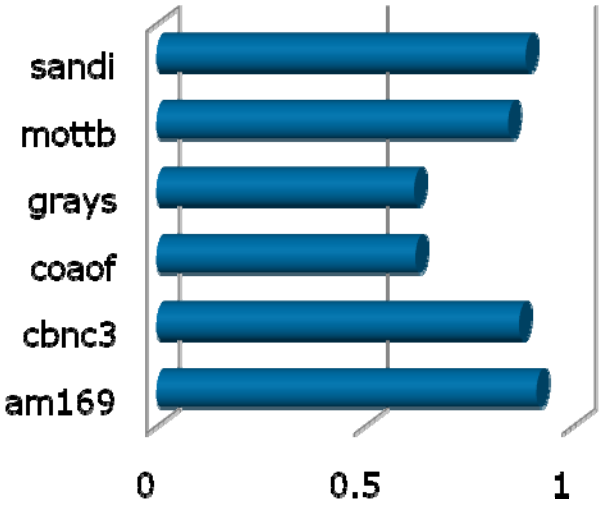
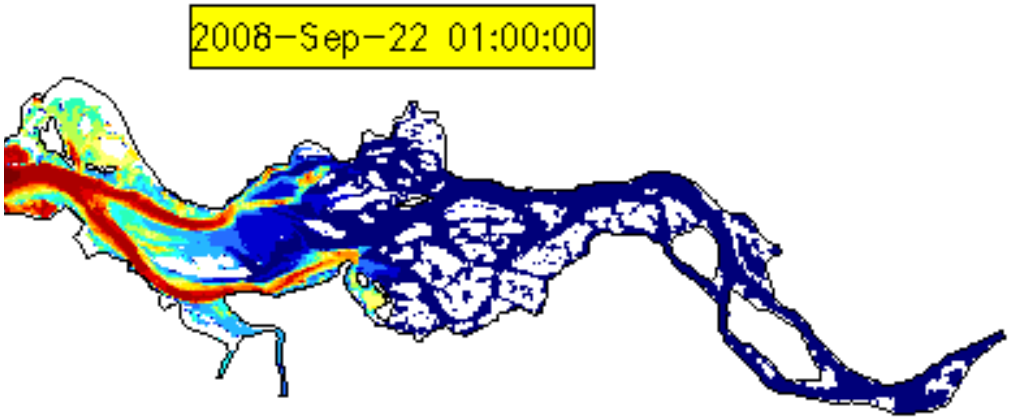
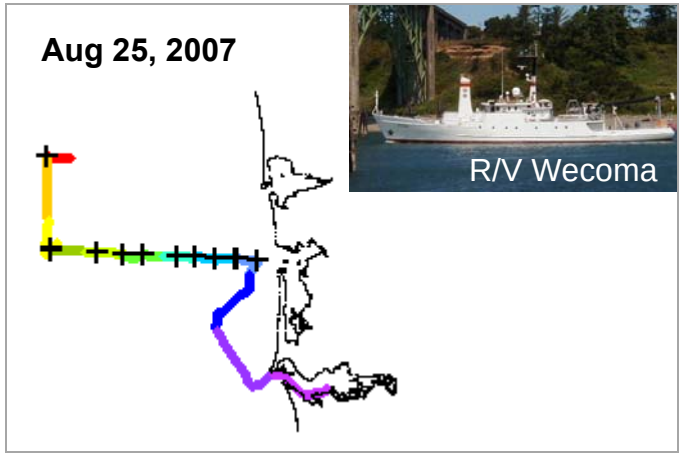
Today's Columbia River estuary

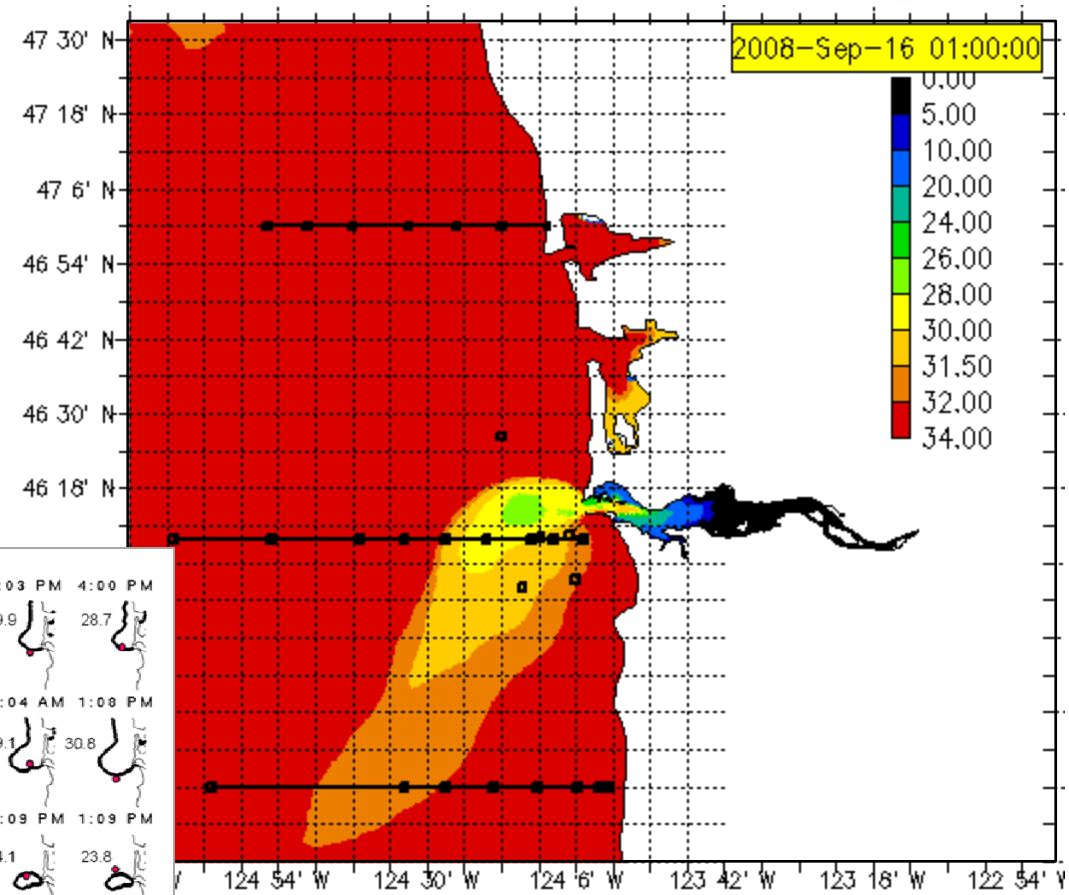
Correlation skill

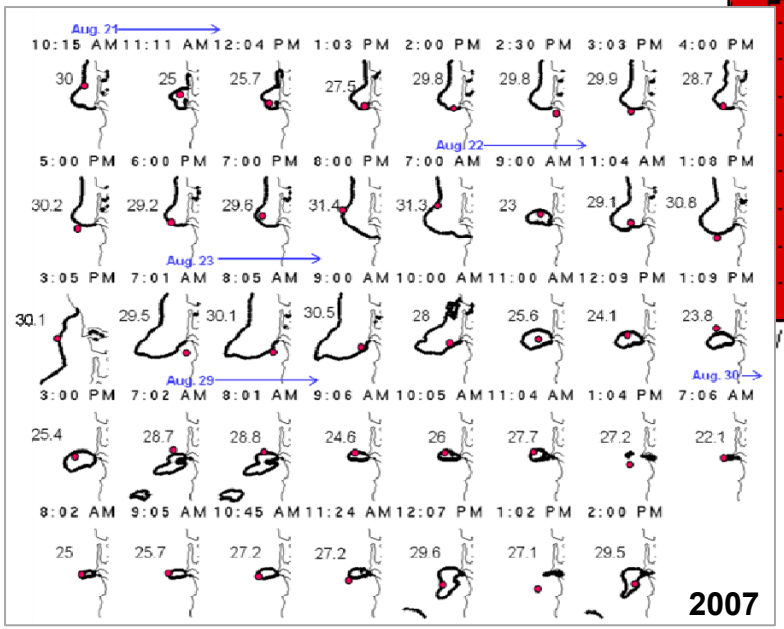




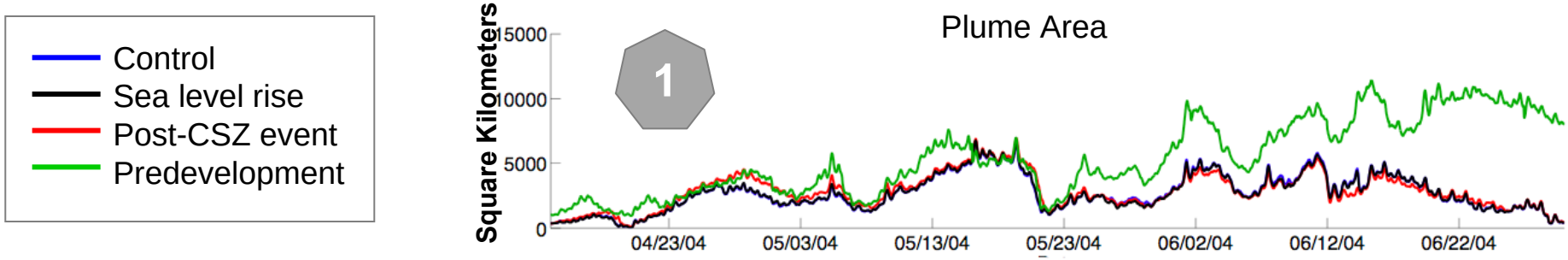
“Today’s” Columbia River plume

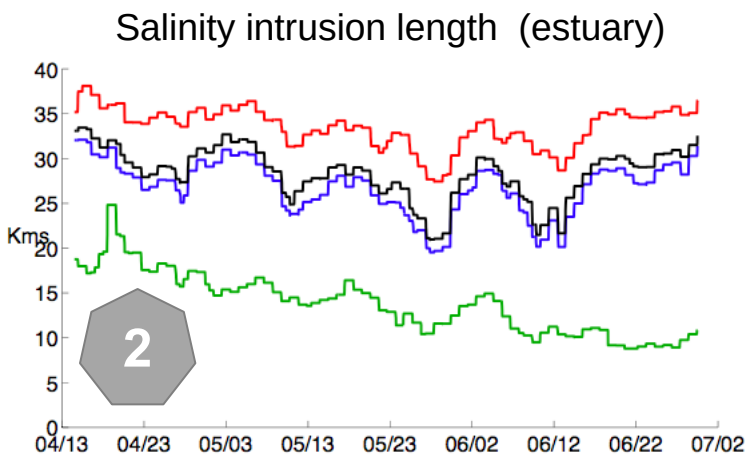


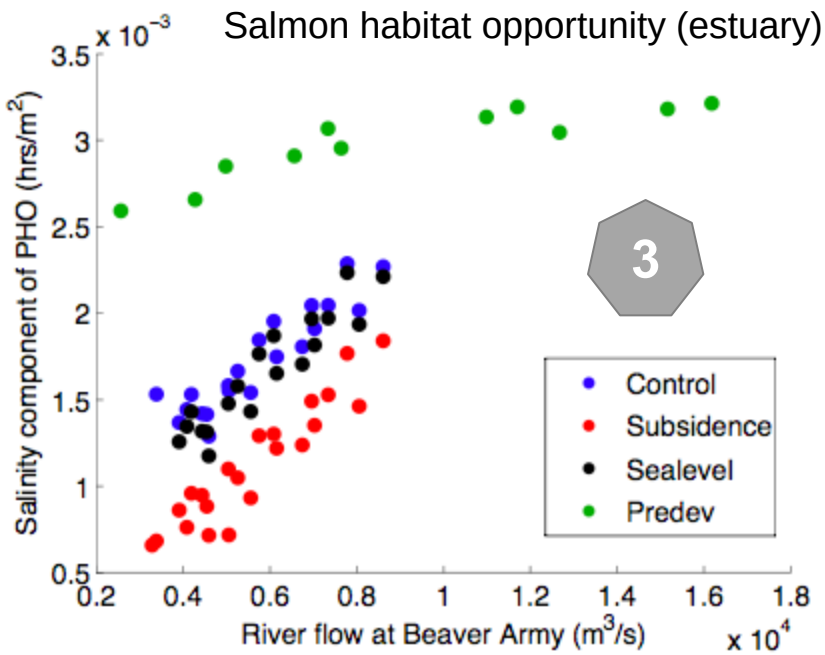




The CR estuary & plume: variability vs. change







Ocean observatories …

… are cyber-enabled integrations of observations, simulations and analyses, aimed at delivering the right information at the right time in the right format to both specialized and general audiences

Ocean Observatories Initiative (OOI)

Global • Regional • Coastal

from JOI 2007

INTEGRATED OCEAN OBSERVING SYSTEM

NANOOS

Northwest Association of Networked Ocean Observing Systems

NEPTUNE

revolutionizing ocean science

VENUS

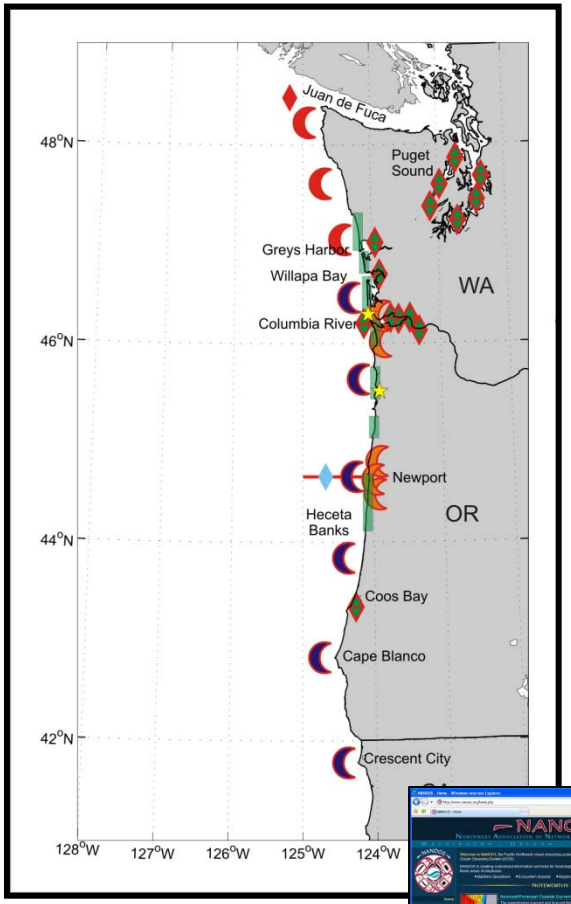
SATURN

CMOP

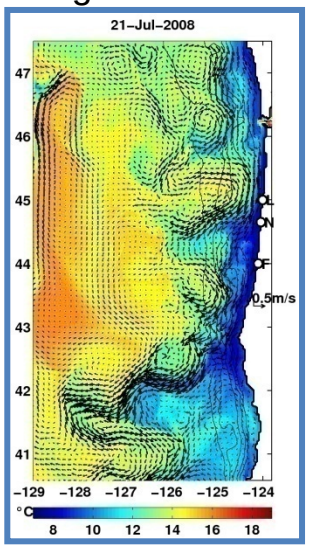
Center For Coastal Margin Observation & Prediction

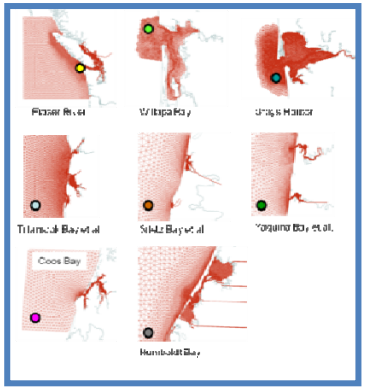
Observatories in the Pacific Northwest
a. NANOOS

António Baptista,
President-Elect and member of Executive Committee,
NANOOS

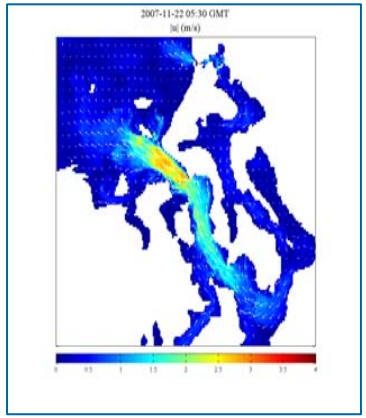


Oregon coast

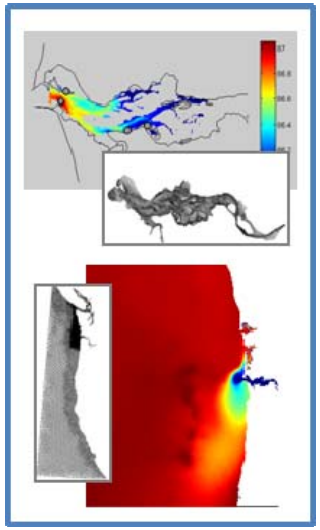




Other PNW estuaries

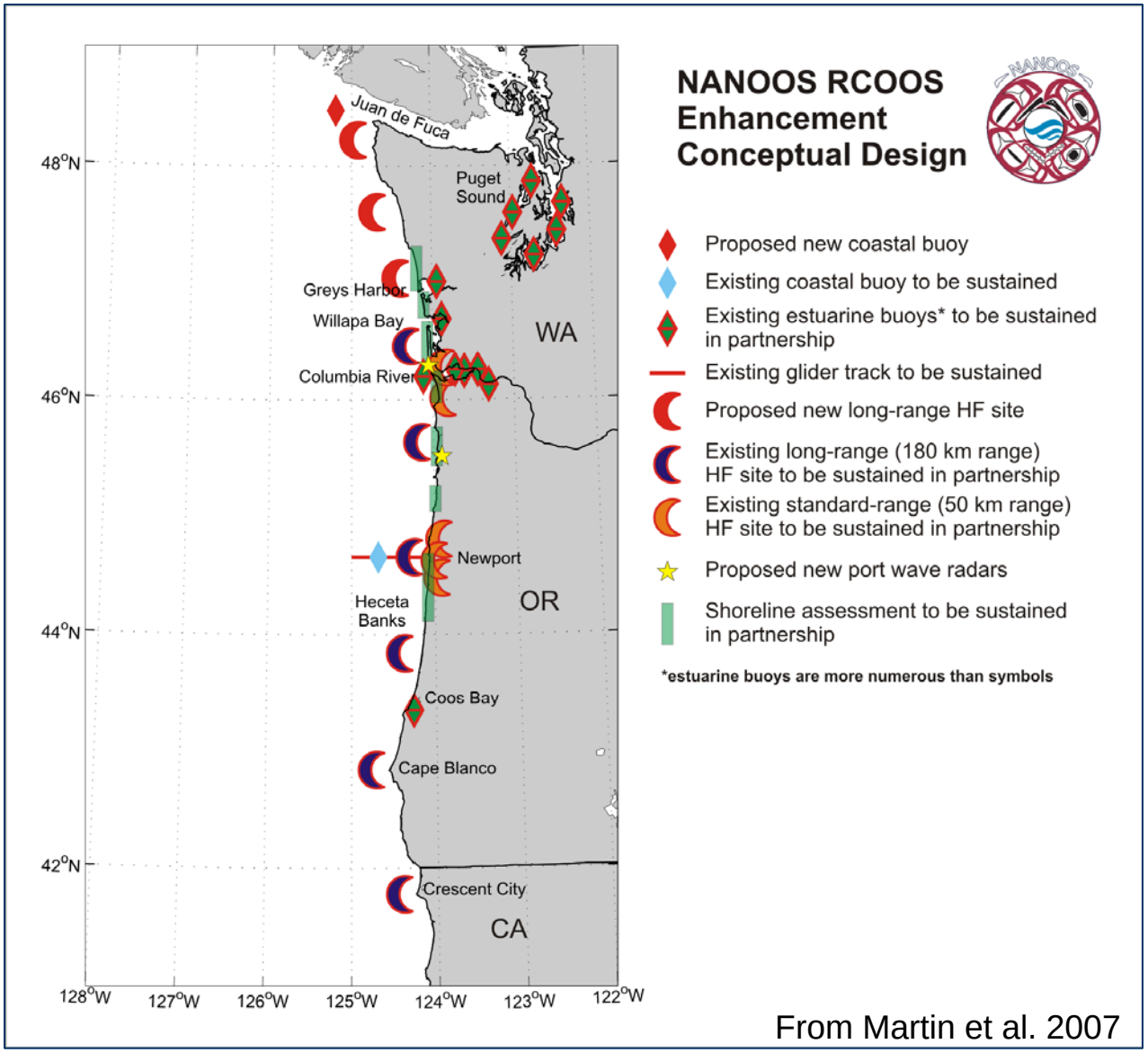


Puget Sound



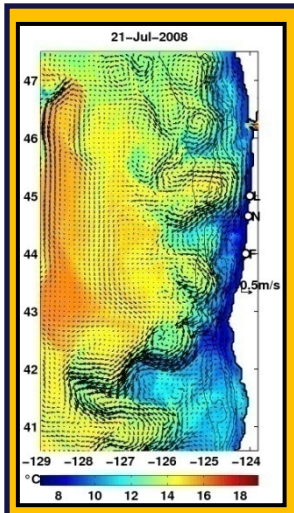
Extended Columbia River

NANOOS observation network



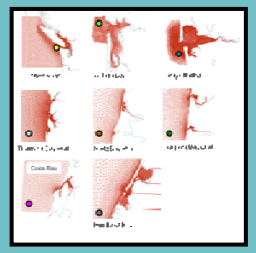
From Martin et al. 2007

NANOOS modeling system



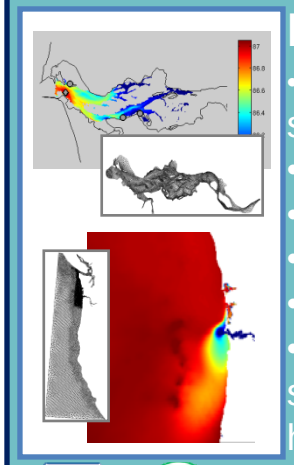
Oregon coast

- 24/7 forecasts of circulation since 2005
- Process simulations (circulation, ecology)
- Maintained by OSU
- Observations: ORCOOS
- Uses: science
- Models: ROMS



Other PNW estuaries

- 24/7 forecasts of circulation since 2006
- Tsunami simulations
- Maintained by OHSU
- Observations: scattered, minimal
- Uses: hazard mitigation, waves (via NOAA), education
- Models: SELFE



Extended Columbia River

- 24/7 forecasts of circulation since 1998
- Simulation databases (s. 1999)
- Process simulations
- Network optimization
- Observations: SATURN/CORIE
- Uses: science, RT cruise support, management (fisheries, hydropower, navigation, …), education, waves (via NOAA)
- Models: SELFE, ELCIRC

Puget Sound

- 24/7 forecasts of circulation since ~2007
- Maintained by APL-UW
- Observations: HCDOP, ORCA
- Uses: PSMEMC, hypoxia, HABs
- Models: POM
- Data avaiable via Opendap

NANOOS web site

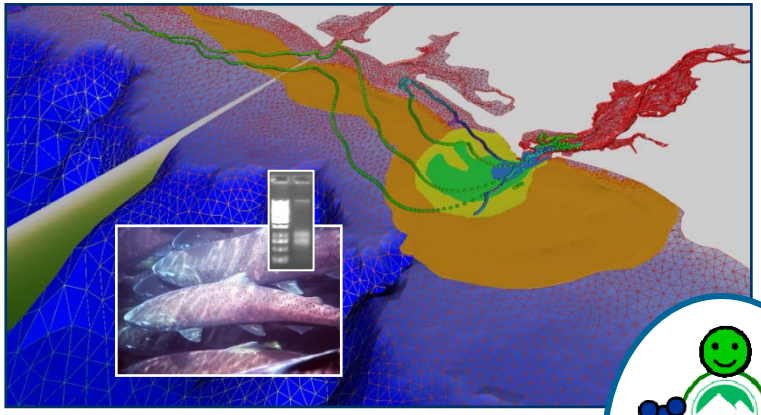
http://www.nanoos.org

Observatories in the Pacific Northwest

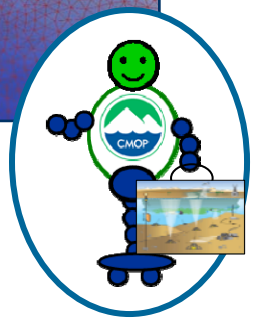
b. The NSF Science and Technology Center for Coastal Margin Observation and Prediction (CMOP)

António M. Baptista
Professor and CMOP Director
Oregon Health & Science University

Observation • Understanding • Prediction



Research • Education
Diversity • Knowledge Transfer



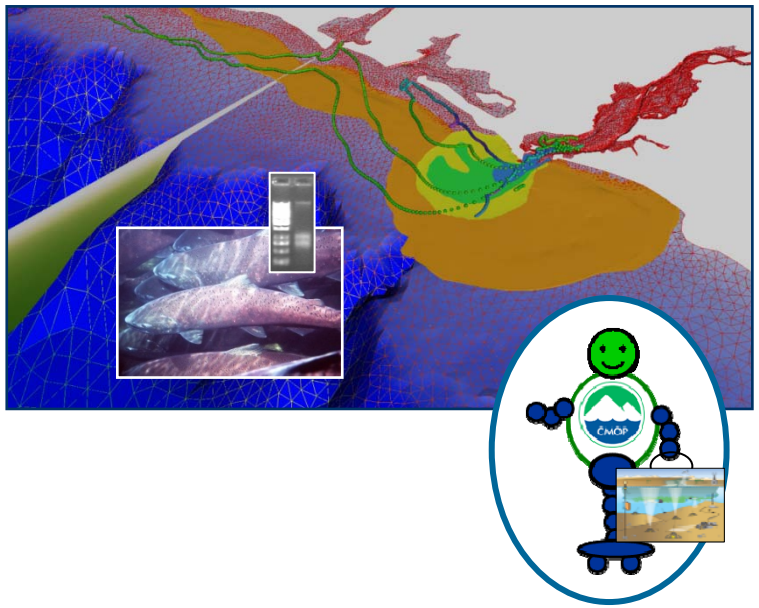
CMOP
Center For Coastal Margin Observation & Prediction

OREGON HEALTH&SCIENCE UNIVERSITY
OHSU

CMOP at a glance

- One of 17 NSF Science and Technology Centers nationwide.
- Only STC ever focused on coastal margins.
- One of two STCs directly focused on the ocean.
- Created July 2006. $4M/y core funding. 10 years. Mid-term exam.

Observation • Understanding • Prediction



Mission

To study coastal margins …

… using novel observation and prediction technologies

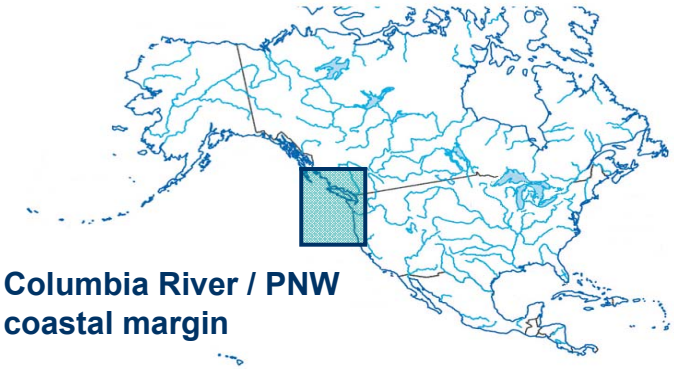
… to transform understanding of river-to-ocean ecosystems

… to train an effective and diverse workforce

… and to serve as catalyst for regional and industrial partnerships

Research • Education • Diversity • Knowledge Transfer (KT)

Framing the challenge – coastal margins



Columbia River / PNW coastal margin

MSNBC, Dec 14, 2007

Economic and social importance

- Coastal areas comprise less than 20% of the contiguous US, but support more than 50% of the US population.
- Over a trillion dollars of coastal infrastructure are deployed in the US every year.

Vulnerability

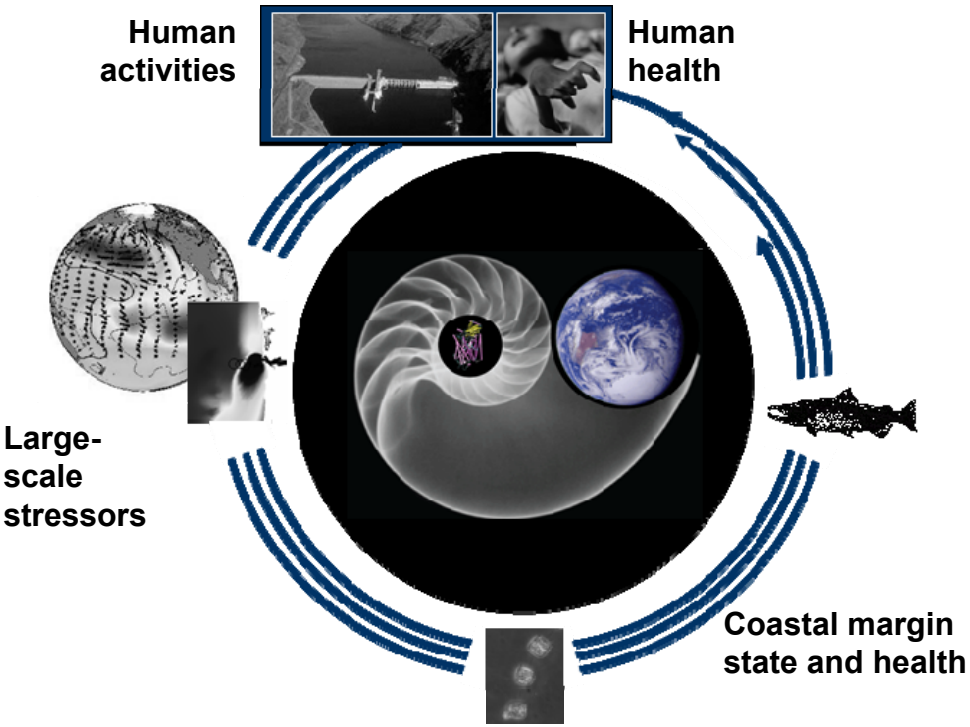
- Natural and man-made hazards in coastal areas cost the US more than $2 billion annually.
- Highly productive ecosystems and resources are very sensitive to climate and human activity.

Sustainability and development

- Effective decision making on sustainability and development would benefit from a different type of challenge

Framing the challenge – a world in change

"Anticipatory" understanding …



… as key to coastal margin sustainability?

Grand challenge

Coastal-margin ecosystem sustainability under changing human and earth stresses

A shifting view of science?

From reactive to anticipatory oceanography: how far can we go?

Change agents

- ❑ Gene-to-climate thinking
- ❑ Ocean observatories
- ❑ Environmental genomics
- ❑ Integrative assessments
- ❑ Environmental sentinels
- ❑ People

Framing the challenge – environmental genomics

Craig Venter

- At NIH, developed expressed sequence tags, a revolutionary new strategy for discovering genes.
- At Celera Genomics, sequenced the human genome (and well as the fruit fly, mouse and rat genomes.)
- At the Venter Institute, embarked on a global expedition to obtain and study microbes from the world's oceans (and beyond)

Mariya Smit

- 15 years of molecular biology experience in academia
- 6 years of experience with DNA microarrays and gene expression analyses
- 2 years of industrial experience in a microarray company
- At CMOP, partnerships with SHARP and CombiMatrix to adapt to oceanography biosensors developed for medical fields

Framing the challenge – what workforce?

The engagement challenge

"Imagine the day when a Native American geneticist in Oklahoma wins the Nobel Prize in Medicine, for her contributions to the sustainable management of the Columbia River"

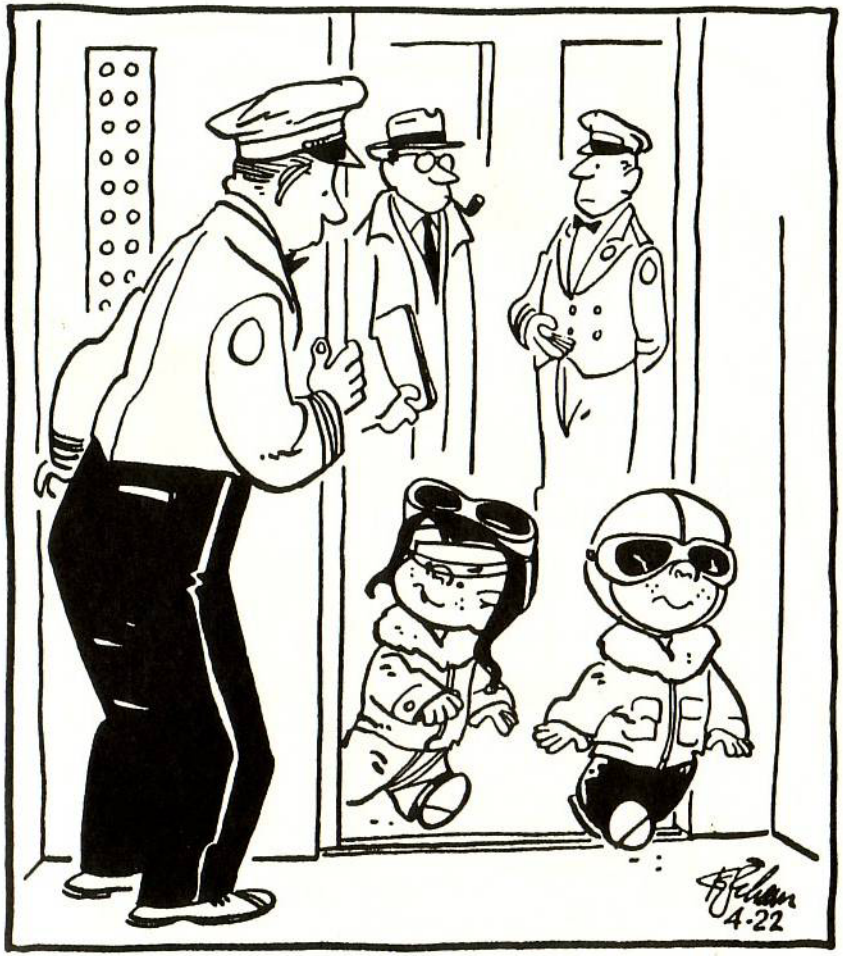
The early engagement challenge

US	Oregon	Source: The Oregonian, Dec
68.8%	72%	HS graduation rate
55.5%	45.5%	enter college directly
38.2%	32.8%	"chance for college"
45.9%	43.8%	adult population with college education
		(2025 projection; 55% for best-performing nations)

Aggravating factor: most HS graduates are not qualified to pursue STEM-based careers

The NSF mandate to STCs

Dennis the Menace, by Hank Ketcham, 1955-1956



"Take 'er up to the wild blue yonder and then drop 'er straight down to the basement."

- Be bold
- Be relevant
- Be transformative
- Find your own path (no academics as usual)
- Build sustainability

- Develop effective synergies across multiple missions
  - research,
  - education,
  - knowledge transfer,
  - diversity

To meet the challenge …

CMOP is …

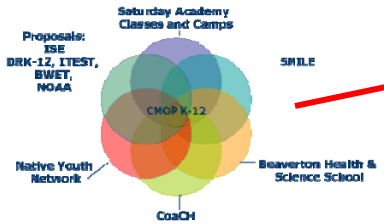
- … an intellectual environment
  (where research, education, outreach and broadening participation come together)
- … a multi-institutional partnership
  (heterogeneous and inherently evolutionary)
- … an academic and administrative unit of Oregon Health & Science University (OHSU)

CMOP is not …

- … a limited-duration activity / research project

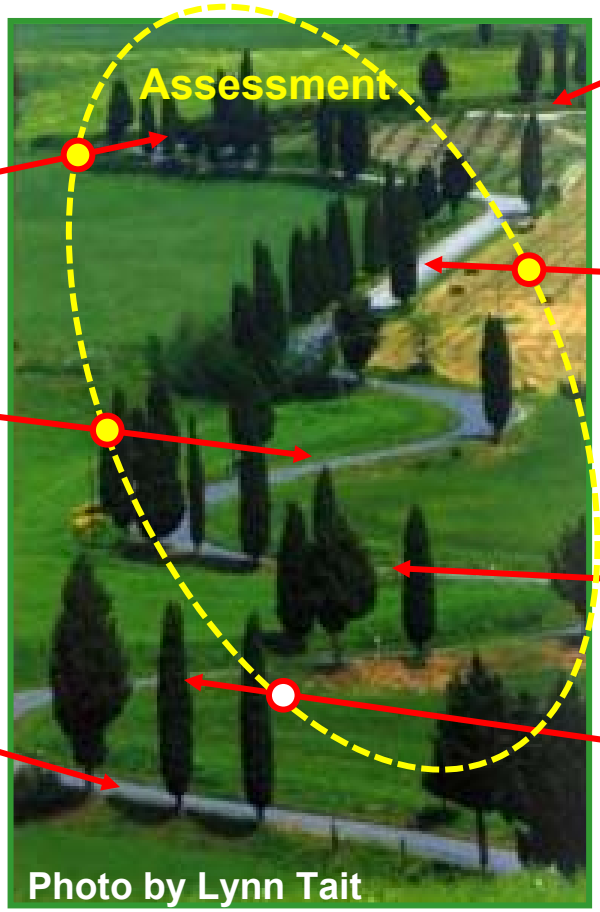
CMOP's winding road of education

Cluster of activities for K-12 kids



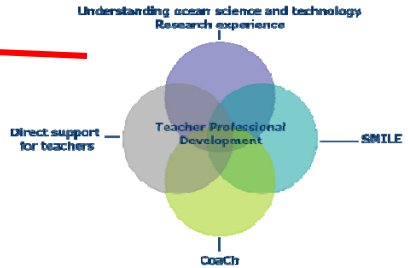
Undergraduate Interns

Post-doctoral fellows and beyond …



Casual contact

Cluster of activities for K-12 teachers

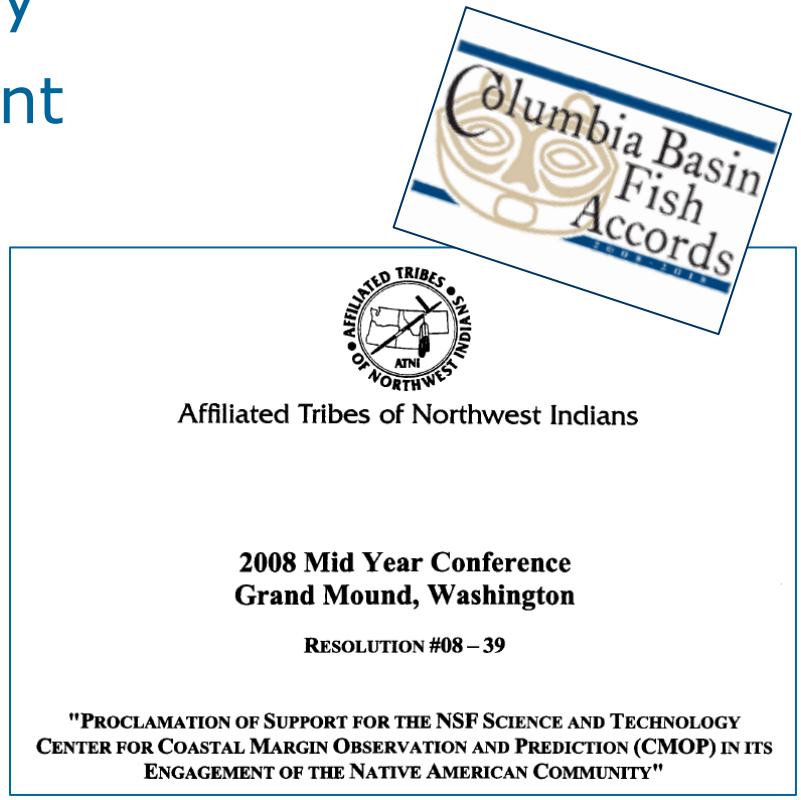


Undergraduate faculty/programs

Graduate students/programs

Broadening participation

- Commitment and philosophy
- Native American engagement
  - Affiliated Tribes of Northwest Indians (ATNI)
    - CRITFIC
    - NWIC
    - NAYA
    - CMOP Staff
    - CMOP Students
    - …
  - Yukon Watershed Council
    - Joint proposal



- Engagement of other underrepresented groups
- Impact within OHSU

Knowledge transfer

Scientific community

- Open data policy
- Cruise participation / support
- Seminar series (VTC and webcast)

State, federal and Tribal agencies

- NOAA NWFSC / BPA / USACE
- PNNL
- DOGAMI
- CRITFIC
- Opportunity: Tri-State Ocean Agreement

Industry

- WetLabs – LOBO station
- SHARP and CombiMatrix – Biosensors
- Boeing – NANOOS cyber-infrastructure
- Microsoft – eServices

Important opportunities for impact

Columbia Basin Fish Accords

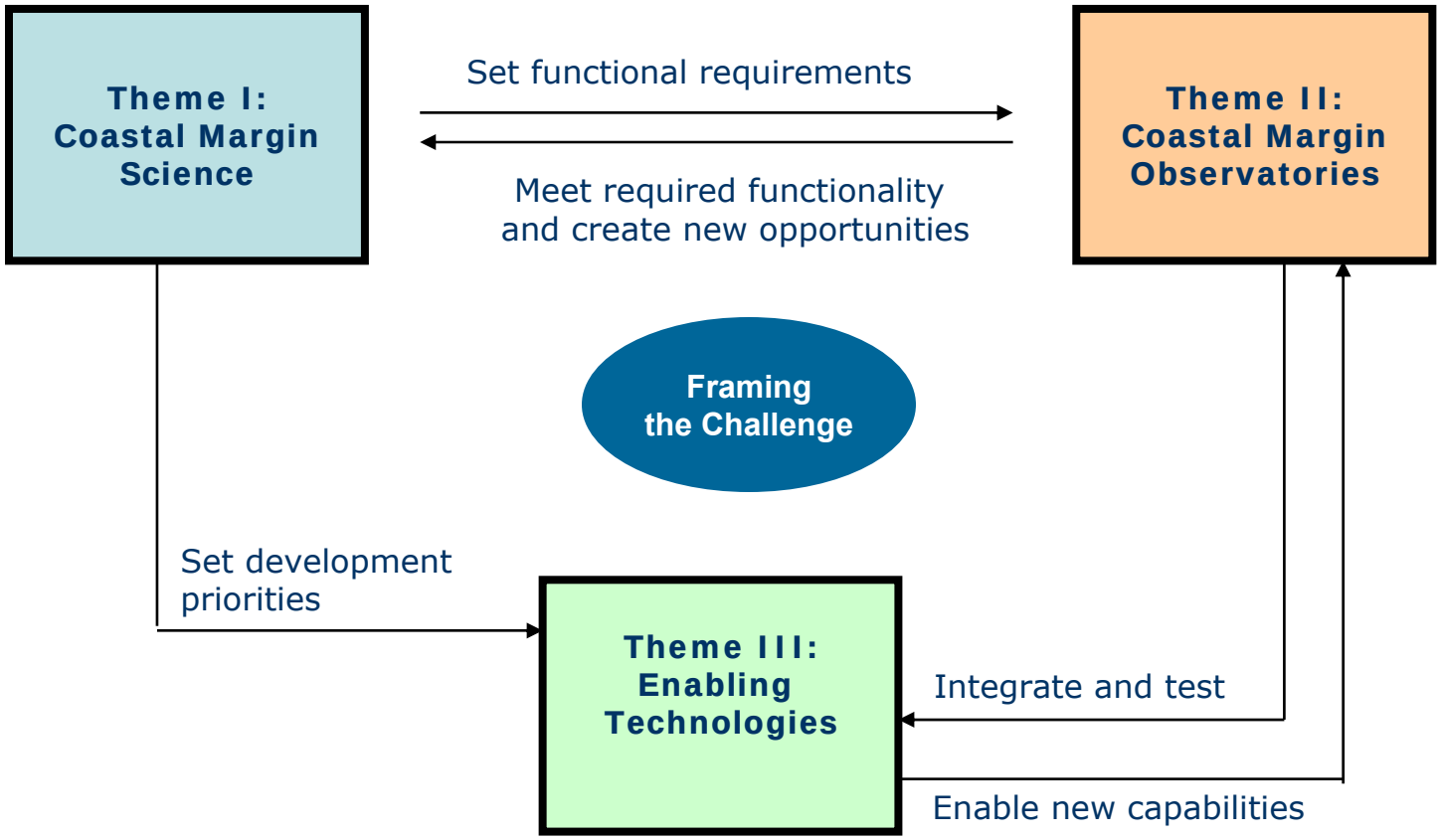
2008

The **Columbia Basin Fish Accords** are the foundation for a new working relationship between tribes, states, and federal agencies with responsibility to manage and protect salmon and other natural resources in the Pacific Northwest.

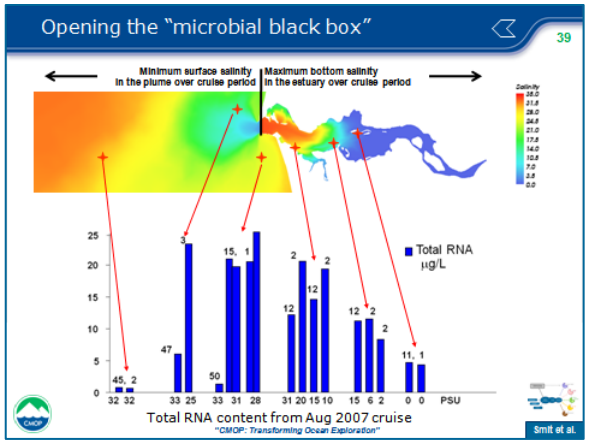
The **Tri-state Ocean Agreement** will forge a long-term partnership across WA-OR-CA to tap world-class experts in each state and tackle challenges facing the ocean and coast, including:

- Protecting and restoring healthy ocean and coastal habitats;
- Promoting effective ecosystem-based management of ocean and coastal resources;
- Expanding ocean and coastal scientific information, research, and monitoring;
- Increasing ocean awareness and literacy among tri-state residents; and
- Fostering sustainable economic development in coastal communities.

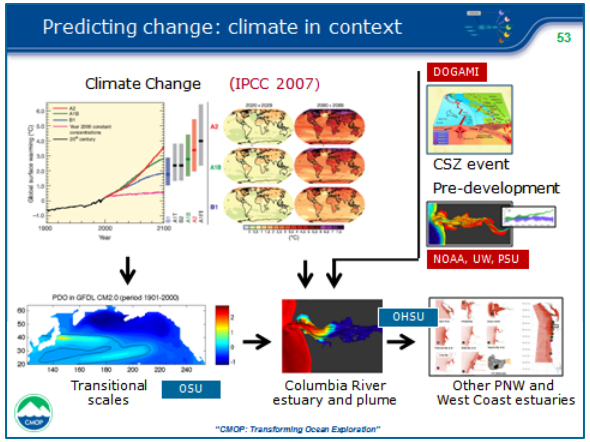
CMOP Research



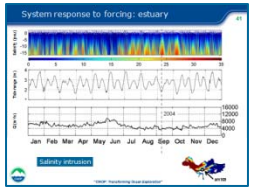
Coastal margin science

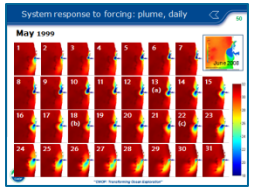


Opening the "microbial black box"



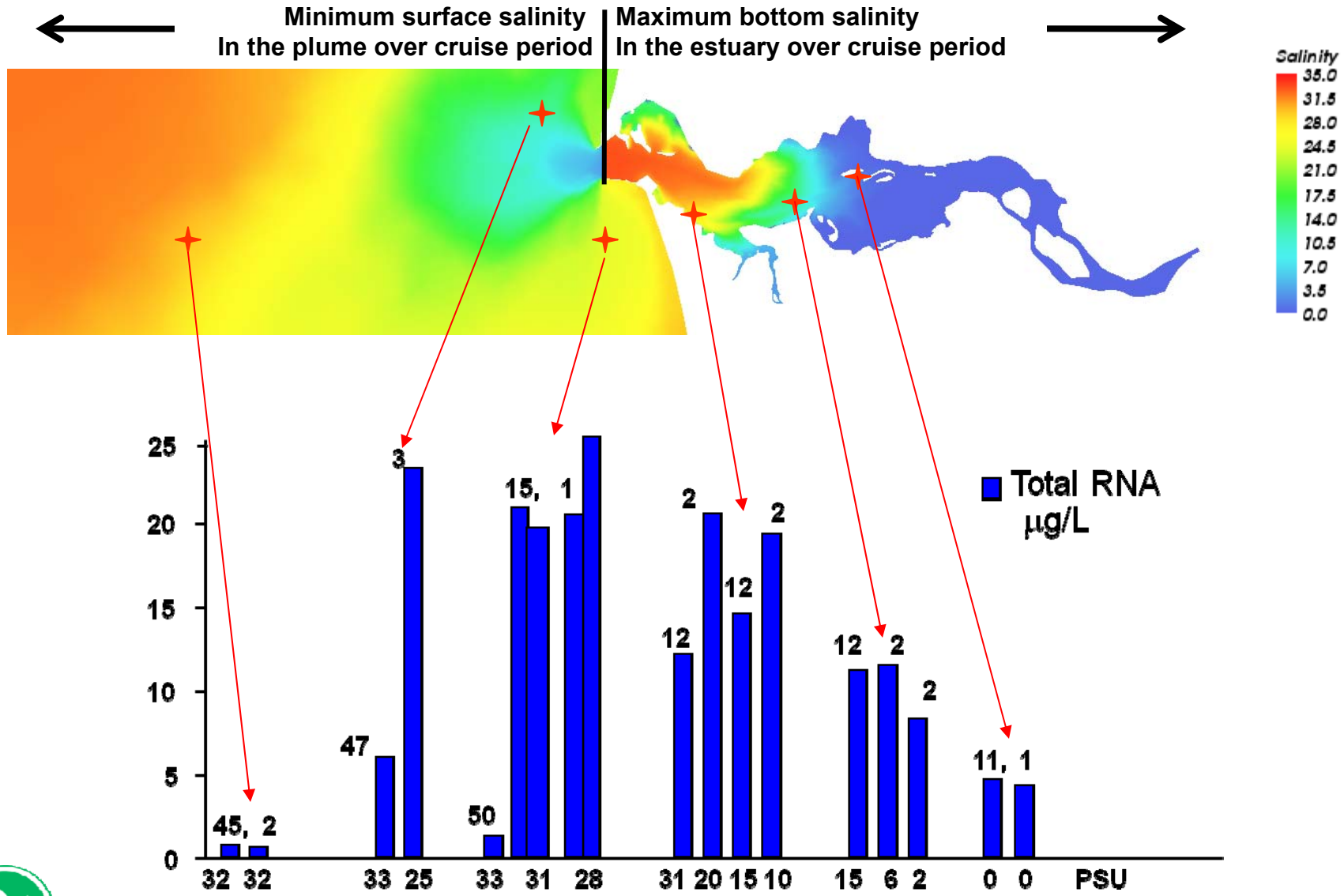
Predicting change





Characterizing variability

Opening the "microbial black box"

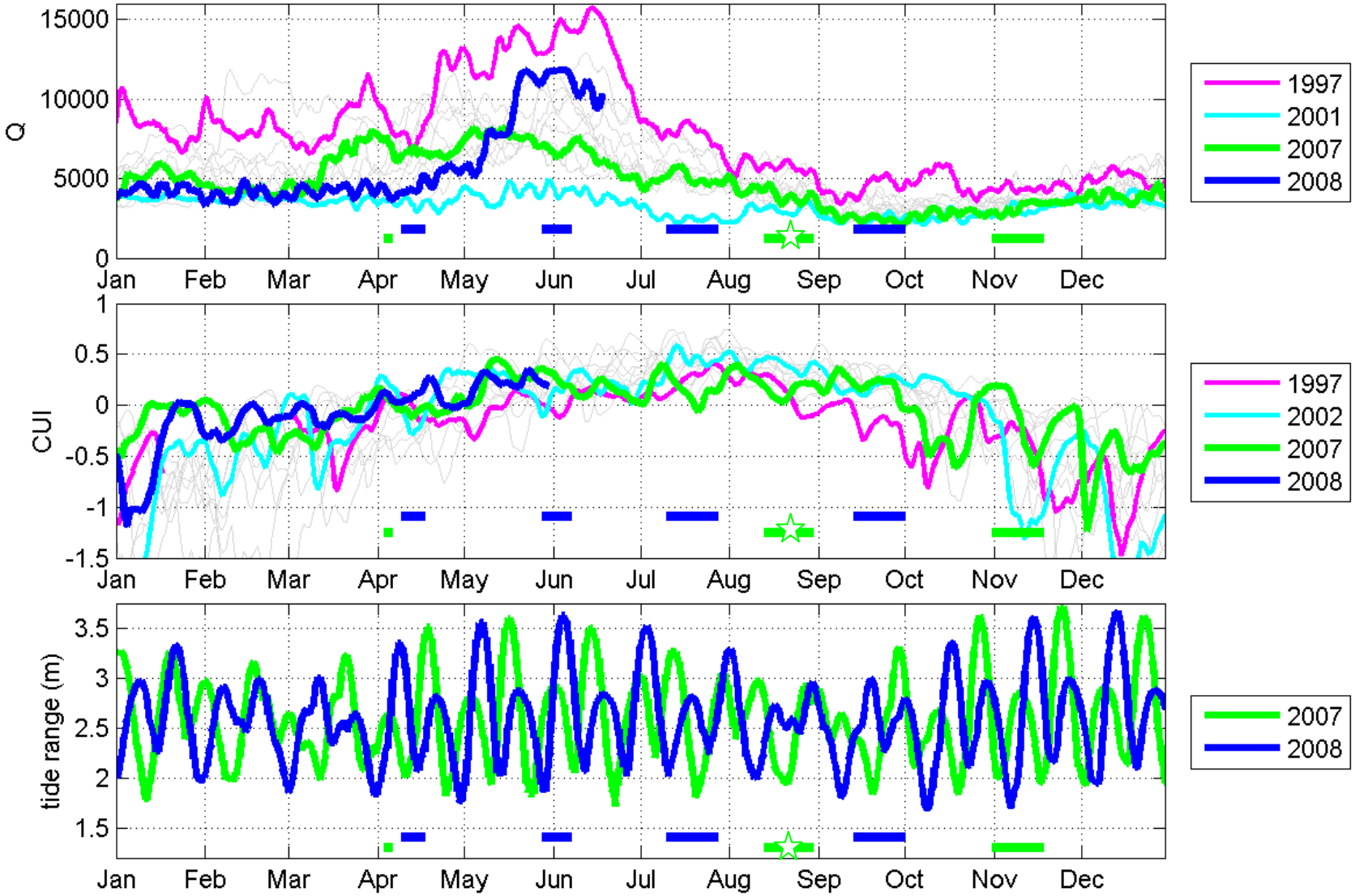


Total RNA content from Aug 2007 cruise

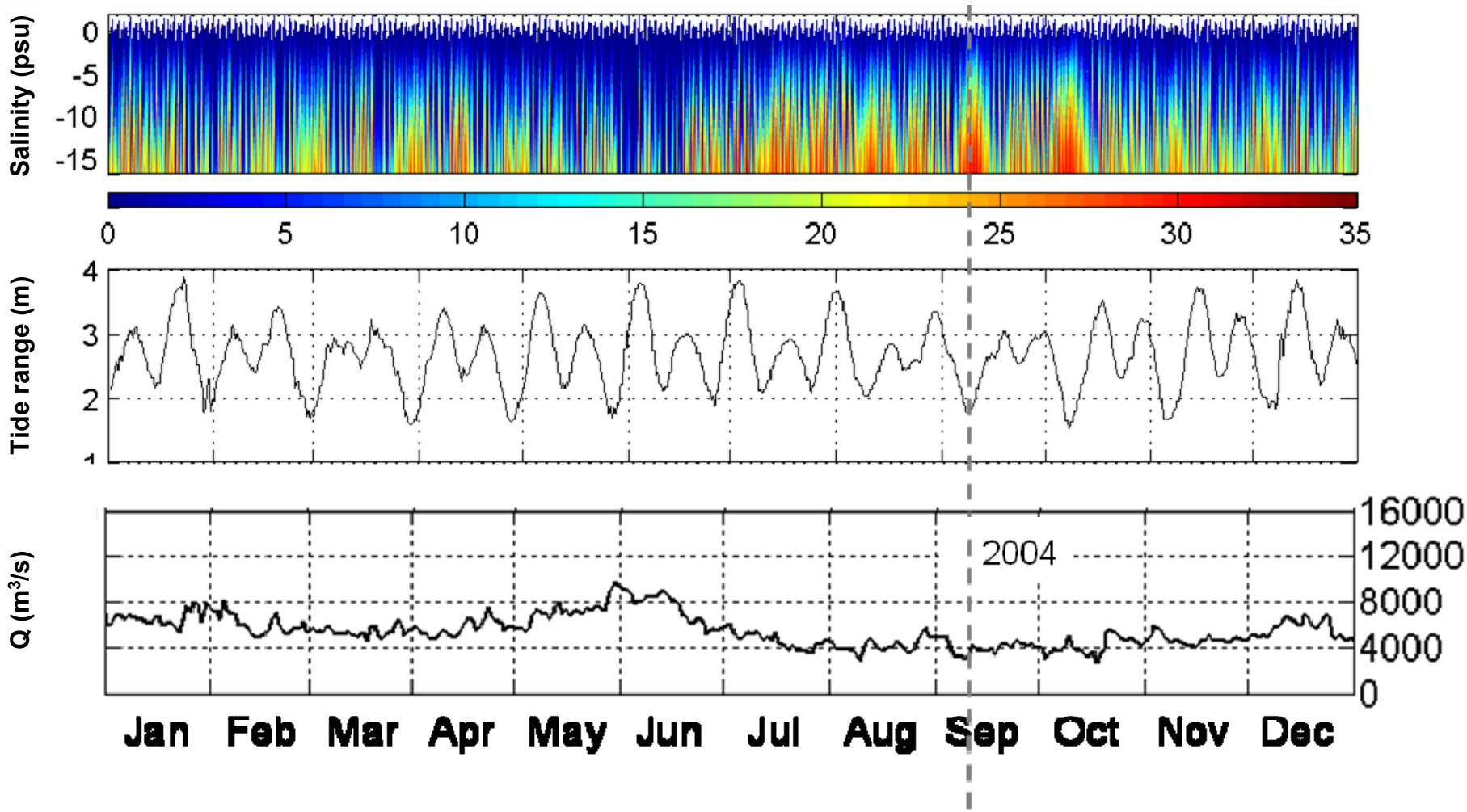
"CMOP: Transforming Ocean Exploration"

Smit et al.

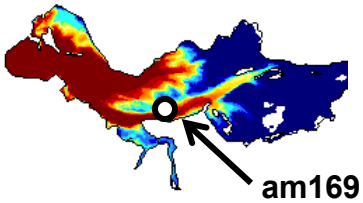
Variability of influential forcings



System response to forcing: estuary



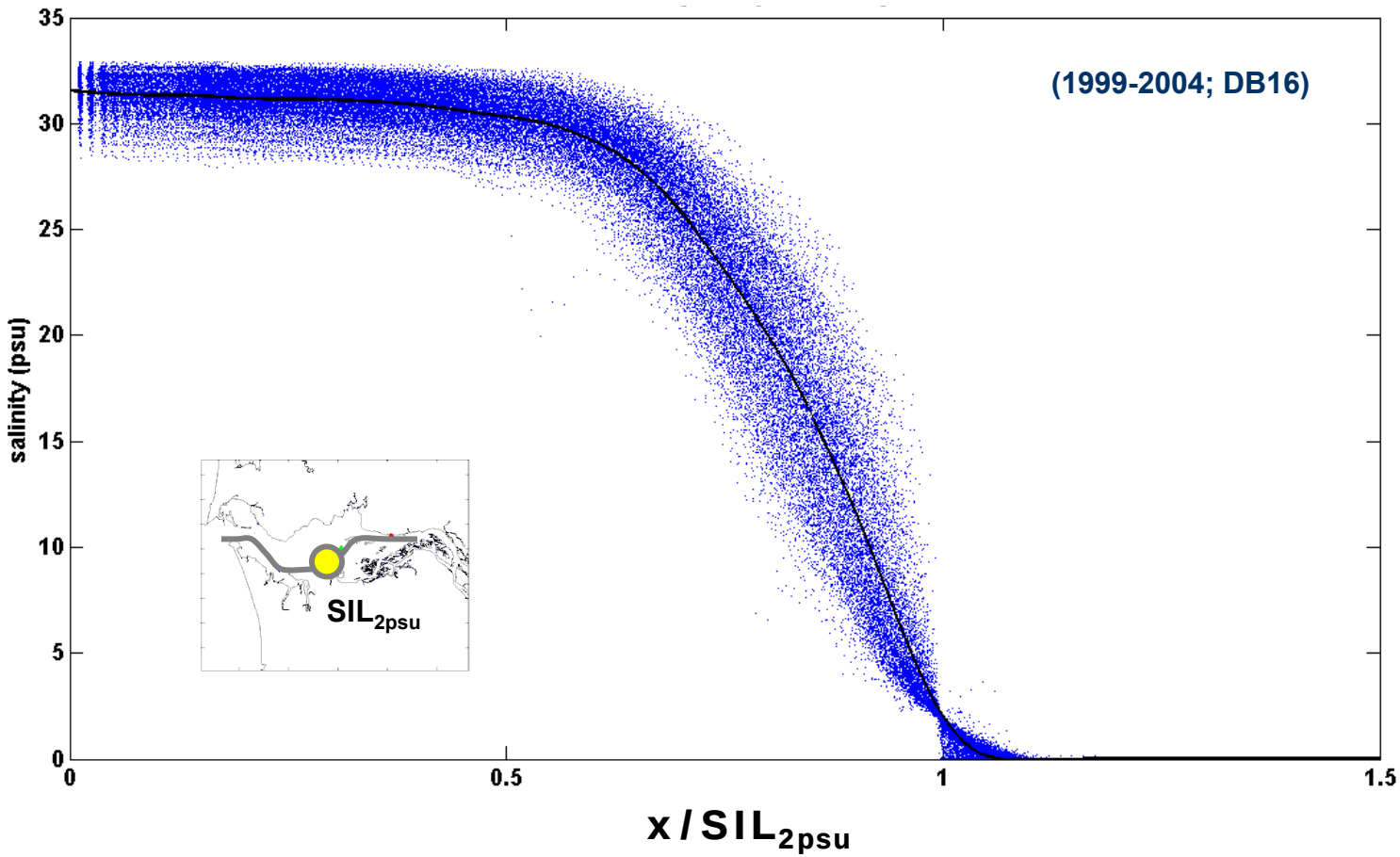
Salinity intrusion



Salinity intrusion length as a sentinel?

Relevant

SIL normalizes system behavior, enabling estuary-specific fingerprinting



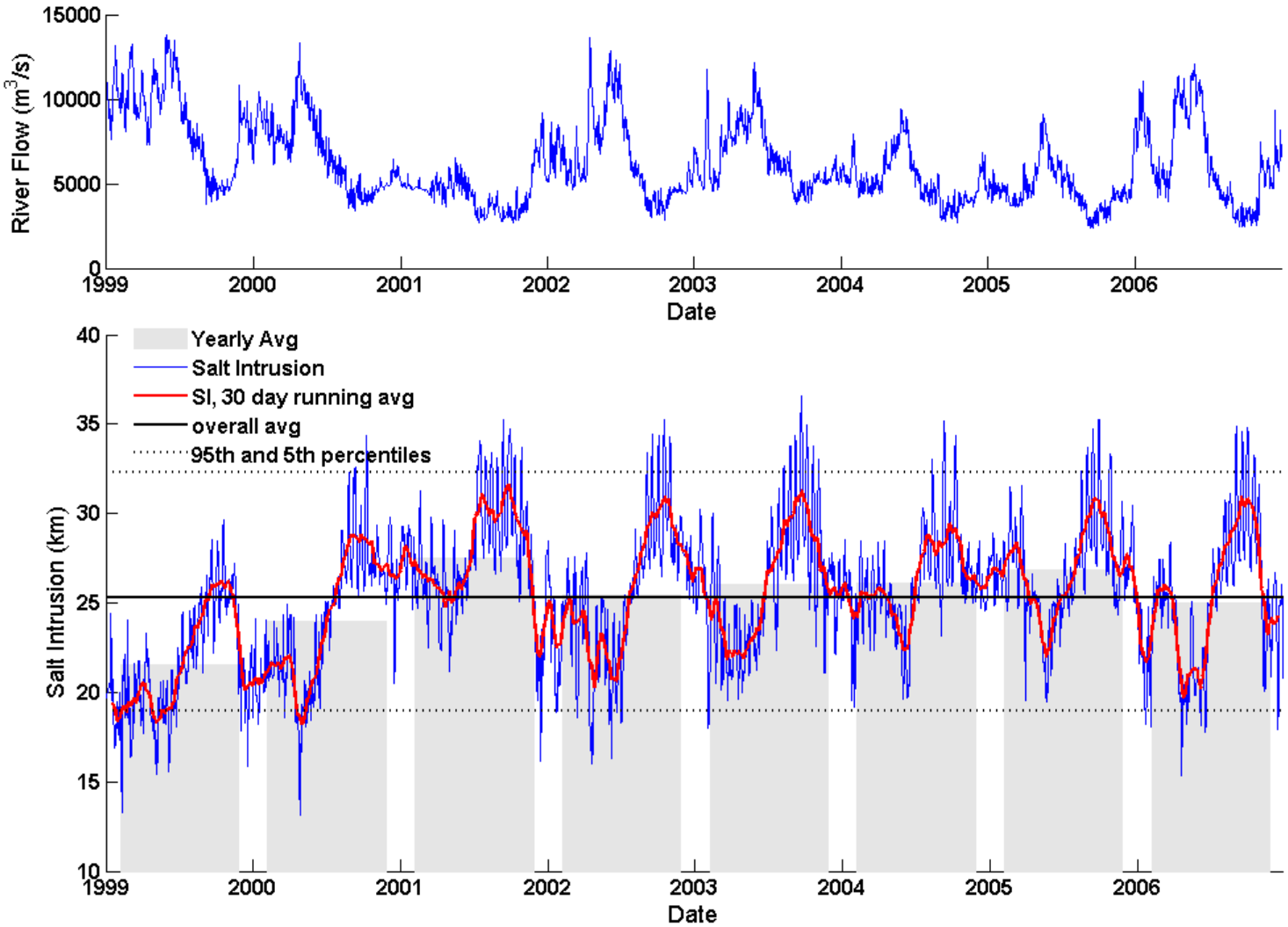
Distribution of maximum bottom salinity per tidal cycle, scaled by salinity intrusion length (SIL)

Whalen et al. (REU 2007)

Salinity intrusion length as a sentinel?

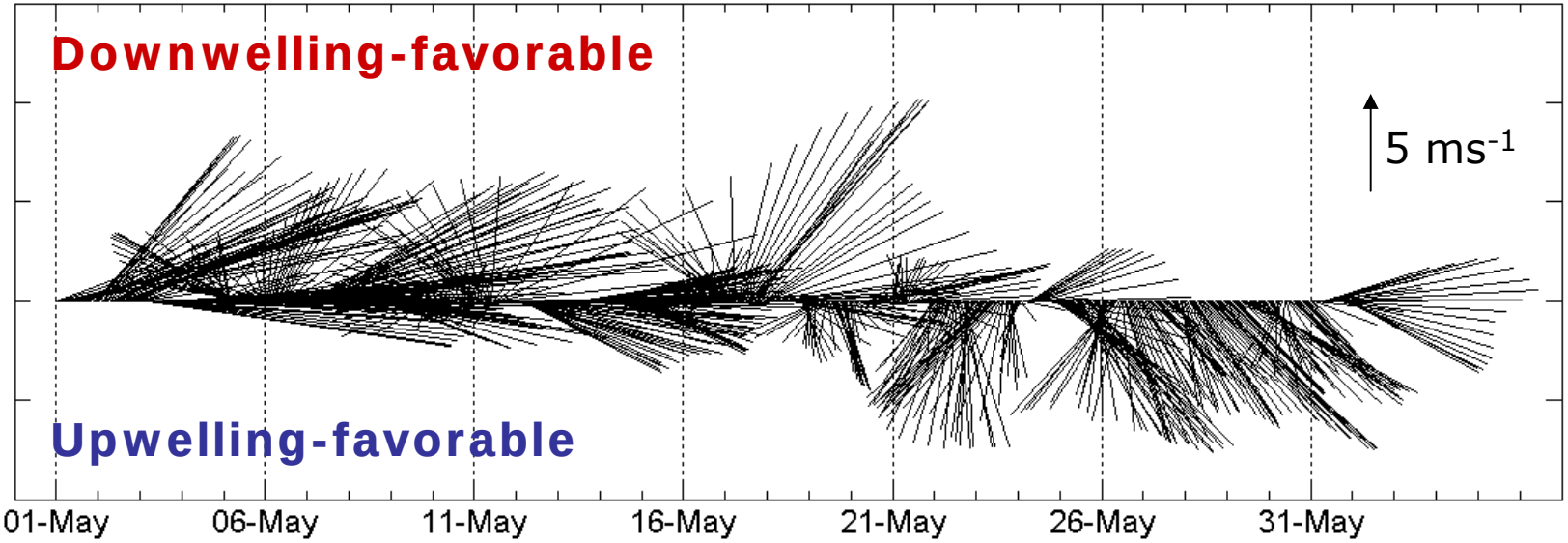
Responsive

Clear response to river discharge …



Wind forcing – May 1999

Hourly wind off the river mouth



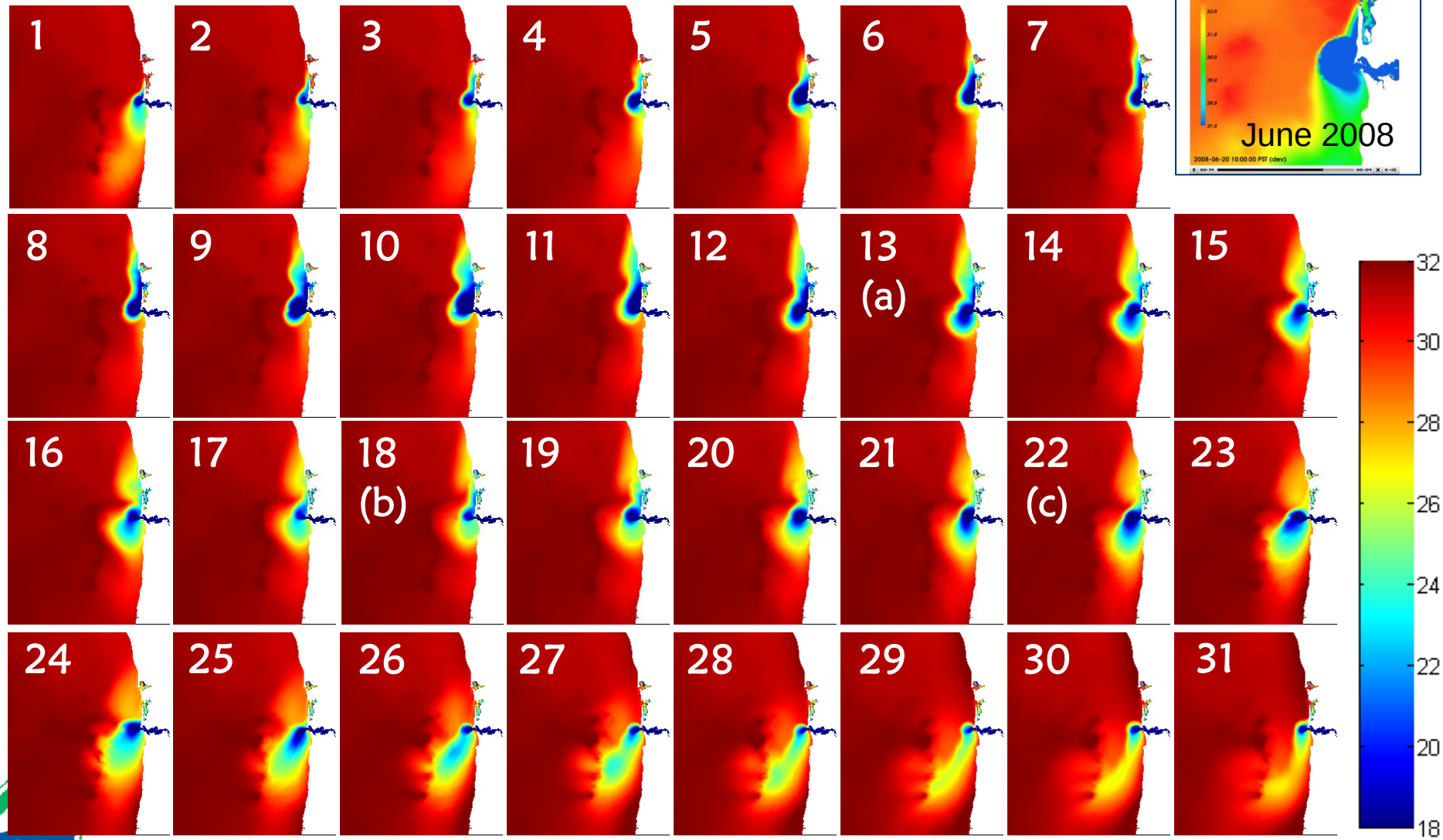
(a) Transition to prevailing upwelling–favorable regime

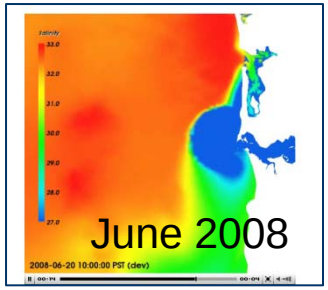
(b) Downwelling episode

(c) Persistent strong upwelling-favorable winds

System response to forcing: plume, daily

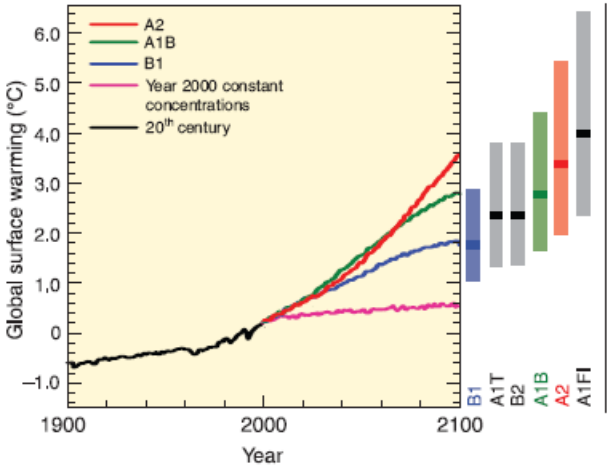
May 1999

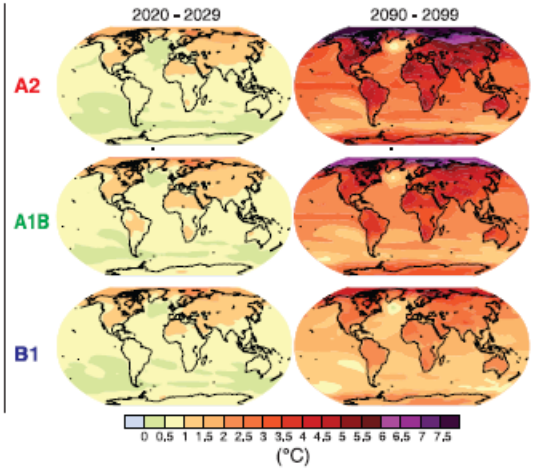




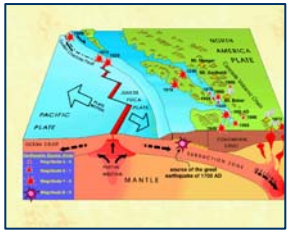
Predicting change: climate in context

Climate Change (IPCC 2007)



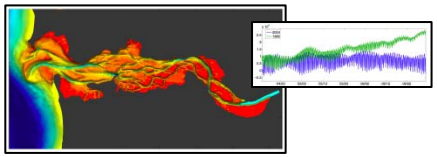


DOGAMI

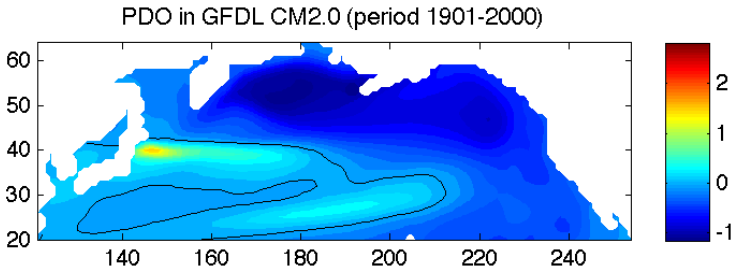


CSZ event

Pre-development

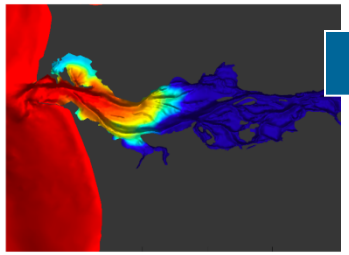


BPA, NOAA, UW, PSU



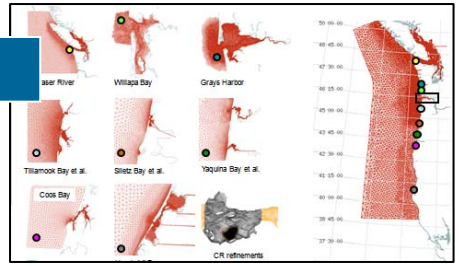
Transitional scales

OSU



OHSU

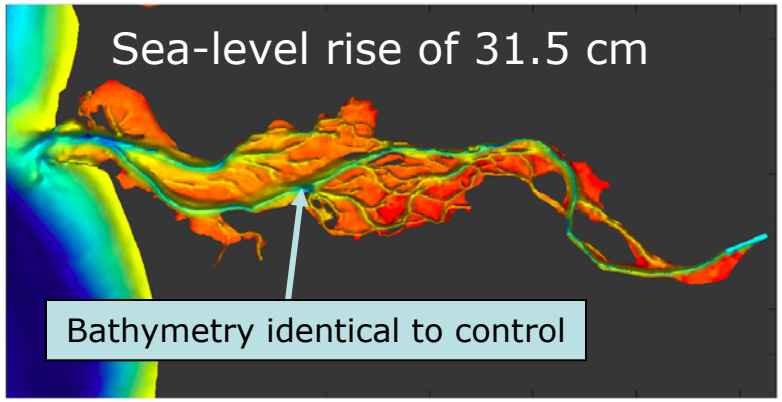
Columbia River estuary and plume

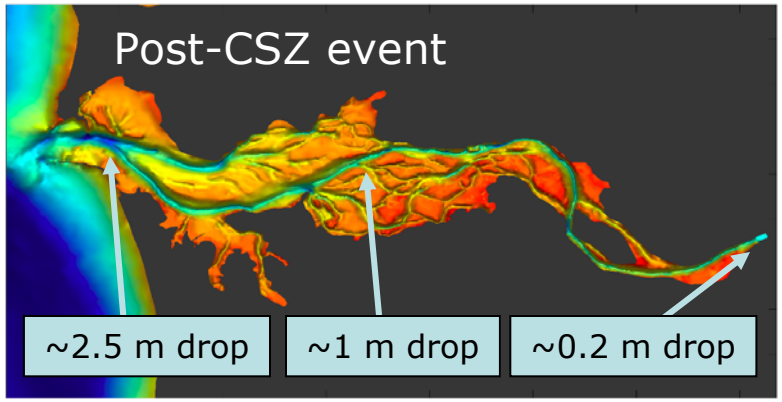


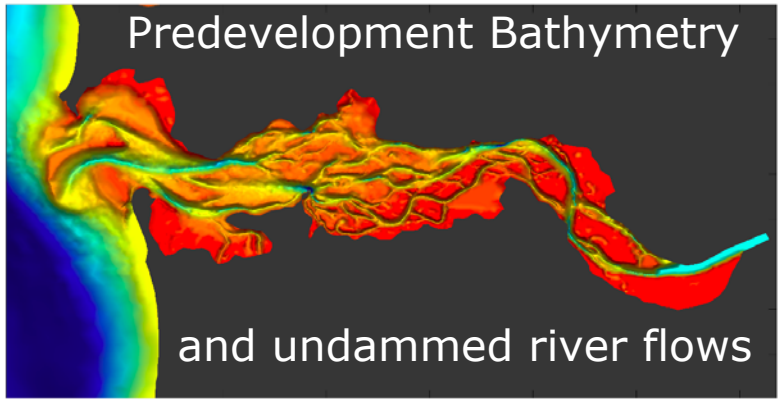
Other PNW and West Coast estuaries

Simulation scenarios

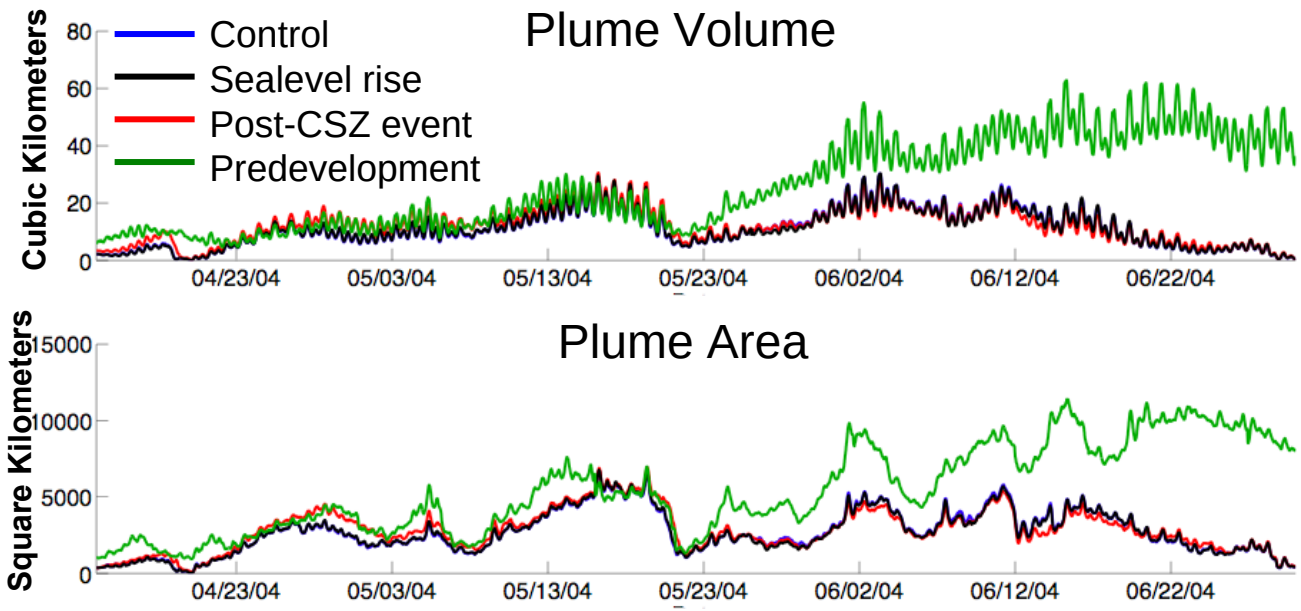
- All simulations are run under spring 2004 forcings (the predevelopment run uses an estimate of undammed spring flows)
- Post-CSZ event bathymetry is based on models developed by DOGAMI and collaborators
- Predevelopment (ca. 1880) bathymetry was estimated by Burke, Simenstad, and Jay using historical depth records and vegetation maps. Flows were estimated by Jay using historical records.

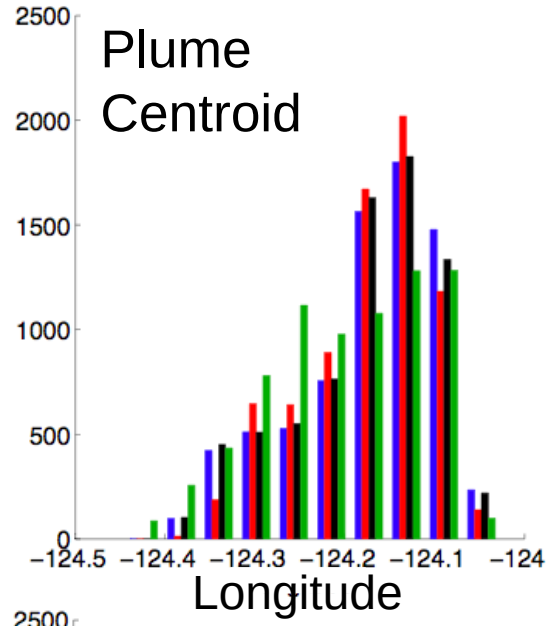


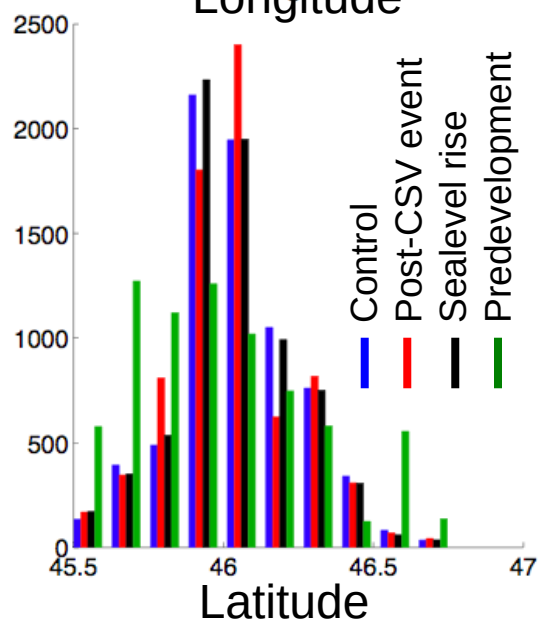




Columbia River Processes: plume







- Predevelopment plume significantly larger, and positioned further south, than all others
- Sea level rise has relatively little impact on plume processes, but the post-CSZ run produces a slight northward and eastward shift in the position of the plume centroid
- Established correlations between plume size and steelhead smolt survival (Burla, et al, in press) suggest a mechanism by which estuarine development may have played a role in long-term salmonid population declines

Plume and smolt-to-adult ratios

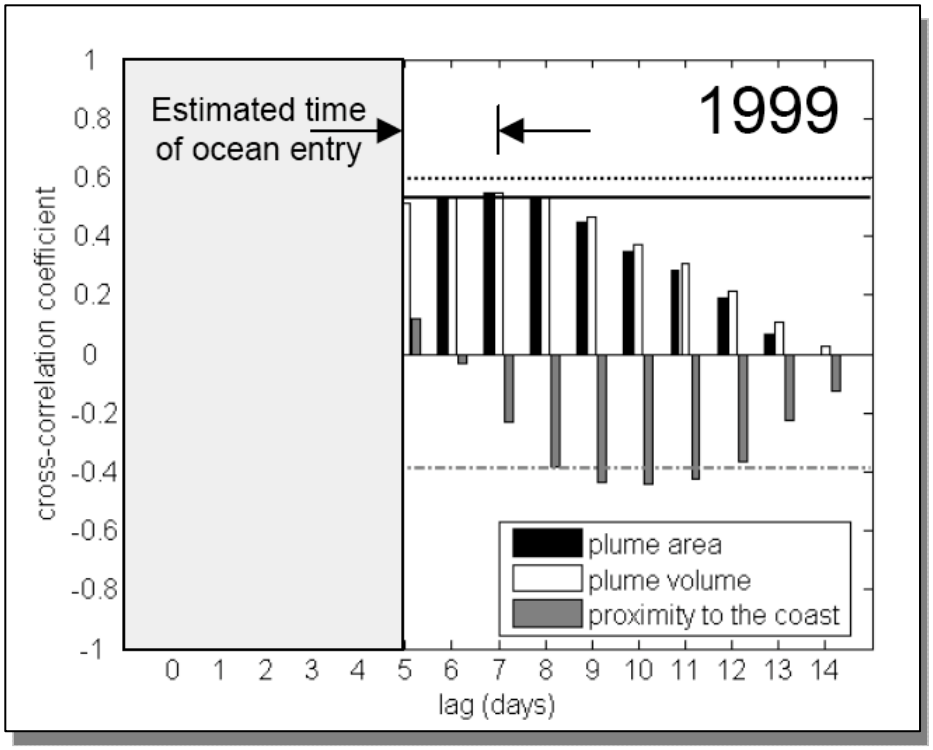
- Modern system

  Correlations between smolt-to-returning adult ratios (SAR) and plume magnitudes have been described for steelhead – large, detached plumes at time of ocean exit are a positive factor

- Changes from pre-development plume may have played a role in long-term steelhead population declines

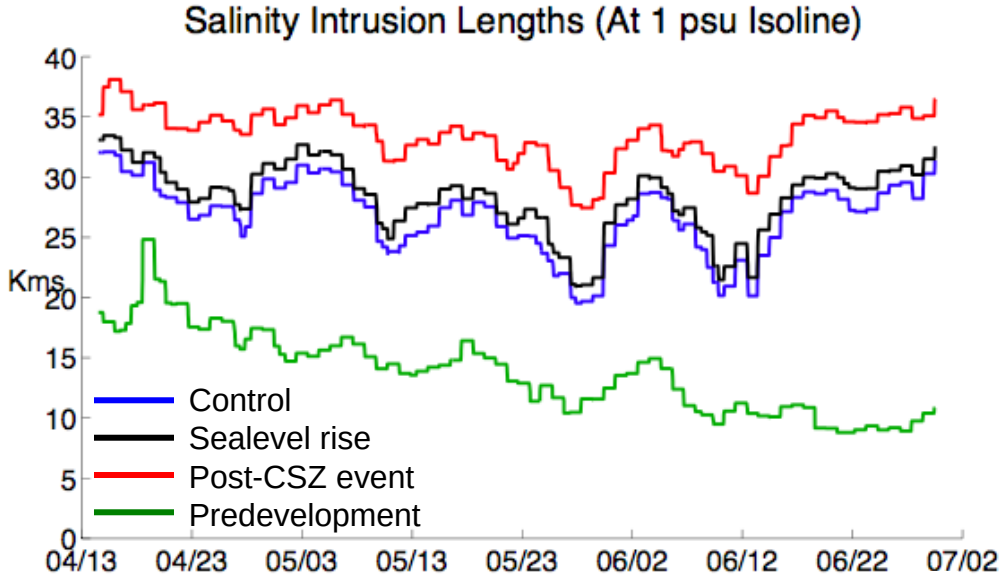
- Sea level rise may not be a major factor (but other climate change factors might)

- Post CSZ scenario will likely be slightly unfavorable

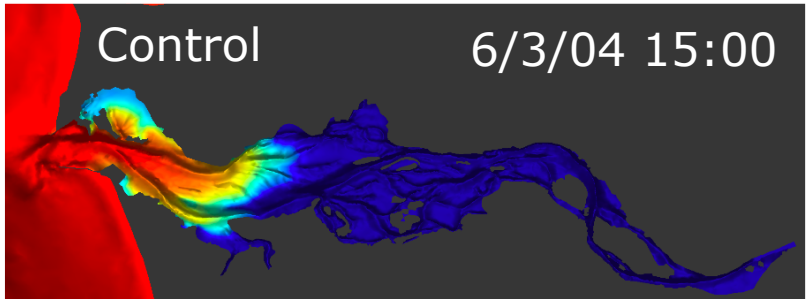


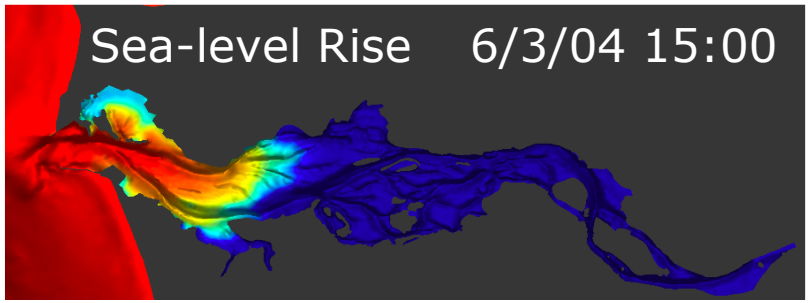
Burla et al., in revision

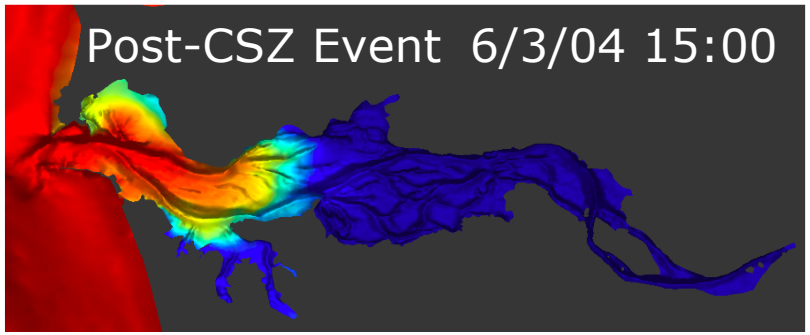
Columbia River Processes: salinity intrusion

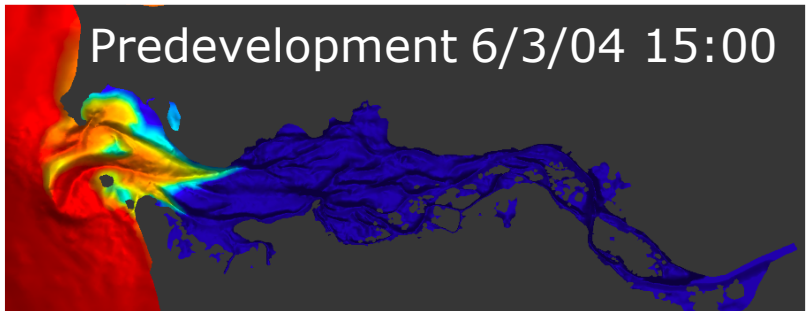


- SIL's in the sea level rise simulation were slightly longer than the control
- The strongest SIL response was displayed by the predevelopment run, but the post-CSZ run moved significant salt up-estuary - often as far as Cathlamet and Gray's Bay
- The predevelopment bathymetry does appear to influence salinity intrusion, but the strength of this scenario's response is primarily due to the high river flows

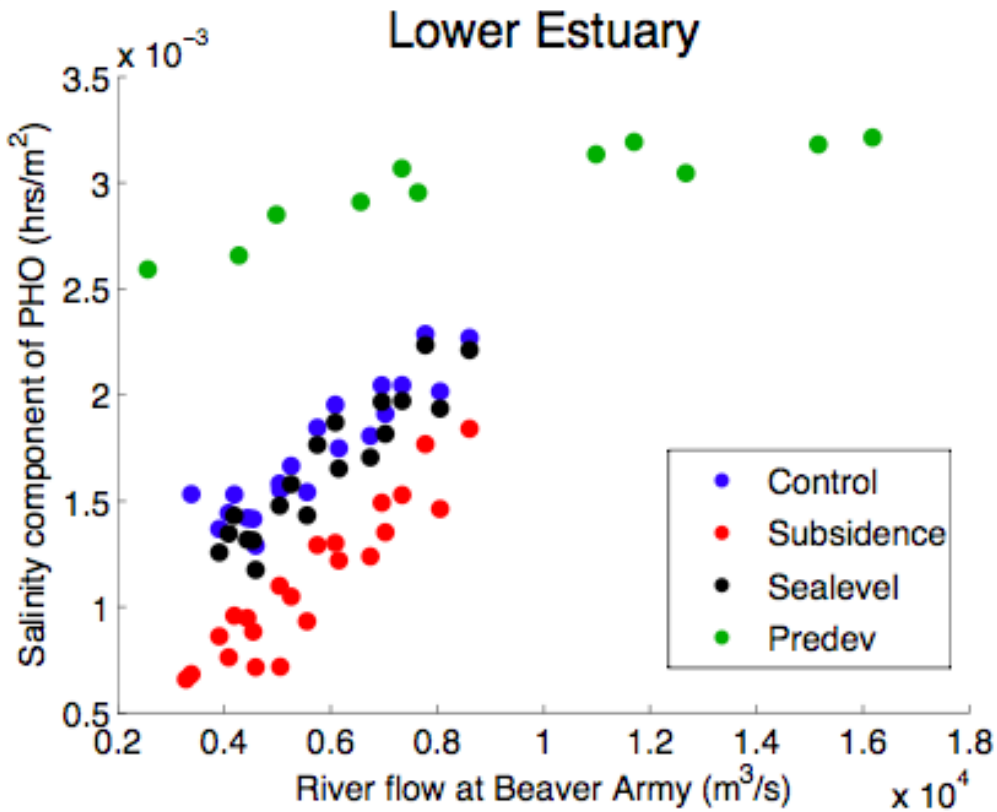


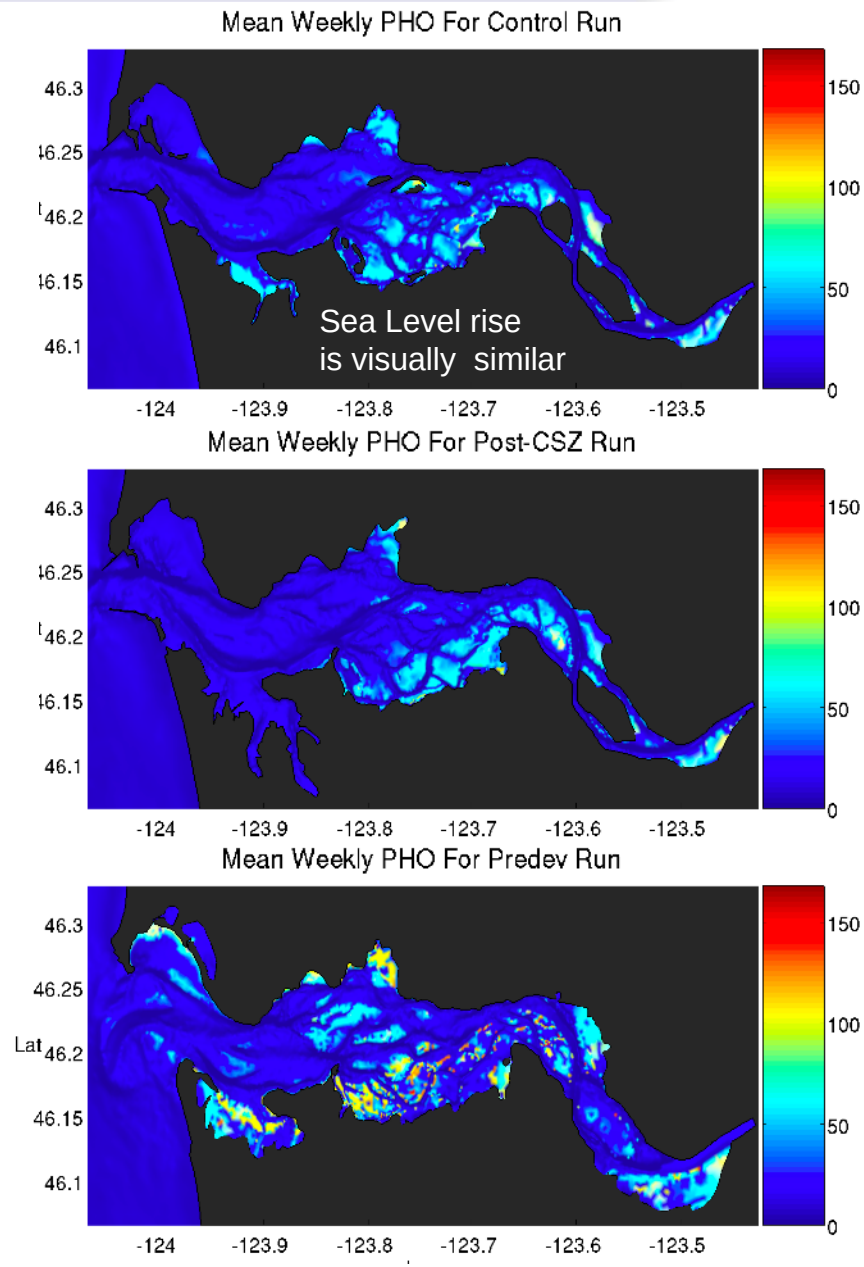






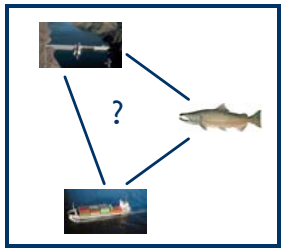
Physical Habitat Opportunity (PHO)

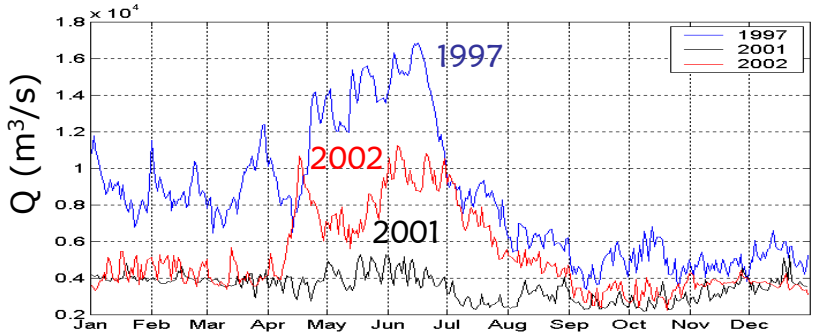




Depth (m)	$0.1 < z < 2$
Salinity (psu)	$0 < S < 5$
Temp (^{0}C)	$0 < T < 19$
Velocity (cm/s)	$0 < u < 30$

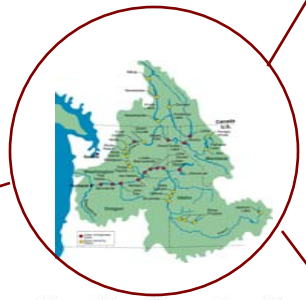
PNW context and issues

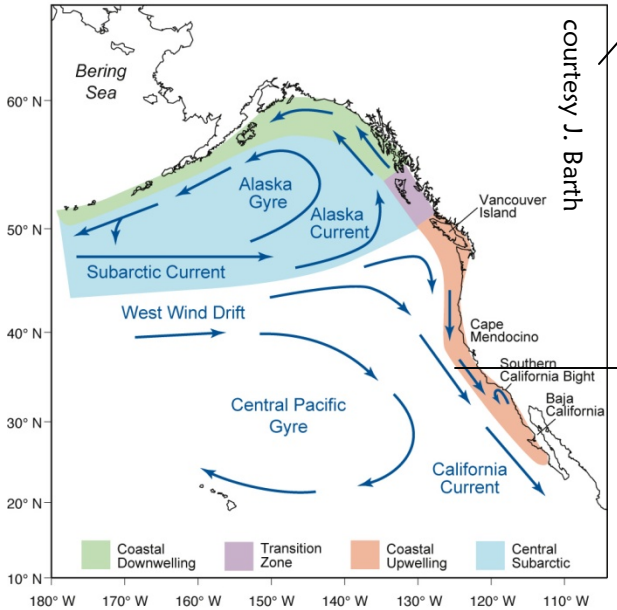


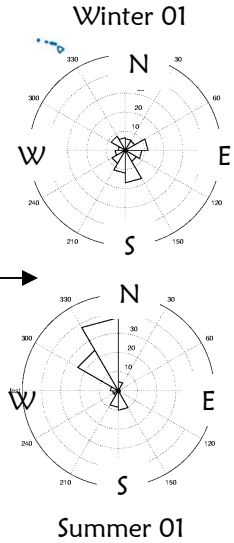


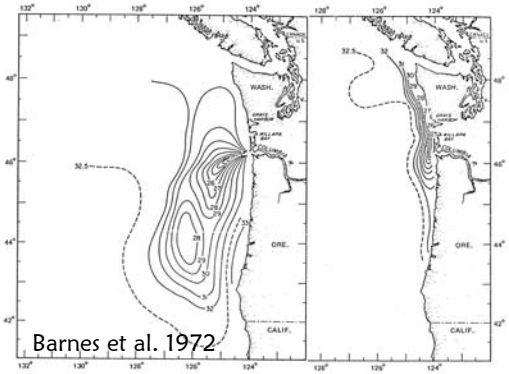
Climate forcing

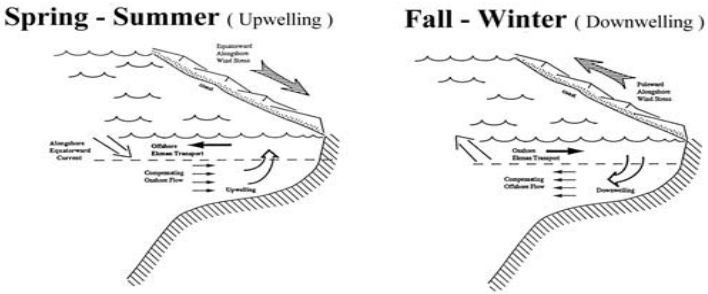
- Pacific Decadal Oscillation & ENSO (precipitation, ocean climate)
- Global climate change (sea level rise, snow pack)



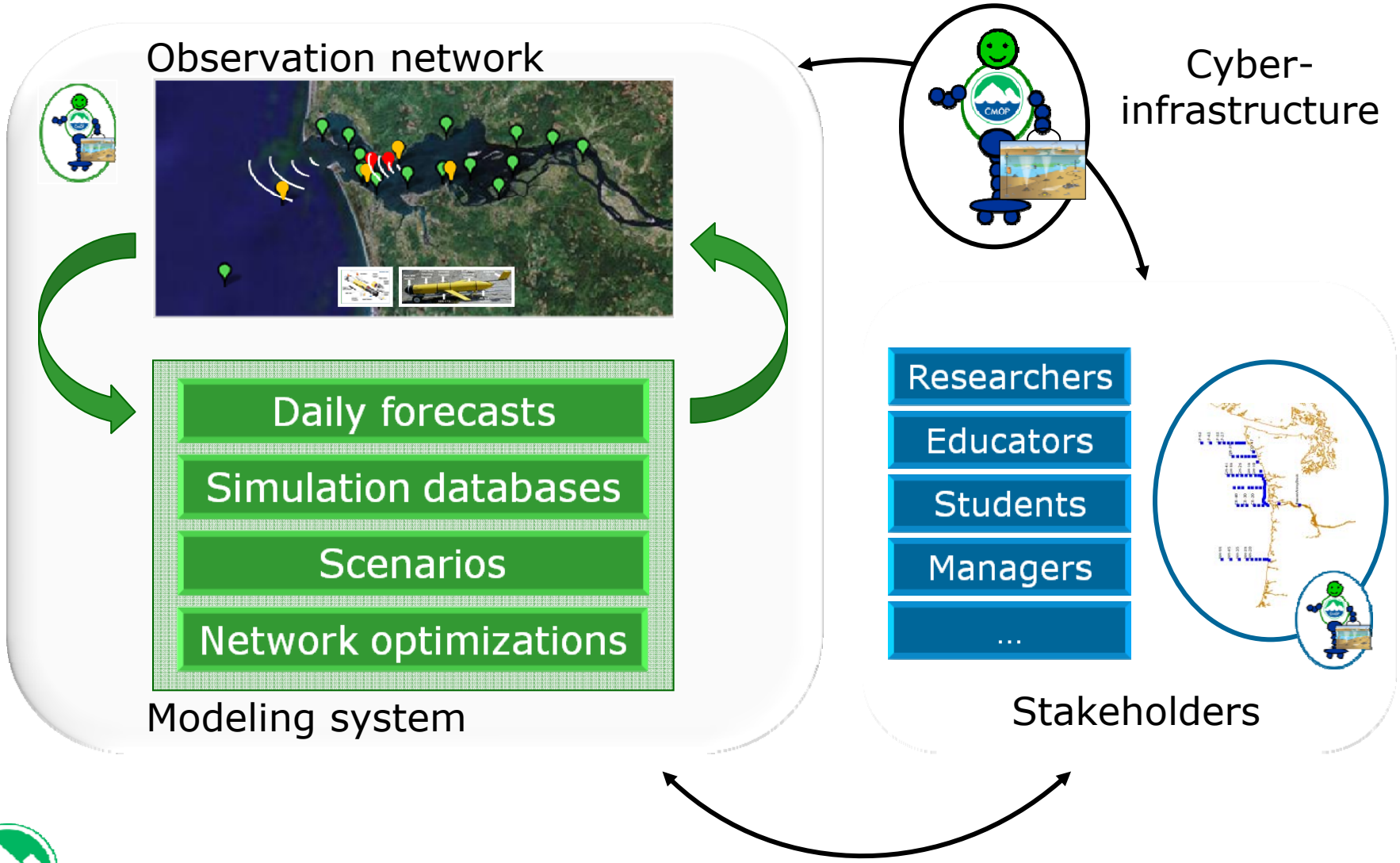








CORIE → SATURN: an end-to-end observatory

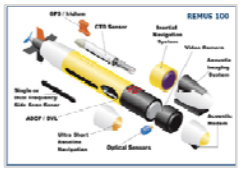


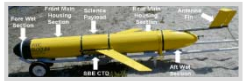
Observation network

- CORIE stations
- SATURN "endurance" stations
- SATURN "pioneer" stations
- SATURN land-based remote sensing

Context networks:

- SATURN mobile platforms

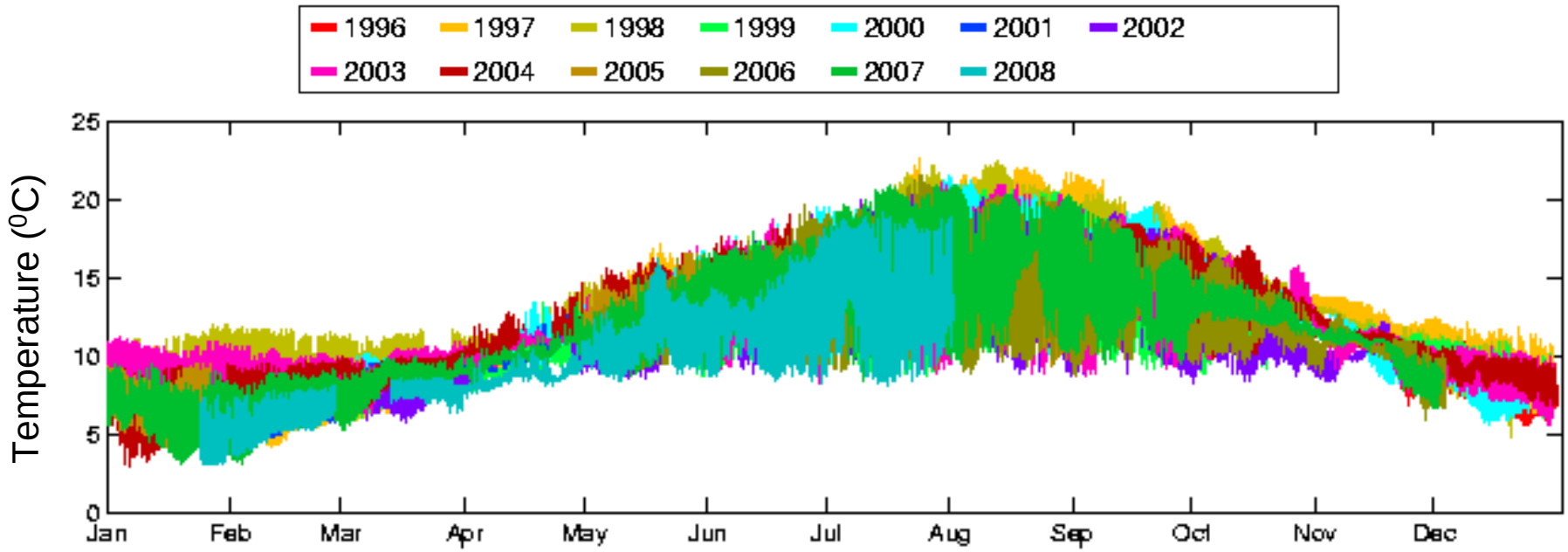




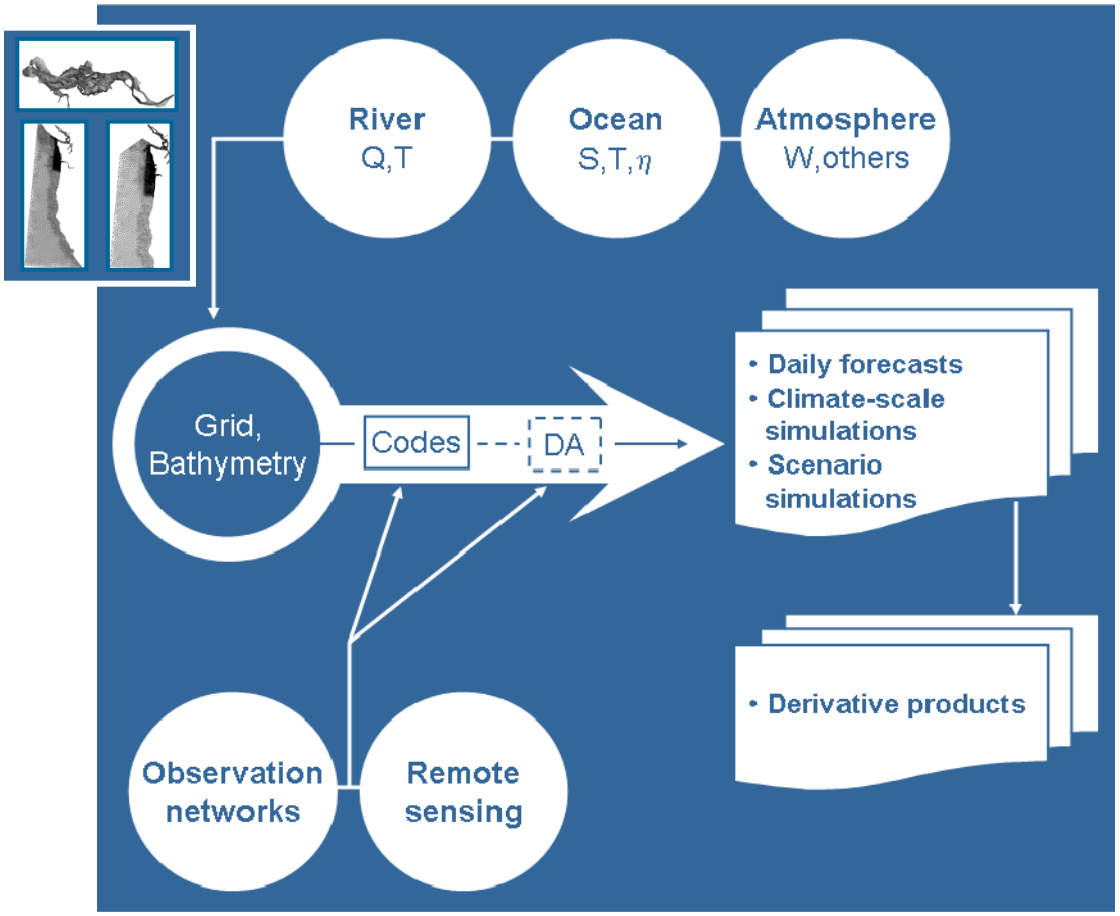
1 Slocum glider
2 REMUS-100

- CMOP cruises

The essential need for long-term data



Circulation modeling system



• Redundancy (models/simulations) and systemic skill assessment as philosophy
• Codes (current): ELCIRC, SELFE

Function

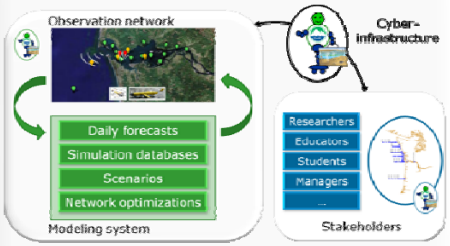
- Support cruise planning, execution and analysis
- Characterize processes
- Characterize long-term variability
- Characterize and anticipate change
- Re-design observation network

Mechanisms

- Daily forecasts (multiple)
- Multi-year simulation databases (multiple; since 1999)
- Scenario simulations
  - Climate
  - Human activities
  - Plate displacement

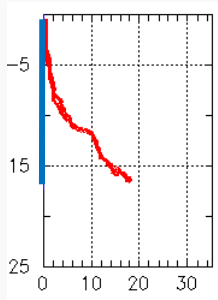
Continuous, systemic improvement

The “mature” observatory



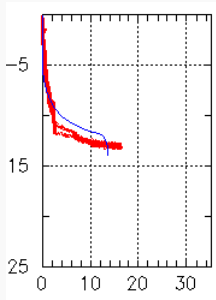
since 1996

The “inconvenient” cruise



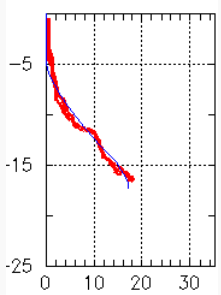
Jul 2008

The short term “fix”



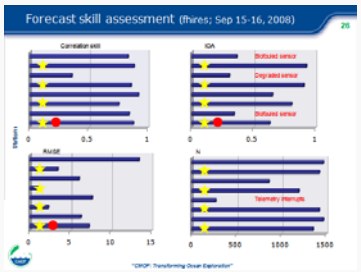
Jul 2008

“retrospective“ analysis



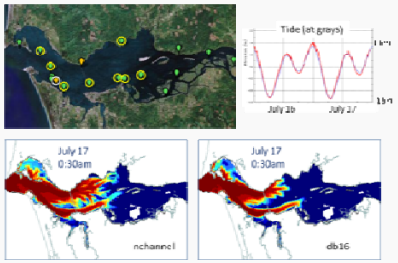
Aug-Sep 2008

Skill metrics



Sep 2008

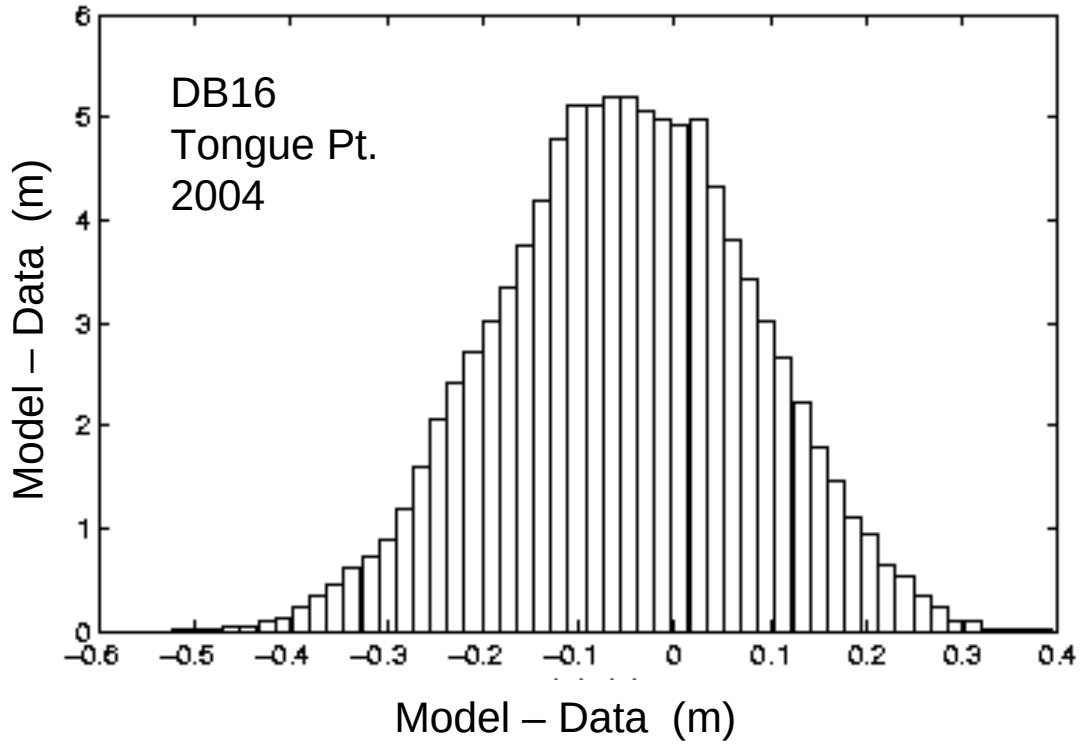
Open benchmark



Improved skill

“CMOP: Transforming Ocean Exploration”

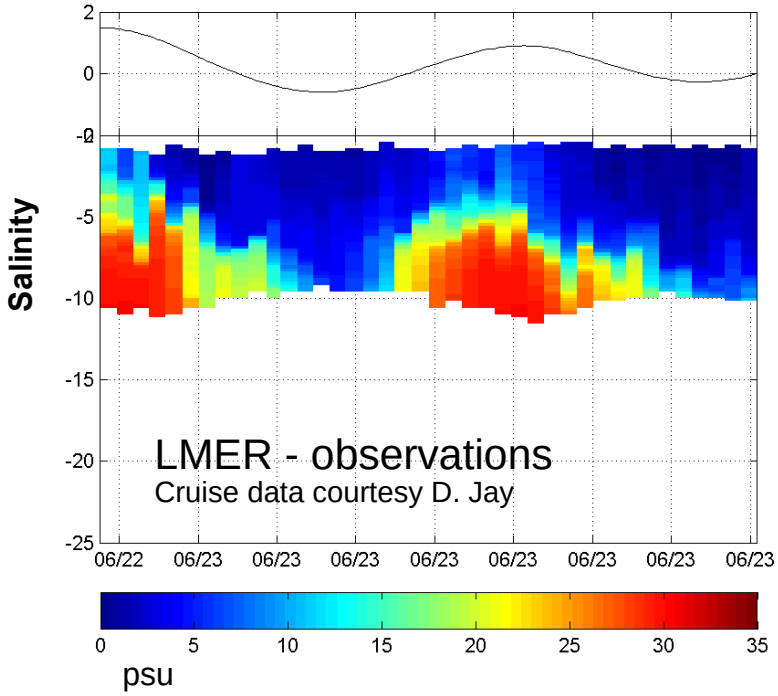
Water levels

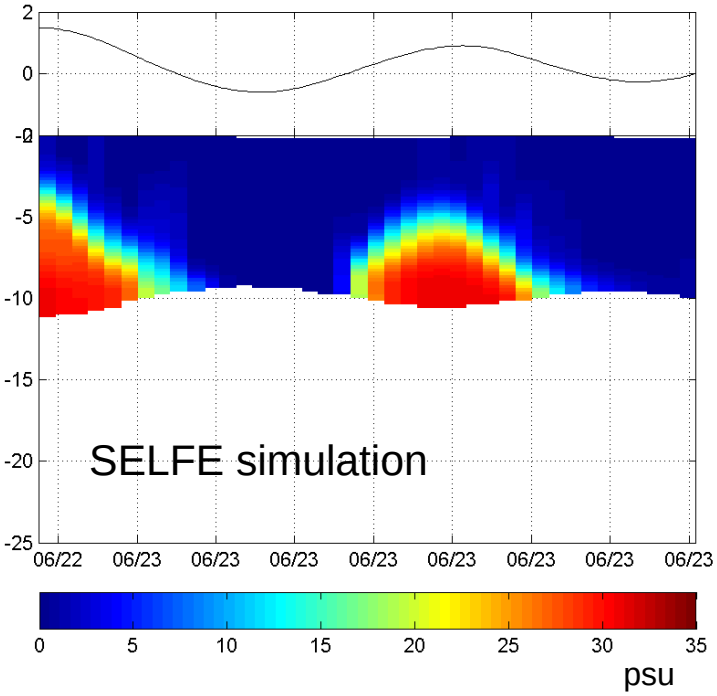


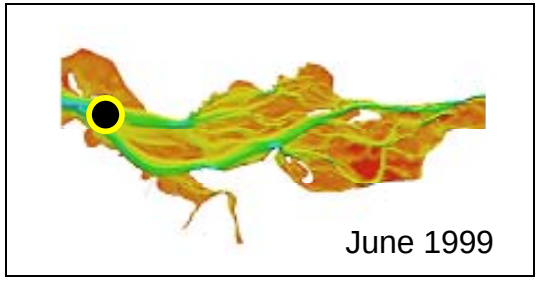
N	87309
Max over	0.38
Max under	–0.52
Avg Err	–0.05
Std Dev	0.13
RMS	0.14

5 % = –0.27	10 % = –0.23	25 % = –0.14	50 % = –0.05
75 % = 0.04	90 % = 0.12	95 % = 0.16	

Blind retrospective cruise analysis – estuary

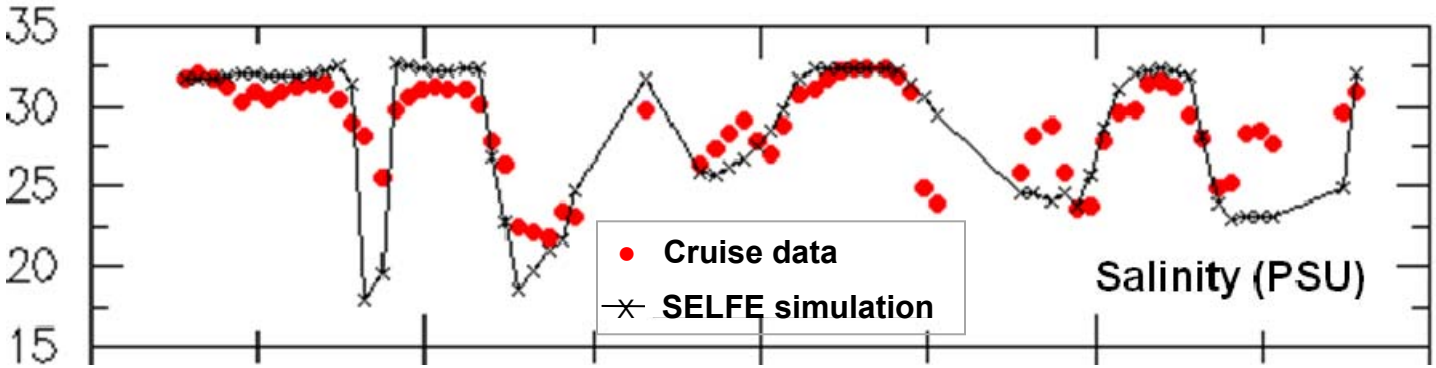




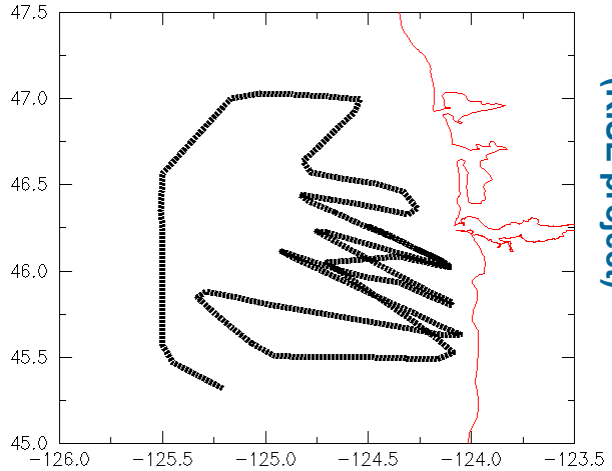


… shows ability to represent complex and episodic features

Blind retrospective cruise analysis – plume



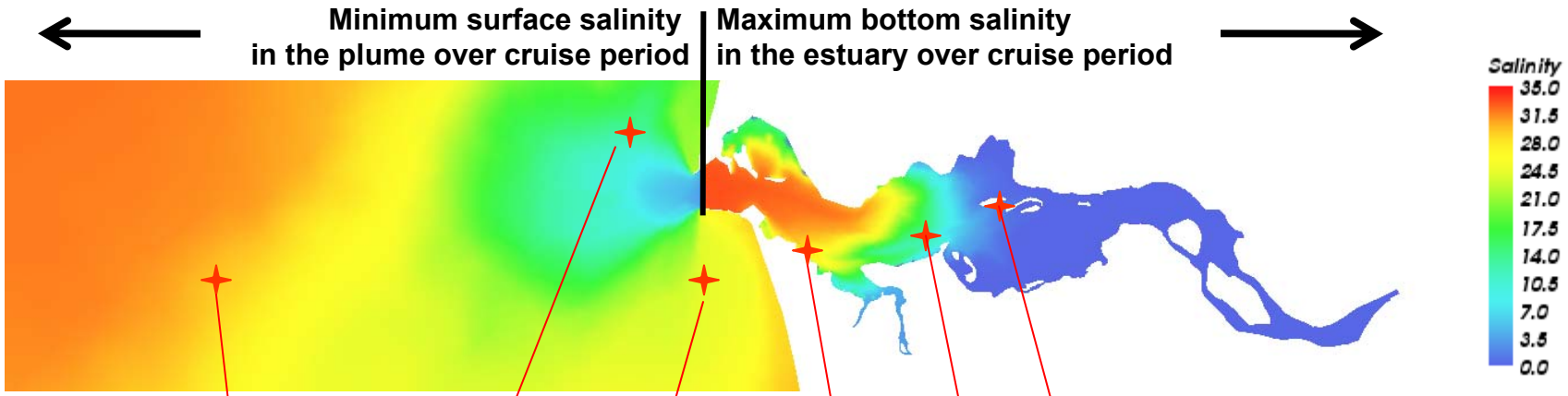
RMSE=2.64 psu
correlation = 0.80

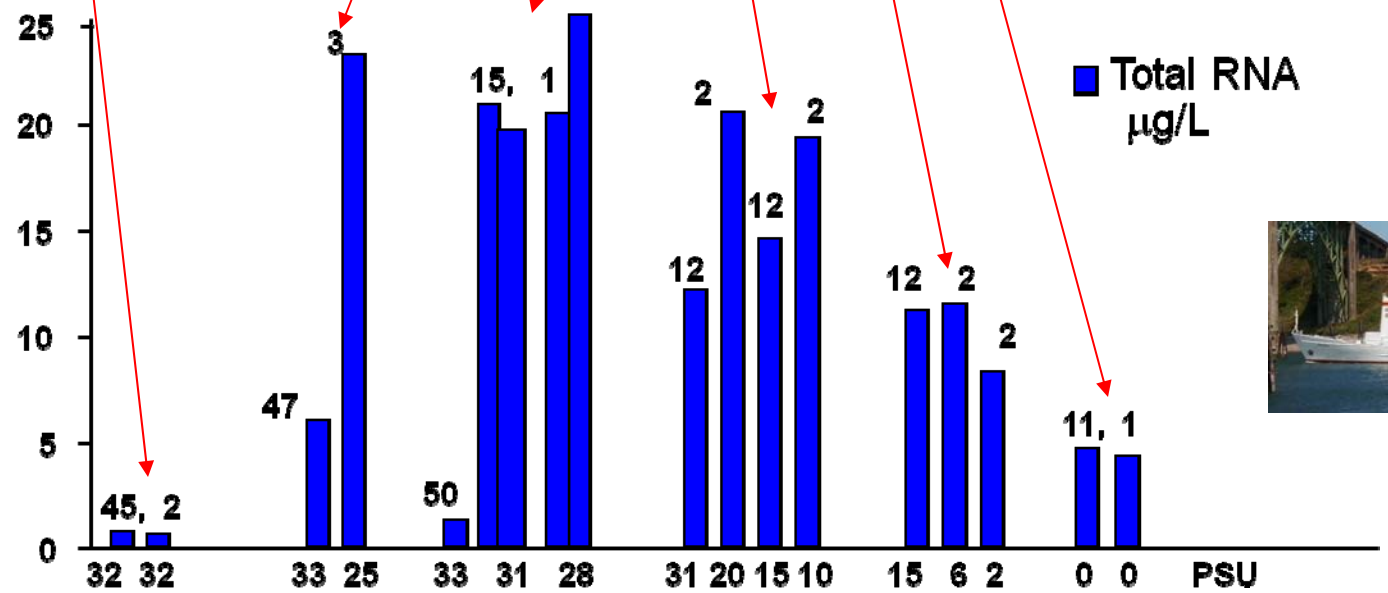


Data courtesy D. Jay (RISE project)

Pt Sur path (surface)

Coarse scale cruise planning/analysis



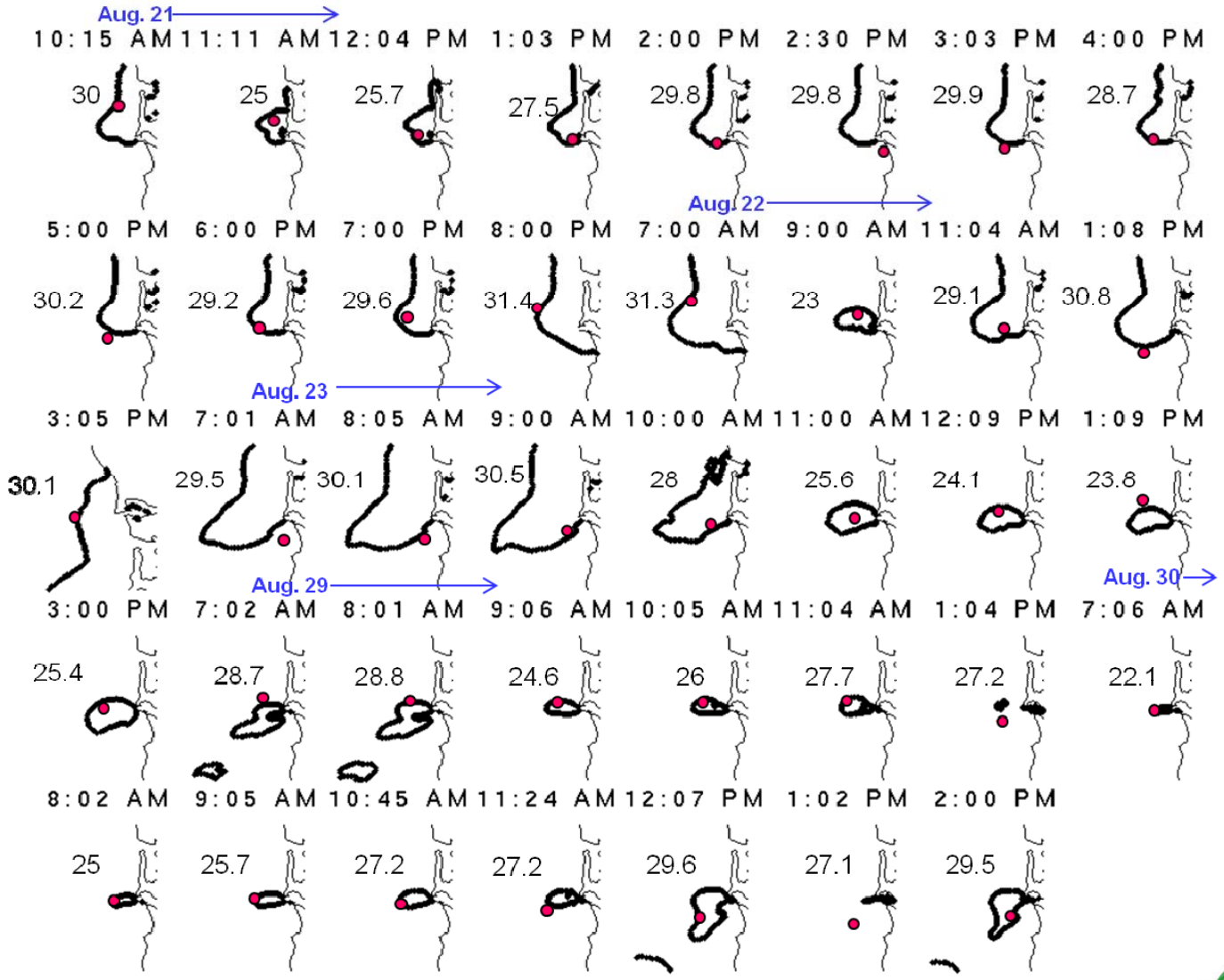


Total RNA content from the Aug 2007 CMOP cruise

Cruise data courtesy
L. Herfort and M. Smit

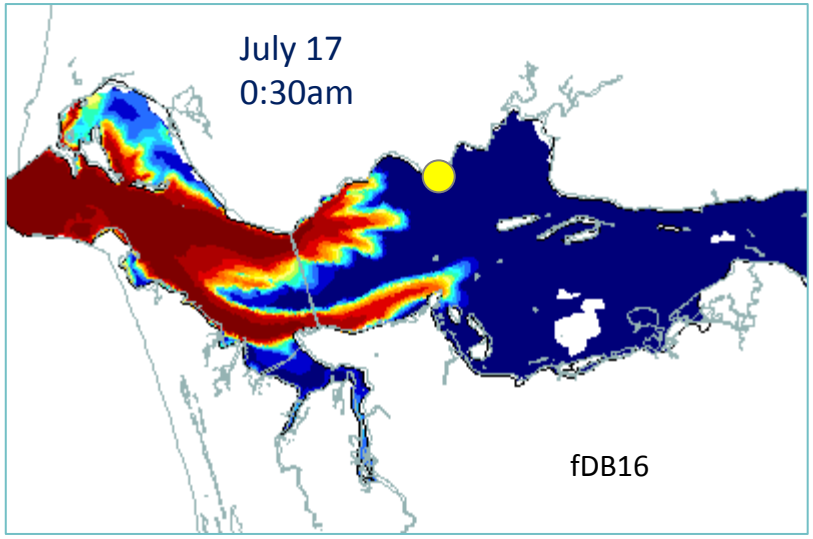
"CMOP: Transforming Ocean Exploration"

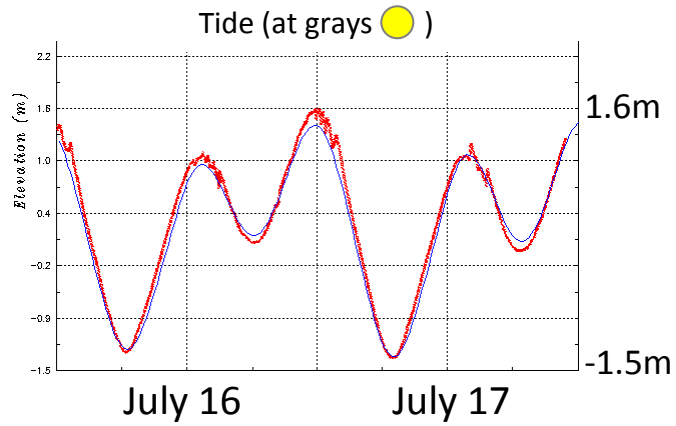
Forecast skill: prediction of plume location

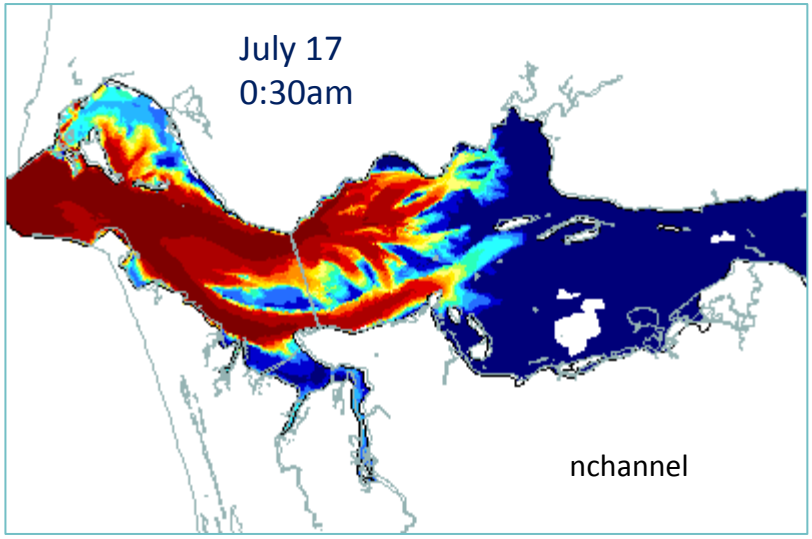


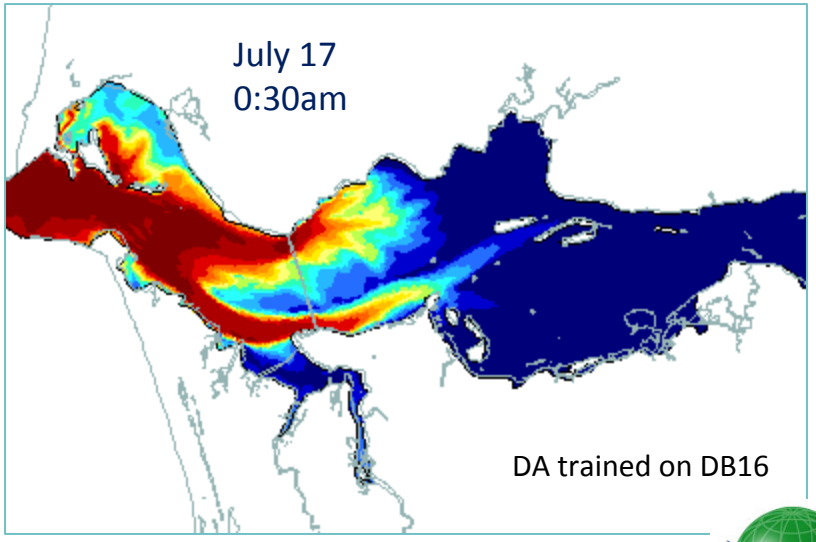
Cruise data courtesy B. Crump

Forecast skill: bottom salinity

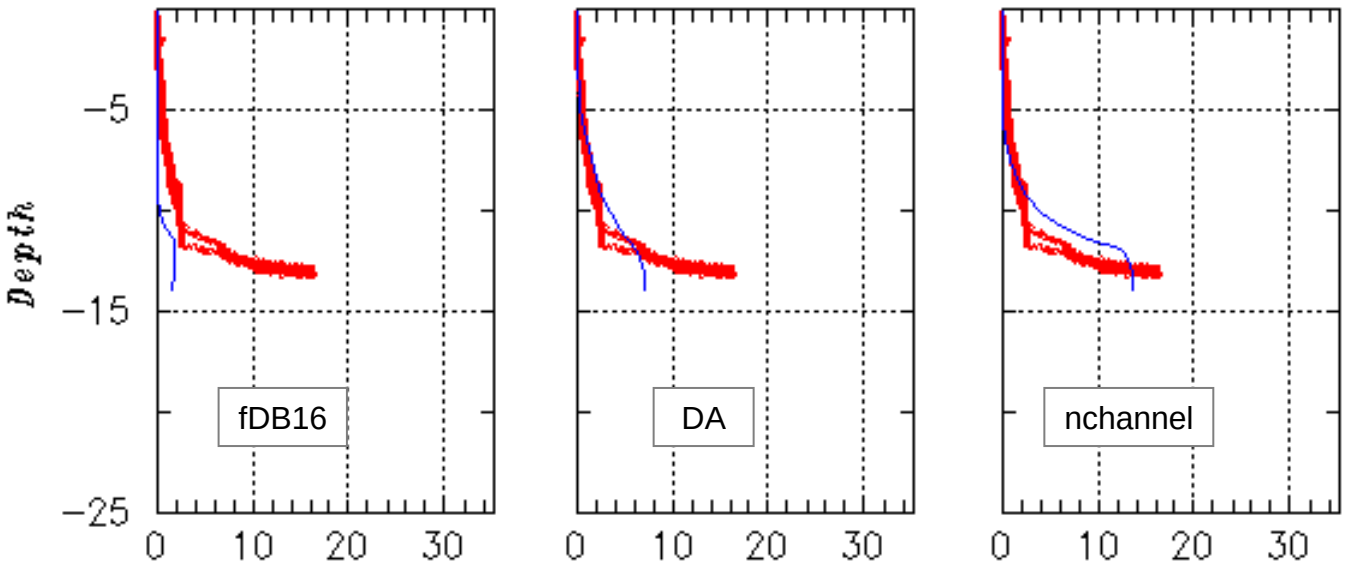


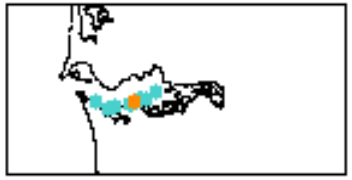




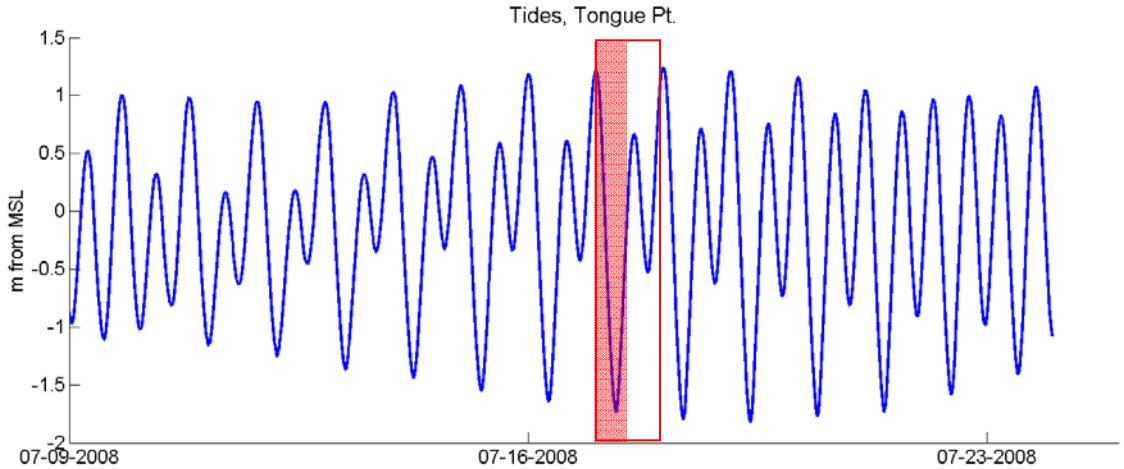


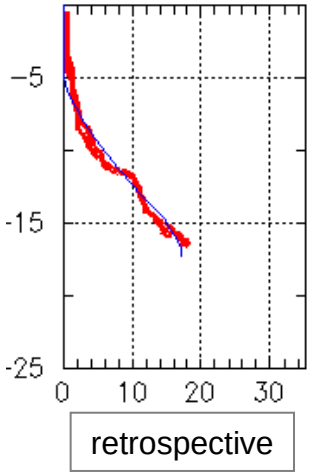
Forecast skill: bottom salinity



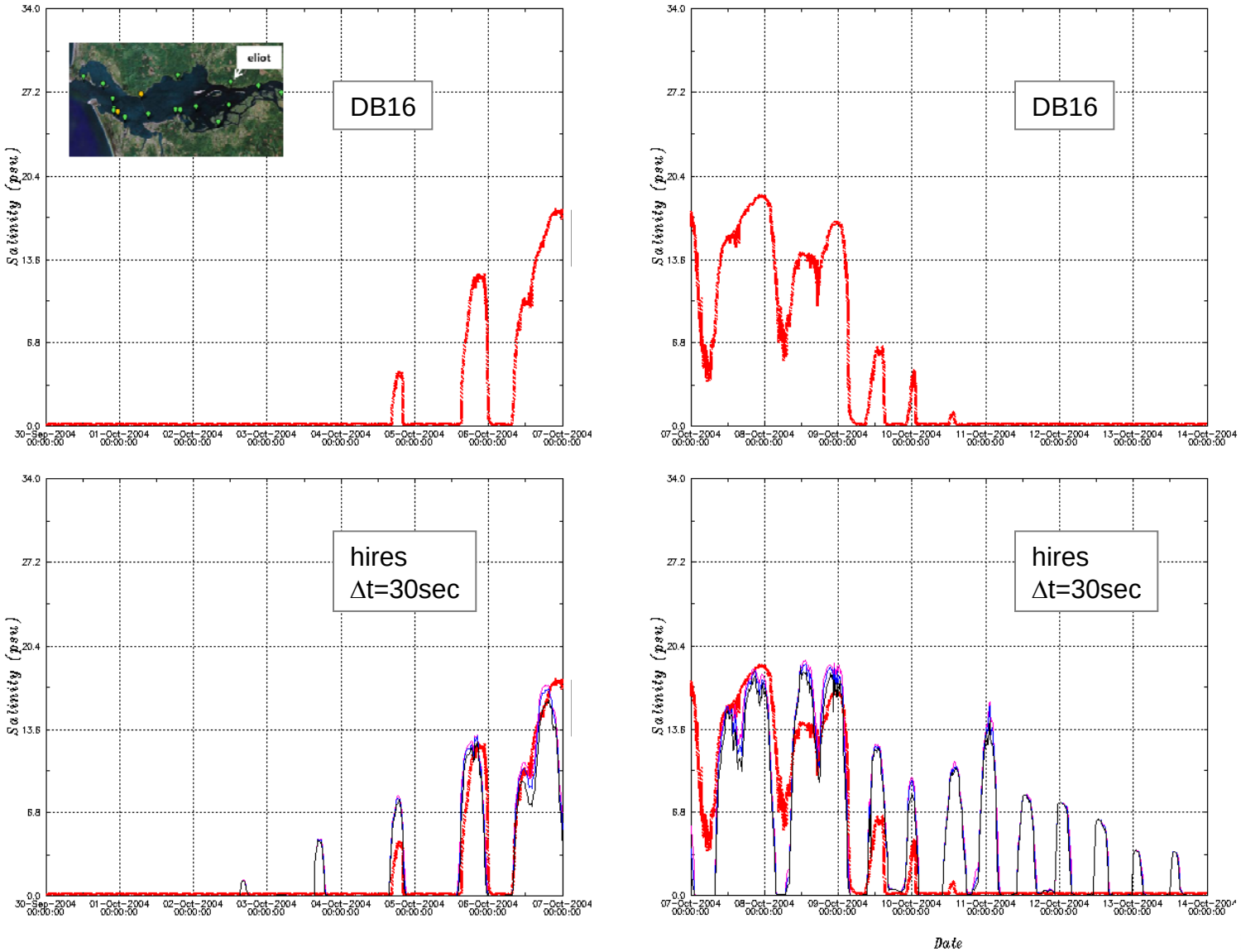


July 17 2008
09:59

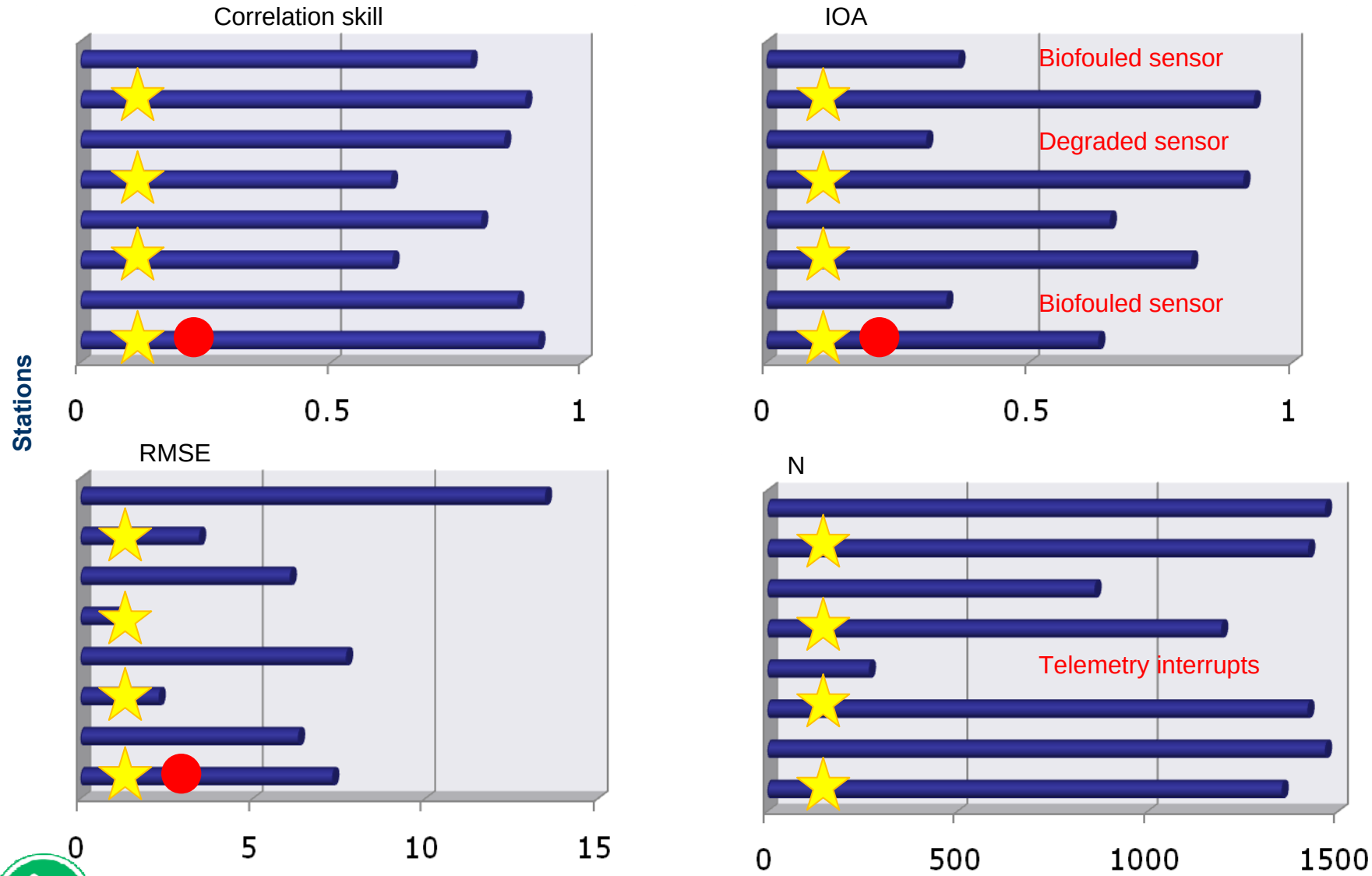
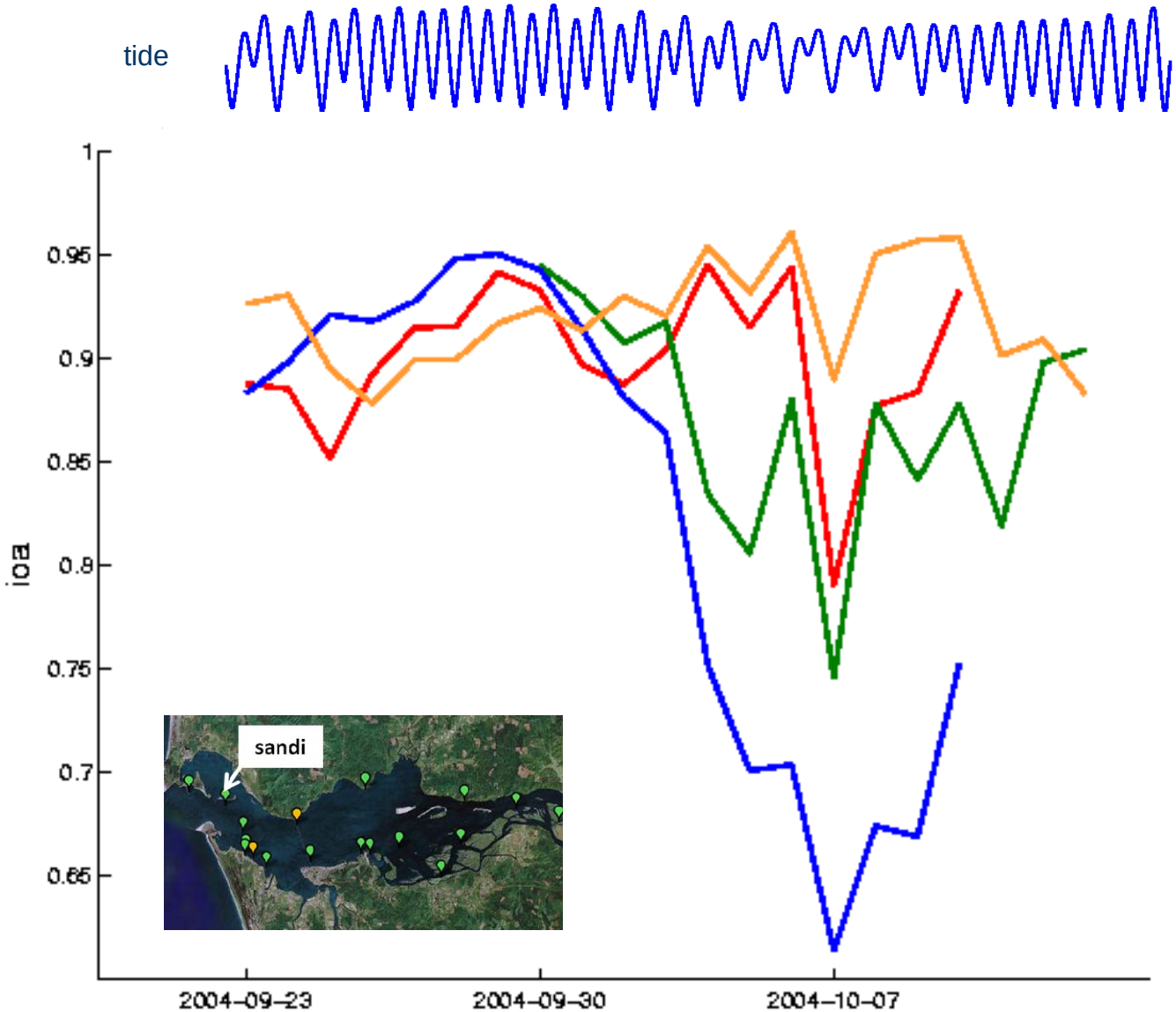




Model enhancement – episodic events



Forecast skill assessment (fhires; Sep 15-16, 2008)



Hindcast skill assessment (sandi; salinity; IOA)