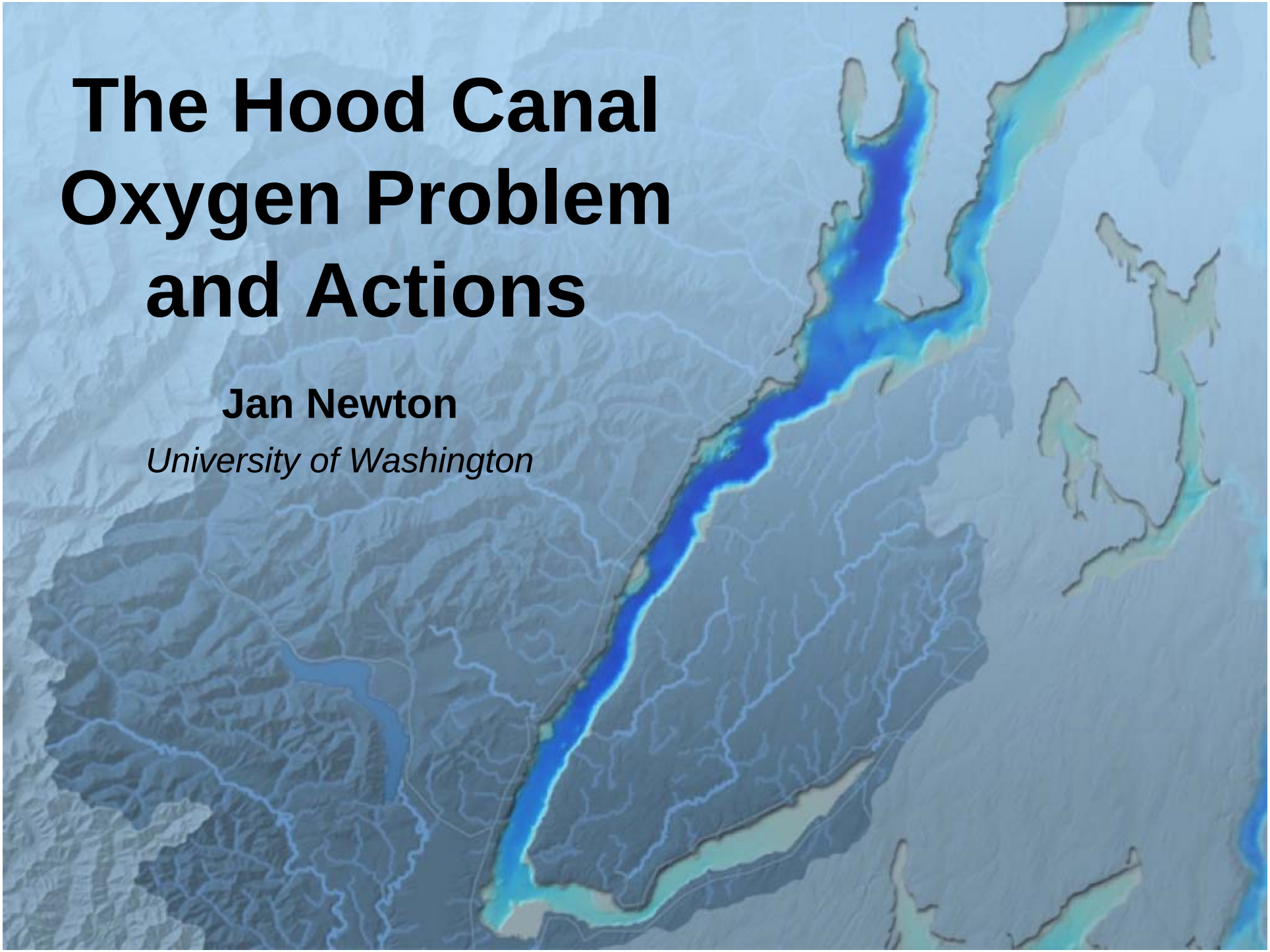
The Hood Canal Oxygen Problem and Actions

Jan Newton

University of Washington



Low oxygen in Hood Canal is not a new observation

- Collias et al., 1974**: UW observations from 1930's-1960's documented low values.**
- Curl and Paulson, 1991, PS Research Conf.: **UW-OSU observations from 1980's lower than Collias data; questioned if changes were occurring.**
- Newton et al., 1995, PS Research Conf.: **Comparison of Ecology (1990's) and UW (1950's) data showed some changes.**
- Ecology's *"Washington State Marine Water Quality during 1998 through 2000"* (Newton et al., 2001):

  "**Similar to our previous assessment (Newton *et al.*, 1998a), four observations from the monitoring data indicate the possibility that DO conditions may be deteriorating in southern Hood Canal, that the spatial extent of low DO may be increasing northwards, and that eutrophication could be one of the processes contributing to this change. Impacts of other human activities (e.g., freshwater diversions) as well as natural cycles must also be fully evaluated."**

  - **Hypoxia more frequent.**
  - **Northward increase in the horizontal extent of hypoxia.**
  - **High chl *a* concentrations observed when nutrient limitation of phytoplankton growth expected.**
  - **Nutrient-addition experiments show that primary productivity was increased as much as three-fold (Newton *et al.*, 1995).**

And then came fall 2002…

State closes Hood Canal to most fishing

The Associated Press

10/22/02 2:01 PM

BREMERTON, Wash. (AP) -- State officials have ordered a halt to fishing in Hood Canal, except for salmon and crab, because of extremely low oxygen levels that are killing some marine organisms and driving fish to the surface.

And 2003…

Hood Canal closed to fishing earlier than last fall

9/13/03 - Associated Press

BREMERTON, Wash. (AP) — Hood Canal will be closed to most fishing because low levels of dissolved oxygen are creating stressful conditions for marine life, sending fish and other animals into shallower waters.

Beginning Monday, the only fishing allowed will be for salmon and crab.

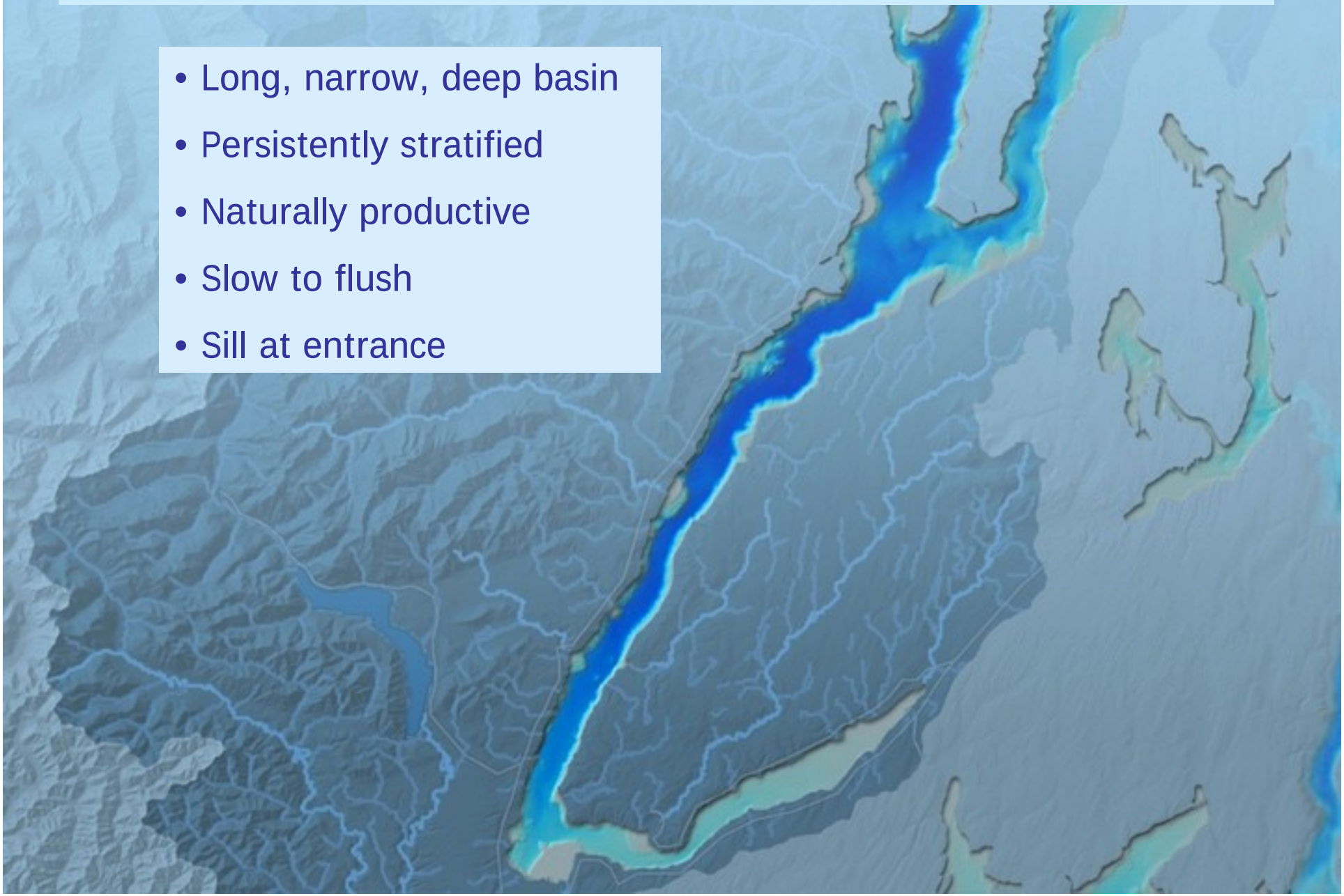
The emergency closure comes six weeks earlier than a similar action last fall.

The fishing ban is to protect bottom fish, which came to the surface last year to get oxygen, said Greg Bargmann of the state Department of Fish and Wildlife.

“These conditions are especially hard on marine fish and other species that live deep below the surface, where dissolved oxygen levels are the most depressed," he said. "Those fish are coping with extreme conditions, and we need to give them some breathing room."

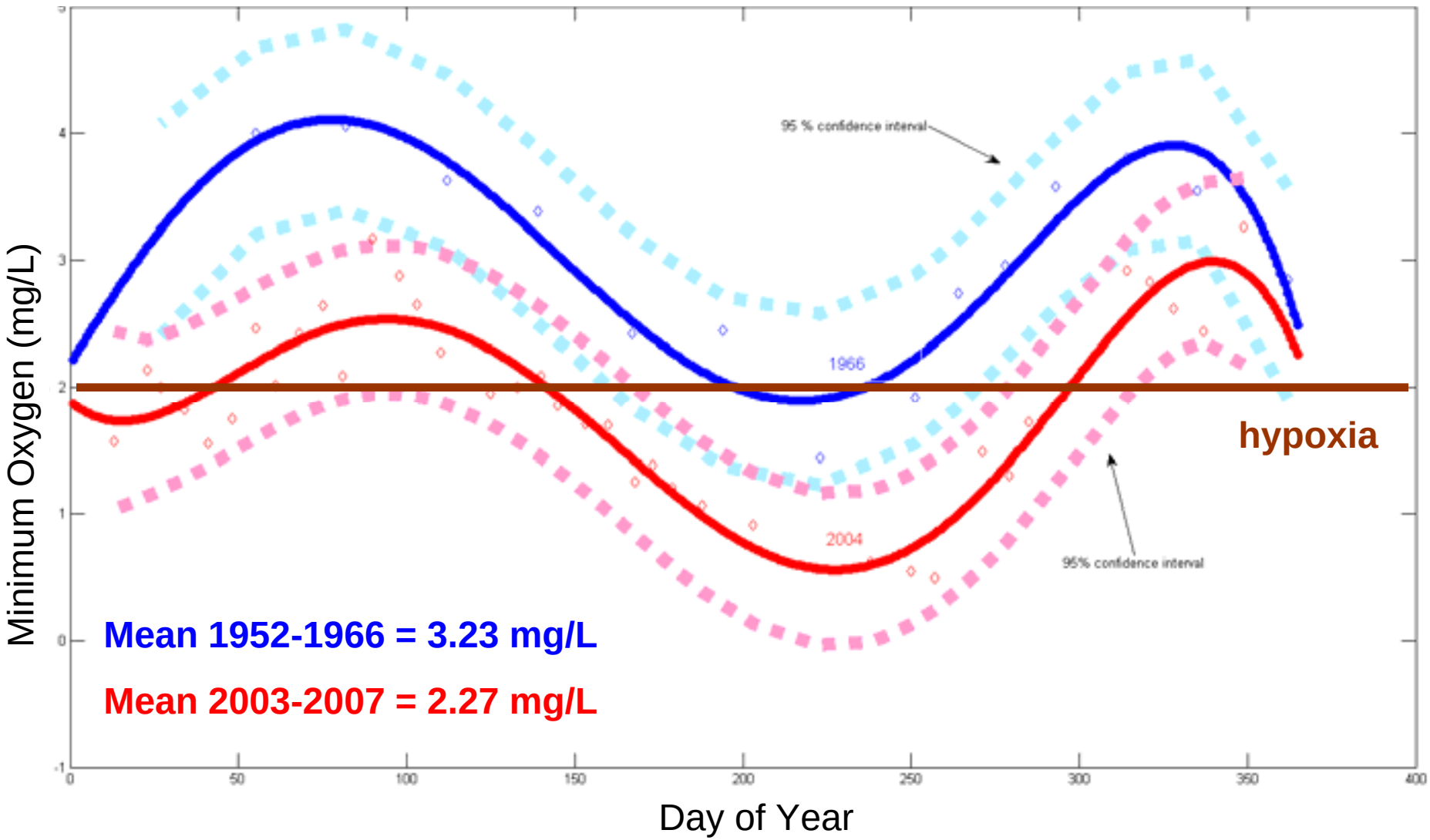
Natural Factors to Consider

- Long, narrow, deep basin
- Persistently stratified
- Naturally productive
- Slow to flush
- Sill at entrance



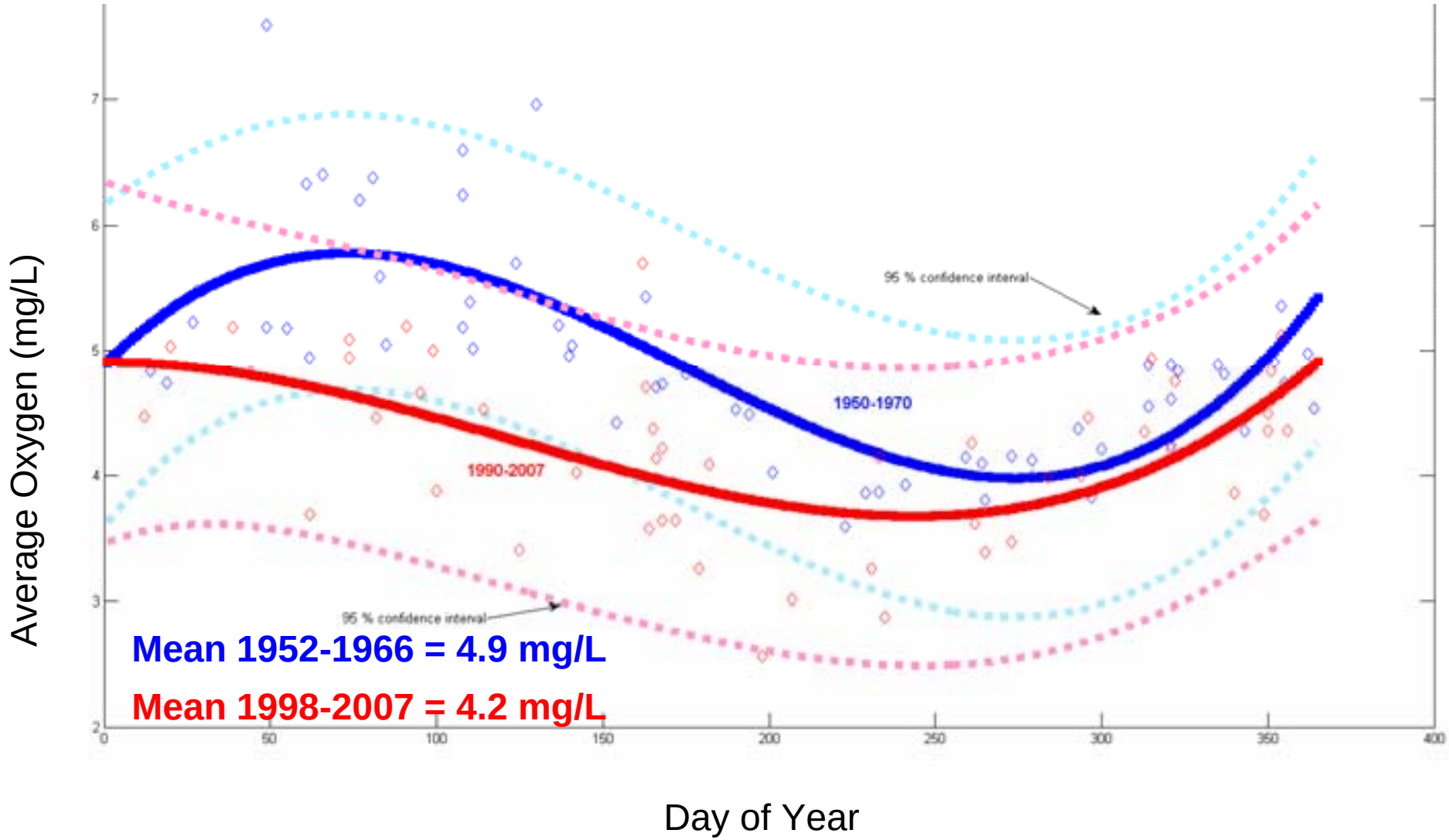
Is the oxygen really different ??

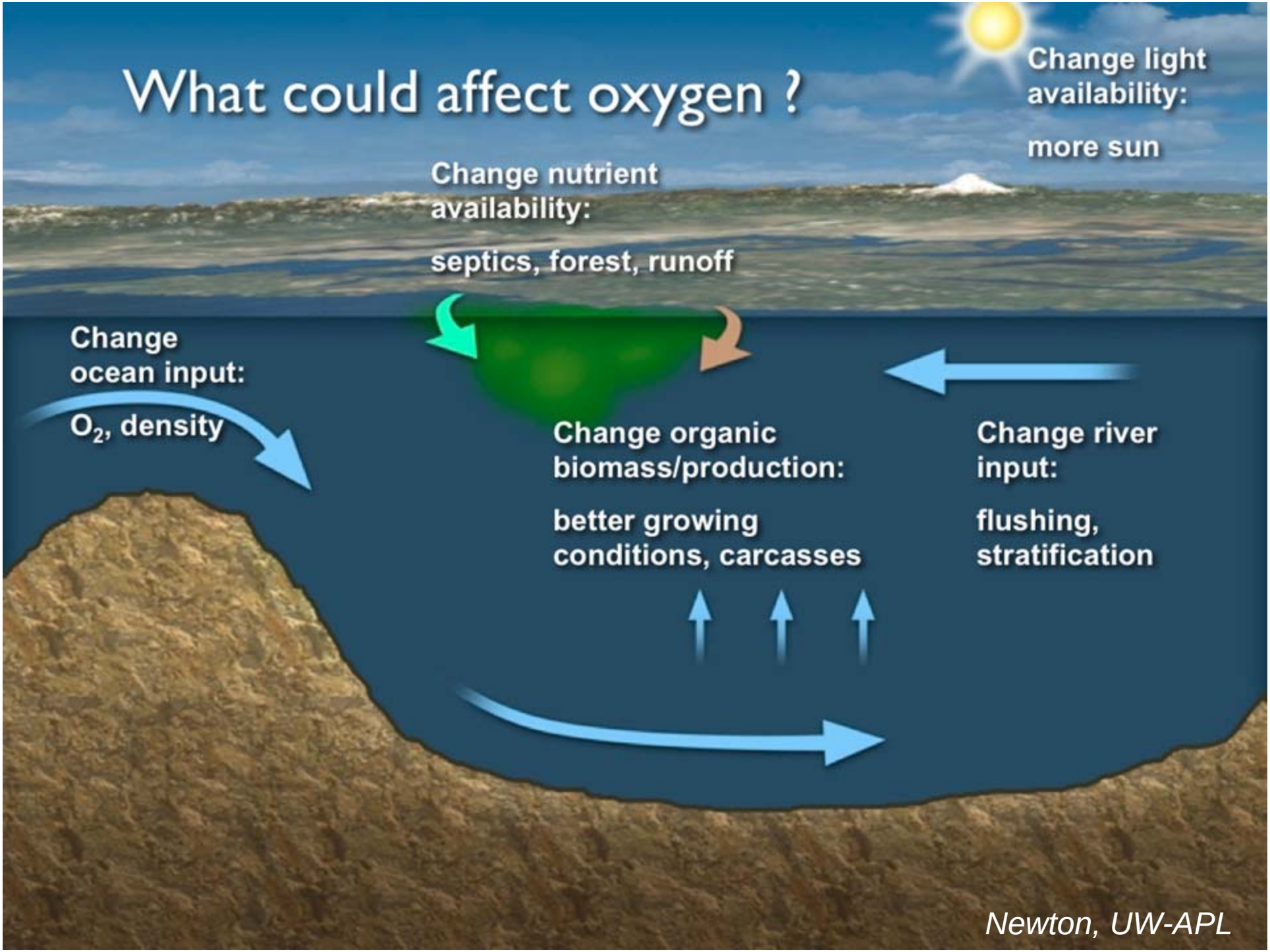
Lower Hood Canal Oxygen THEN versus NOW

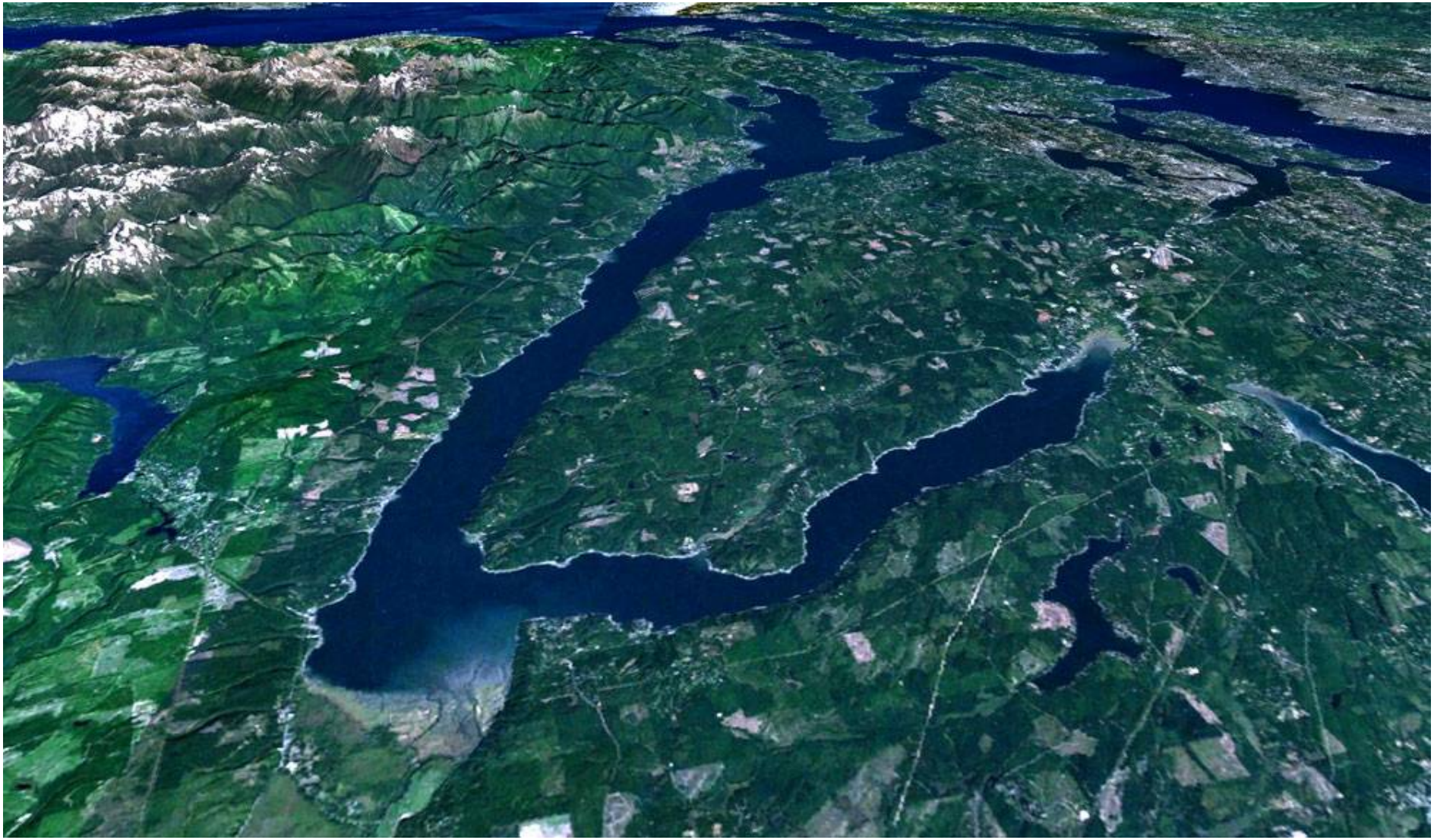


Is the oxygen really different ??

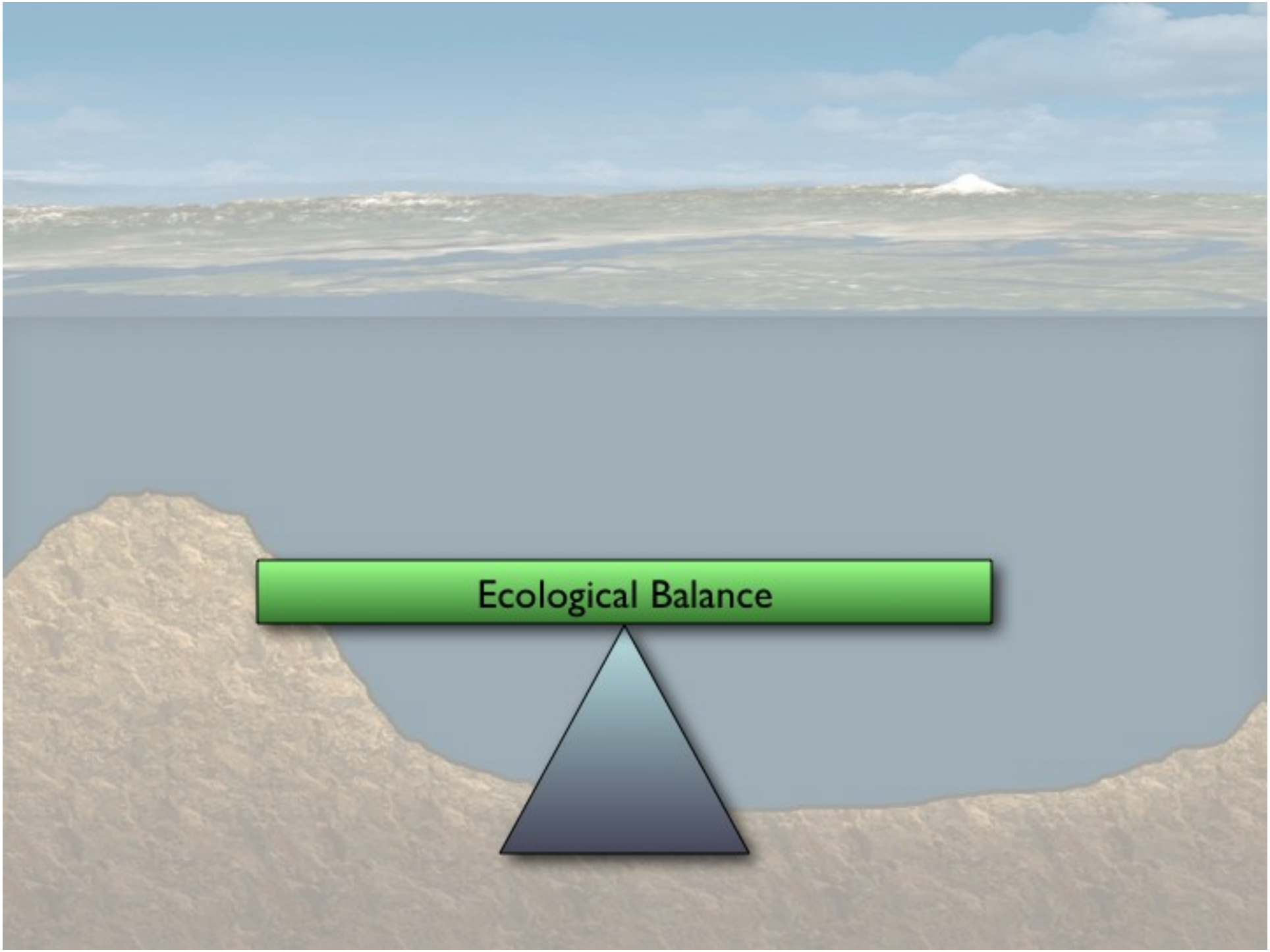
Mainstem Hood Canal Oxygen THEN versus NOW

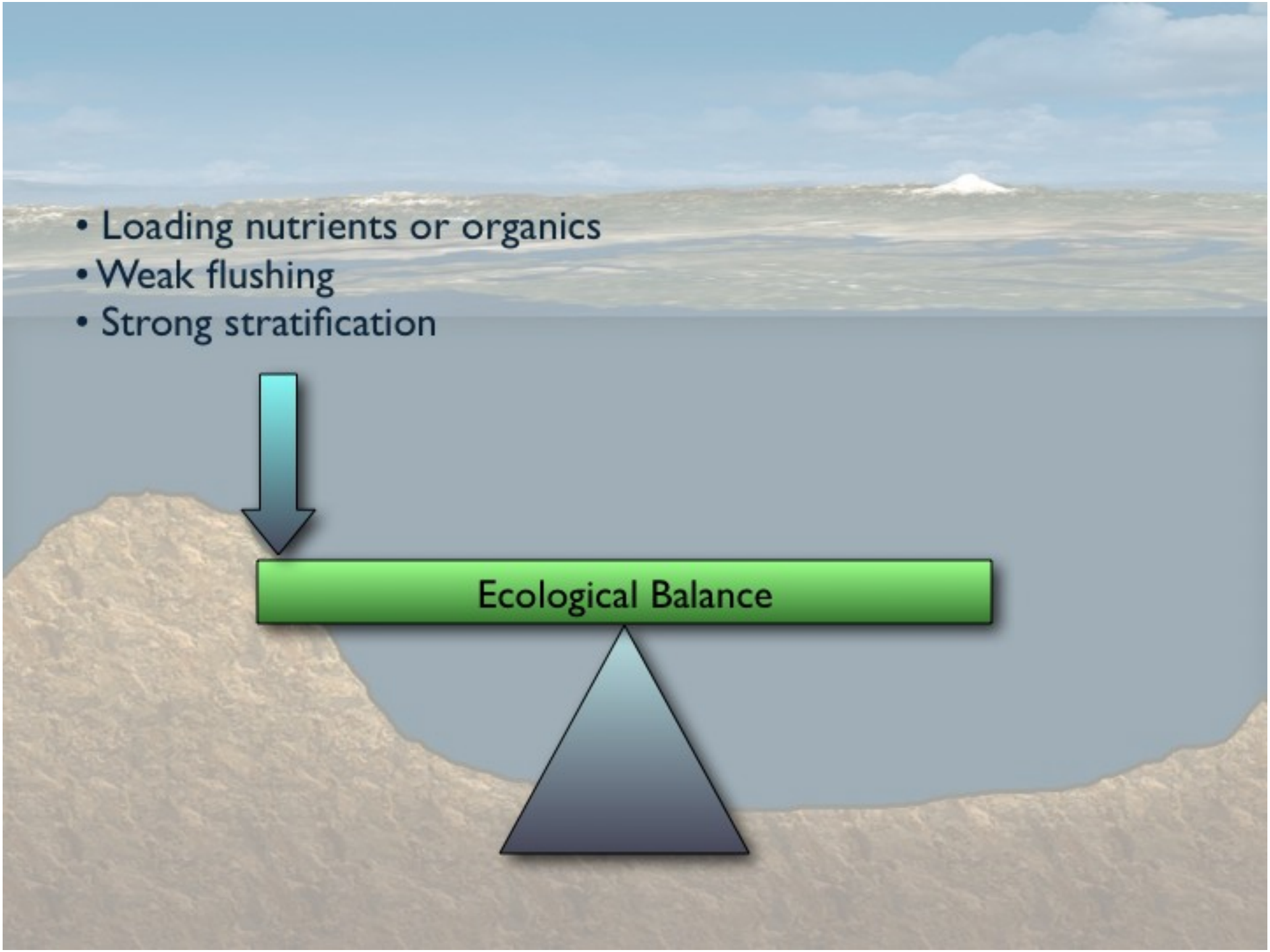



What could affect oxygen ?
Change light availability:
more sun
Change nutrient availability:
septics, forest, runoff
Change ocean input:
O_2, density
Change organic biomass/production:
better growing conditions, carcasses
Change river input:
flushing, stratification
Newton, UW-APL



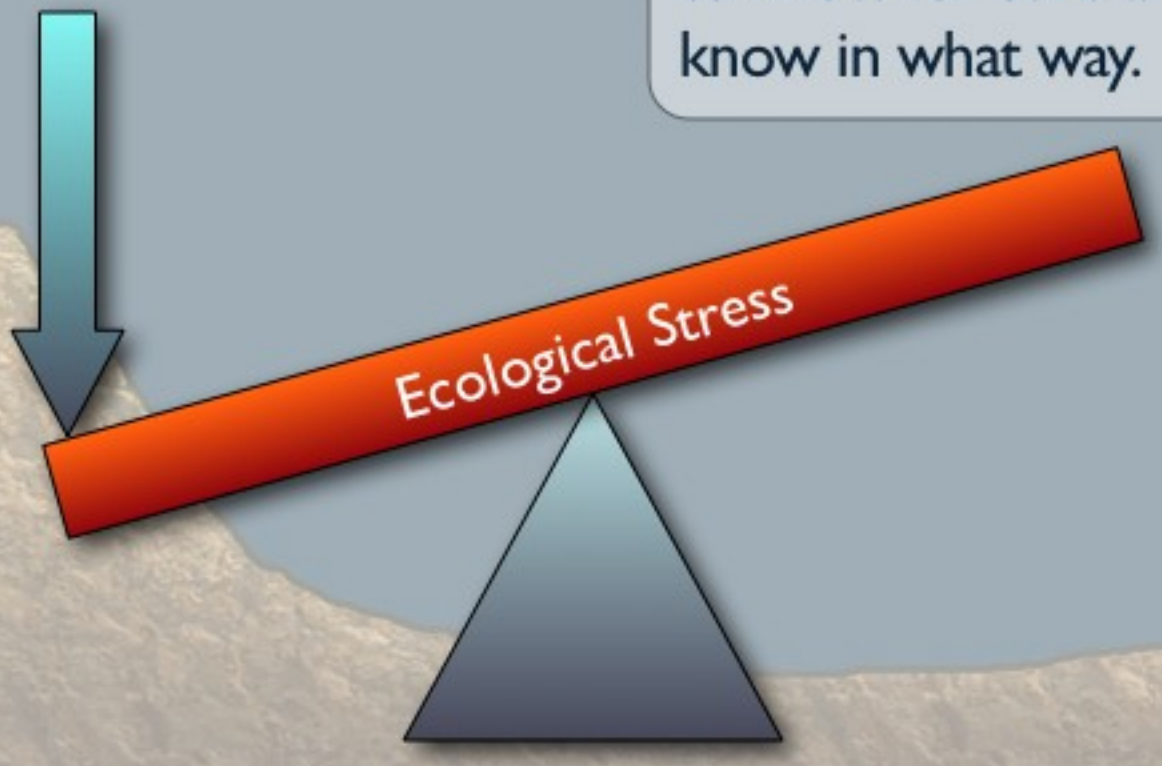
NOAA


Ecological Balance


• Loading nutrients or organics
• Weak flushing
• Strong stratification
Ecological Balance

- Loading nutrients or organics
- Weak flushing
- Strong stratification

Natural and anthropogenic processes are involved, but are humans tipping the balance? Seems possible, because of change with time, but we need to know for sure and need to know in what way.



Different causes of the problem have different solutions

1. *Caused by Nitrogen loading*

ACTION → Stop the loading -- but need to know the source: septics? forests? carcasses?

2. *Controlled by river flow input*

ACTION → Alter flows in Skokomish River; mitigate weather effects

3. *Controlled by ocean input*

ACTION → Plan, forecast, and try to mitigate

Next steps (2003) and approach

- **Draft a 3-yr science study plan**
- **Assess what we can do NOW !!**
- **ID roles**
- **Find funding**

Next steps (2003) and approach

- **Draft a 3-yr science study plan**
  - Integrated Assessment & Modeling (IAM) study
- **Assess what we can do NOW !!**
  - Corrective Actions & Education (CAE) actions
  - Outreach information
- **ID roles**
  - Formed HCDOP, coordinate efforts, network w/ decision makers
- **Find funding**
  - Congressional, Governor and State Legislature, leverage from federal, state, county, tribal, NGO, university, etc., assets

The Hood Canal Dissolved Oxygen Program

Local govt
State
Tribes
Federal
Academic
NGO
Private
Partnerships

HCDOP Partners:

Hood Canal Coordinating Council
Hood Canal Watershed Education Network
Jefferson County
Kitsap County
Lower Hood Canal Watershed Coalition
Mason County
Northwest Indian Fisheries Commission
Pacific Northwest National Laboratory/Battelle
Pacific Northwest Salmon Center
Port Gamble S'Klallam Tribe
Puget Sound Marine Environmental Modeling Consortium
Skokomish Tribe
U.S. Army Corps of Engineers
U.S. Geological Survey
University of Washington-Applied Physics Laboratory
University of Washington-Aquatic & Fishery Sciences
Washington Department of Ecology
Washington Department of Health
Washington Sea Grant Program-University Washington
Western Washington University

Hood Canal Salmon Enhancement Group
Jefferson Conservation District
Kitsap Conservation District
Kitsap County Health District
Mason Conservation District
National Oceanographic and Atmospheric Administration
NW Association of Networked Ocean Observing Systems
Pacific Shellfish Institute
Paladin Data Systems
Puget Sound Partnership
PRISM (UW Puget Sound Regional Synthesis Model)
U.S. Environmental Protection Agency
U.S. Fish & Wildlife Service
U.S. Navy
University of Washington-School of Oceanography
University of Puget Sound
Washington Department of Fish & Wildlife
Washington Department of Natural Resources
Washington State University Extension
WRIA 16 Planning Unit

Hood Canal Dissolved Oxygen Program

Structure:

HCDOP

Coordinating Group

Integrated Assessment and Modeling team (IAM)

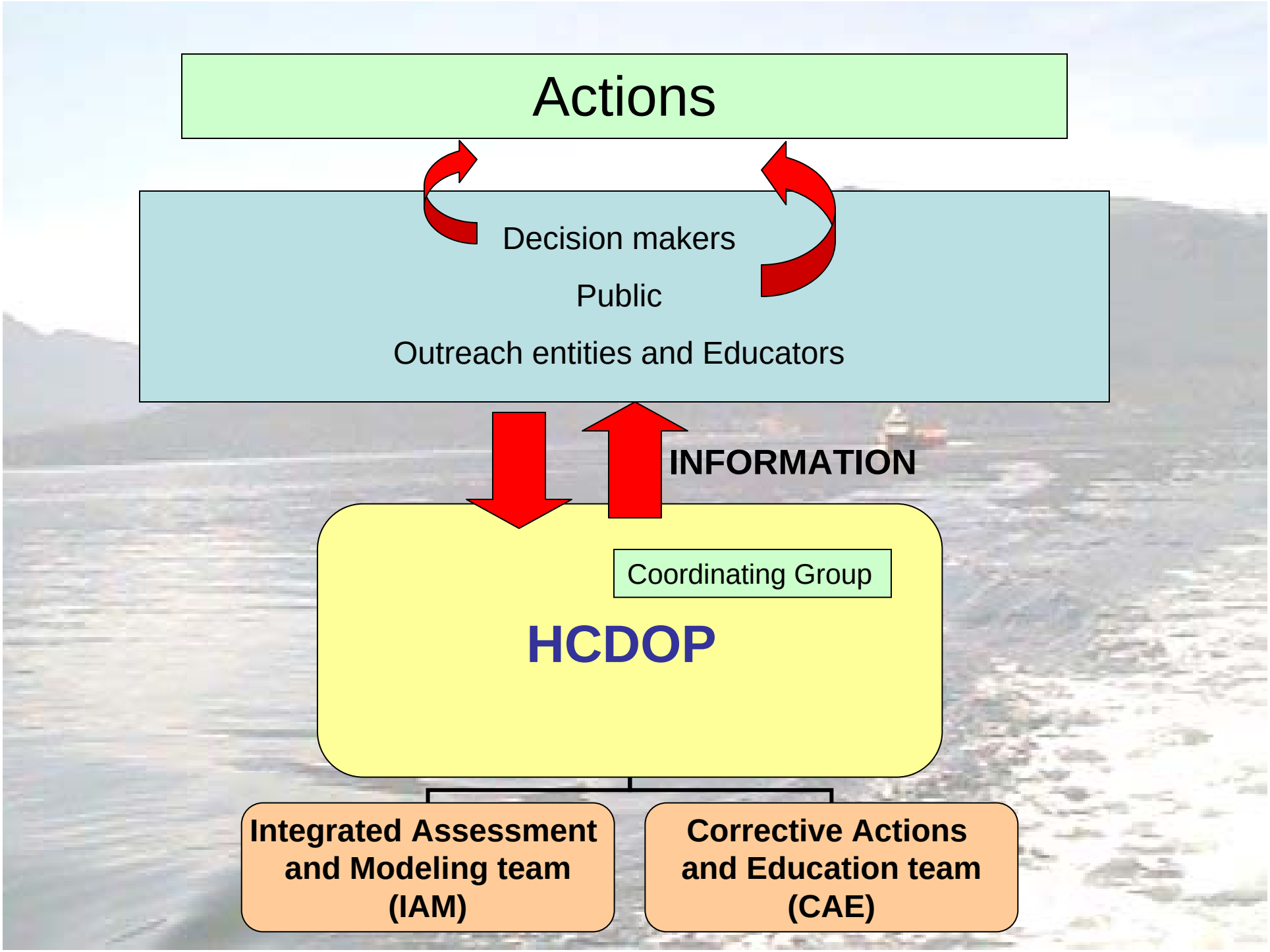
SCIENCE STUDY ON LOW DO CAUSE AND POTENTIAL CORRECTIONS

- Establish automated marine buoys and weekly salt water sampling
- Establish automated stormwater samplers and coordinate river sampling
- Measure N loads to Hood Canal
- Study food-web and biota
- Evaluate using computer models

Corrective Actions and Education team (CAE)

CORRECTIVE ACTIVITIES, INPUT TO POLICY, AND PUBLIC OUTREACH

- Remove salmon carcasses
- Plan for sewer systems
- Evaluate alternative septic technologies
- Establish anaerobic digester to reduce organic load to Hood Canal
- Enhance and coordinate education and public involvement efforts.


Actions
Decision makers
Public
Outreach entities and Educators
INFORMATION
Coordinating Group
HCDOP
Integrated Assessment and Modeling team (IAM)
Corrective Actions and Education team (CAE)

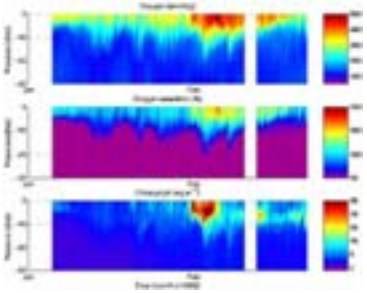
Keys to success, so far

- Activities
  - Combination of research and no-regret actions
  - Ability to partner across entities
  - Consistent coordination
  - Involvement of local community (tribes, counties, citizens)
- Information
  - Strong outreach, availability of information & data
  - Communication with decision-makers
- Scope
  - Focus on system (basin, watershed, humans, climate)
  - Focus on an issue
- Funding made available

Hood Canal Dissolved Oxygen Program's Integrated Assessment and Modeling Study

IAM is a scientific study on the cause for the decline in oxygen in Hood Canal and the efficacy of potential corrective and mitigative actions.

- *Science study partnership:*
  - universities
  - tribes
  - federal agencies
  - state agencies
  - counties
  - conservation districts
  - NGOs
  - citizen volunteers
- *Primarily congressionally funded through Congressman Norm Dicks*
- *Strong leverage from State and other programs*

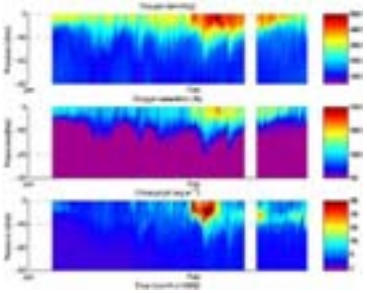


www.hoodcanal.washington.edu

Hood Canal Dissolved Oxygen Program's Integrated Assessment and Modeling Study

The study utilizes automated technology, observing networks, and numerical modeling to:

- Quantify **marine** processes
- Quantify **watershed** loadings
- Assess **biota**-oxygen interactions
- **Model** key processes to quantify driver(s) of oxygen and evaluate potential corrective actions



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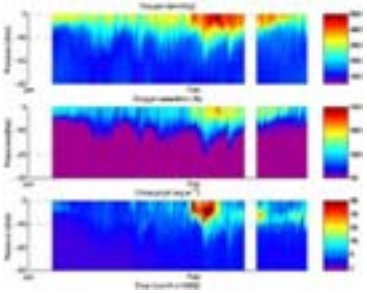
Hood Canal Dissolved Oxygen Program's Integrated Assessment and Modeling Study

What have we done?



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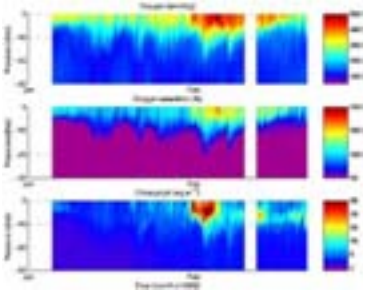
Hood Canal Dissolved Oxygen Program's Integrated Assessment and Modeling Study

To date:

- Established remote automated monitoring of Hood Canal marine waters and watershed
- Established survey networks, largely from locals, HCSEG, Skokomish Tribe
- Began studies on Hood Canal biota and food web energetics
- Applied computer models to Hood Canal marine waters and watershed, linked with atmospheric model output



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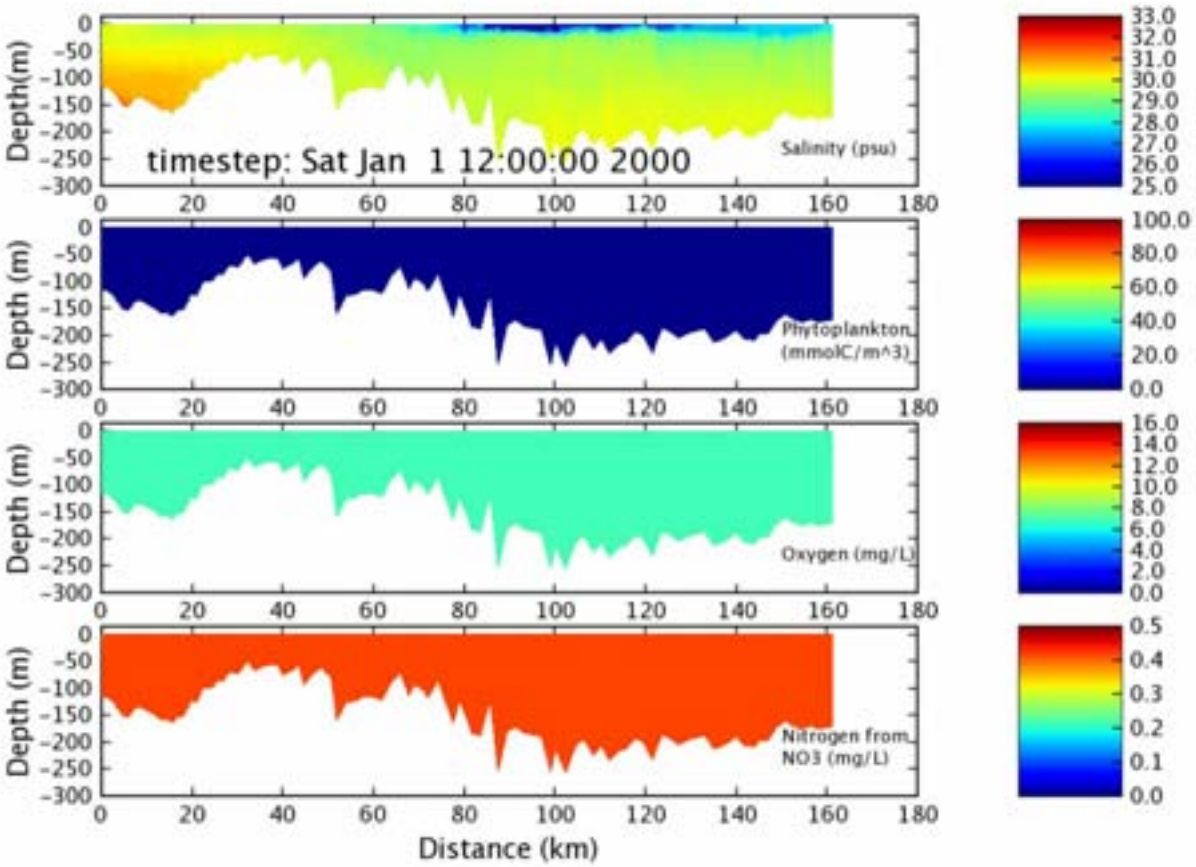
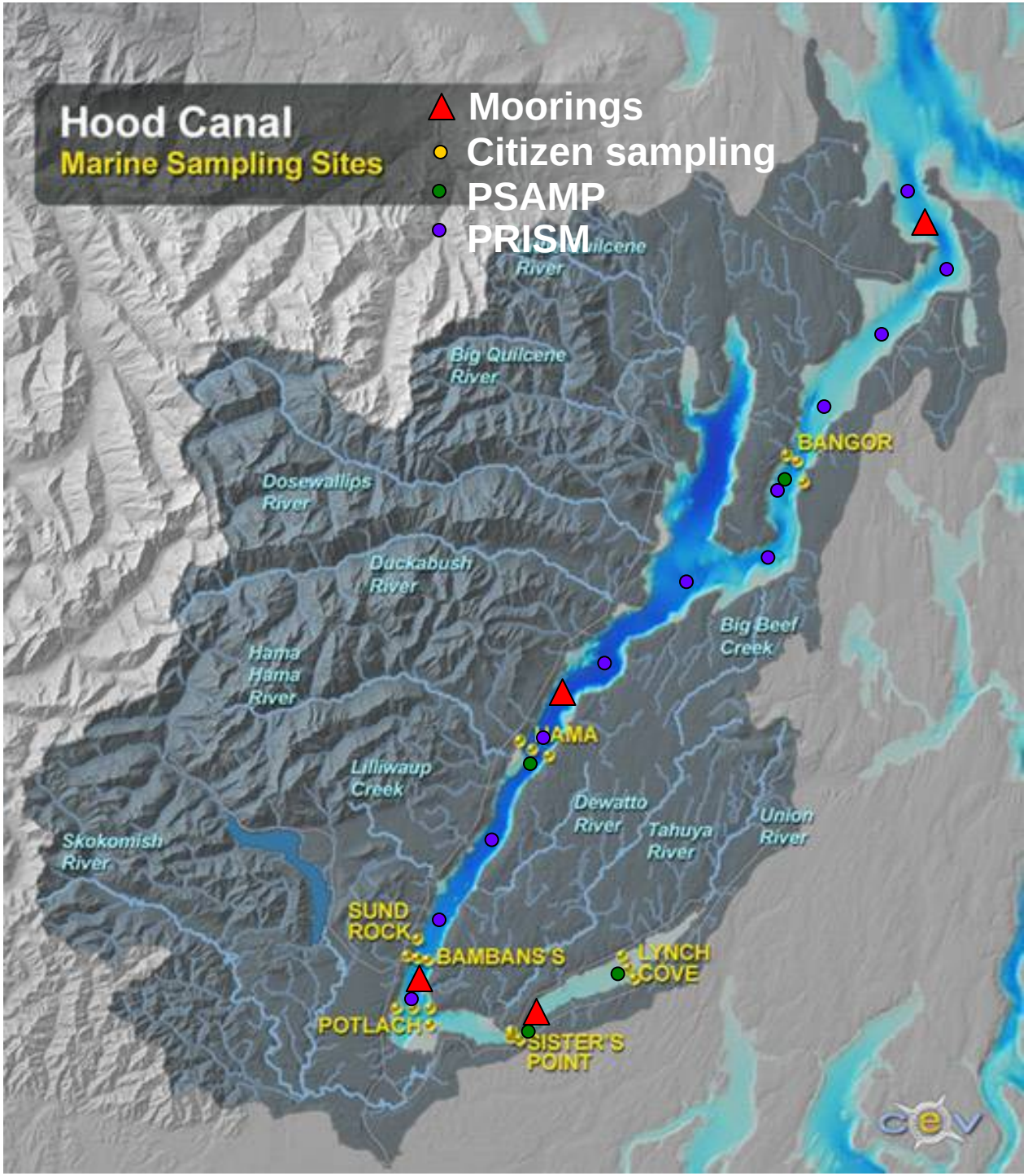
How a model yields understanding of processes





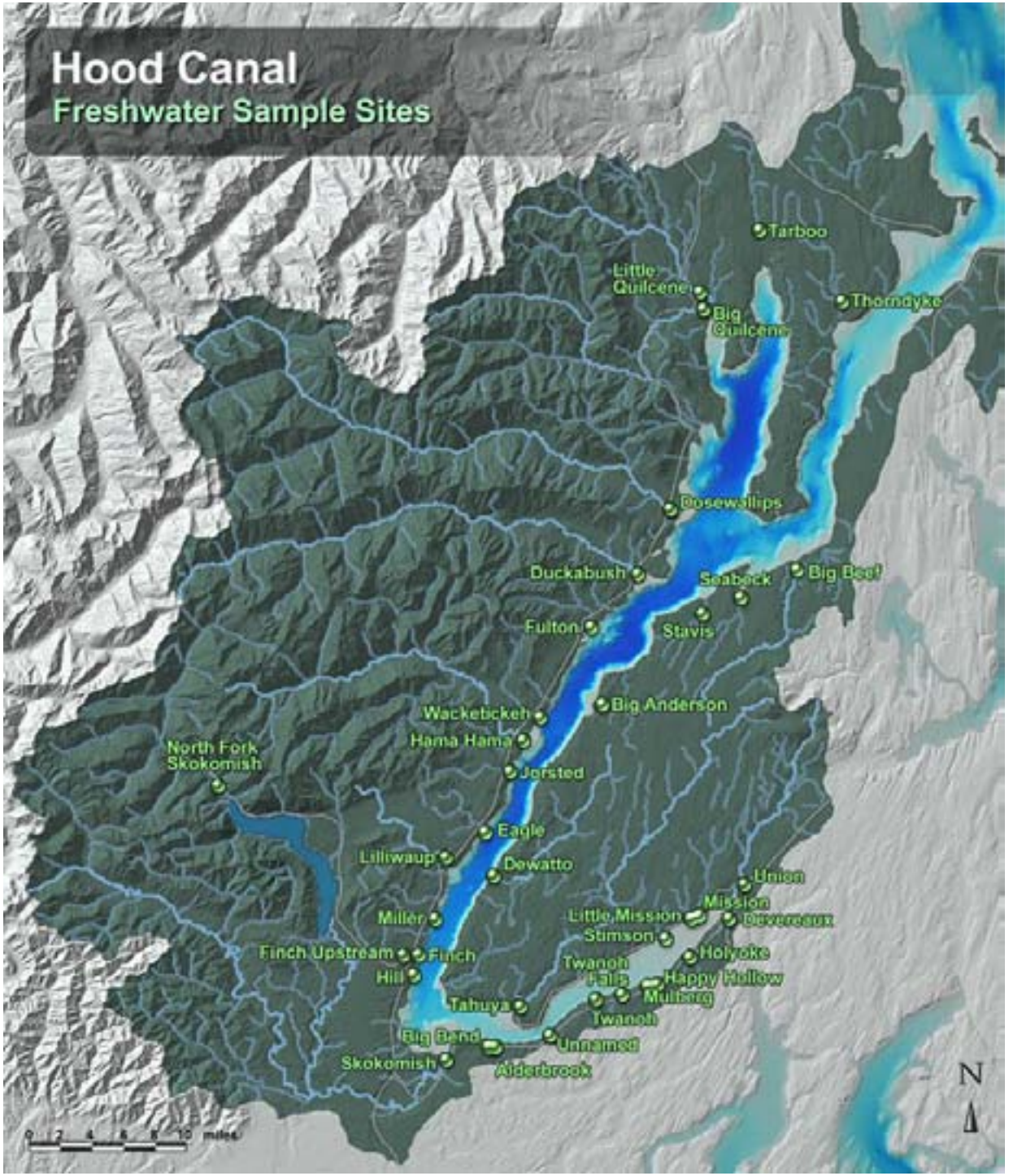
Marine

Sampling by:

- University of Washington
  PRISM, APL
- Hood Canal Salmon
  Enhancement Group
- Skokomish Tribe
- HCDOP Citizen Monitoring
- WA Dept of Ecology
  PSAMP

Modeling by:

- University of Washington
  PRISM
- USGS



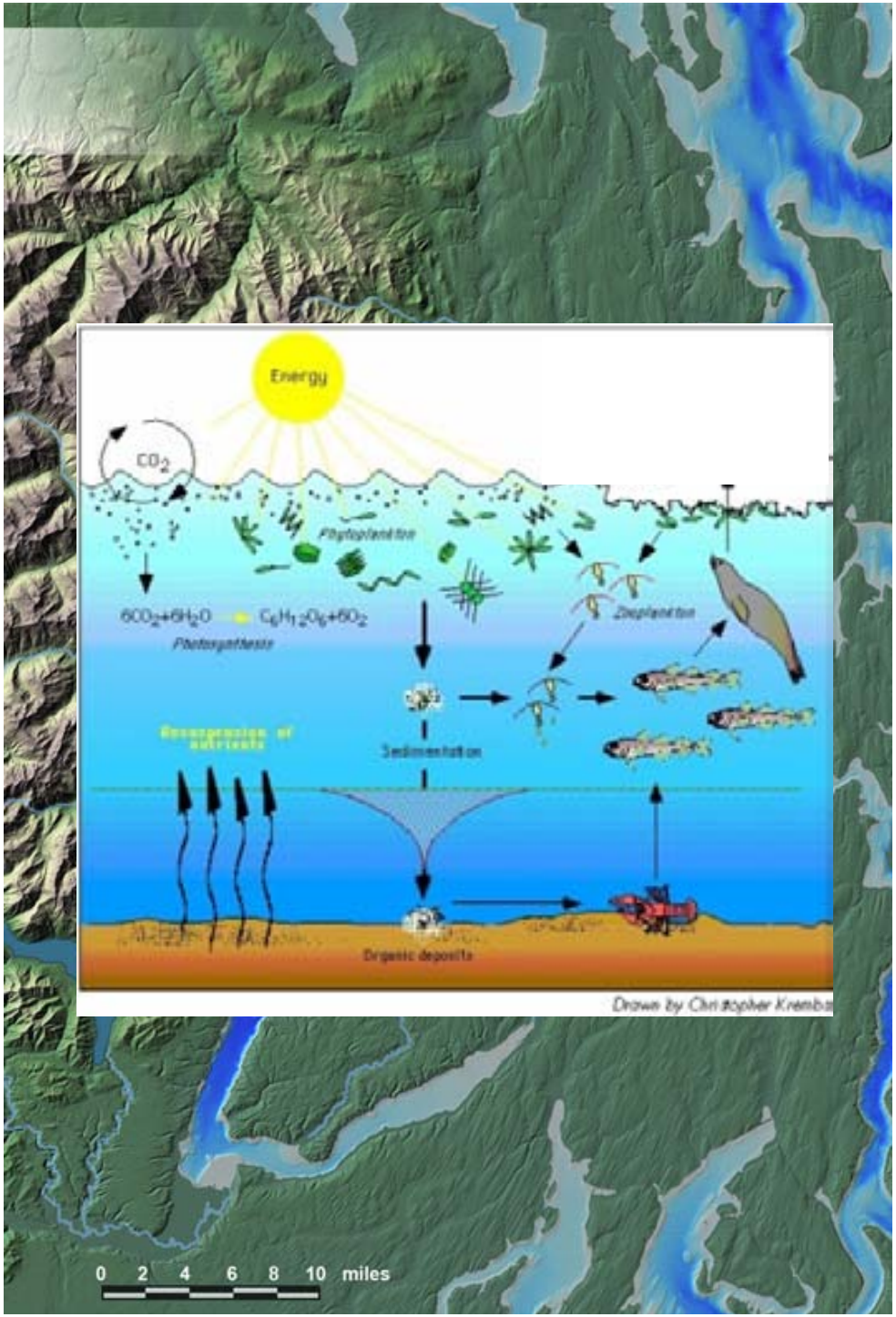
Watershed

Sampling by:

- University of Washington PRISM
- USGS
- Hood Canal Salmon Enhancement Group
- WA Dept of Ecology
- Skokomish Tribe
- Jefferson Conservation Dist.
- Kitsap Health District
- Mason Conservation District
- Mason County Health Dept.
- EnviroVision

Modeling by:

- University of Washington PRISM



Biota

Sampling by:

- University of Washington
  APL, Oceanography, SAFS
- Hood Canal Salmon
  Enhancement Group
- Department of Ecology
- Skokomish Tribe
- Port Gamble S'Klallam Tribe
- Western Washington University
- Pacific Shellfish Institute
- USGS
- University of Puget Sound
- WDNR
- WDFW
- Battelle
- Northwest Indian Fisheries Comm.

Modeling by:

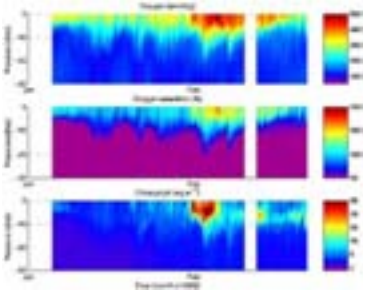
- University of Washington
  SAFS

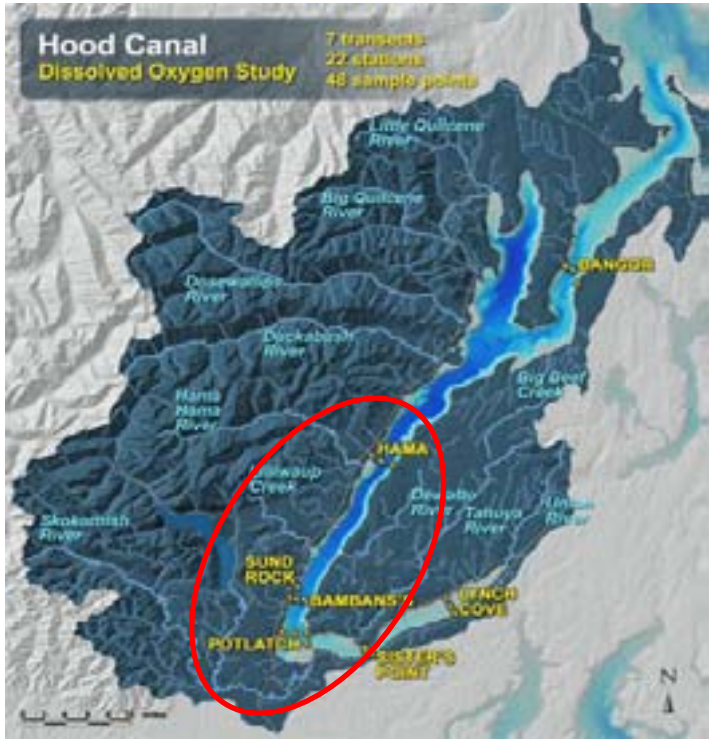
Hood Canal Dissolved Oxygen Program's Integrated Assessment and Modeling Study

What have we learned?

Why did fish die?

Why is there less oxygen?





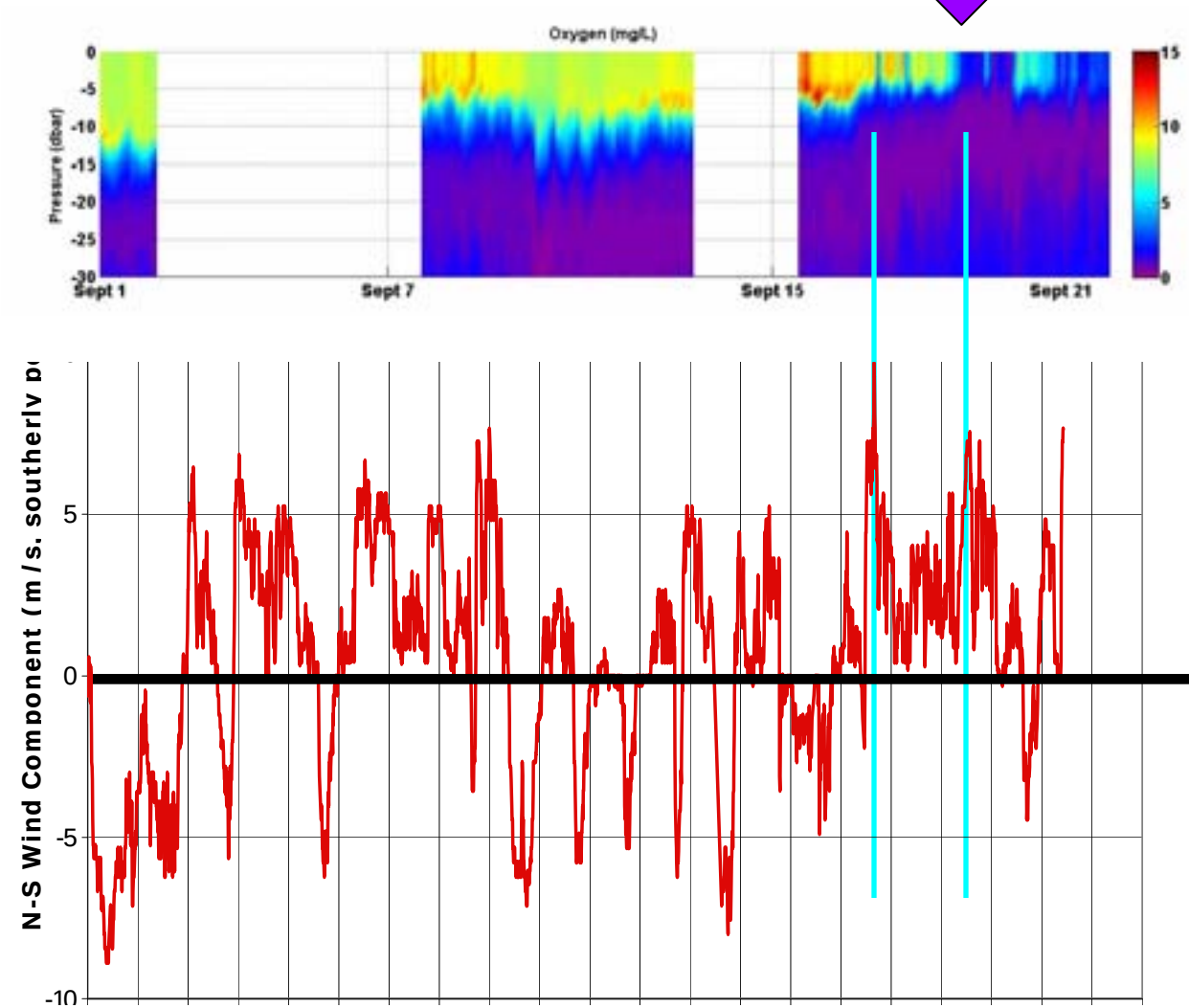
19 Sept 2006

“Several reports of dead fish, including flounder, sticklebacks, wolf eels and shrimp were observed from beaches including Tahuya, Lilliwaup, Hoodsport, Annas Bay, and North Beach off Highway 101.”

Why did fish die ???

- **We know**

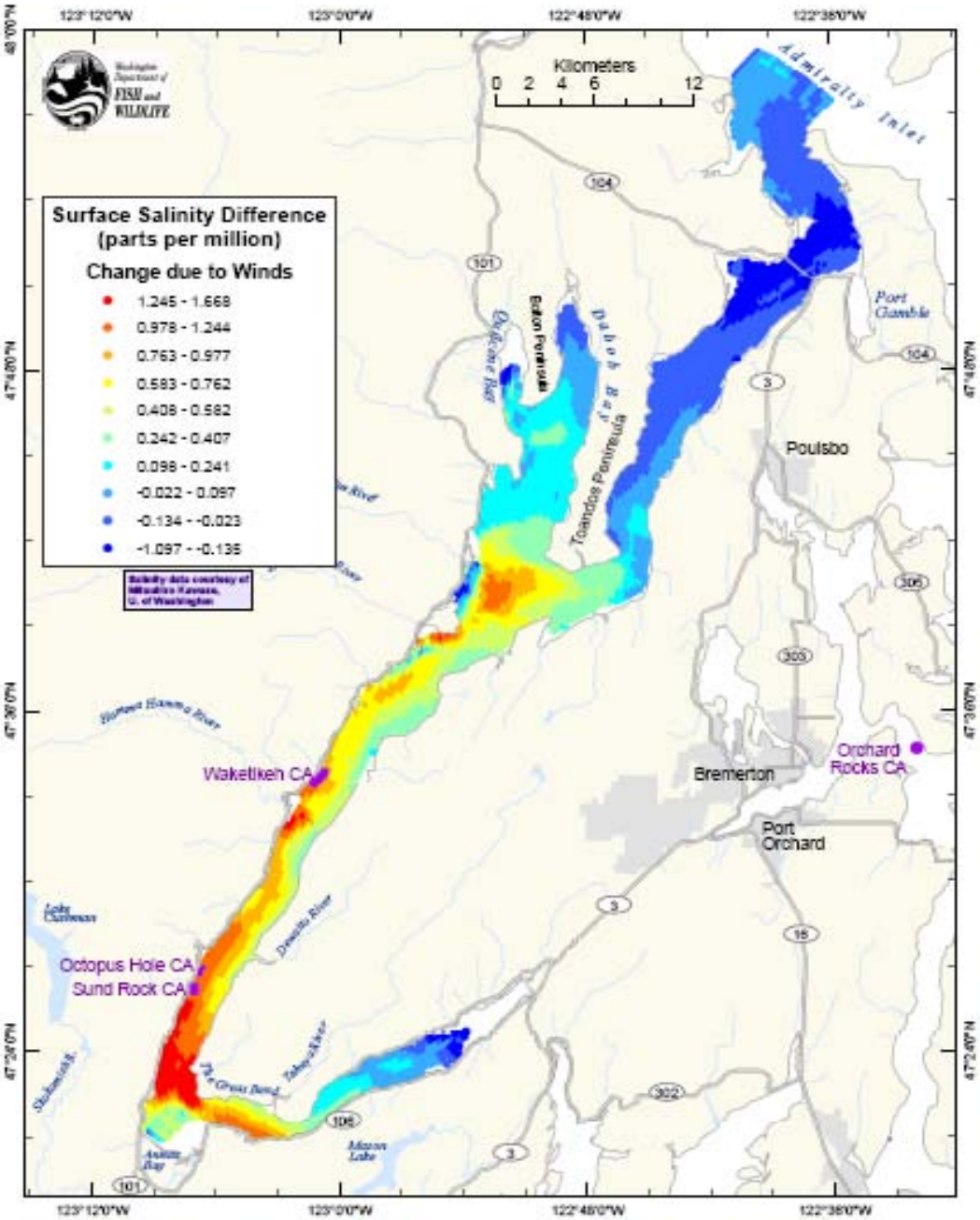
September 19 2006
Fish Kill Event



HOODSPORT ORCA buoy oxygen data

HOODSPORT ORCA buoy wind data

Devol (UW) and HCDOP IAM Team



Episodic Oxygen Stress

- Areas where risk of exposure to episodic low oxygen conditions caused by wind-mediated upwelling is greatest.
- Intensity of red indicates where deep water rises to surface most effectively during southerly wind events.
- This indicates where highest risk of biota stress and mortality due to episodic wind-driven low oxygen events occurs.

Kawase (UW) model output, WDFW projection

Recipe for a fish kill event

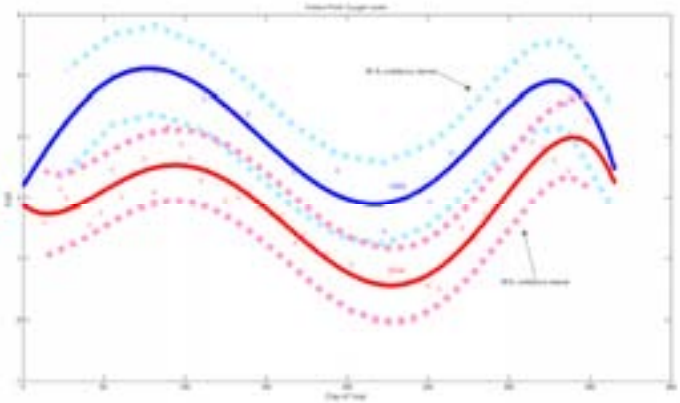
	2003	2004	2005	2006
	Fish kill	**Odd behavior**		**Fish kill**
S winds	X	X		X
Low DO	X	**X**	x	**X**
Shallow/ weak pycno	X			X

Why did fish die ???

- We know

Why is the oxygen lower ???

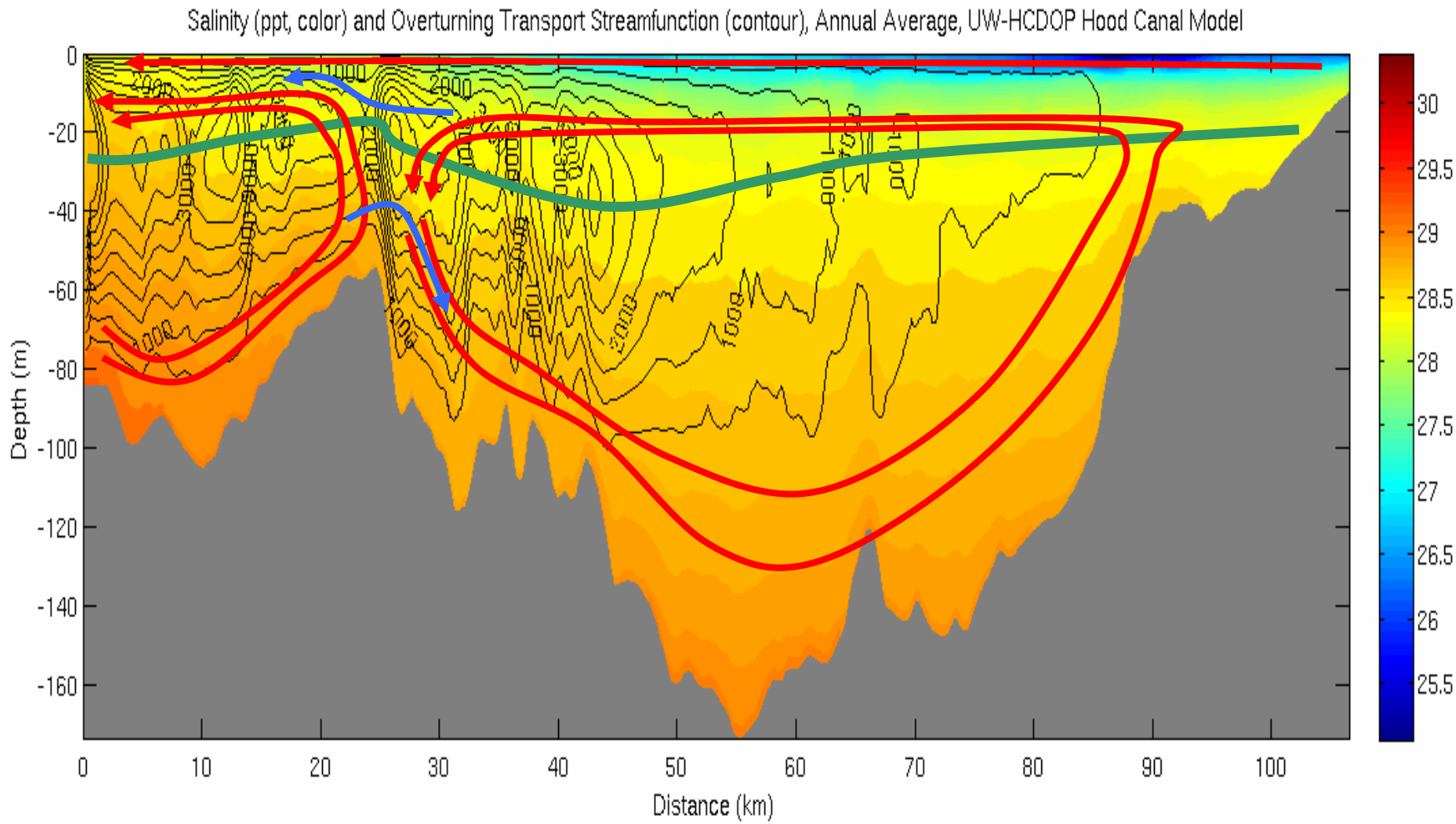
- **We don’t fully know yet**



Role of Ocean:

→ *some N coming in goes out without fertilizing algae*

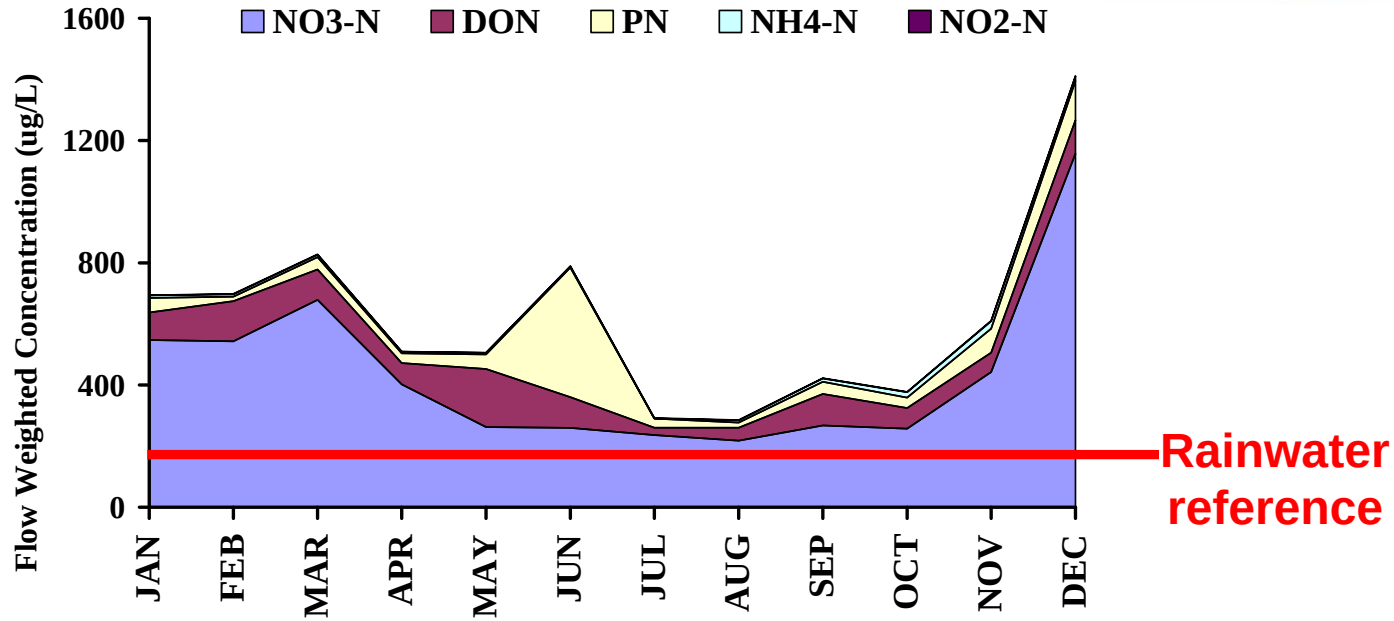
Hood Canal Circulation



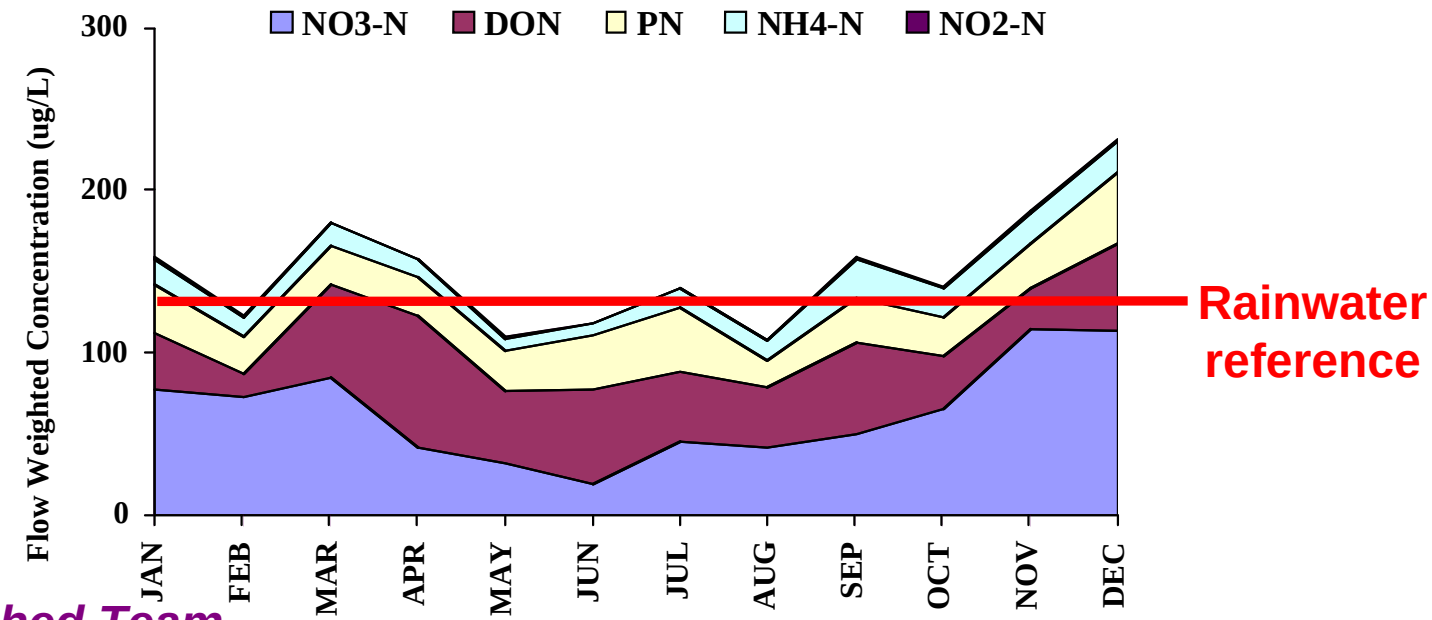
Kawase (UW) and HCDOP IAM Marine Team

Role of Watershed:

Deciduous Mixed Forest

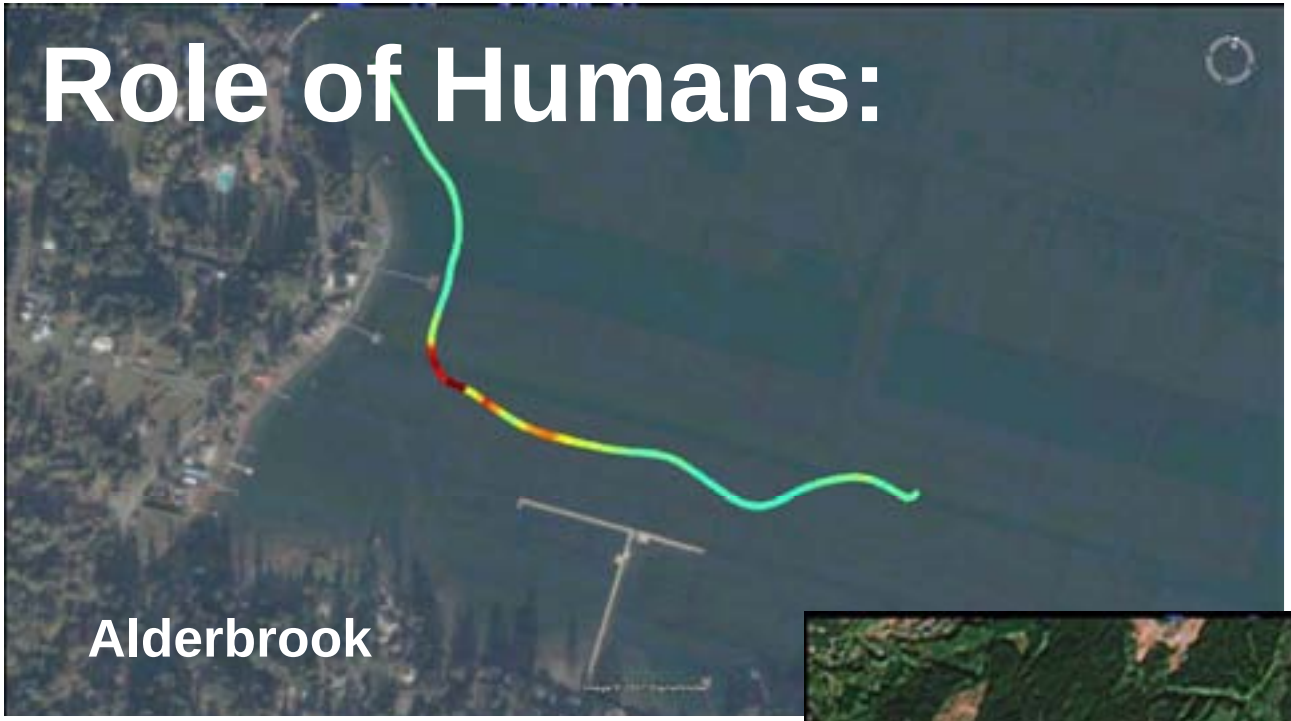


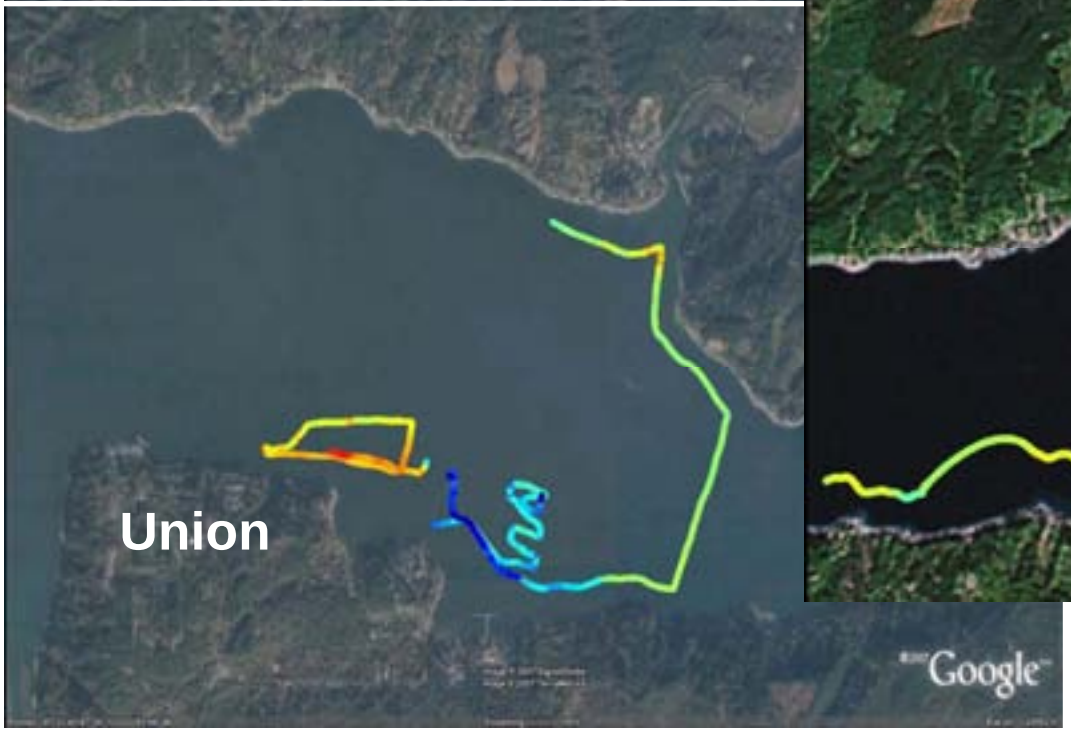
Mature Conifer Forest

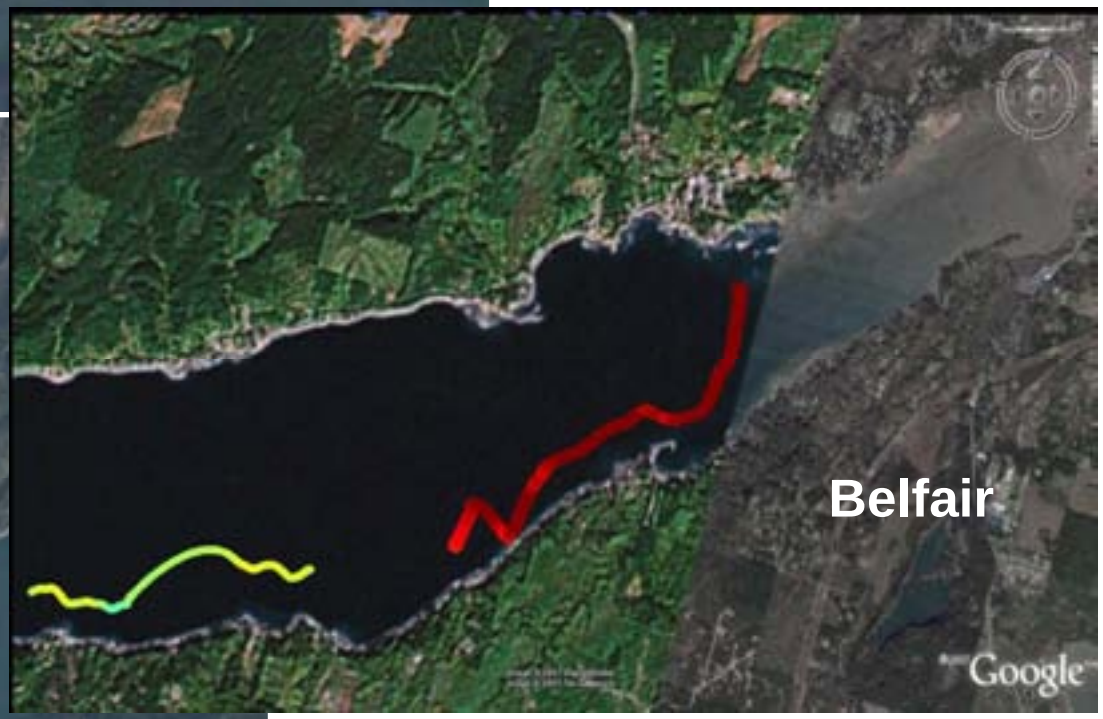


HCDOP IAM Watershed Team

Role of Humans:







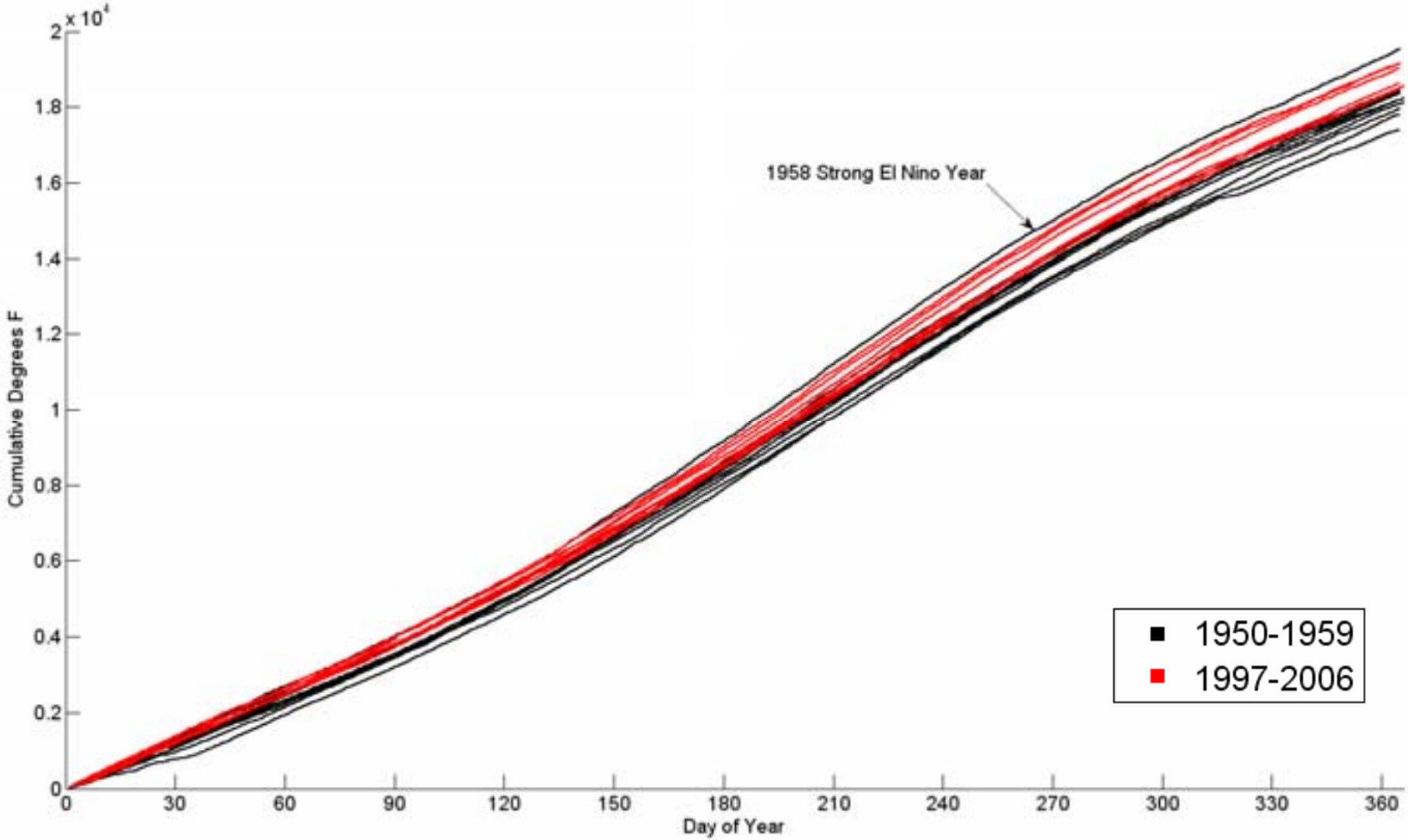
Tracking "optical whiteners"…

- **Shows plume from laundry …**
- **Need link to N**

Bassin, Newton (UW) and HCDOP IAM Team

Role of Climate:

→ *Higher air temp. implications for water temp., growth*



Bassin (UW) analysis, HCDOP IAM Team

Why did fish die ???

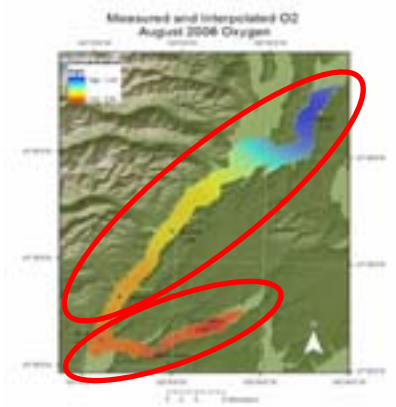
- **We know**

Why is the oxygen lower ???

- **We don’t fully know yet:**

  We are putting the information into models that show effect on oxygen

Recipe for increasing hypoxia



source	*factor*		**Hood Canal**	**Lynch Cove**
Ocean	Low density Low DO		big effect	???
Watershed	Land-use Alders		? effect	? effect
Humans	Loading N		less effect	more effect
River flow	High flows Timing of flow		med. effect	???
Climate	Sunny, warm Winds		effect	effect

Summary

Hood Canal naturally most sensitive to low oxygen and to nutrient loading

Need to fundamentally understand oxygen dynamics so can mitigate impacts

Situation is complex, but answers are being revealed by modeling and observations that bring us closer to recommendations

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