Terrestrial-marine linkages in Puget Sound: trophic subsidies and oceanographic transport of freshwater, nutrients and pathogens to shellfish beds

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Shellfish: major components of nearshore ecosystem in Puget Sound

- **Important ecologically**
  - Link between primary producers and higher trophic levels
  - Filter feeders→ Ecosystem service
  - Reef-forming → Provision of hard substrate
- **Important economically**
- **Puget Sound Partnership recovery indicator**

Shellfish and the land/sea interface

Diet, nutrients, and pathogens

Terrestrial

Marine

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- Terrestrial detritus
- Freshwater phytoplankton
- Nutrients
- Sediment transport
- Pathogens → Fecal coliforms
  - Limits harvest opportunities, associated with rain

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- Phytoplankton
- Seaweeds and eelgrass
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- Pathogens → *Vibrio*
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The relative importance of freshwater and marine inputs will be influenced by:

- Quantity and timing of freshwater delivery
- Land use/ Riparian vegetation
- Oceanographic inputs and transport
- Climate change

Project goals

I. **Transport of freshwater and marine inputs to shellfish beds under alternative climate and land use scenarios**

II. **Relative importance of marine and terrestrial inputs to shellfish diets**

III. **Sources and magnitudes of terrestrial and marine-derived nutrients and pathogens**

IV. **Vulnerability to harvest closures under alternative scenarios**

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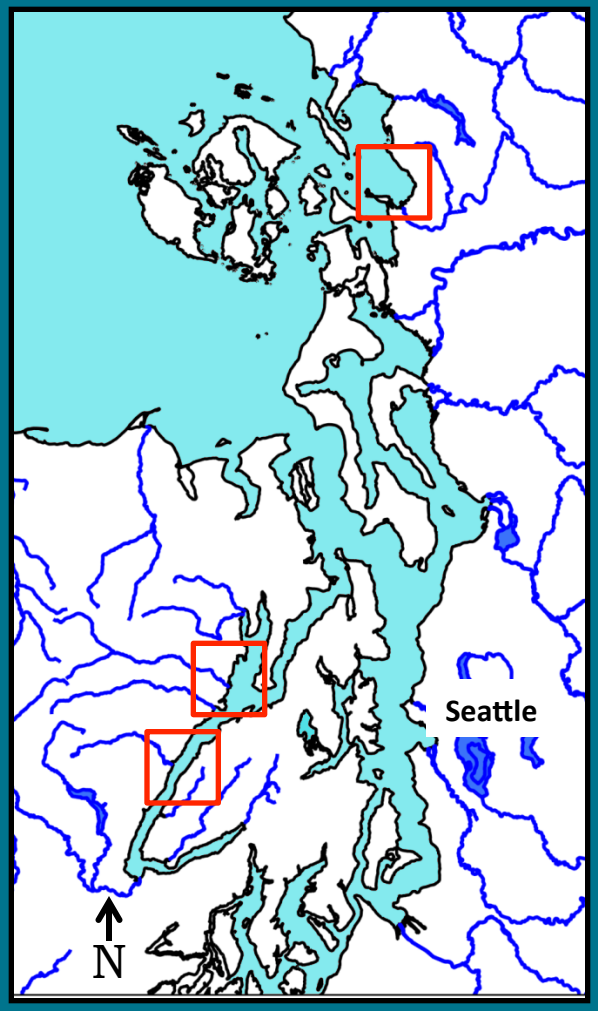
Approach

Three target watersheds

- Each supports significant shellfish harvest
- Variation in land use, watershed and oceanographic characteristics



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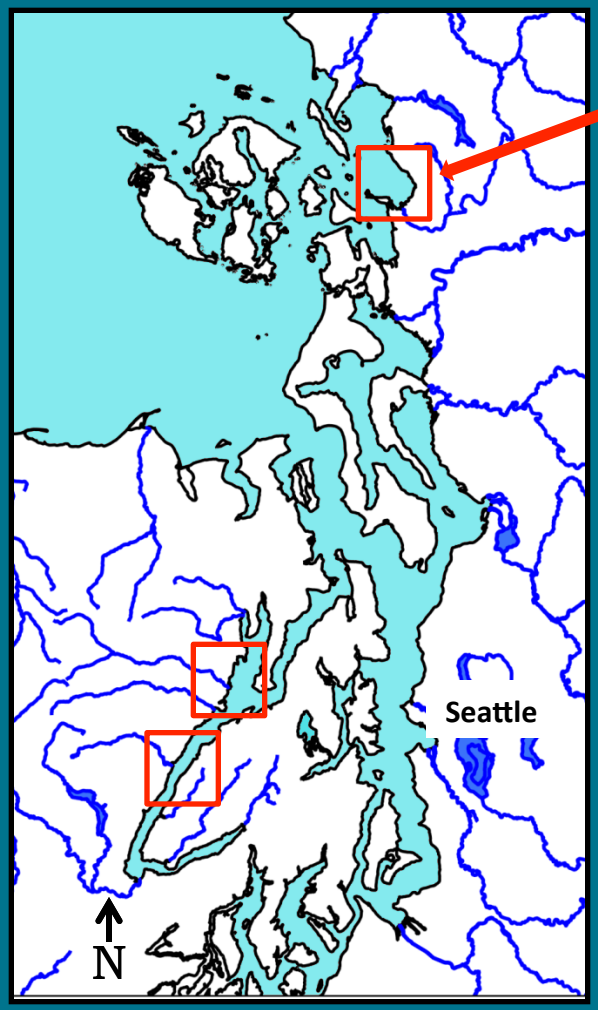

Samish Bay

- Lower elevation
- Agriculture

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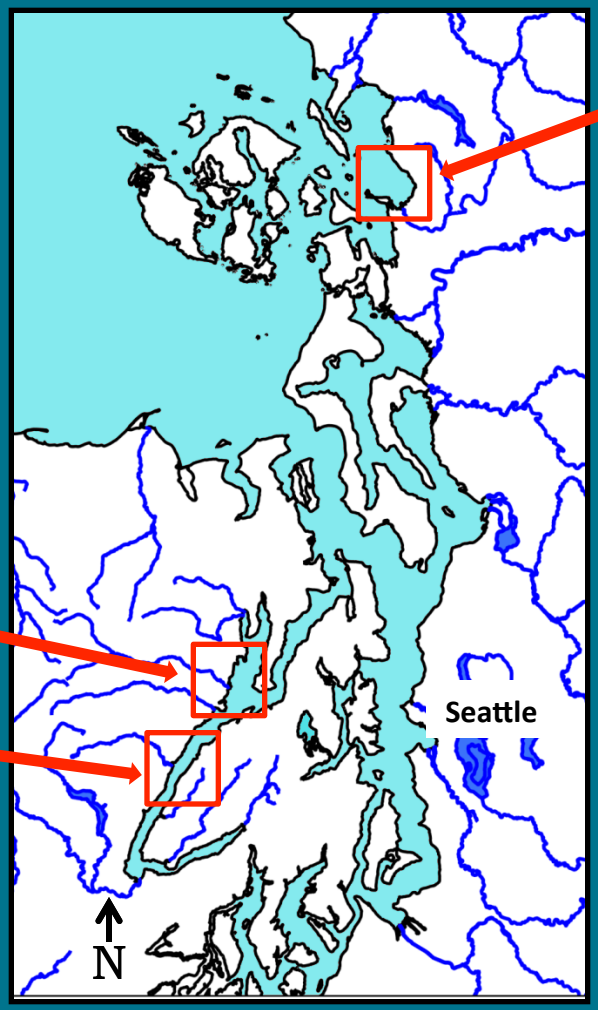


Samish Bay

- Lower elevation
- Agriculture

Dosewallips River

Hamma Hamma River

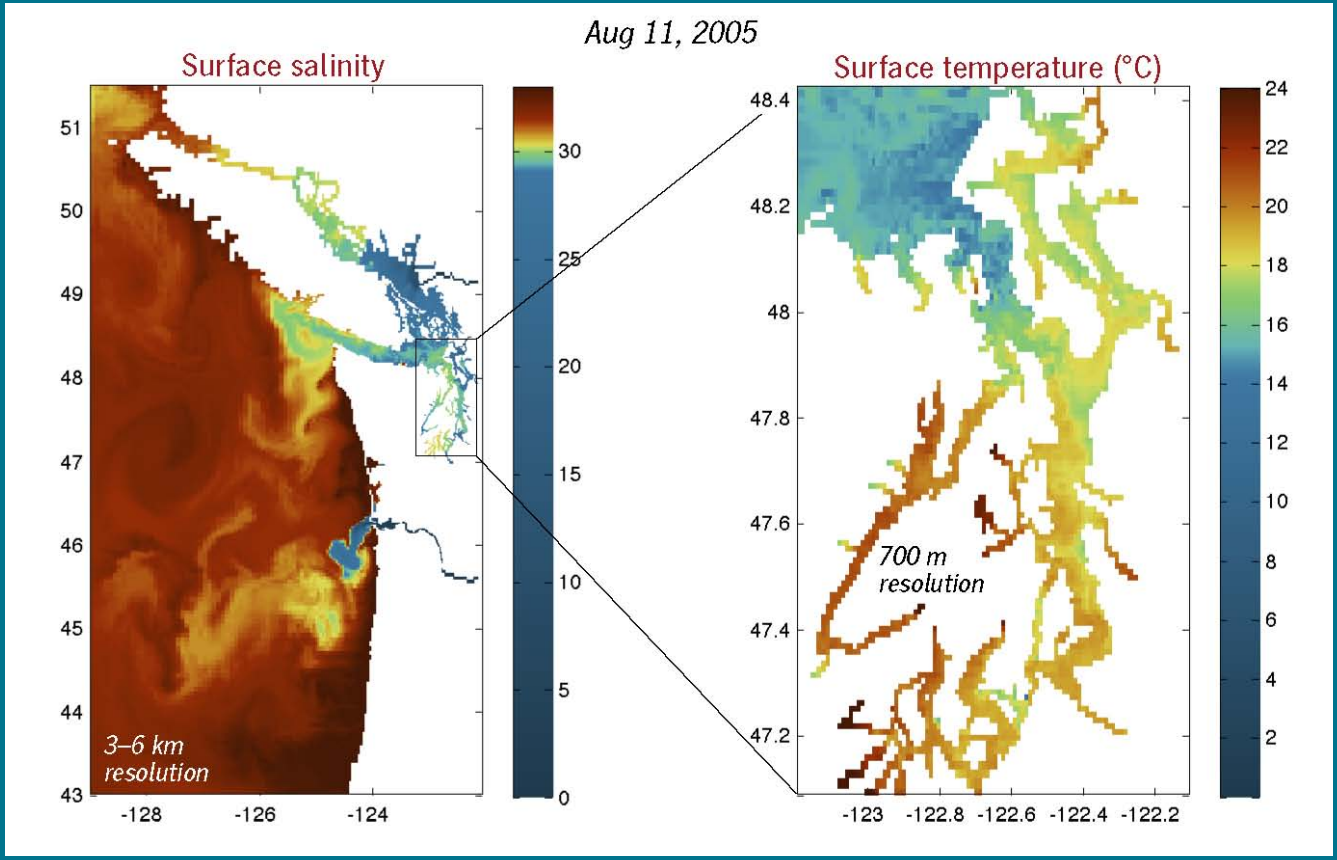
- Higher elevation
- Forest/residential

Oceanographic model

MacCready and Giddings, physics
Banas, Davis, and Siedlecki, biochemistry

PS-AHAB Model (N. Banas, UW Applied Physics Lab)

- Implemented using ROMS (Regional Oceanographic Model System)
- Part of MoSSea (Modeling the Salish Sea)



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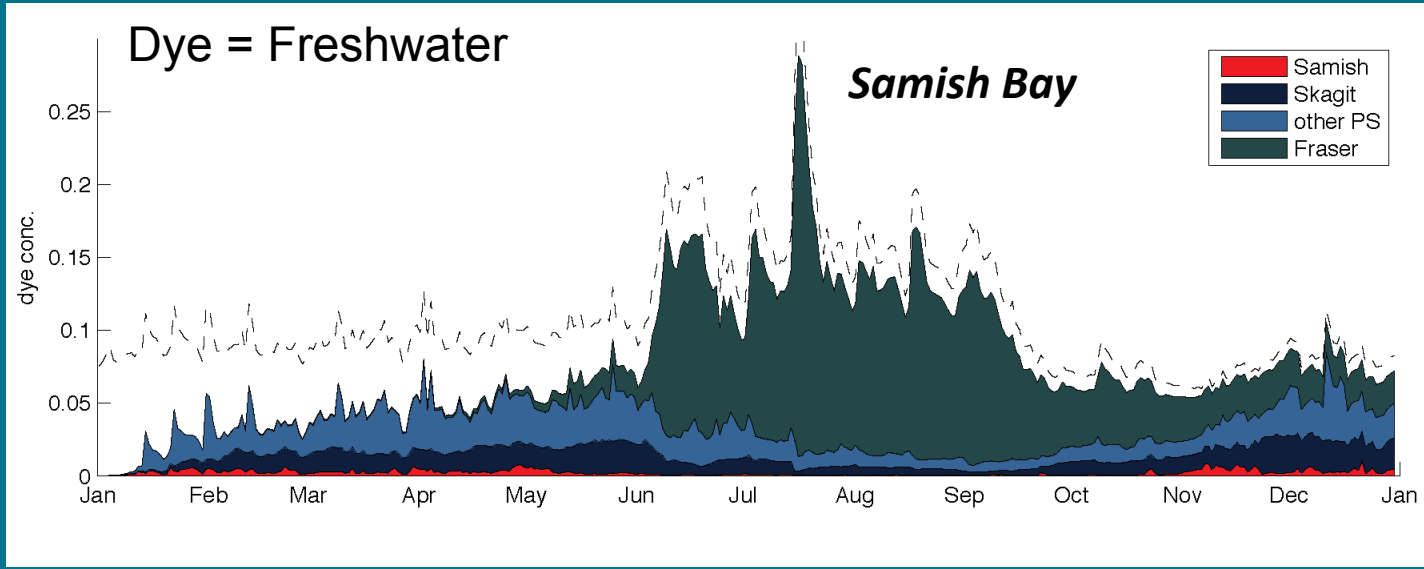
MacCready and Giddings, physics
Banas, Davis, and Siedlecki, biochemistry

Preliminary results



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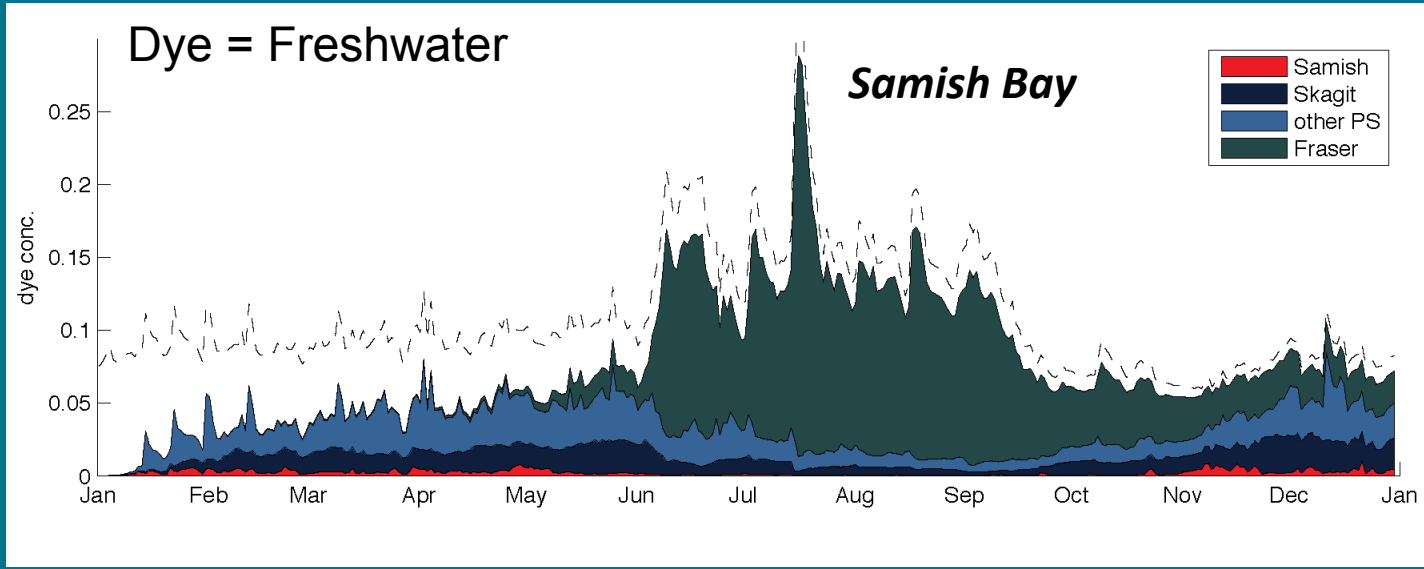

- From ~ 5% to ~30% freshwater predicted to be transported to shellfish bed
- Seasonally variable
- Importance of other rivers

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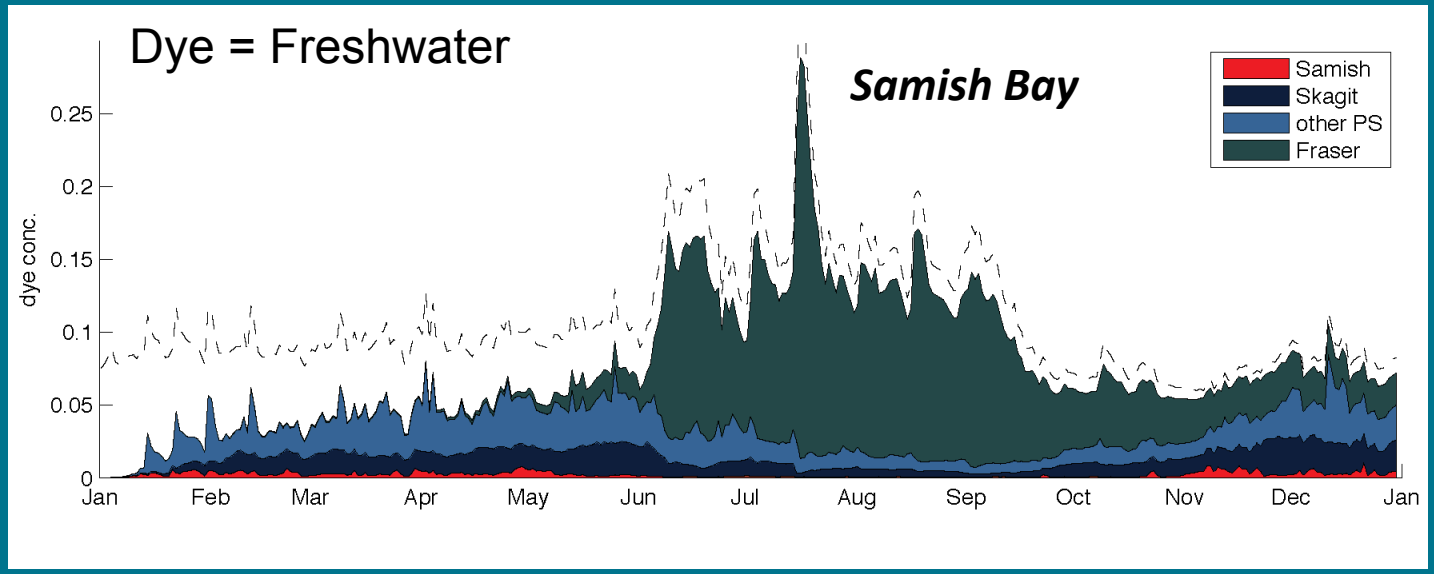

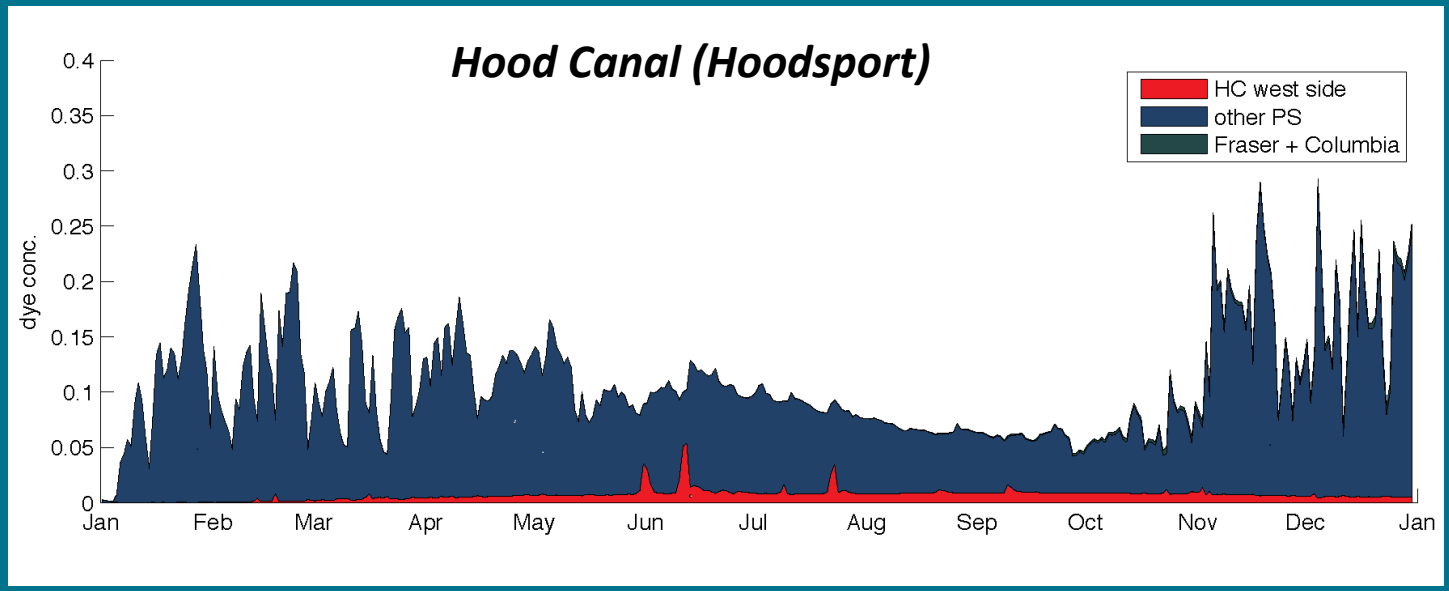

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- Different seasonal pattern for Hood Canal, higher freshwater input

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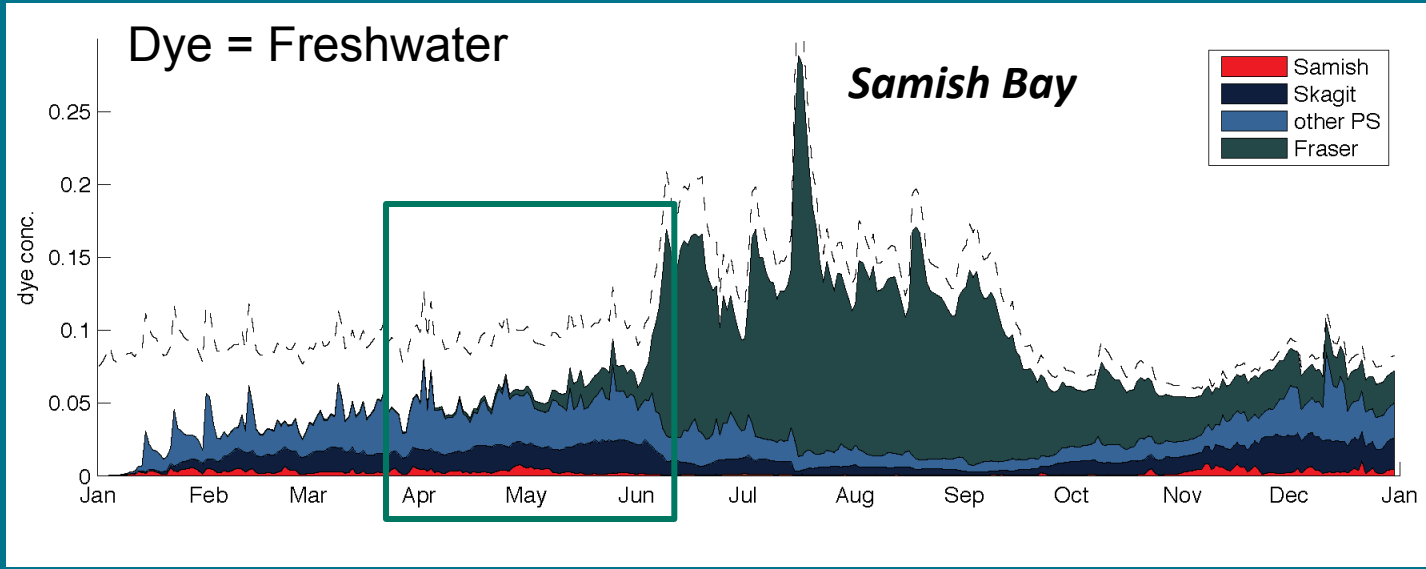
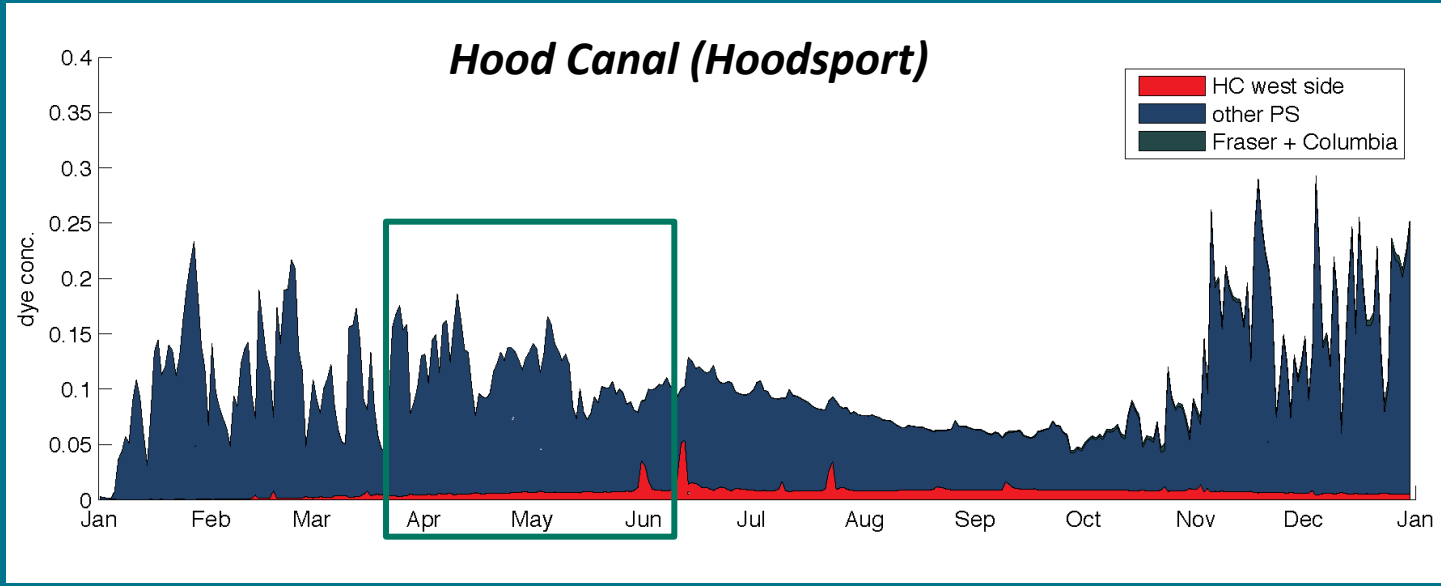


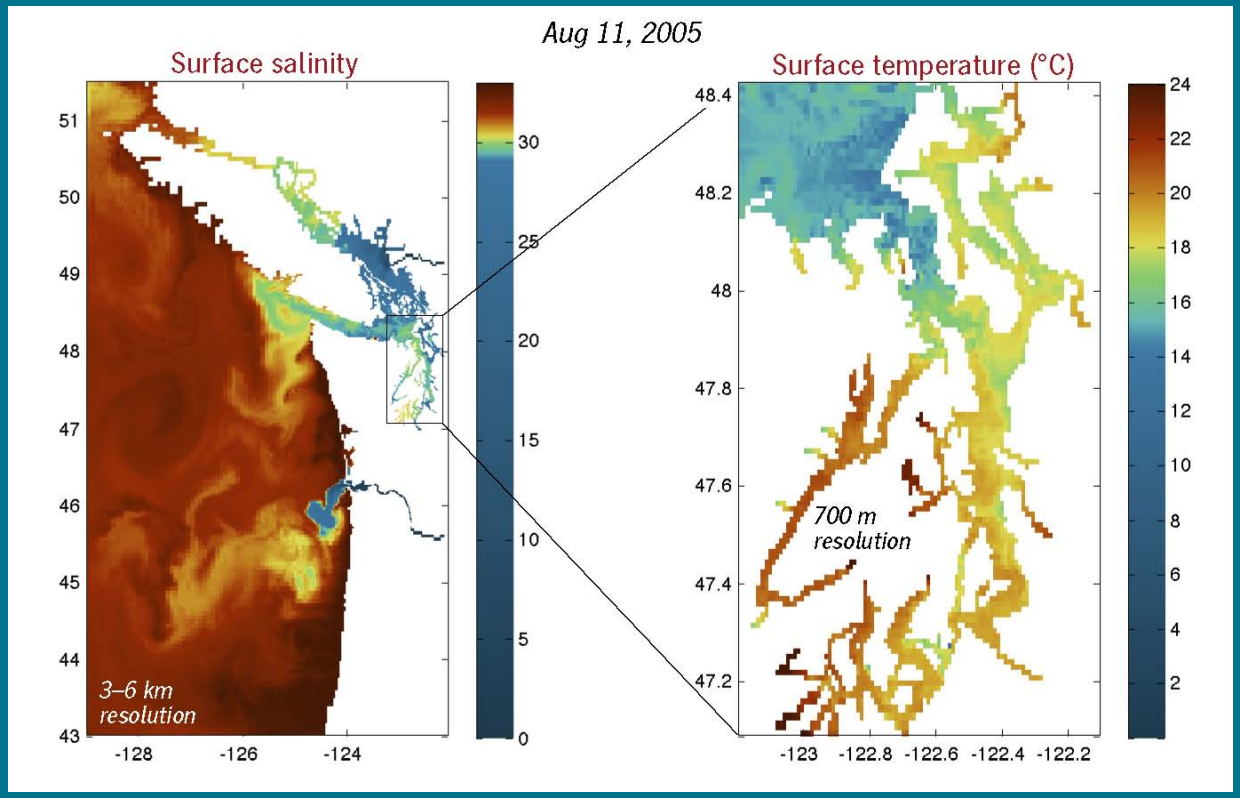


- From ~ 5% to ~30% freshwater predicted to be transported to shellfish bed
- Seasonally variable
- Importance of other rivers
- Different seasonal pattern for Hood Canal, higher freshwater input
- Late Spring/early Summer freshwater contribution of ~5% to ~20%, more in Hood Canal than Samish Bay

Oceanographic model

Ongoing work:

- Different concentrations of tracers to represent nutrient and pathogen loads
- Alternative land use and IPCC climate change scenarios
- Role of extreme events



MacCready and Giddings, physics
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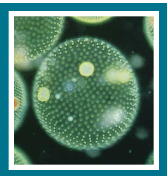
Oyster diets

Stable isotope study: *Crassostrea gigas*

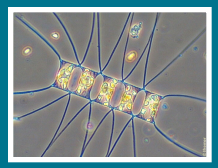
Marsh Plants

Marine macroalgae

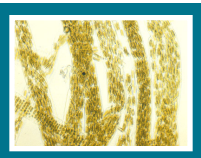
Riverine phytoplankton



Marine phytoplankton

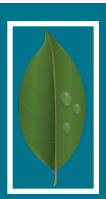


Benthic diatoms



Seagrass

Terrestrial leaf detritus



More terrestrial

$\delta^{13}C$

More marine

Oyster diets

Stable isotope study: *Crassostrea gigas*

Septic nitrogen

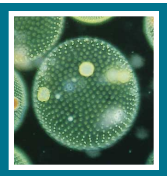
$\delta^{15}N$

Atmospheric nitrogen

Marsh Plants

Marine macroalgae

Riverine phytoplankton



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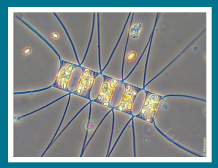

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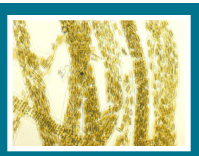

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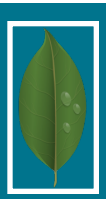

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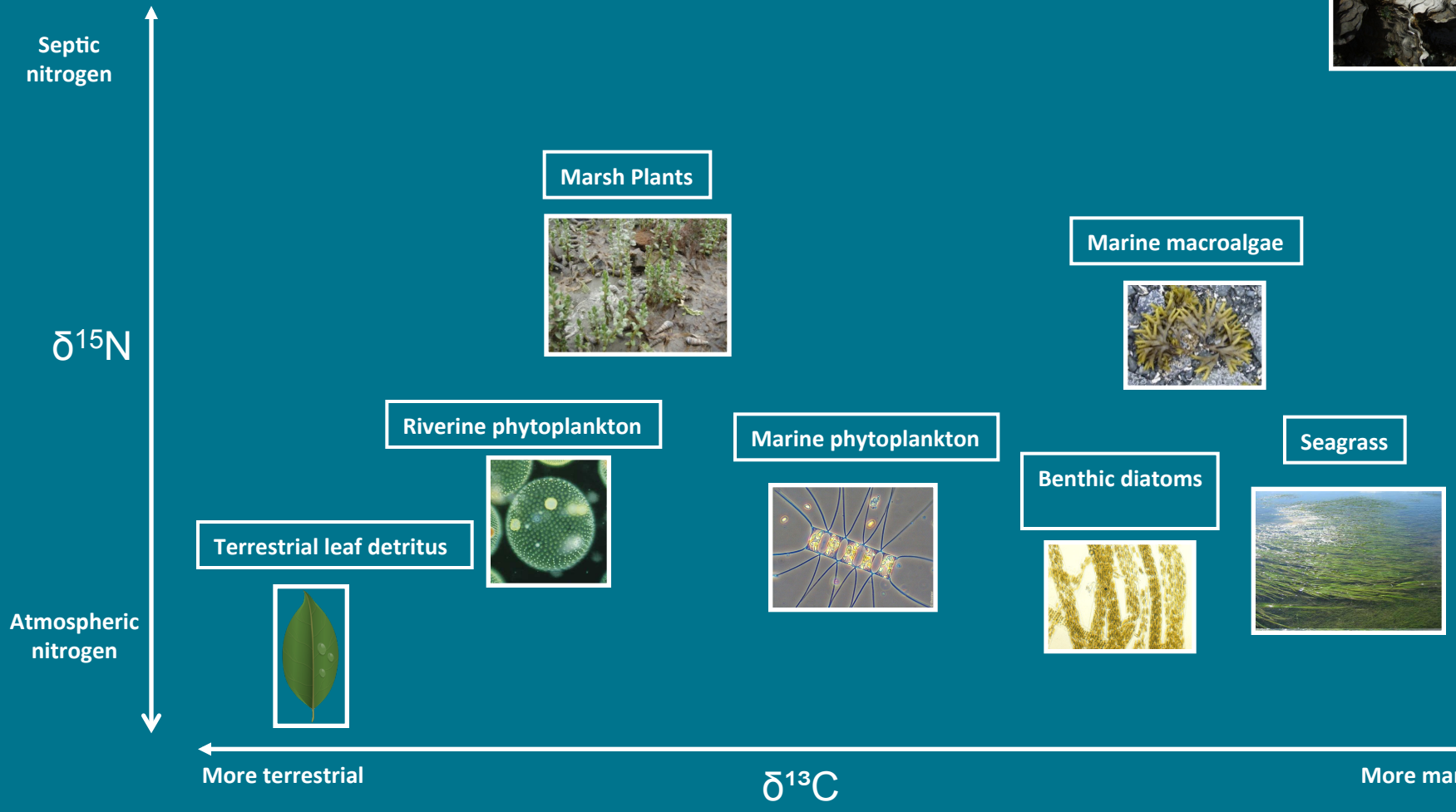
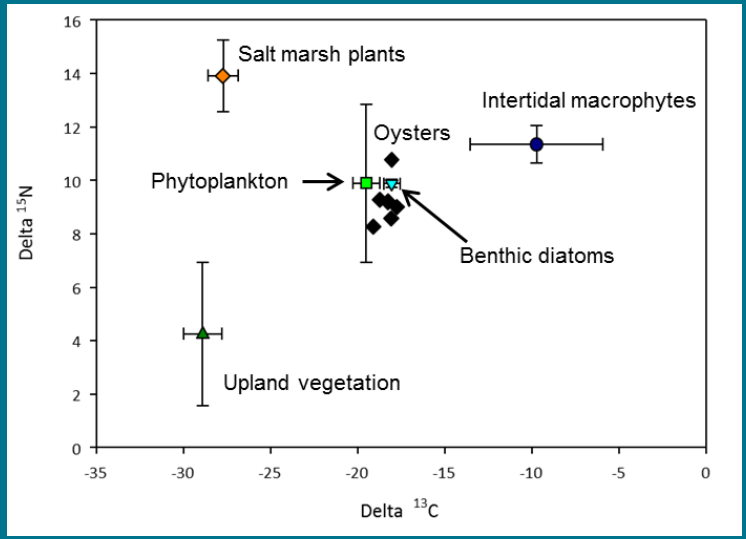


- Collect oyster tissue, source tissue, particulate matter in oyster beds from June 2011- Jan 2012
- Use mixing model to determine relative contribution of freshwater and marine sources

Results so far: subset of June 2011 samples



Samish Bay

- **Oysters and potential diet items**

Sources corrected for trophic enrichment

Phytoplankton and diatom values from E. Howe, UW

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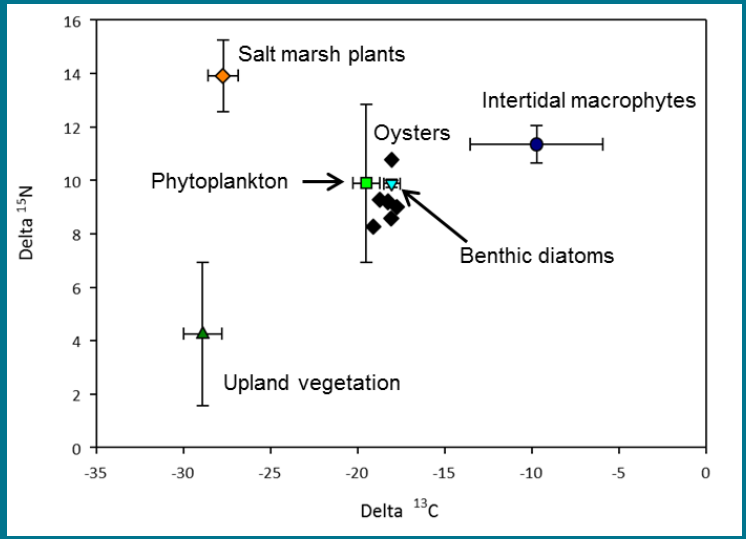

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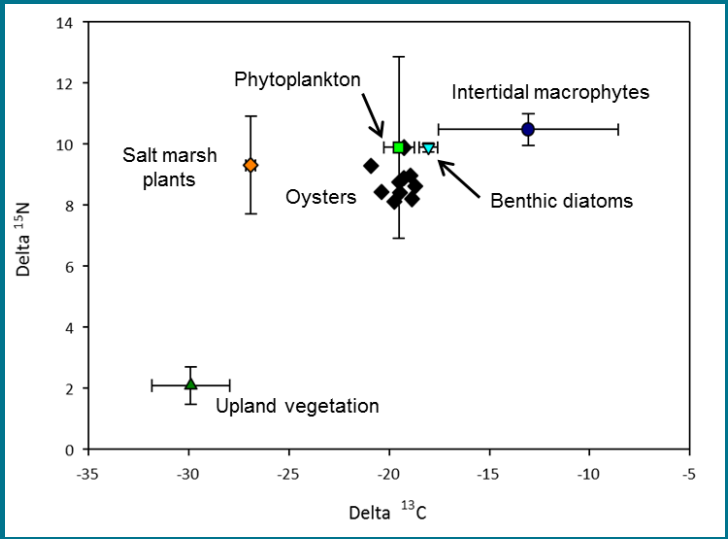
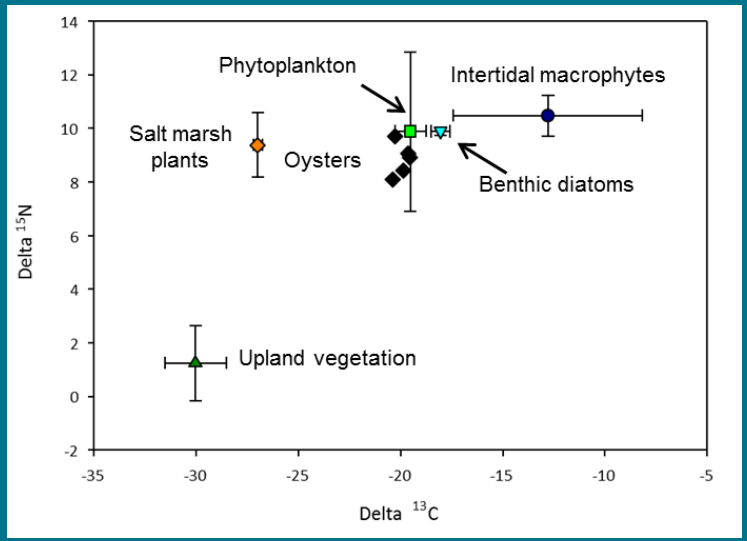


Dosewallips



Hamma Hamma

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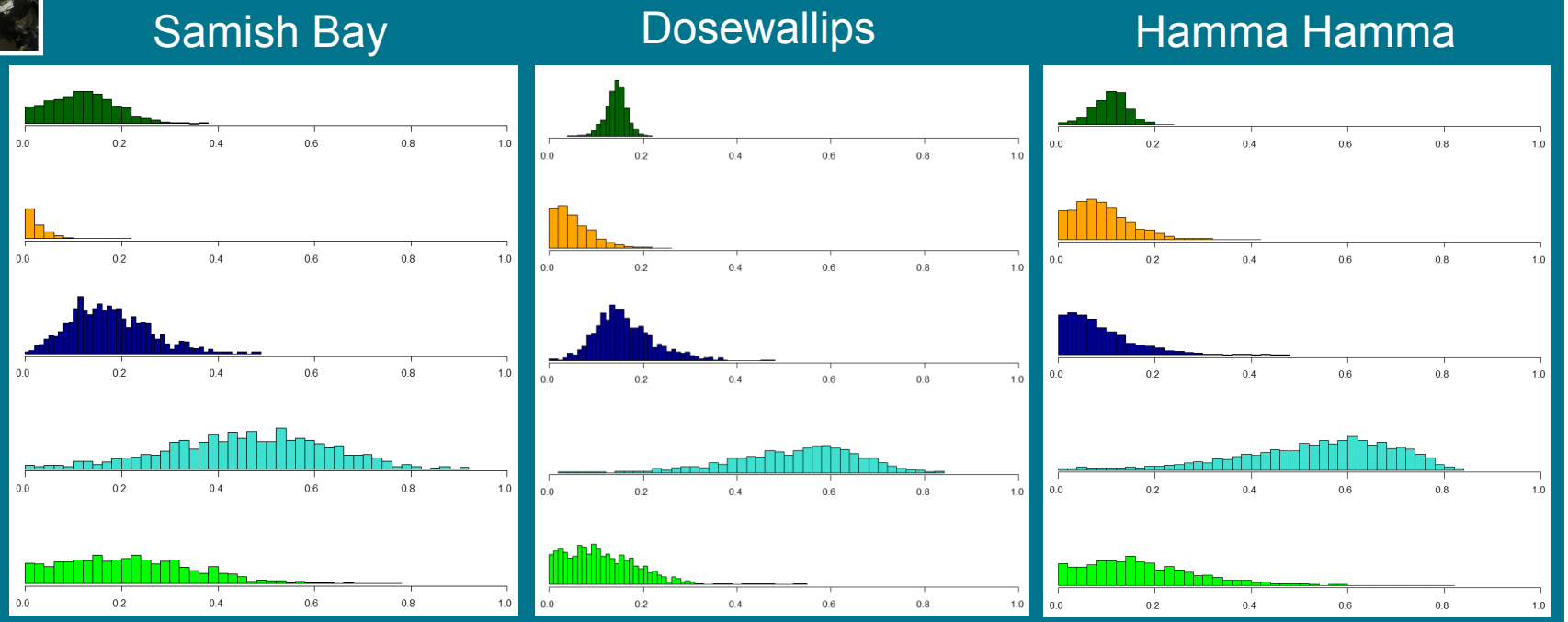
Results so far: MixSIR



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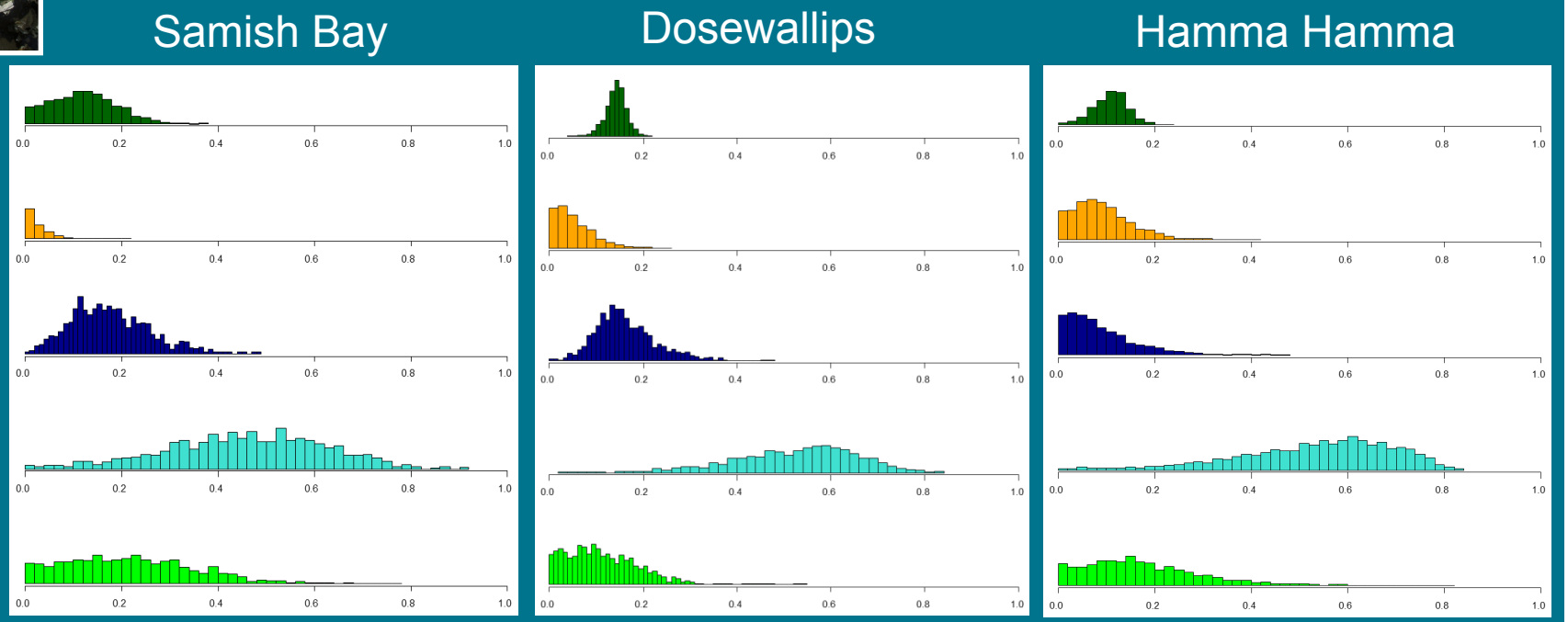
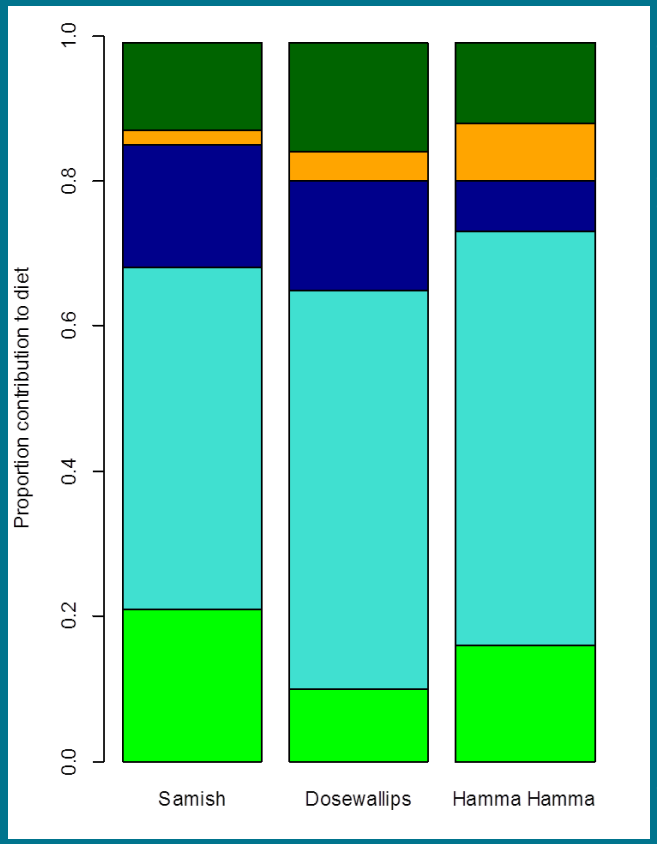


- **Wide ranges of benthic diatom and phytoplankton contributions at all three sites**
- **Largest contribution benthic diatoms**
- **Smallest contribution of salt marsh plants**

Results so far: MixSIR

Upland
Salt marsh
Intertidal
Benthic diatoms
Phyto



More terrestrial

More marine

Median values of contribution

- Importance of marine sources, combined upland and saltmarsh contribution of ~14% (Samish), 20% (Hood Canal)

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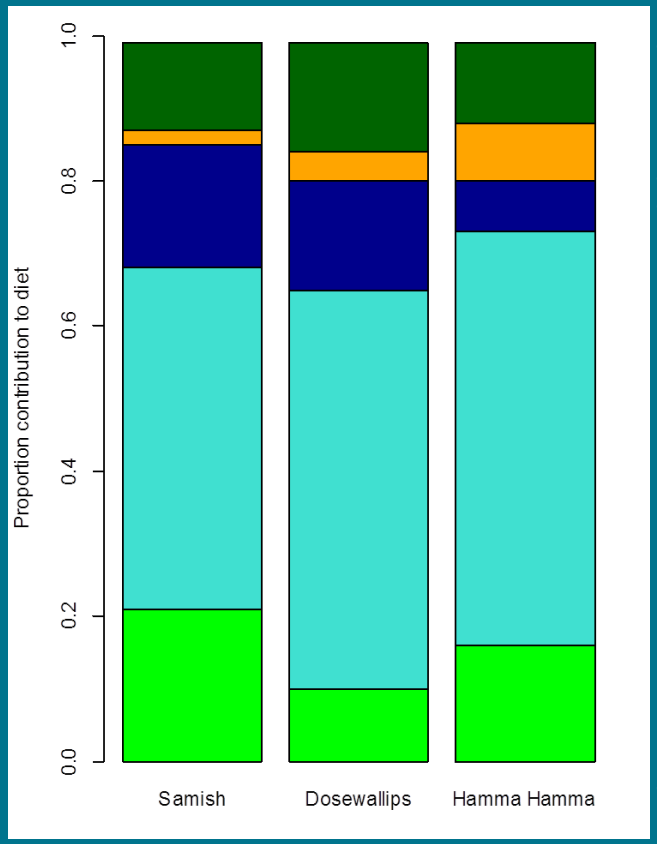

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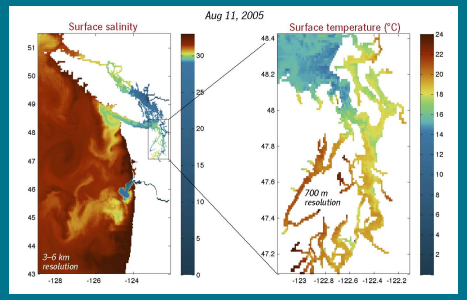

- Importance of marine sources, combined upland and saltmarsh contribution of ~14% (Samish), 20% (Hood Canal)
- General agreement with oceanographic model

Stable isotope study: *Crassostrea gigas*

Ongoing work

- Remainder of oyster and source samples (June, August, November, January)
- Focus on across-site patterns in sources and contributions
- Environmental data from oyster beds (monthly CTD, POM) and river POM
- Use nitrate isotopes to trace sources of nutrients in watersheds

Significance

- Improved understanding of factors influencing shellfish beds and nearshore habitats in Puget Sound
- Potential for regional influence of local shellfish beds
- Oyster diets so far are generally consistent with oceanographic model predictions of freshwater and marine input
- Integration of oceanography, nearshore and watershed ecology, pathology, economics to determine current and future risk of shellfish bed closures

Acknowledgements

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Site Access: Taylor Shellfish (Bill Dewey, Danny Lomsdalen, John Adams), Gary Webb, Dosewallips State Park
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