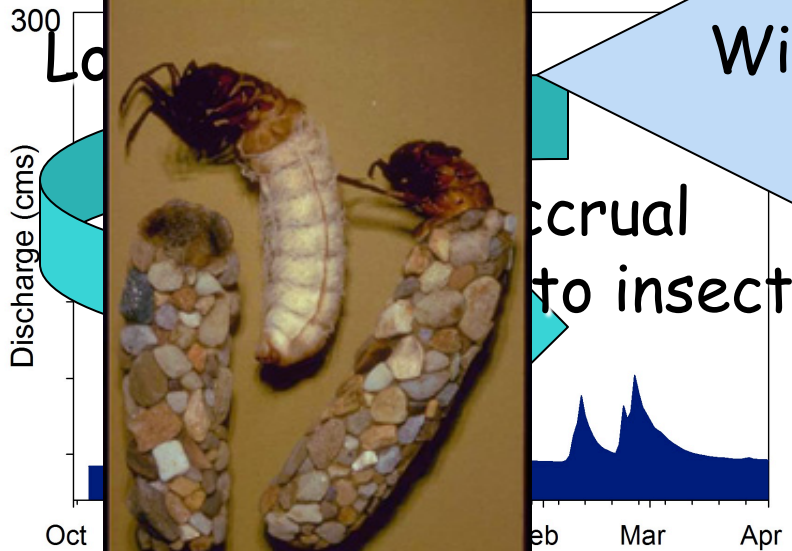
Summer?

Rapidly dropping base
flow→

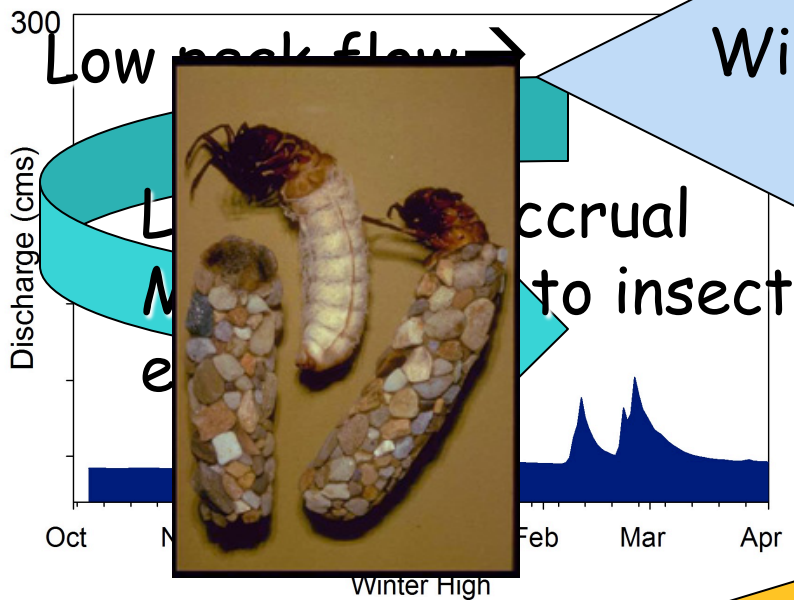
Considerable algal
stranding
Much routed to
terrestrial web

Prolonged high base
flow→

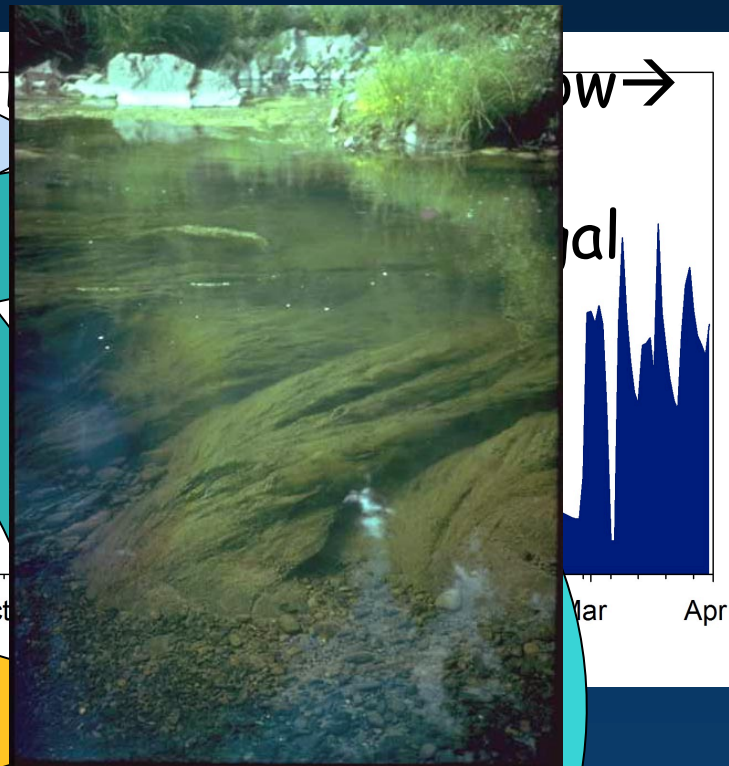
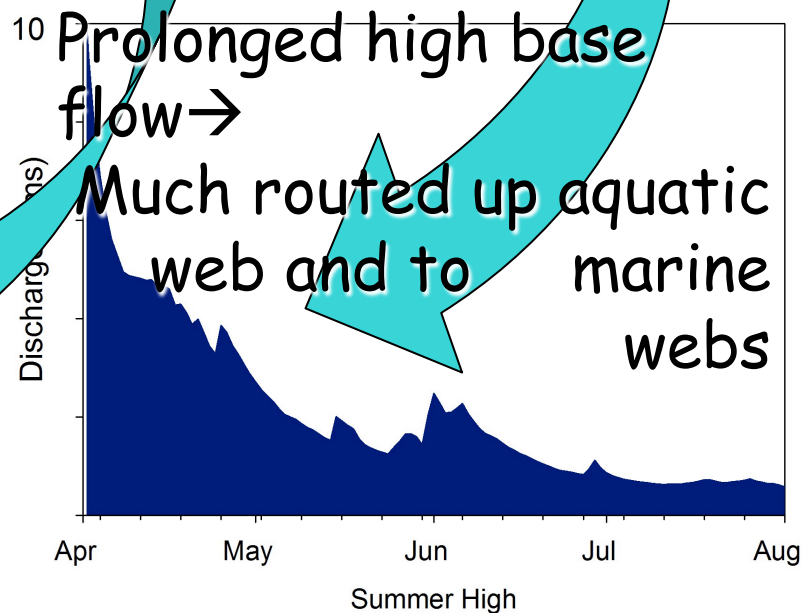
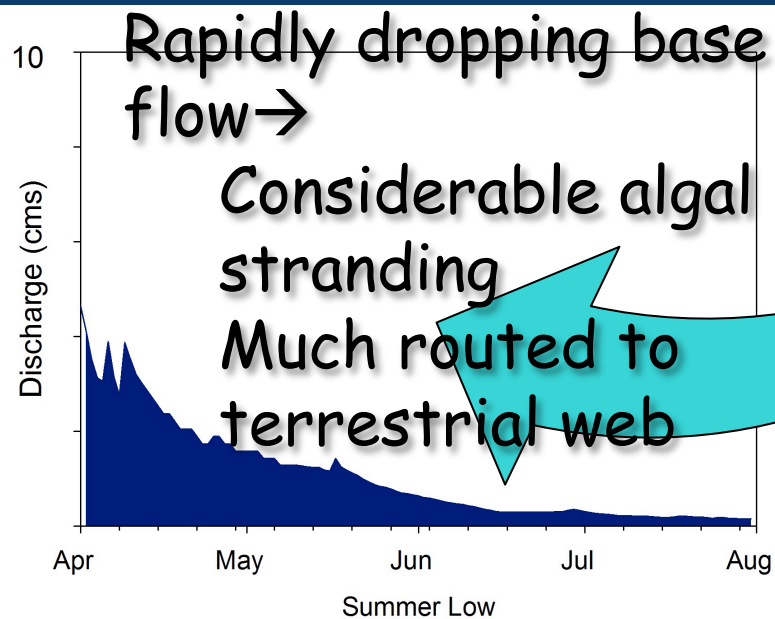
Much routed up aquatic
web and to
marine
webs



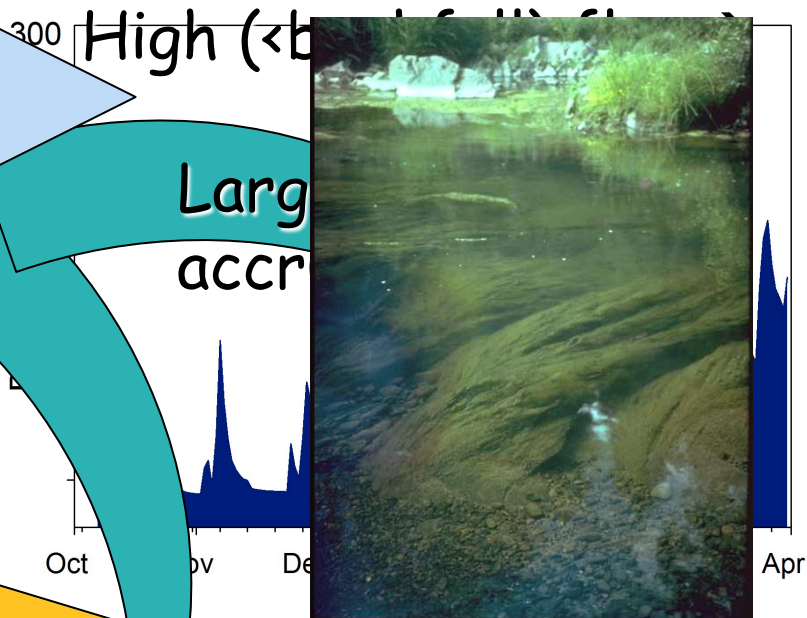
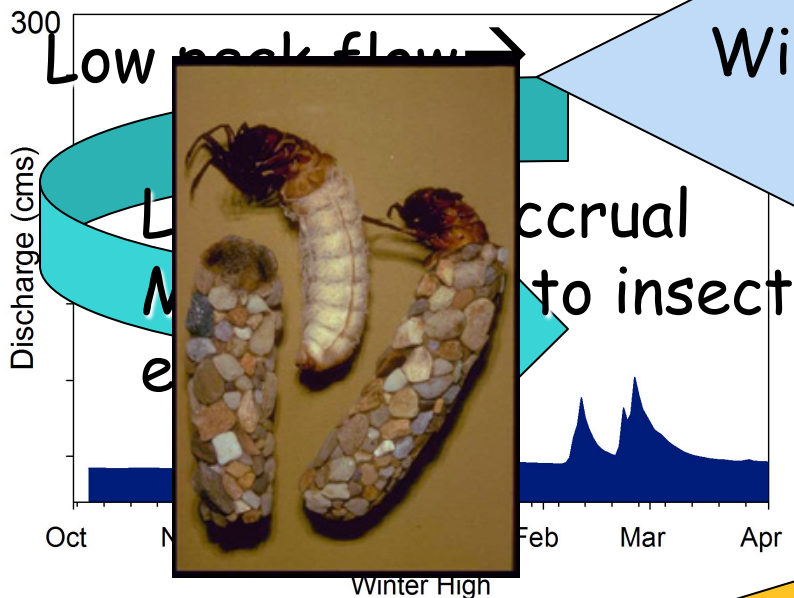
Winter?



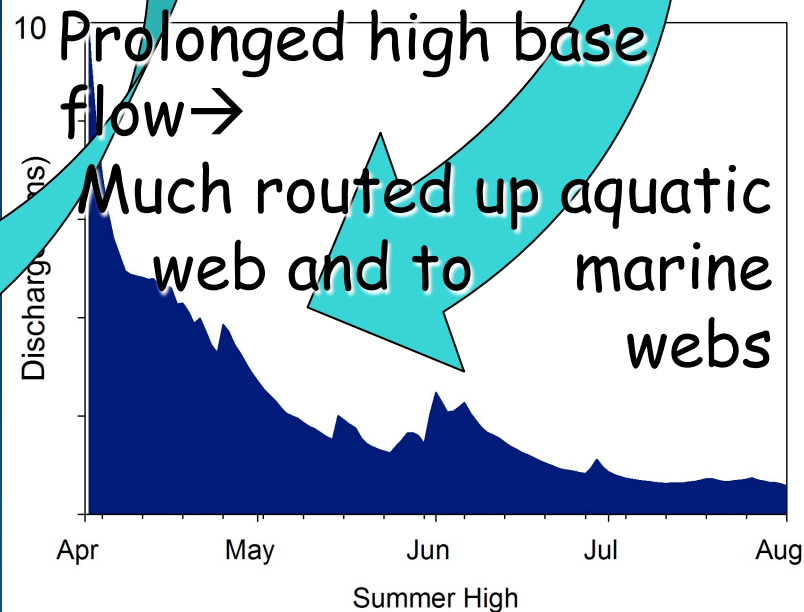
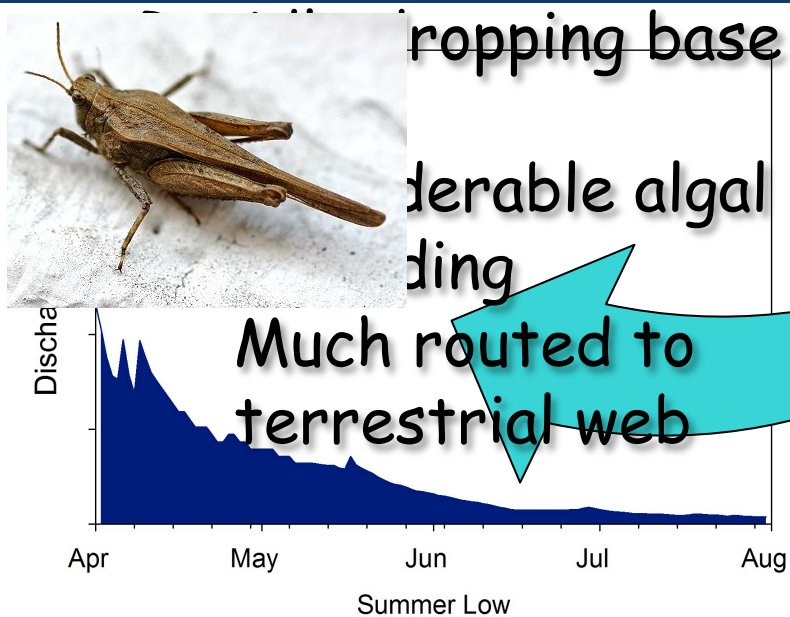
Summer?



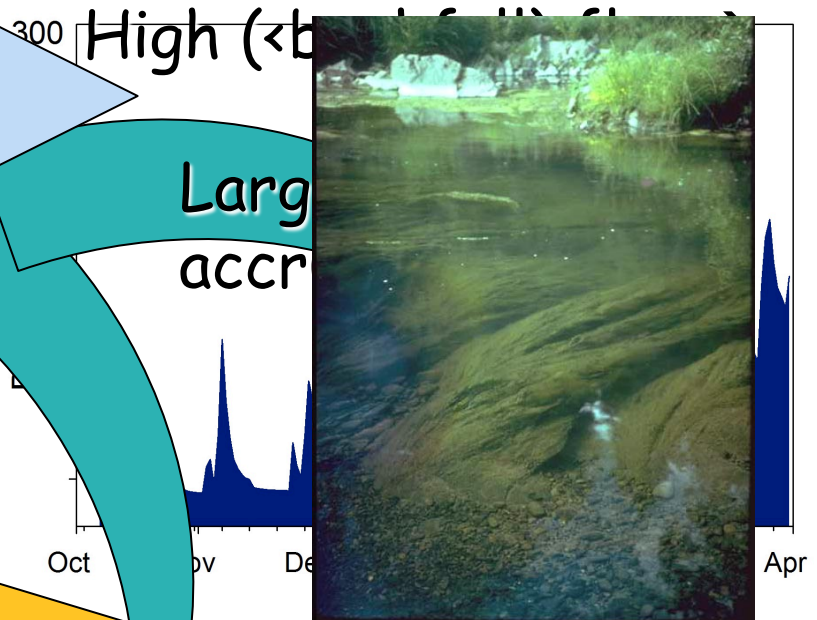
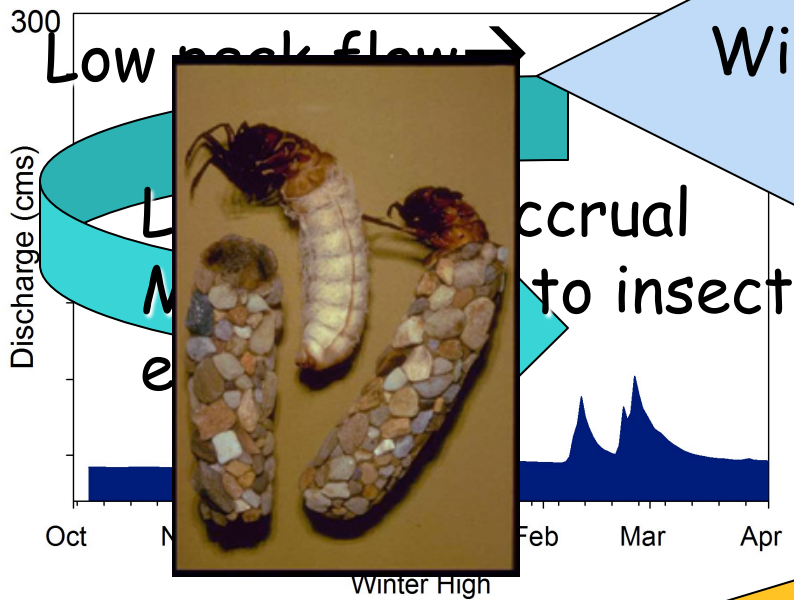
Winter?



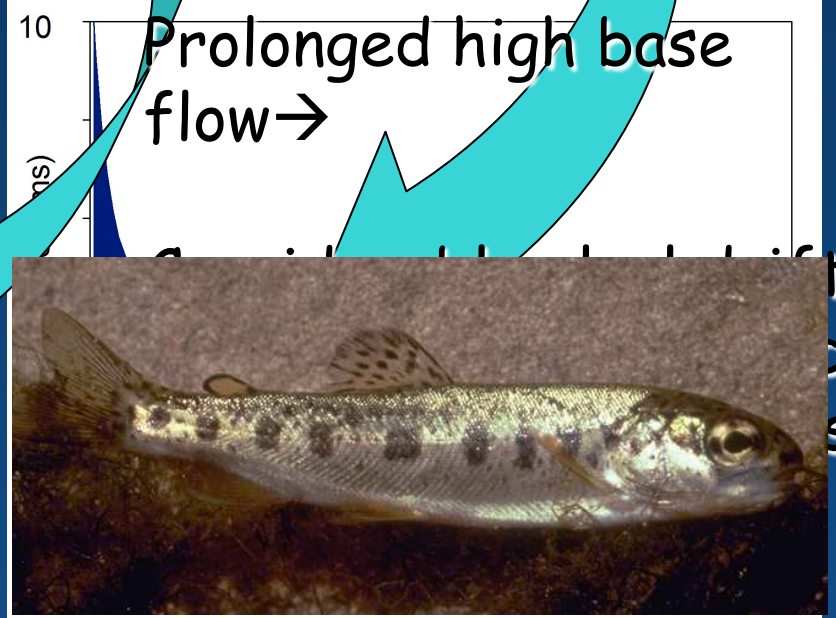
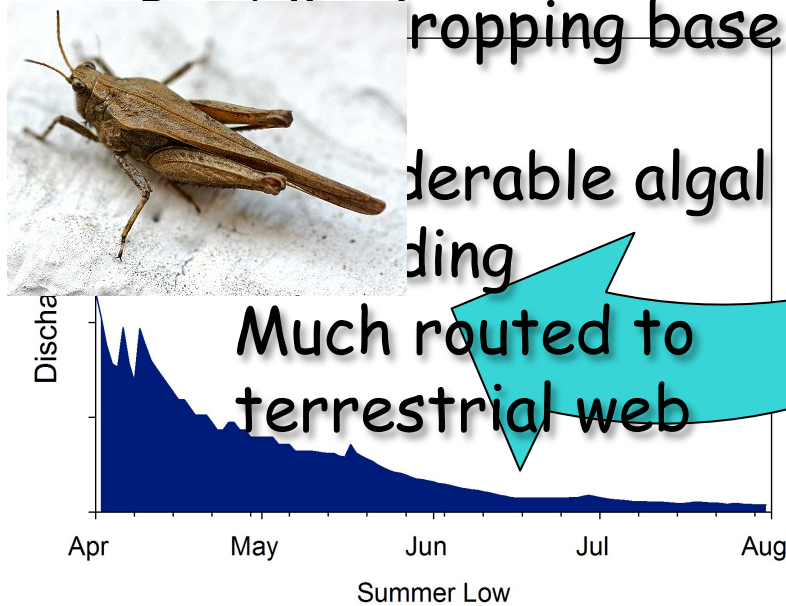
Summer?



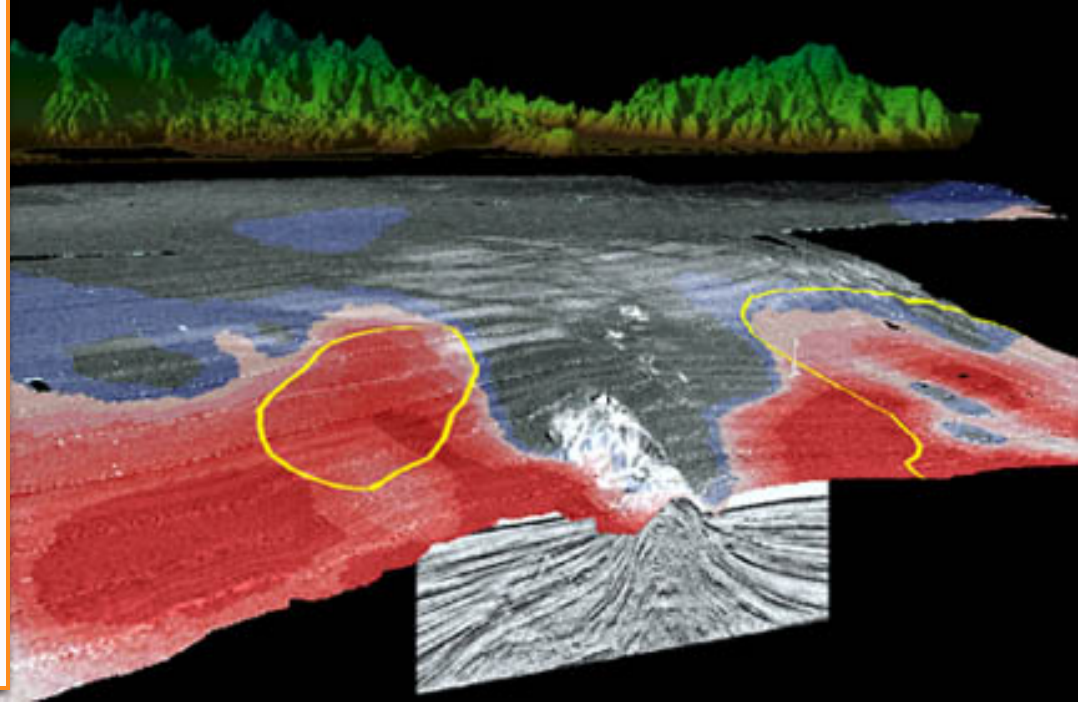
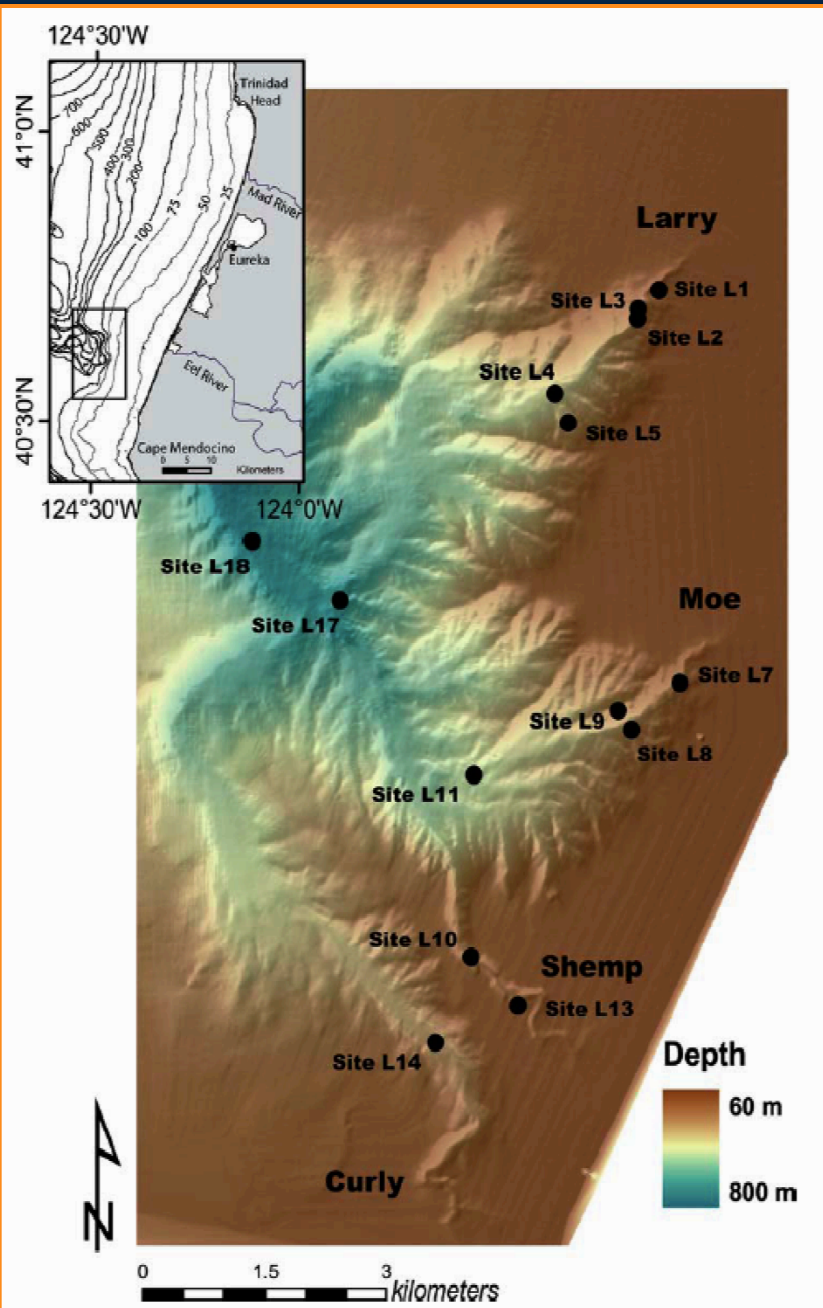
Winter?



Summer?



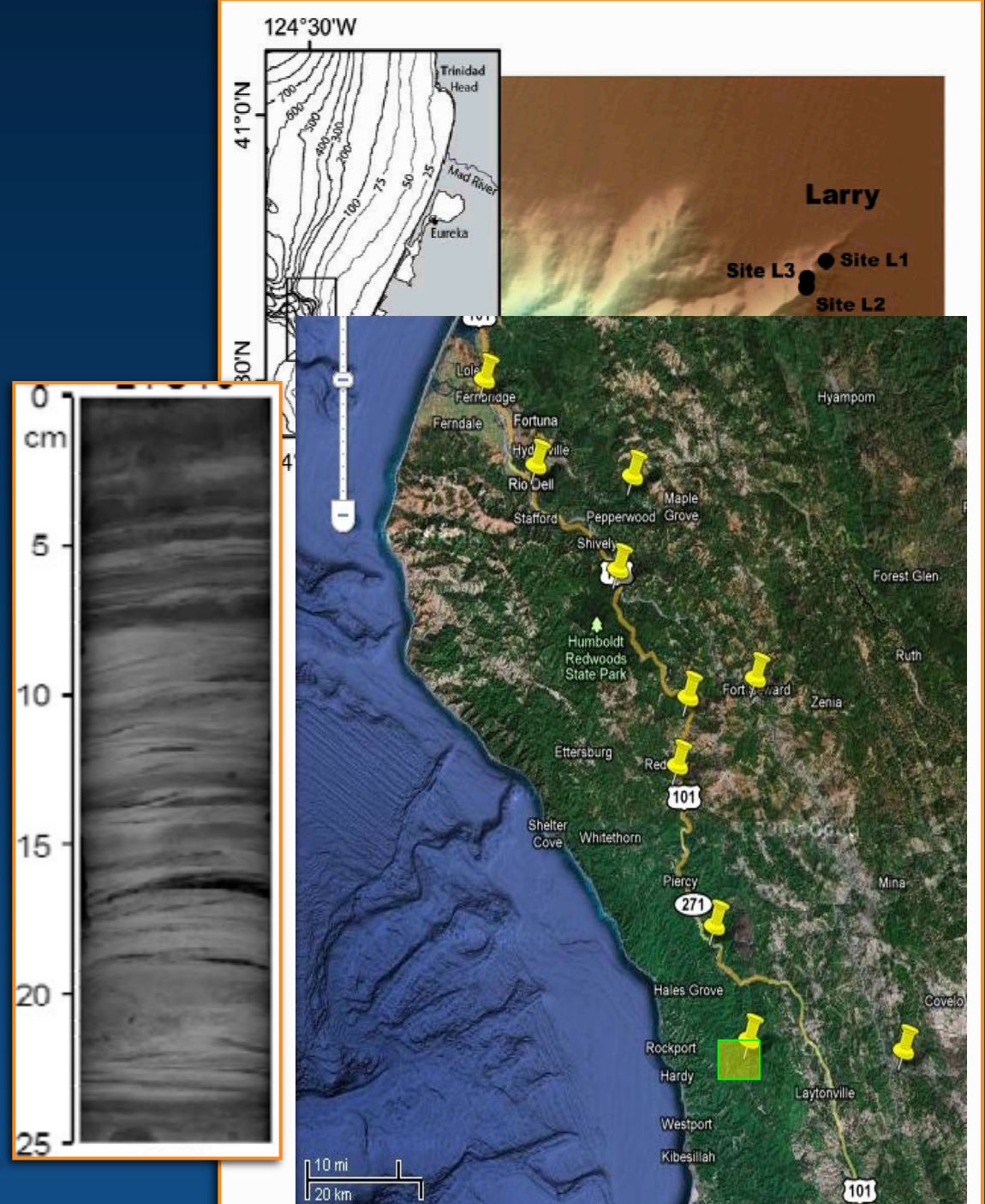
Deep marine
canyons off
mouth of Eel
during low sea
stand...



Epithemia-- a new paleoproductivity indicator (Sculley et al. 2009)

During 18 years when *Cladophora* surveyed, more variance in annual *Epithemia* explained by Angelo bloom magnitude ($r = 0.56$) than by peak discharge ($r = 0.26$)

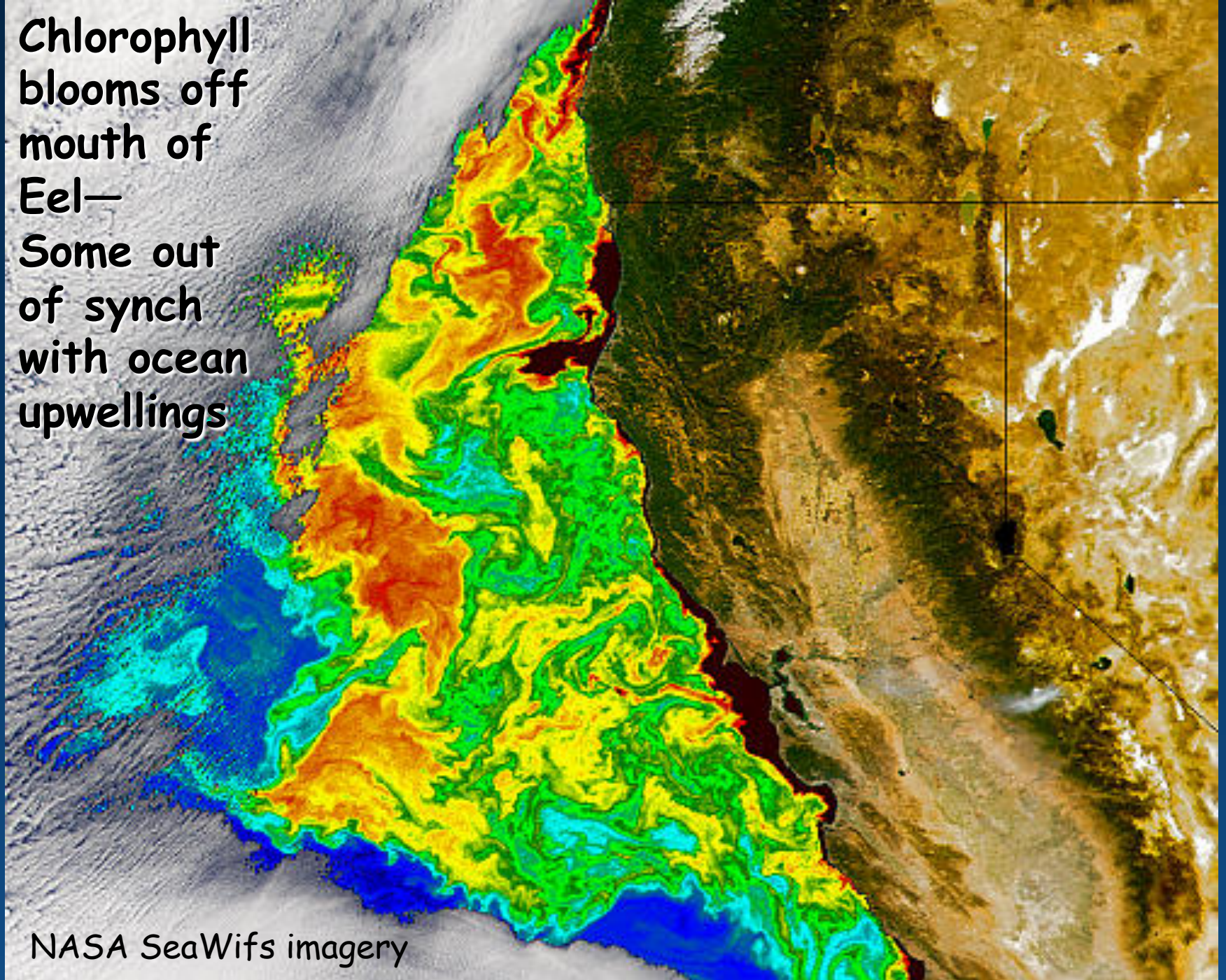
Nittrouer et al.
www.mbari.org/data/mapping/margin/eel_river



Chlorophyll
blooms off
mouth of
Eel—

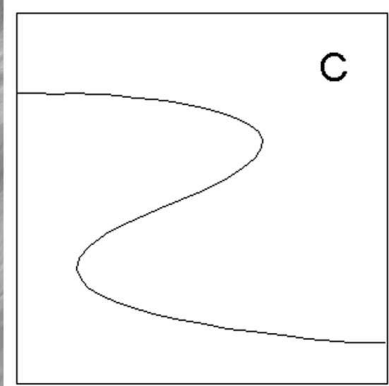
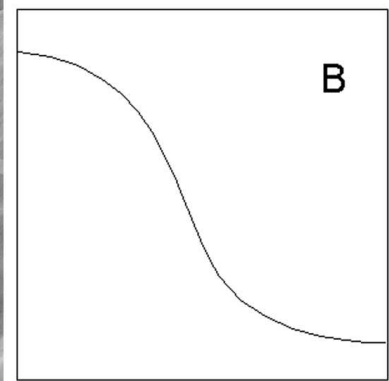
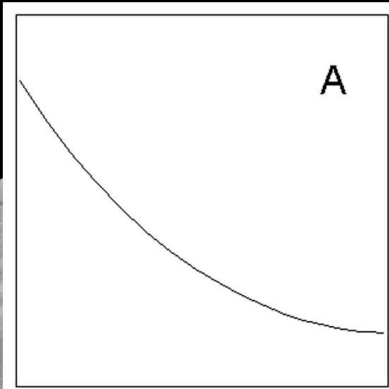
Some out
of synch
with ocean
upwellings

NASA SeaWiifs imagery



Where is the system now and how will it change...?

Ecosystem State



Environmental Condition

(Scheffer et al. 2000)



Feedbacks?!



LIDAR data from NCALM

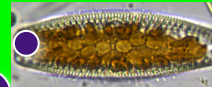
**Insect
emergence**

Terrestrial
food web

Stranding

River food
web: long or
short food
chains?

Algae
(C, N)



Near shore
marine
food web

Intertidal
food web

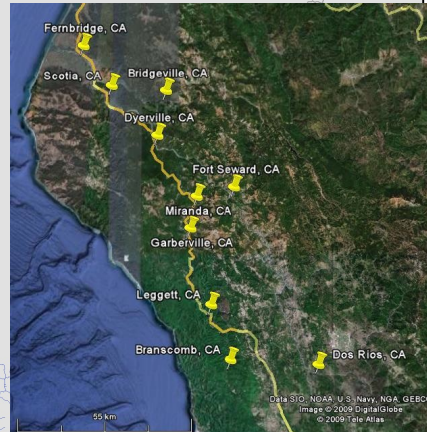
Deep
ocean
burial

N_2
 CH_3

CO_2

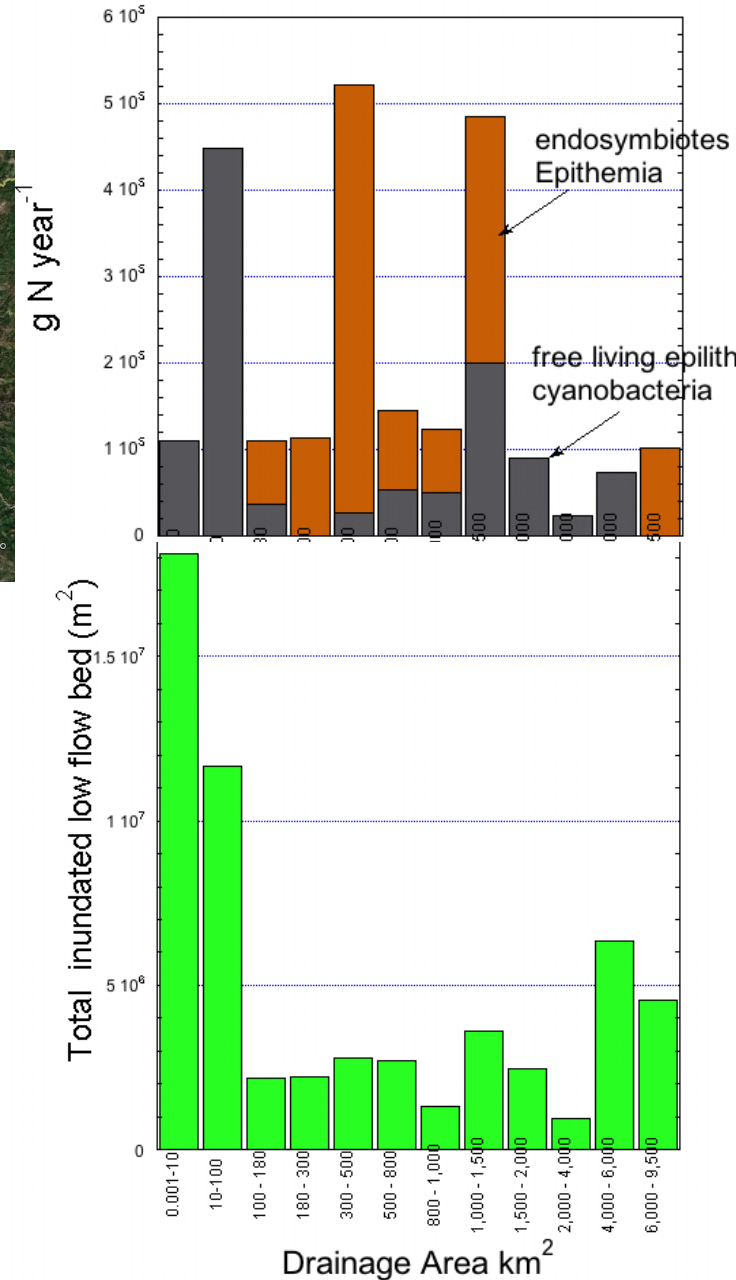
1st basinwide estimate: 24,000 kg y⁻¹ N fixed by Eel River cyanobacteria (low).

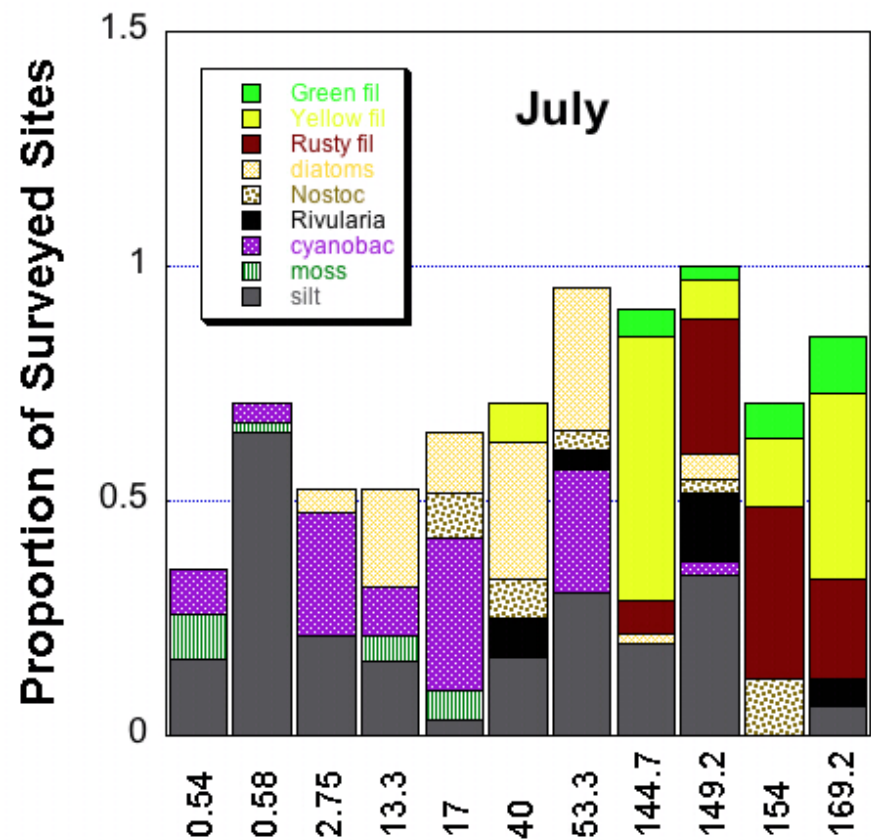
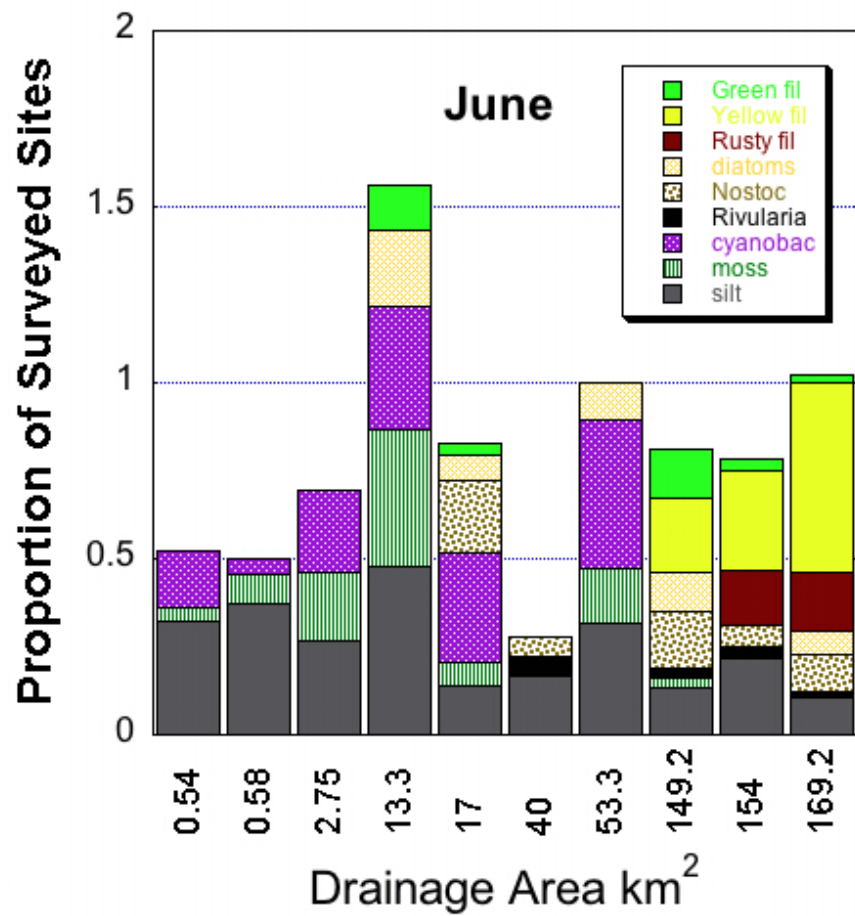
How much makes it to the sea?



20 Kilometers

Basinwide nitrogen loaded by cyanobacteria





'Typical' Mediterranean Seasonality

