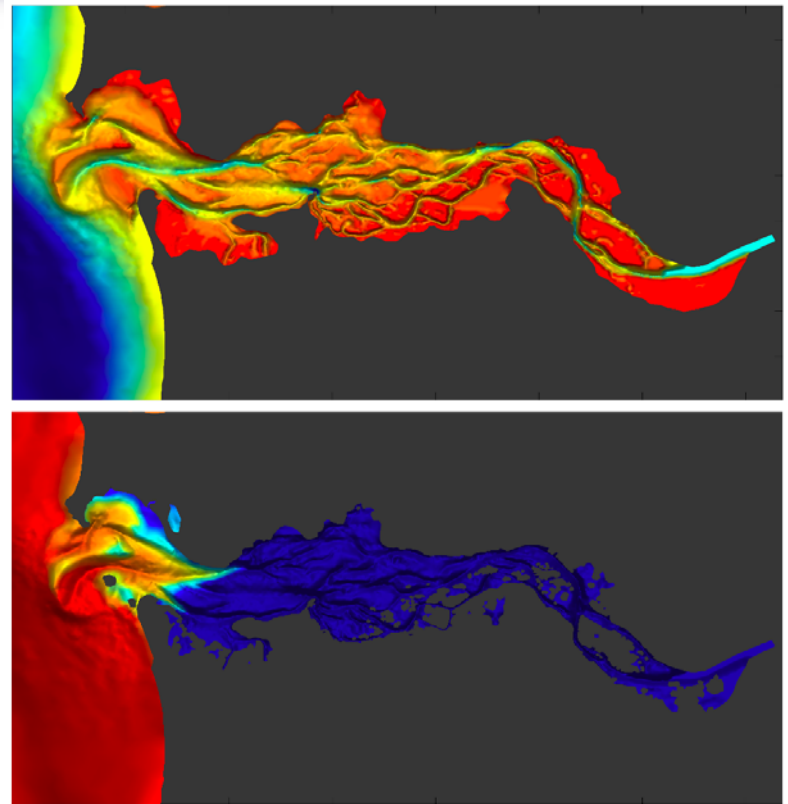


The Virtual Estuary: What can we learn from long-term datasets and modeling efforts?

Antonio Baptista

OHSU-CMOP

Presented by
Grant Law



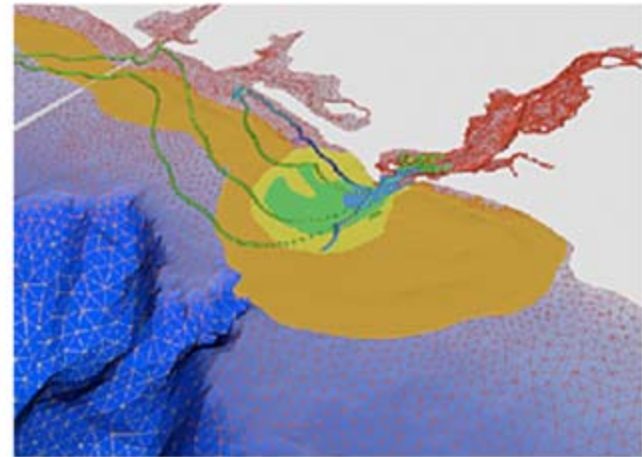
CMOP

Center For Coastal
Margin Observation
& Prediction

- Introduction (5 min)
- The components of the virtual estuary (10 min)
- Virtual estuary applications (25 min)
- Development of high-resolution estuary simulations (10 min)
- Questions/discussion (10 min)

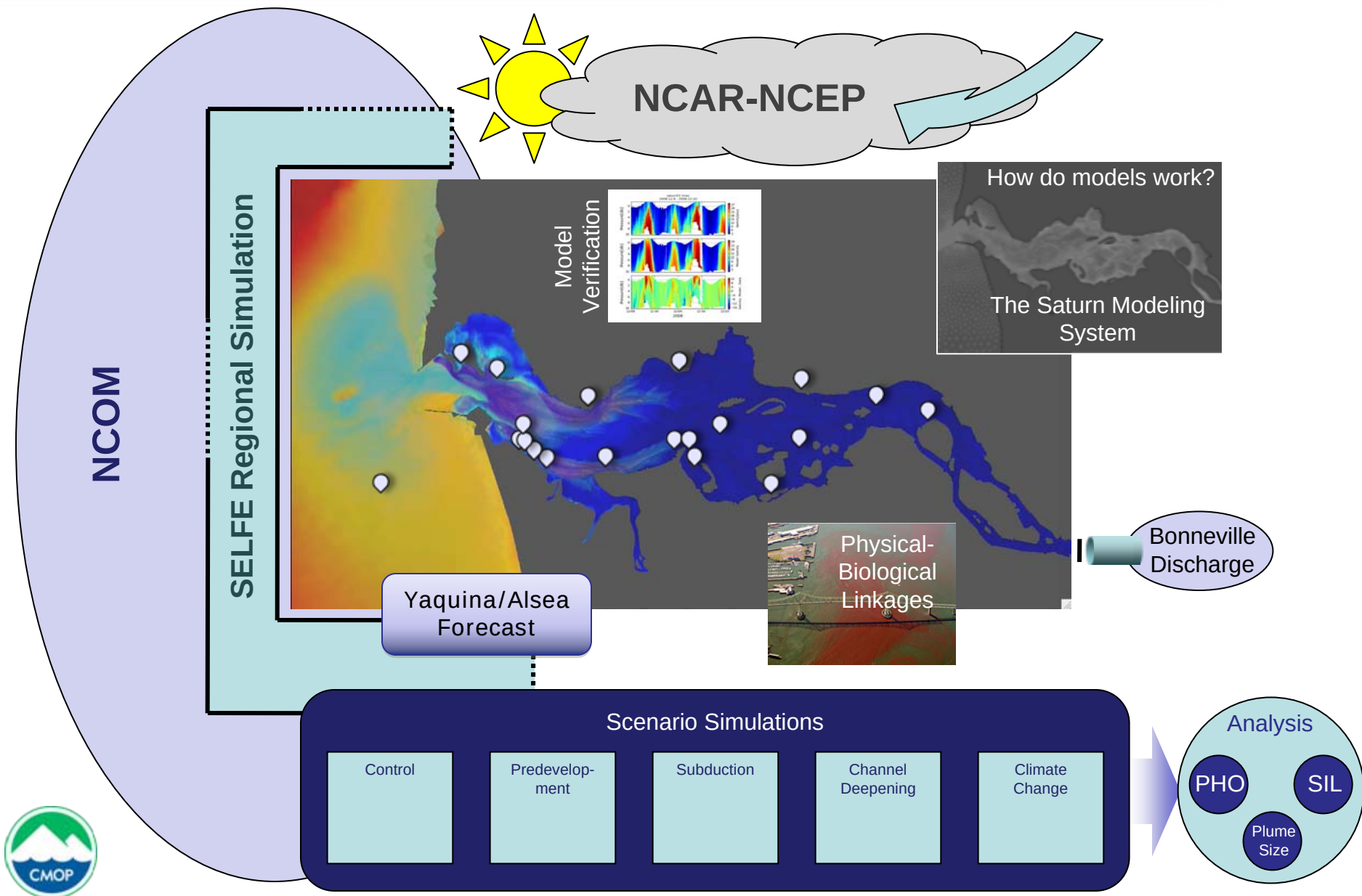
[Home](#) › [Data](#) ›

Virtual Columbia River



The Virtual Columbia River

3



A Virtual Estuary: What can we learn from long-term datasets and modeling efforts?

Antonio Baptista

OHSU-CMOP

Presented by
Grant Law

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Joe Cho
Nate Hyde
Grant Law

Cyber Team

David Hansen
Paul Turner
Charles Seaton
Alex Jaramillo



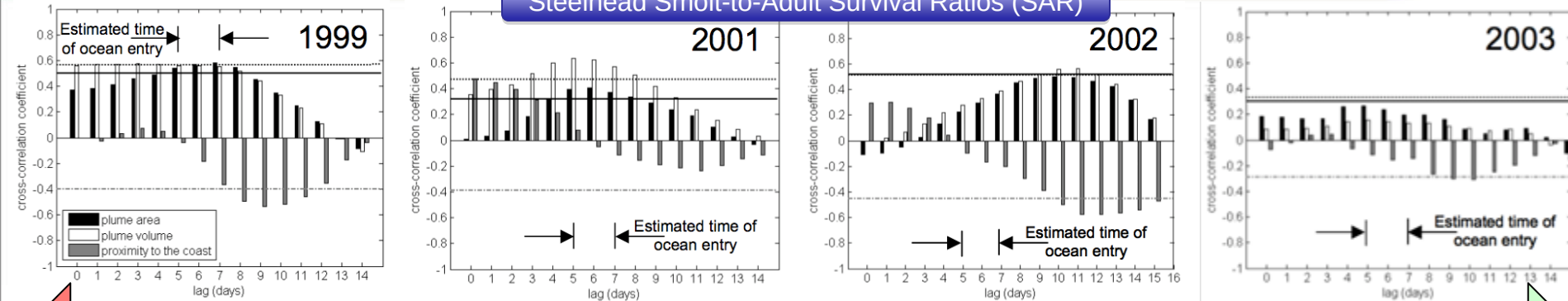
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& Prediction

Physical-Biological Linkages

5

Steelhead Smolt-to-Adult Survival Ratios (SAR)



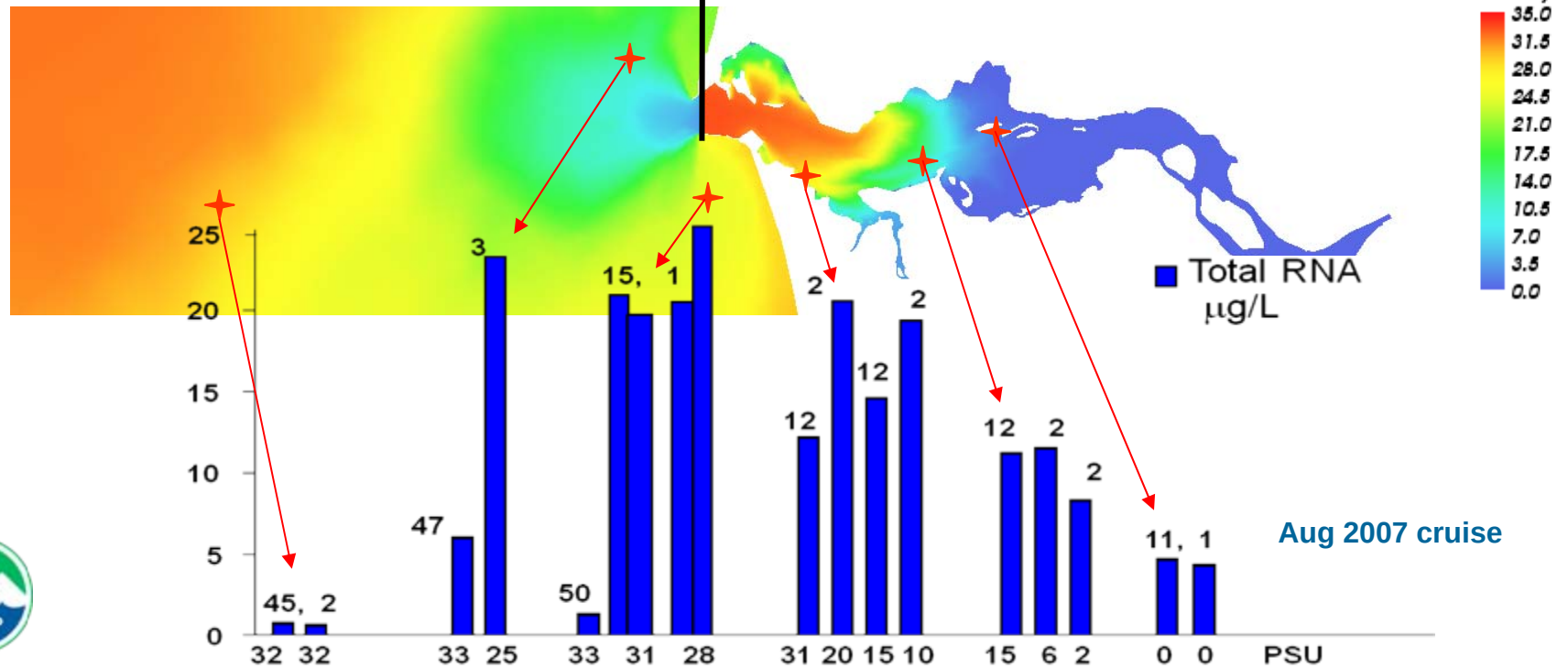
Poor

Large-Scale Ocean Conditions

Favorable

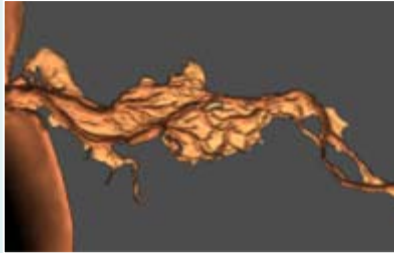
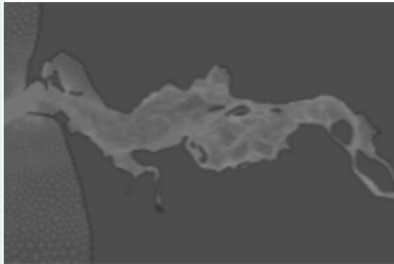
Minimum surface salinity
in the plume over cruise period

Maximum bottom salinity
in the estuary over cruise period



The SATURN Modeling System

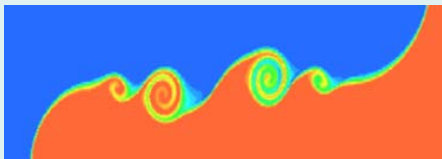
6



SATURN's modeling systems incorporate multiple lines of refinement concurrently:

- Domains and grids
- Codes and forcing
- Skill assessment

Encourages new technologies, such as the recently developed non-hydrostatic version of SELFE



Objective: To create a virtual Columbia River, a semi-operational modeling environment that comprehensively describes the 3D baroclinic circulation in the CR coastal margin, and selectively describes its function as an ecosystem

Daily forecasts

- Semi-operational
 - Run daily
- Self-redundant
- Skill assessed

<http://www.stccmop.org/virtualcolumbiariver/forecasts>

Simulation databases

- Decade plus
- Updated periodically
- Self-redundant
- Skill assessed

<http://www.stccmop.org/virtualcolumbiariver/simulationdatabases>

- Built for each simulation database
- Multiple observed & modeled variables
- Easy web access

<http://www.stccmop.org/virtualcolumbiariver/simulationdatabases/climatologicalatlas>

Climatological atlas

- Climate
- CSZ subduction
- Human impacts (water regulation, irrigation, navigation improvements, restoration)

Scenario simulations

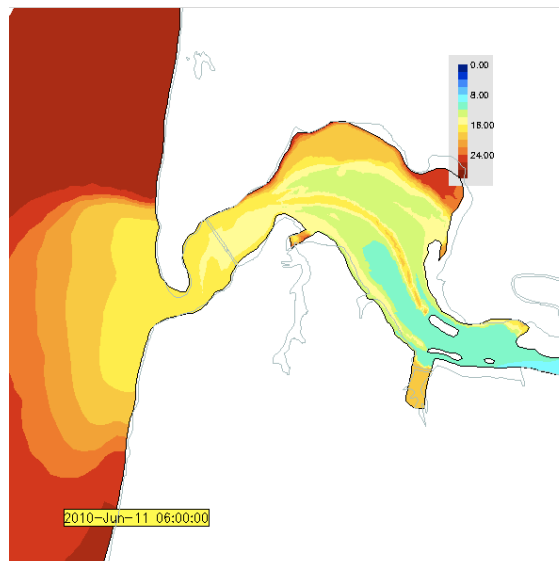
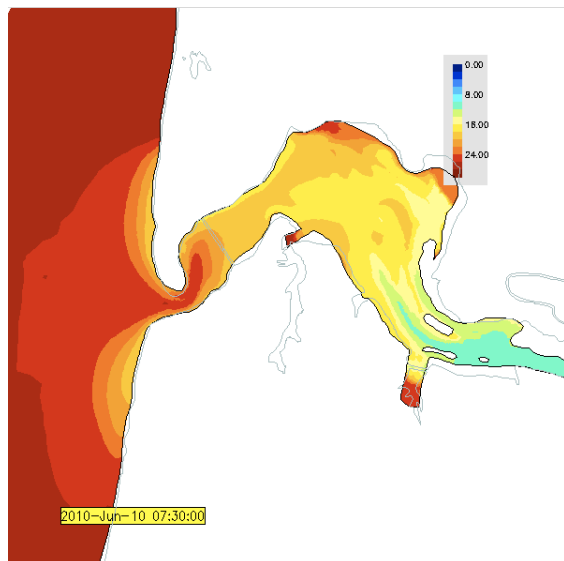
3D baroclinic circulation

The SATURN Modeling System

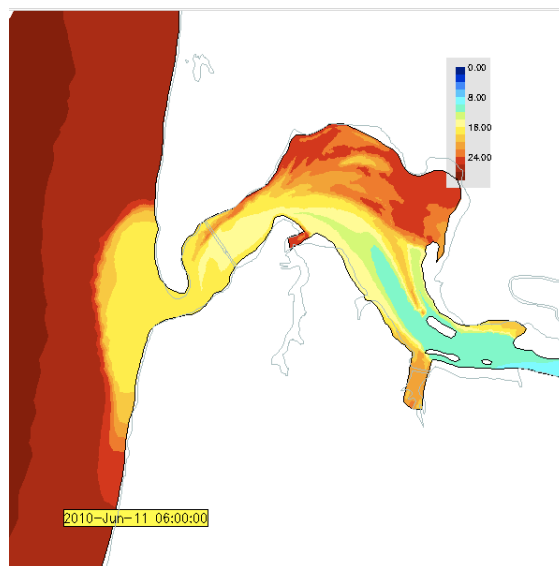
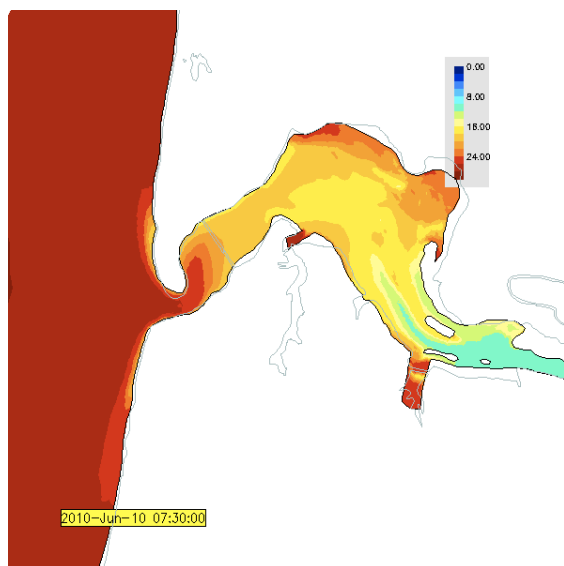
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Salinity

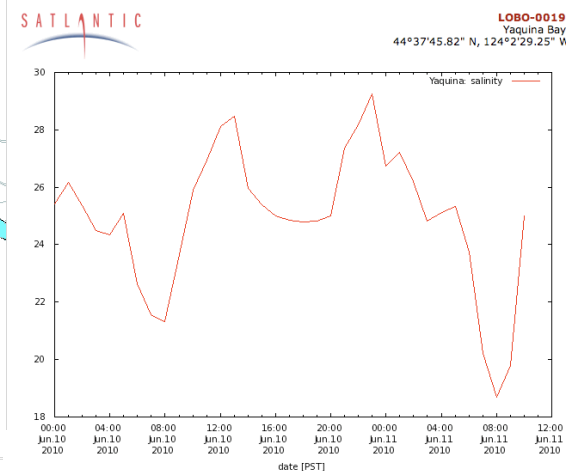
Surface



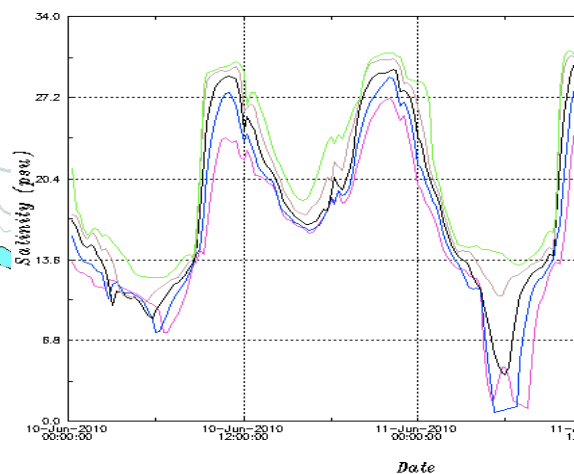
Bottom



Yaquina/Alsea Forecast:
currently active, but in need of
quality observational time-series
of salinity and temperature to
facilitate a full calibration effort

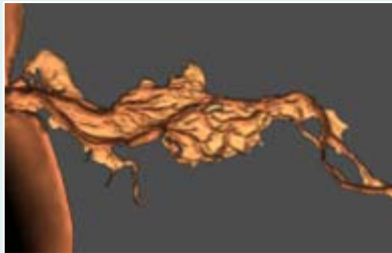
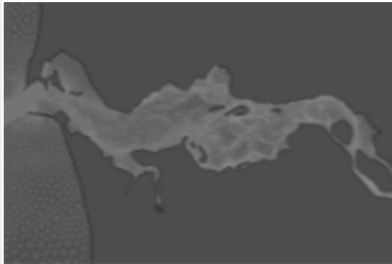


lob19



The SATURN Modeling System

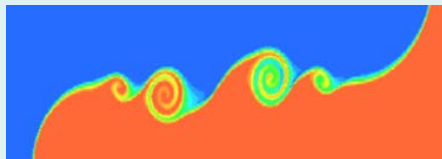
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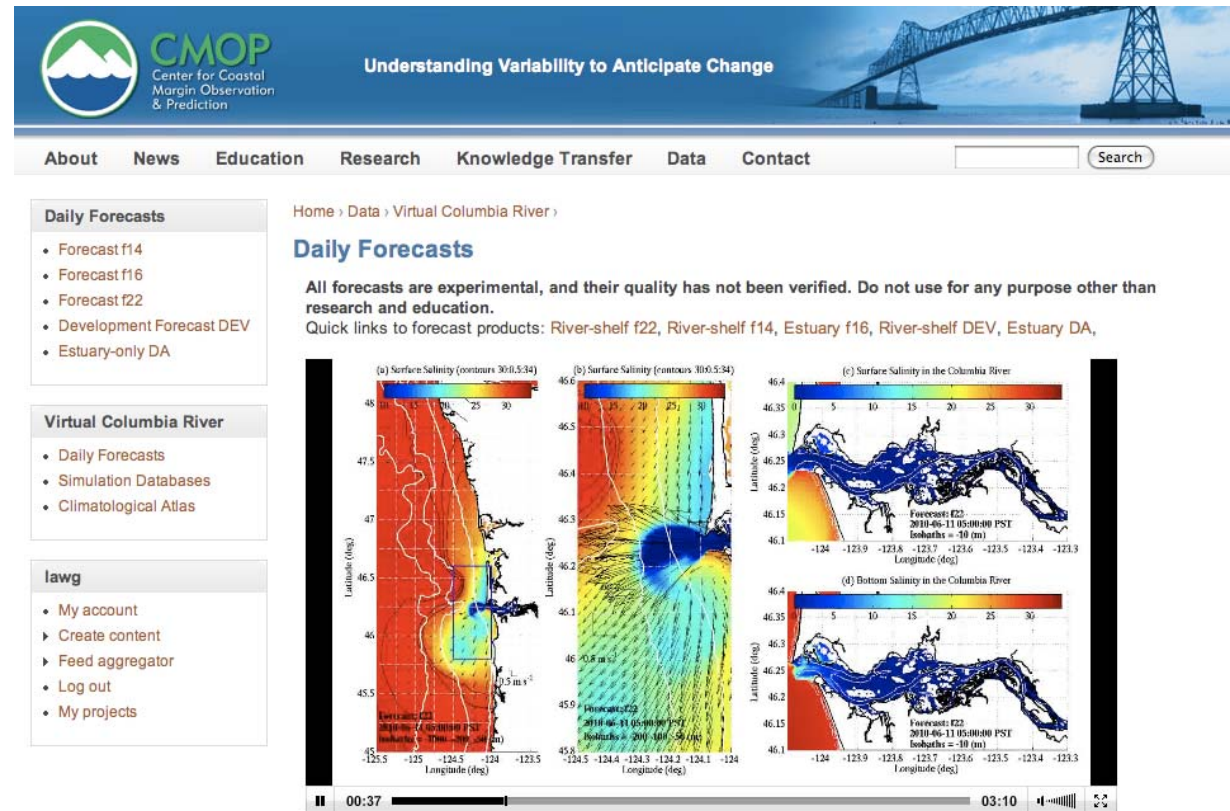
SATURN's modeling systems incorporate multiple lines of refinement concurrently:

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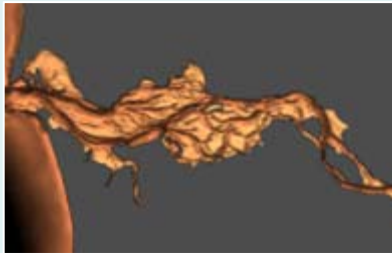
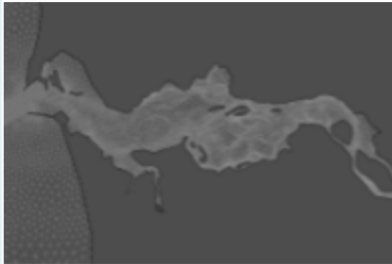
Forecasts: multiple daily forecasts of 4D (space-time) circulation. Used to assist near real-time planning and interpretation of scientific field campaigns. also contribute directly to the maintenance of the the virtual Columbia River simulation databases.



The salinity forecast animation above is for the current day and divided into four areas. The left side is a wide scale map of surface salinity. The image next to it is focused on the area around the plume. The top right shows the surface salinity and the lower right shows the bottom salinity in the Columbia River. Note: The animation above is best viewed using the full screen option of this flash player by clicking on the button in the lower right of the player. This animation is derived from the f22 forecast and is updated daily.

The SATURN Modeling System

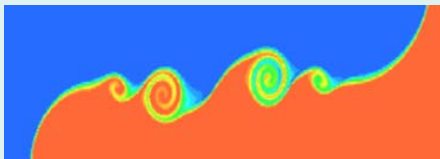
9



SATURN's modeling systems incorporate multiple lines of refinement concurrently:

- Domains and grids
- Codes and forcing
- Skill assessment

Encourages new technologies, such as the recently developed non-hydrostatic version of SELFE



Simulation Databases: includes self-redundant and skill-checked long-term simulation databases of 4D (space-time) circulation, designed to characterize contemporary variability and change. Provides the foundation for a Climatological Atlas of the Columbia River coastal margin



CMOP
Center for Coastal
Margin Observation
& Prediction

Understanding Variability to Anticipate Change



AboutNewsEducationResearchKnowledge TransferDataContact

Simulation Databases

- Database DB11
- Database DB14
- Database DB16
- Database DB22

Virtual Columbia River

- Daily Forecasts
- Simulation Databases
- Climatological Atlas

lawg

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Simulation Database 22

In-brief: This river-to-shelf simulation database is still in construction. It is designed to significantly improve the temperature skill in the estuary, relative to all prior databases. If successful, DB22 will replace DB14 as the reference for multi-year representation of plume dynamics and variability. Major changes relative to DB14 are in the treatment of side-node velocity conversions and of air-water heat exchange. ([Read more](#))

To access products, simply click on the  green square in the year and week range you are interested in.

Weeks	Week range	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1-4	Jan-01/Jan-28												
5-8	Jan-29/Feb-25												
9-12	Feb-26/Mar-25												
13-16	Mar-26/Apr-22												
17-20	Apr-23/May-20												
21-24	May-21/Jun-17												
25-28	Jun-18/Jul-15												
29-32	Jul-16/Aug-12												
33-36	Aug-13/Sep-09												
37-40	Sep-10/Oct-07												
41-44	Oct-08/Nov-04												
45-48	Nov-05/Dec-02												
49-52	Dec-03/Dec-30												
53	Dec-31												

Legend:

Completed and processed	
Run completed but not processed	
In queue	
Temporarily unavailable due to maintenance or disk failure	
Not available	

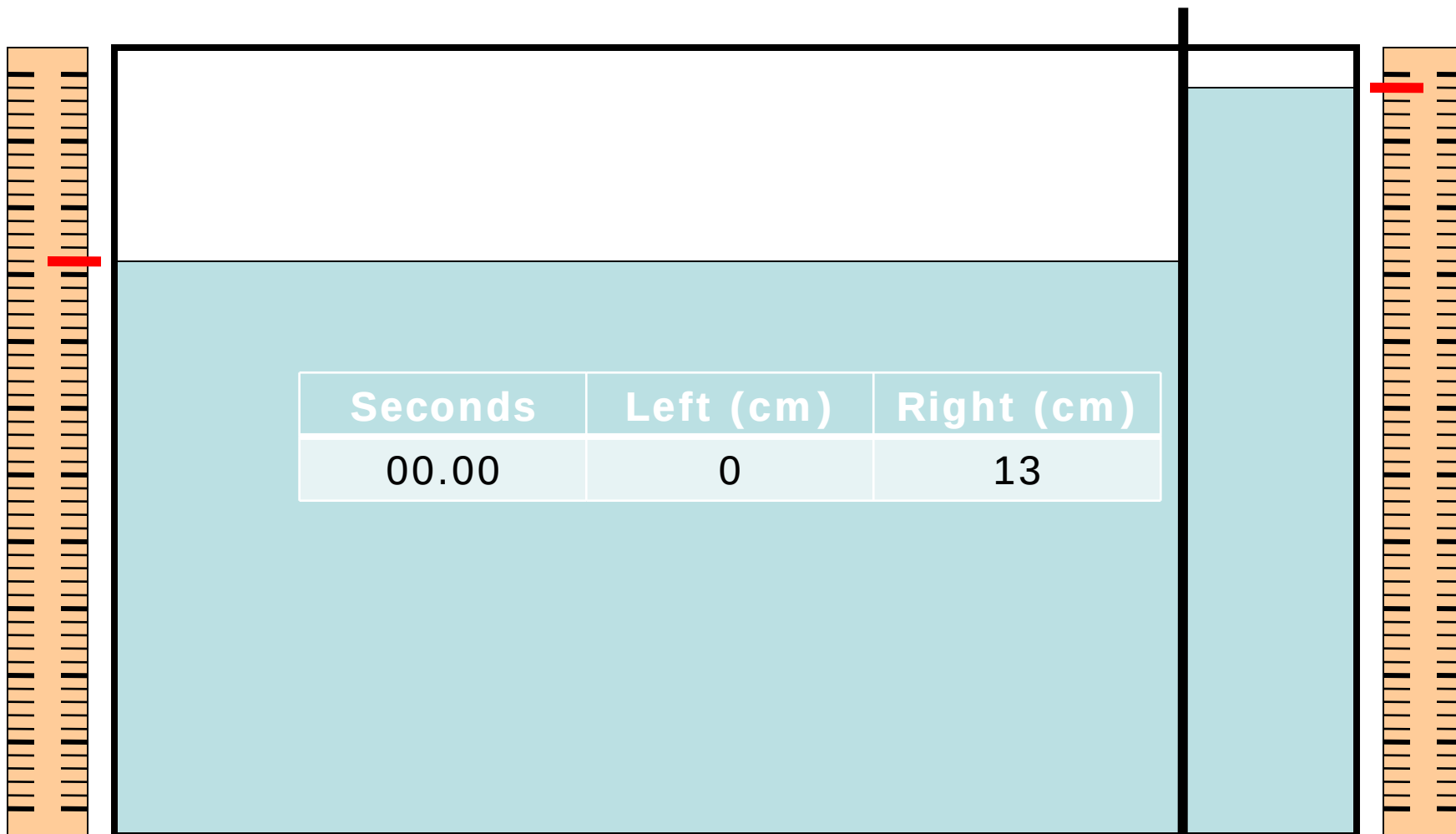
How do circulation models work?

10



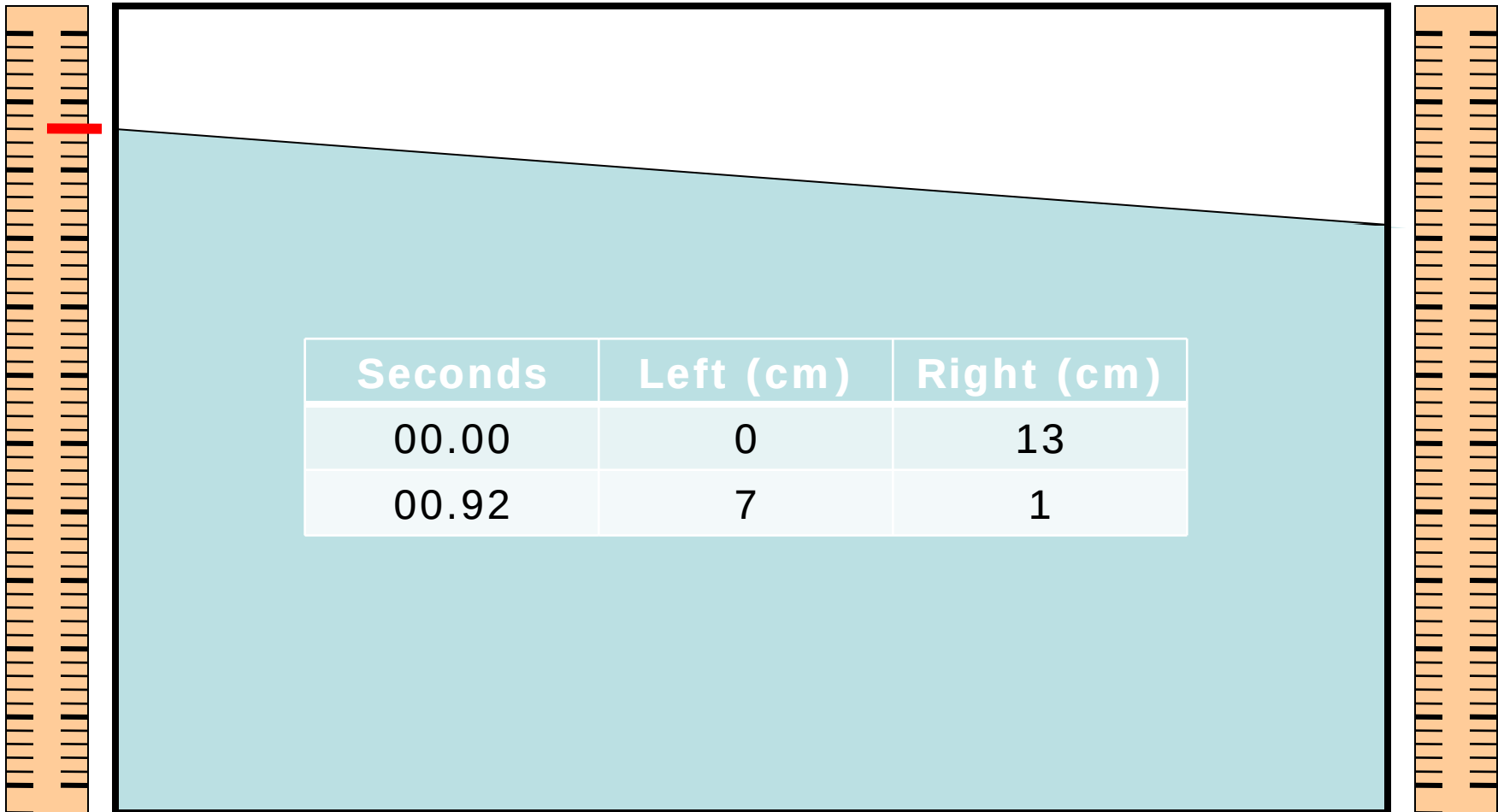
How do circulation models work?

11



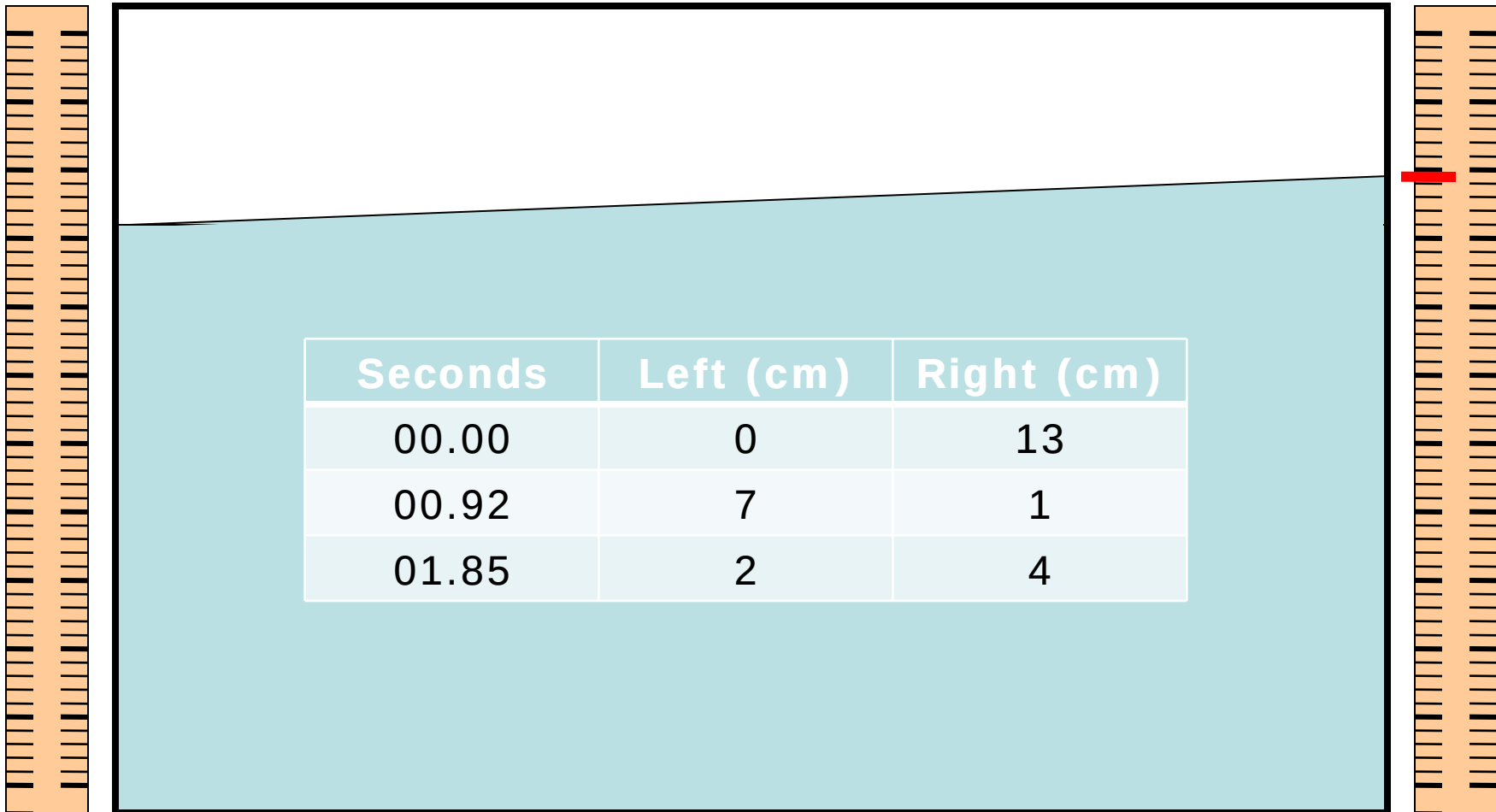
How do circulation models work?

12



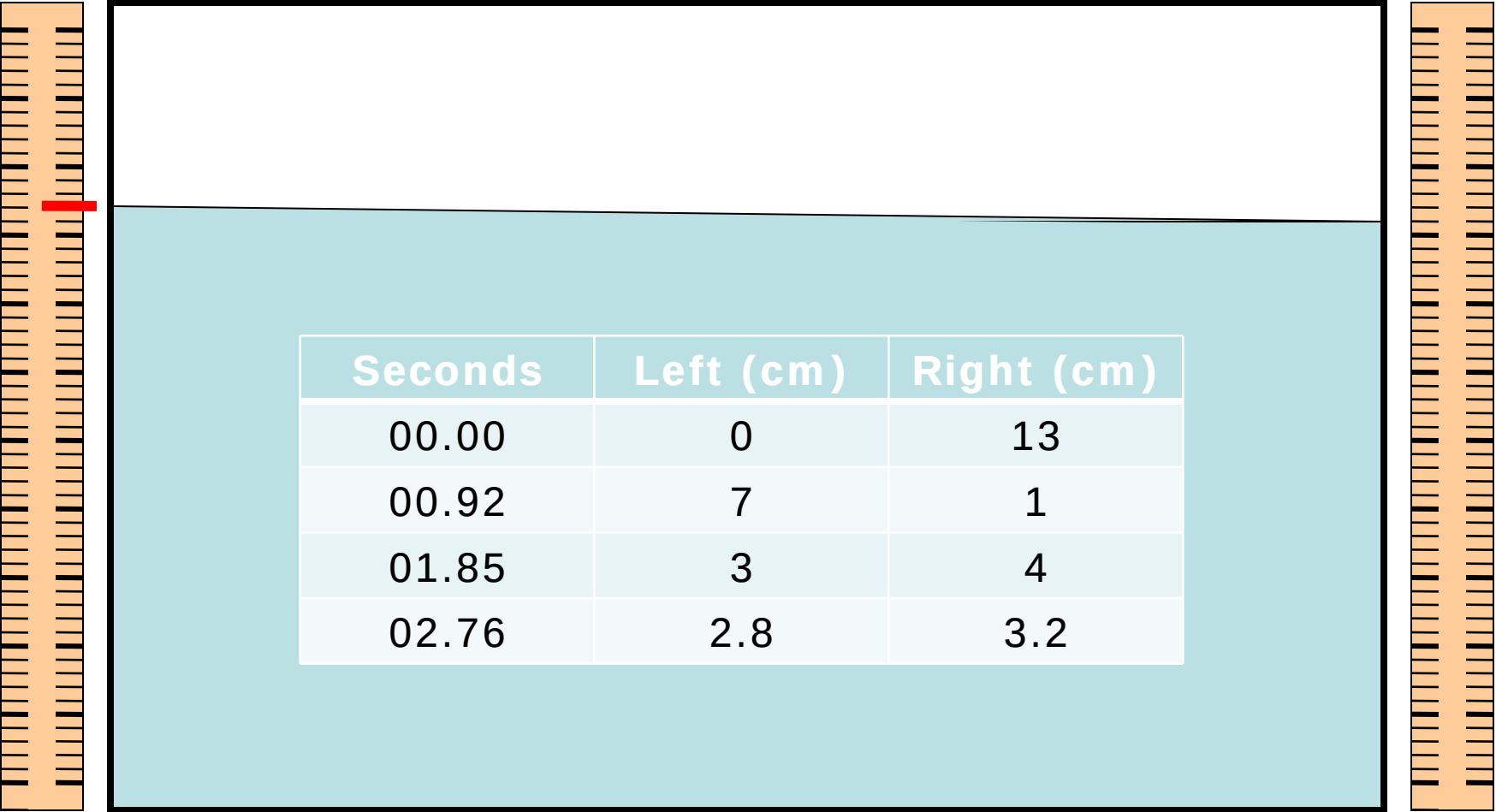
How do circulation models work?

13



How do circulation models work?

14

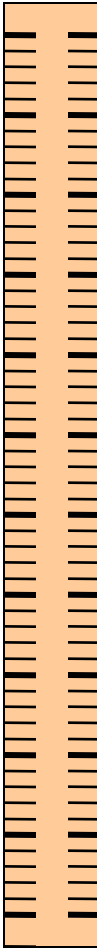
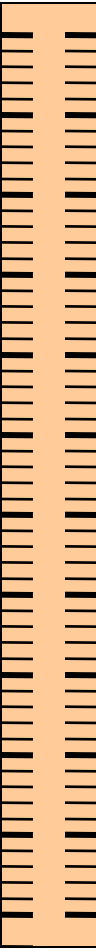


The diagram shows a rectangular tank with a light blue liquid. A white rectangular area is at the top. Two vertical rulers are on the left and right sides. The left ruler has a red horizontal line at the 13 cm mark. The right ruler has a red horizontal line at the 1 cm mark. A table is centered in the tank, showing data for time, left position, and right position.

Seconds	Left (cm)	Right (cm)
00.00	0	13
00.92	7	1
01.85	3	4
02.76	2.8	3.2

How do circulation models work?

15

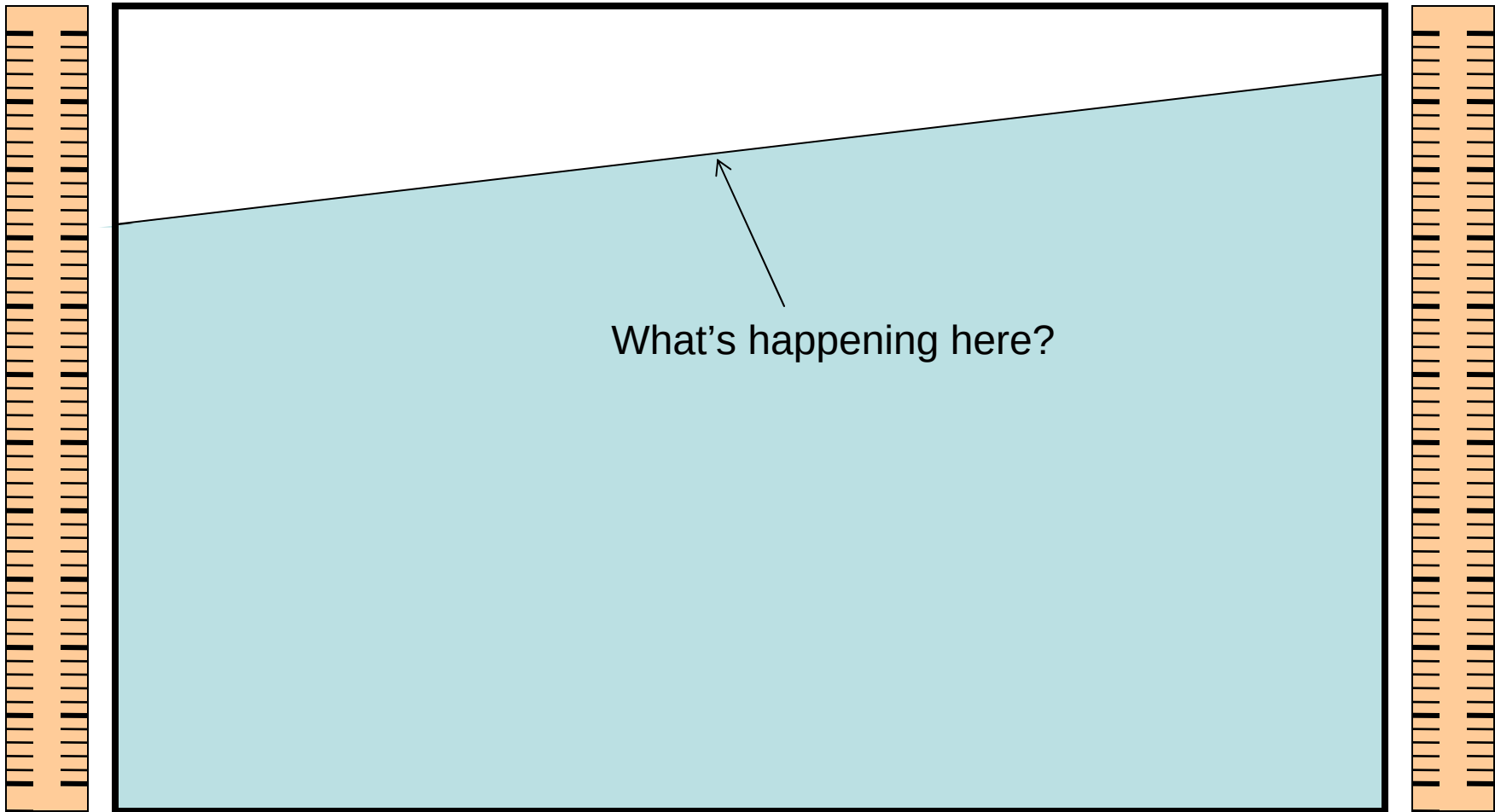


Seconds	Left (cm)	Right (cm)
00.00	0.0	13.0
00.92	7.0	1.0
01.85	2.0	4.0
02.76	2.8	3.2
03.69	3.0	3.0



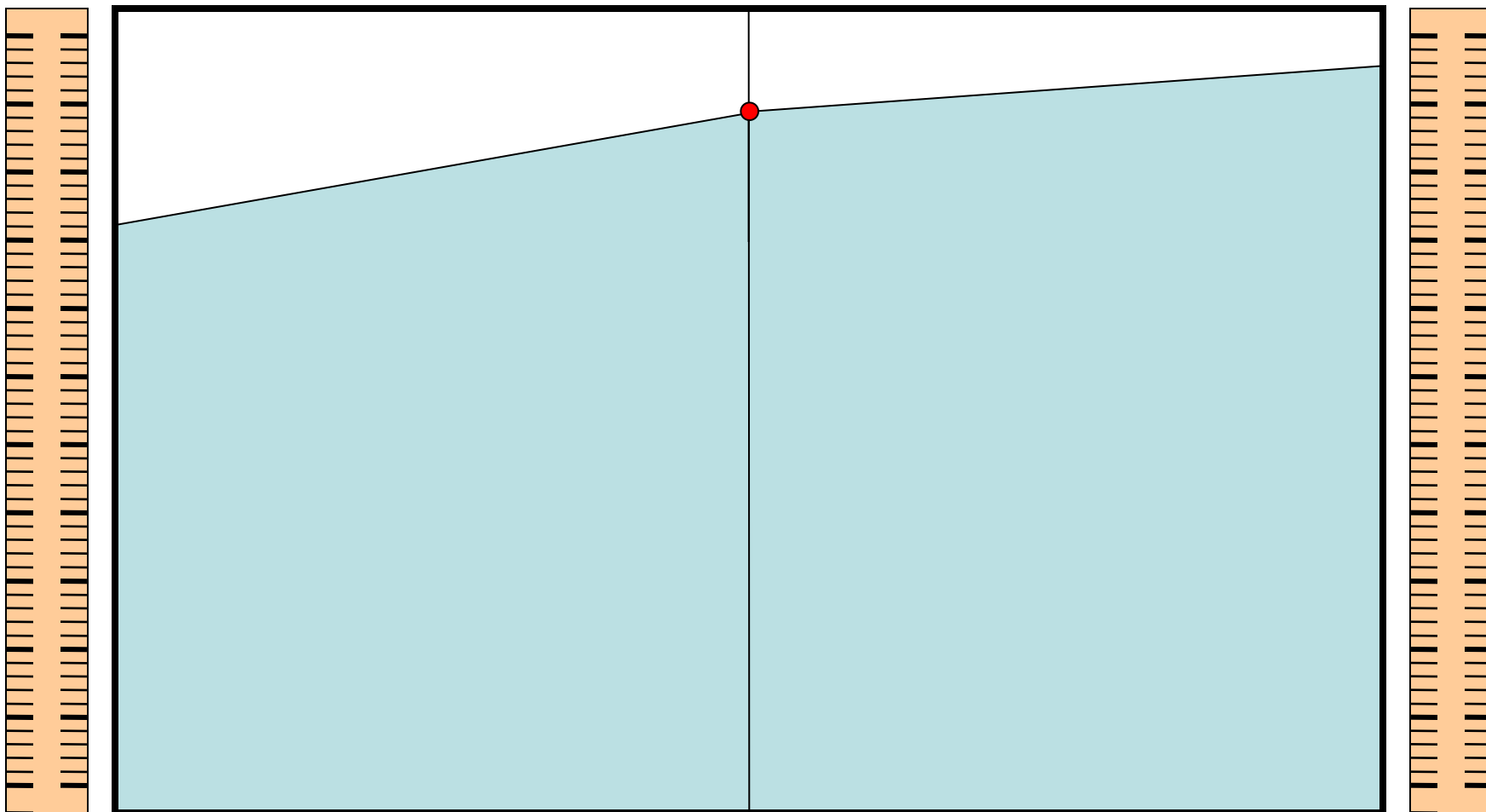
How do circulation models work?

16



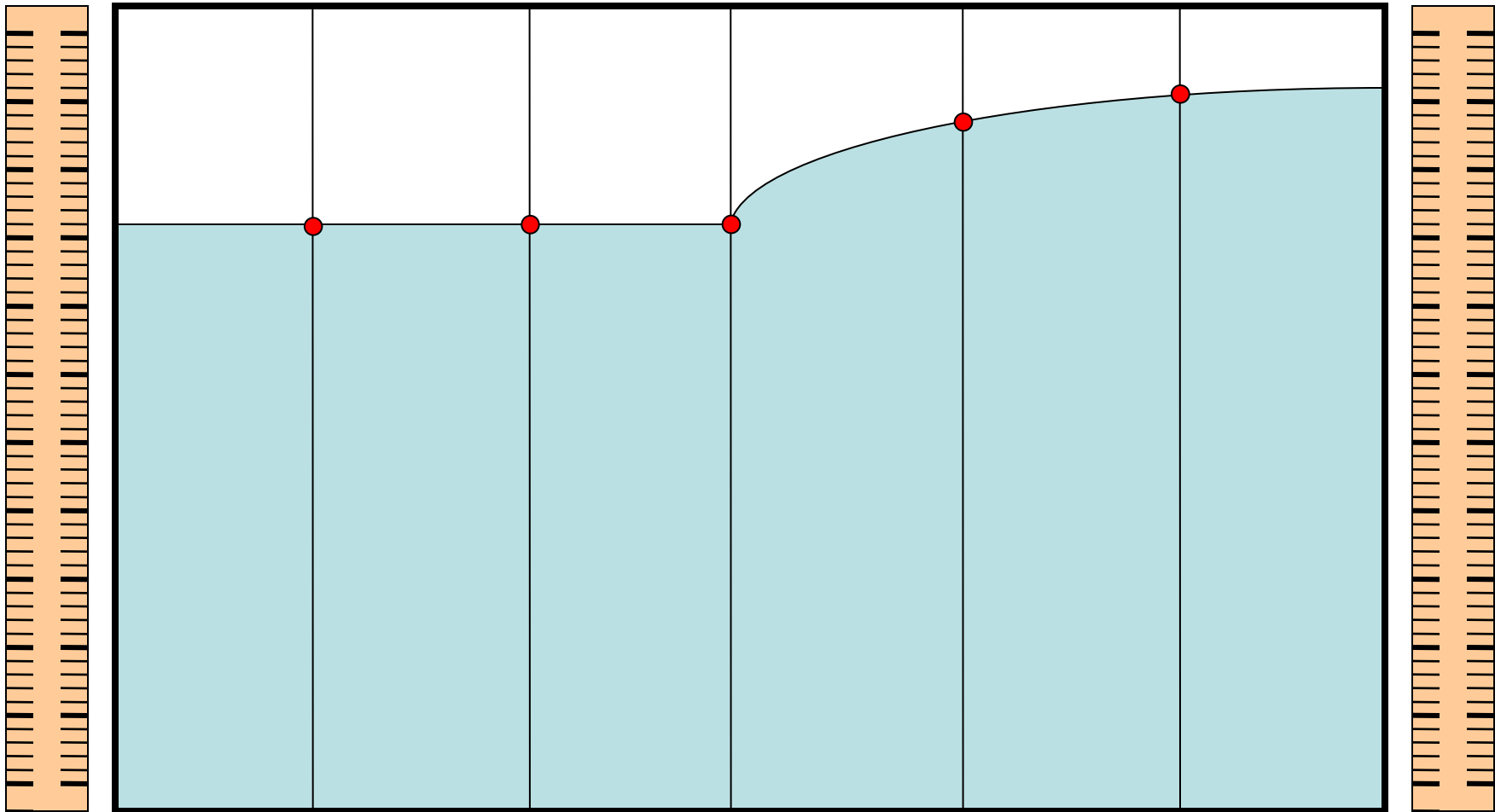
How do circulation models work?

17



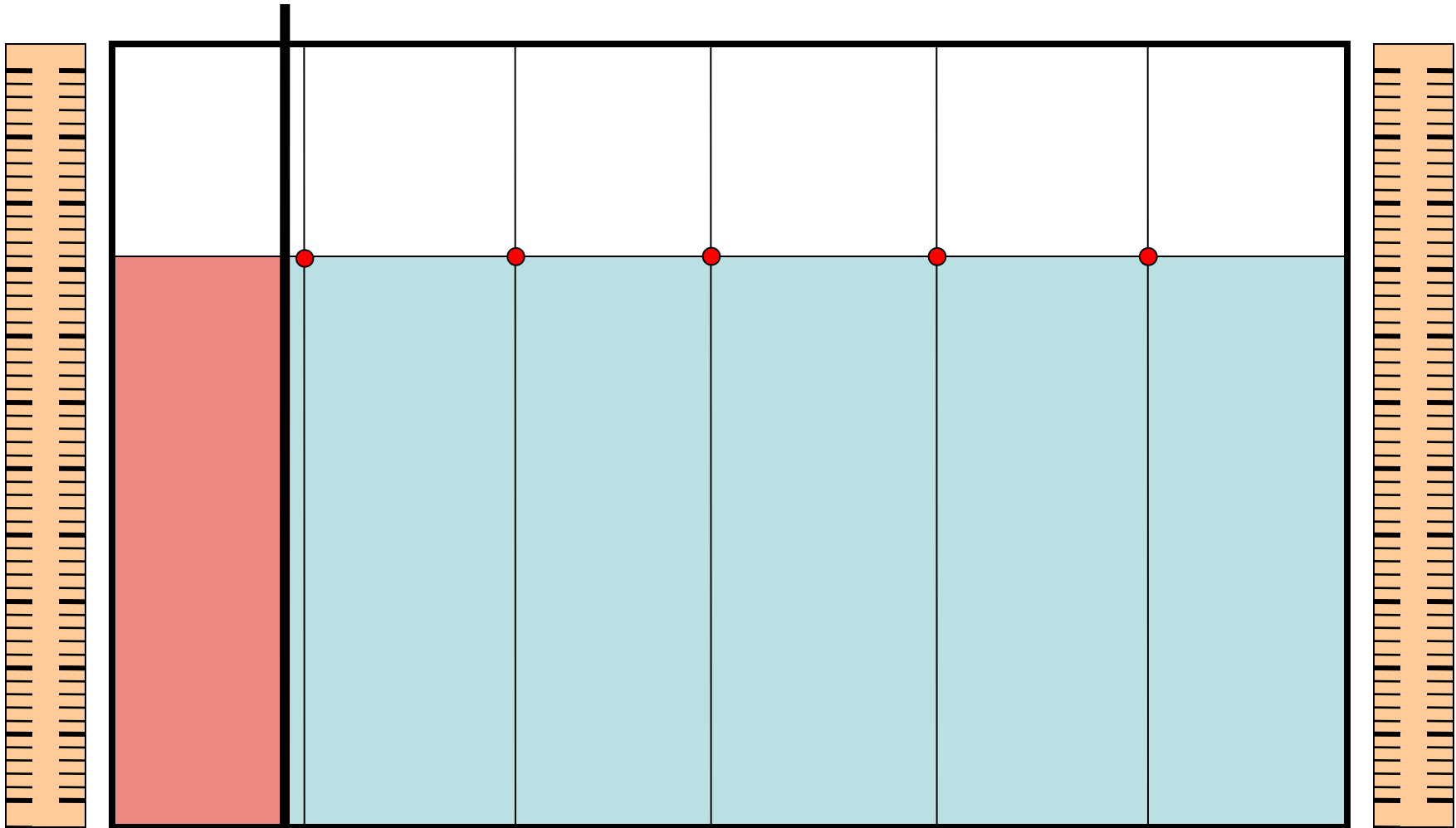
How do circulation models work?

18



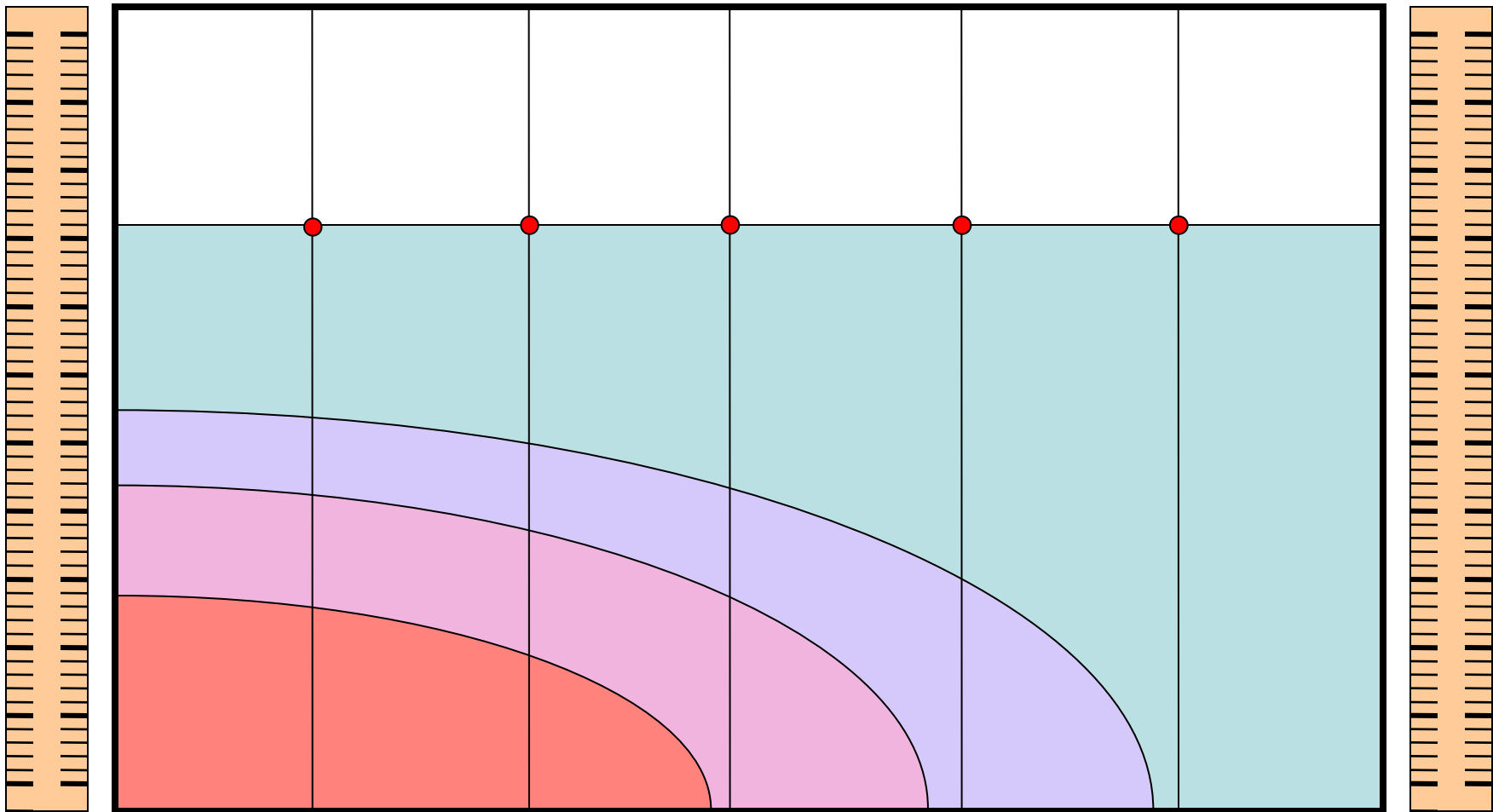
How do circulation models work?

19



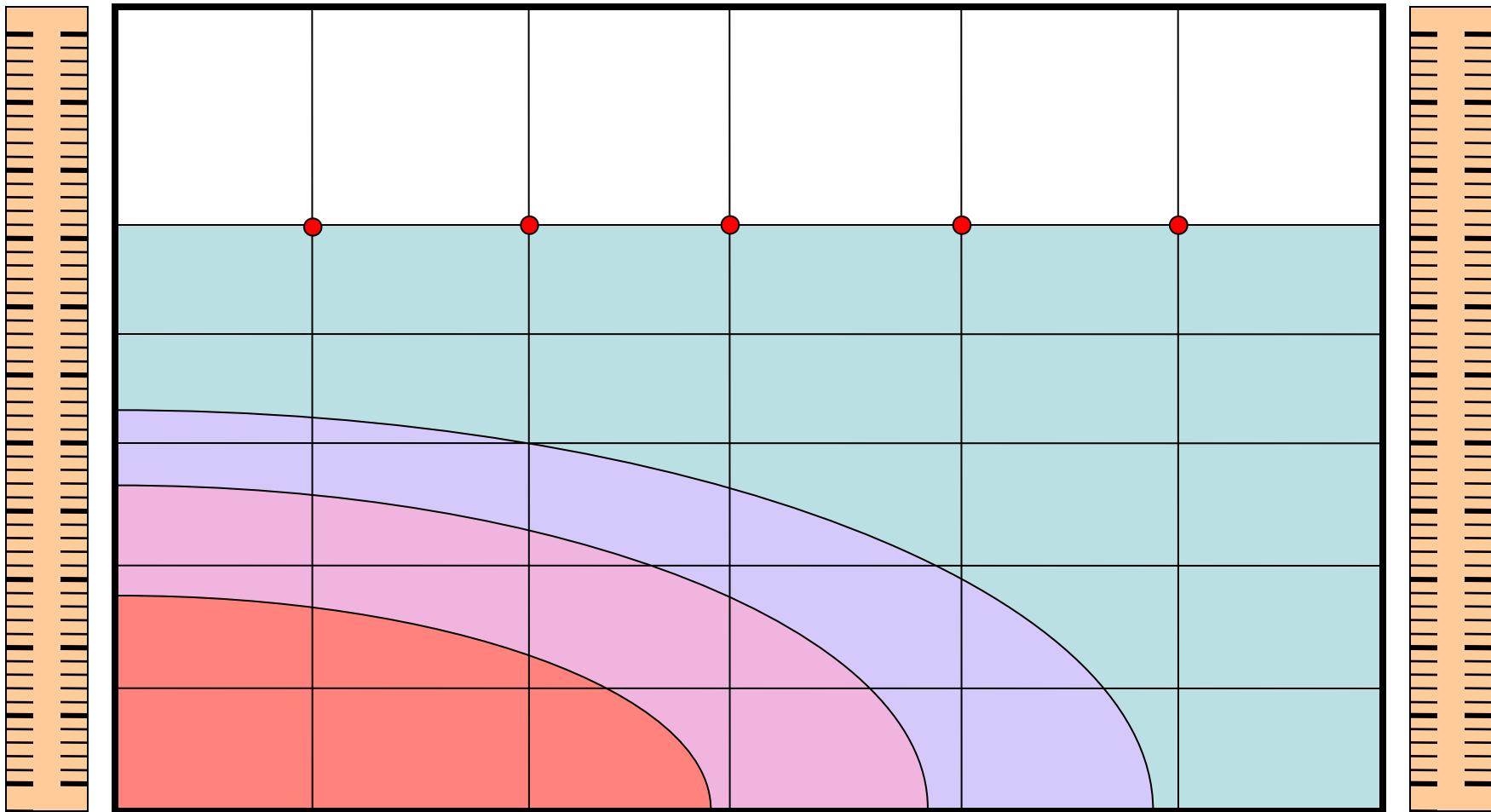
How do circulation models work?

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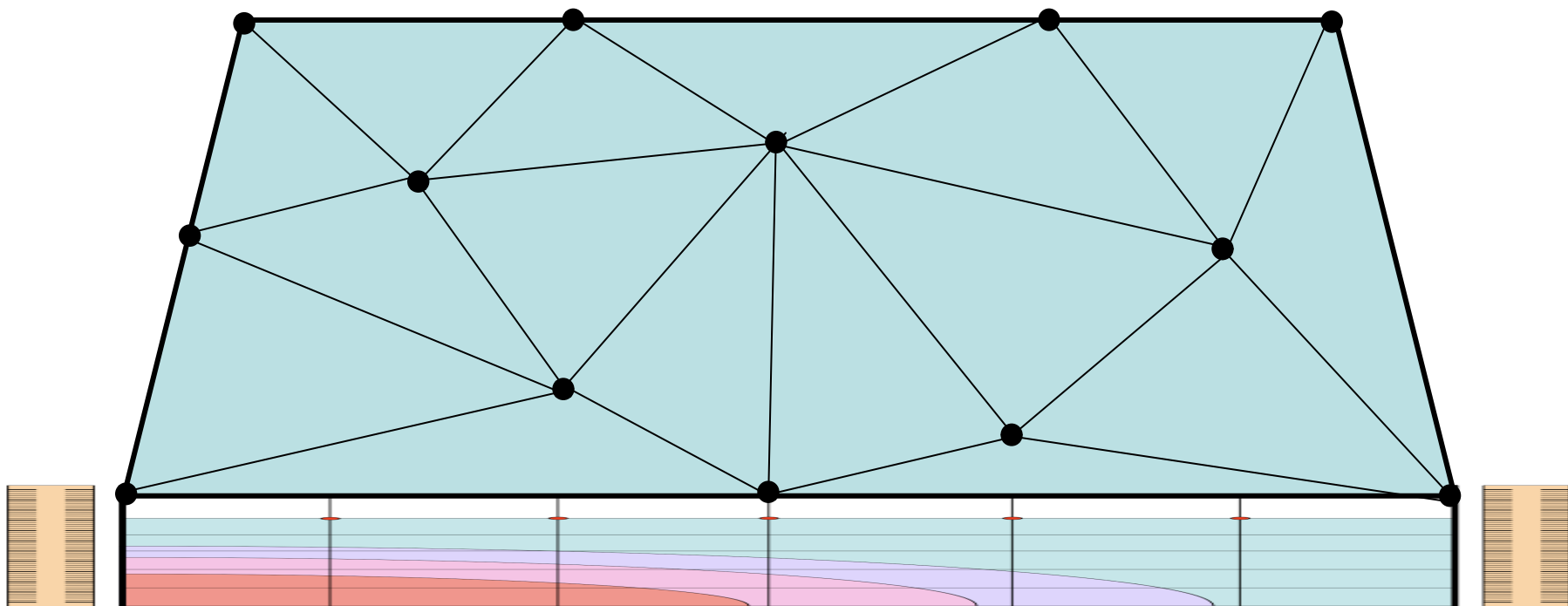
How do circulation models work?

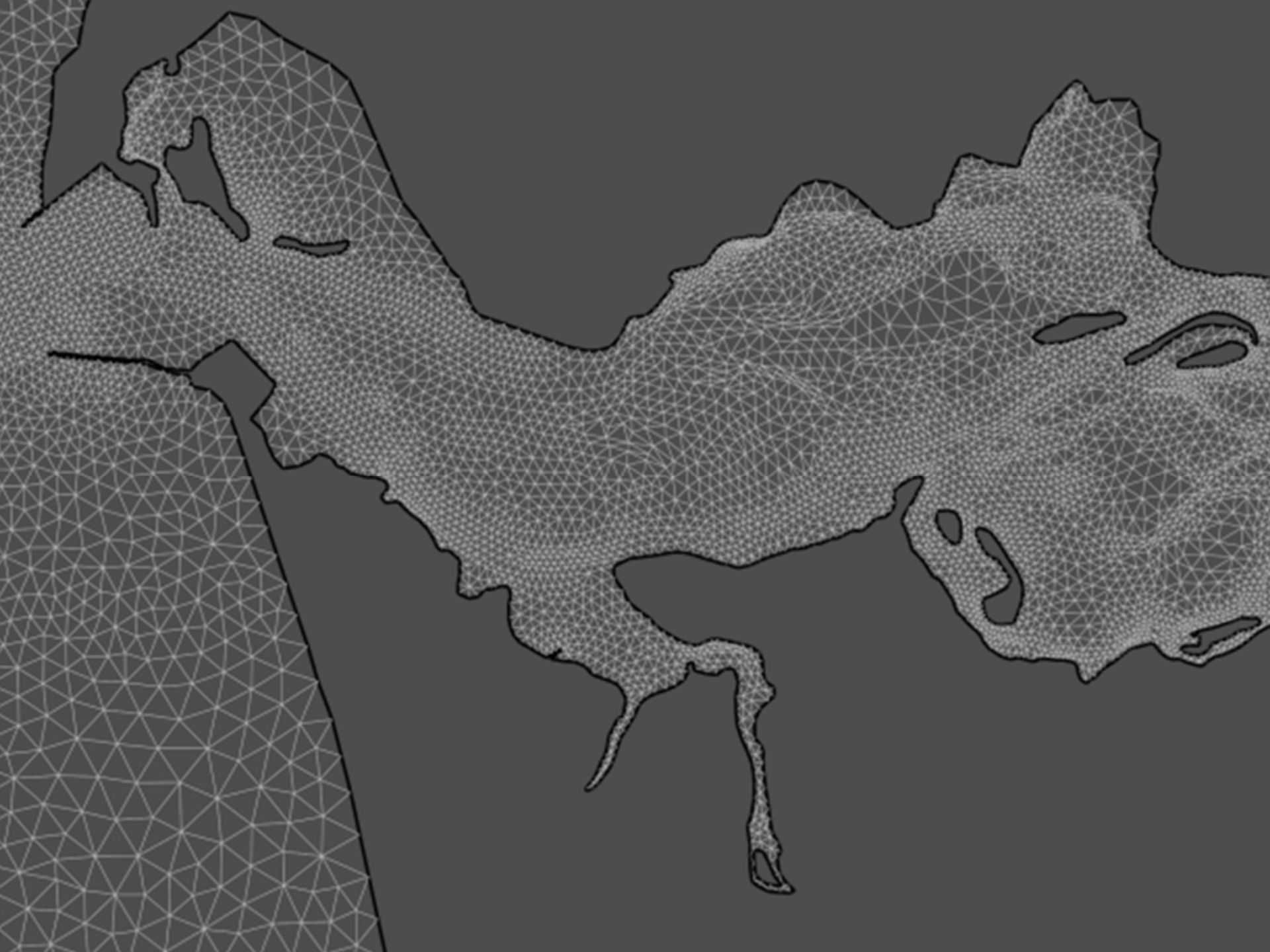
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How do circulation models work?

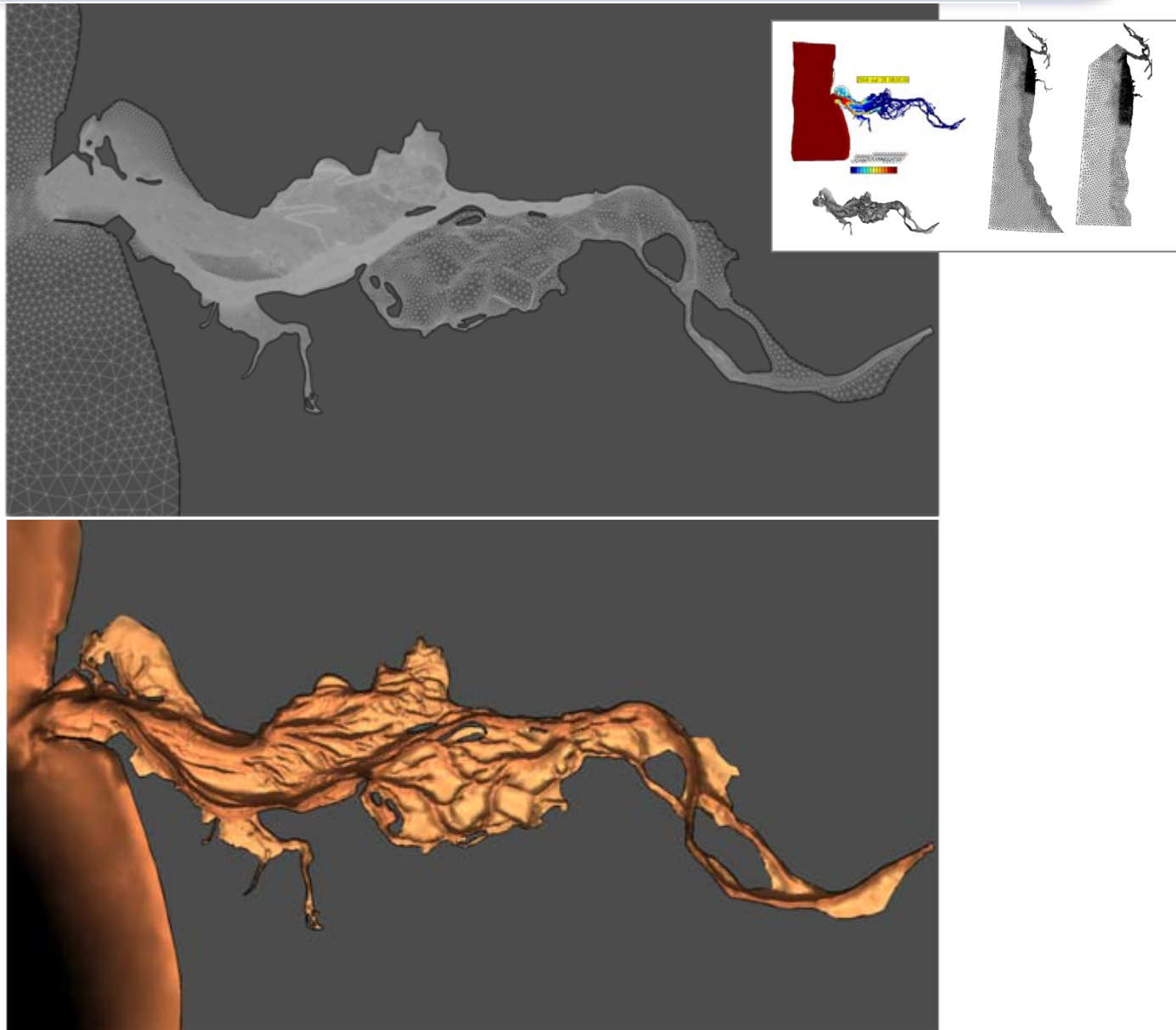
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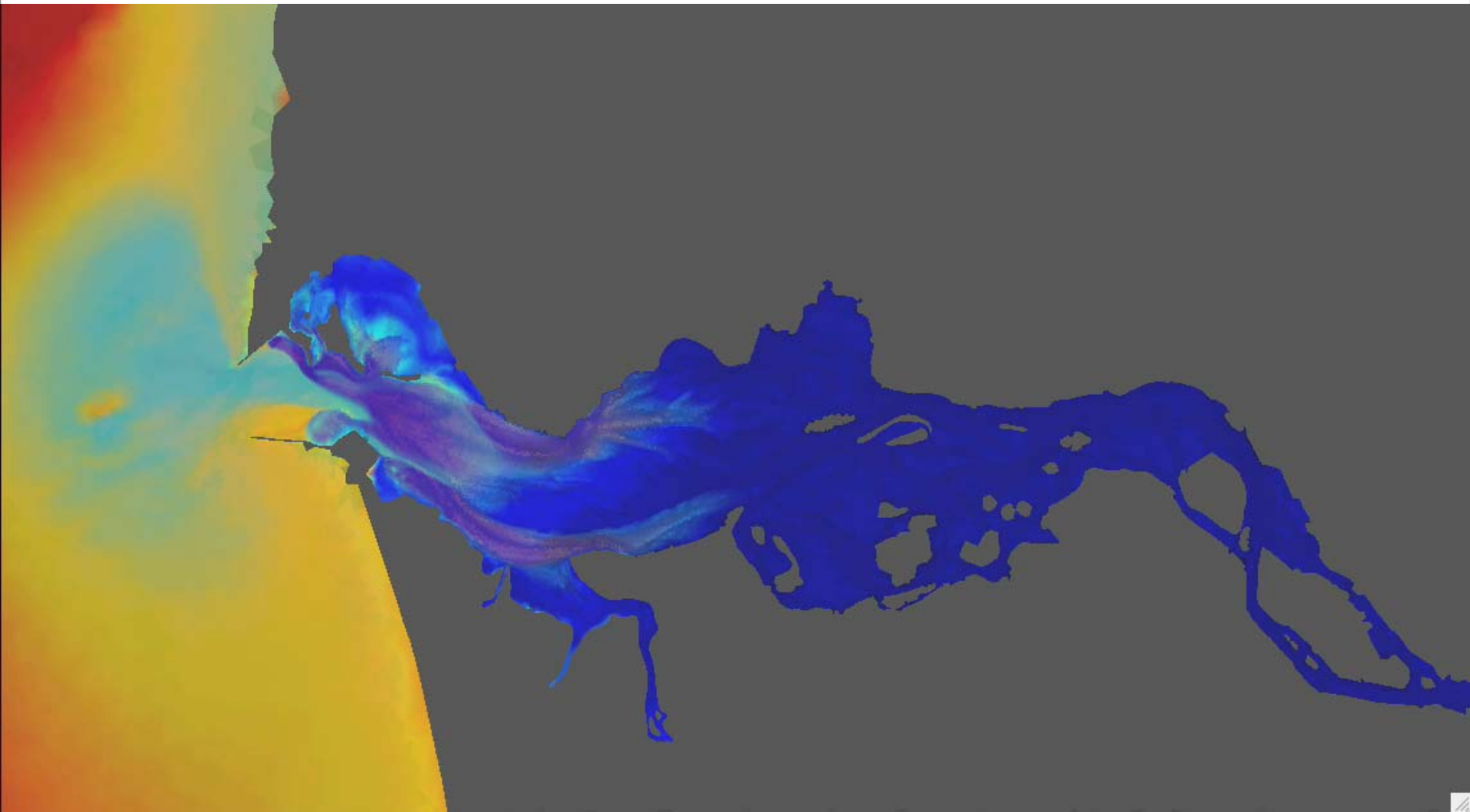
How do circulation models work?

24



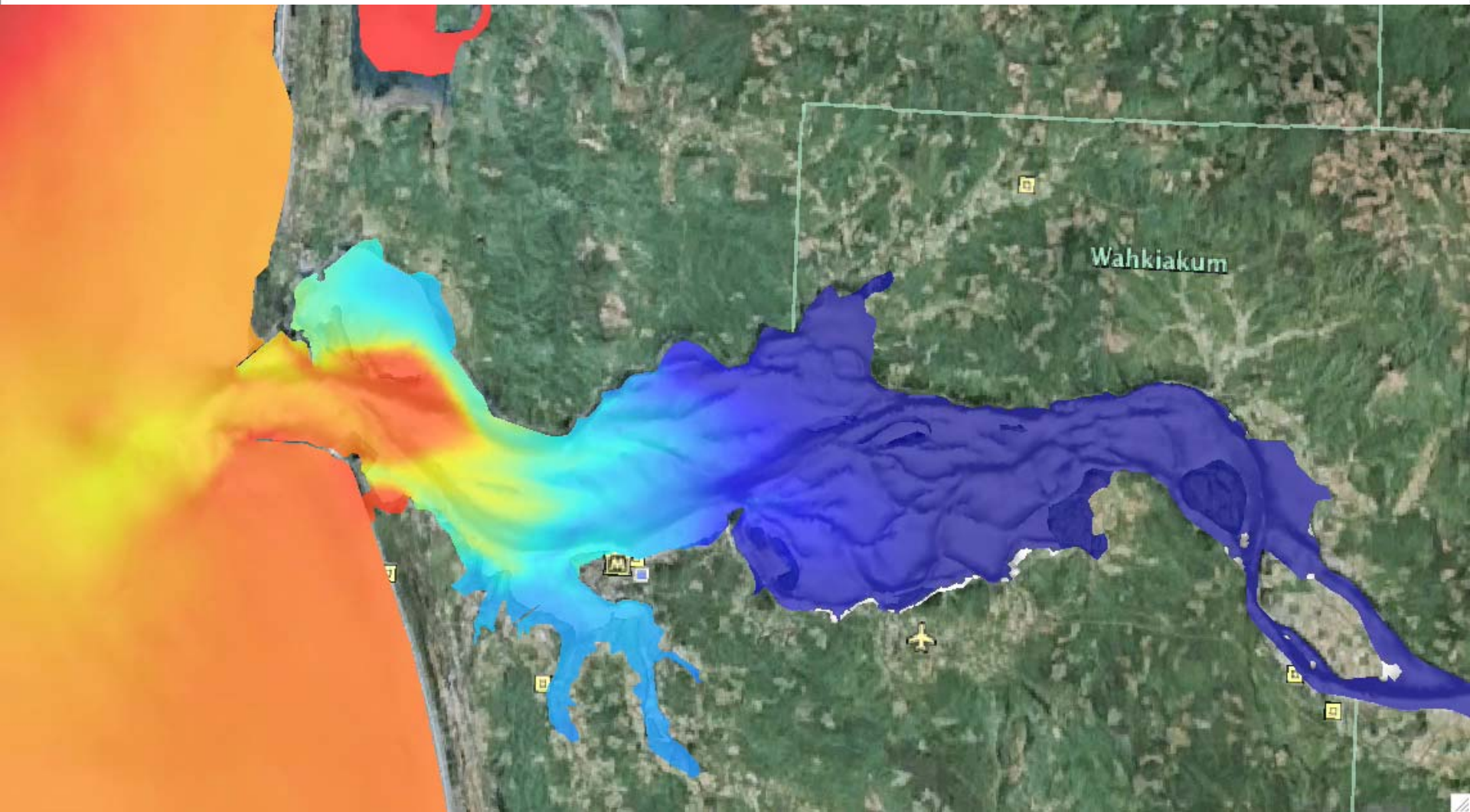
How do circulation models work?

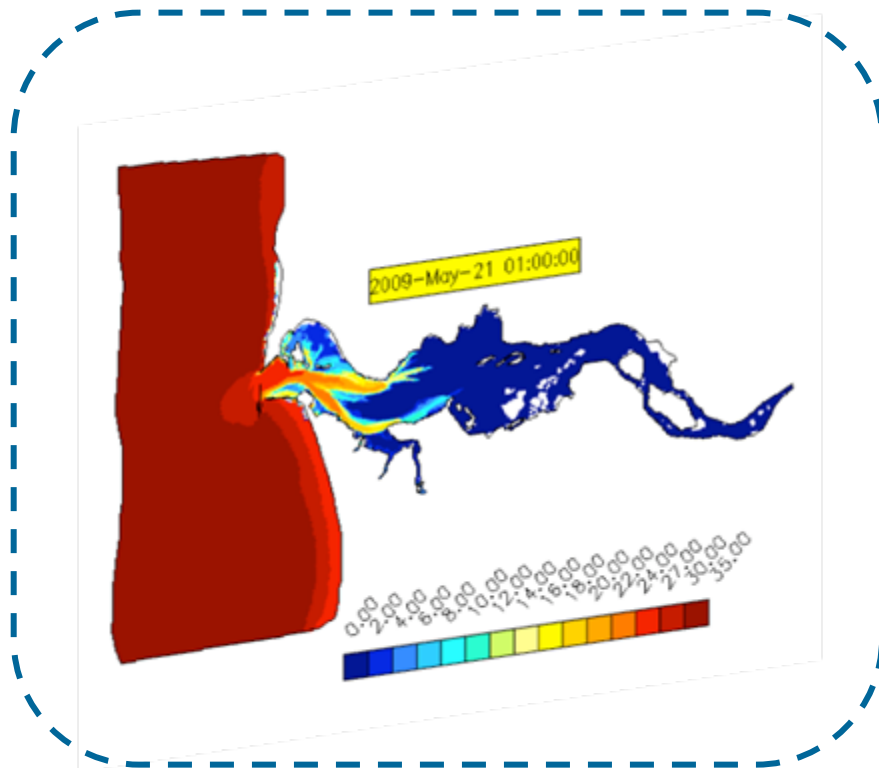
25



How do circulation models work?

26

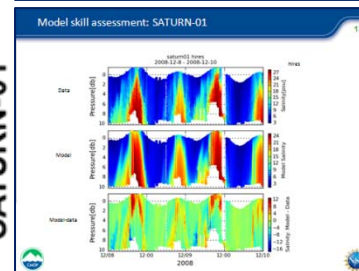




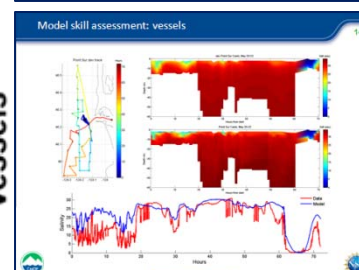
Endurance



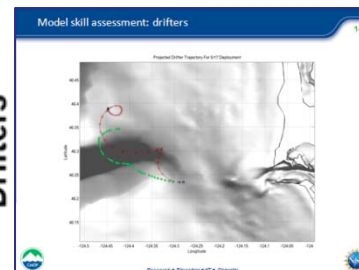
SATURN-01



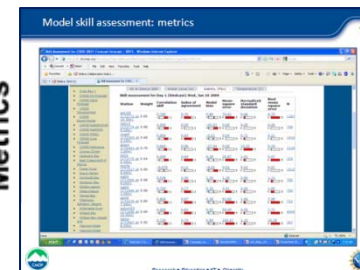
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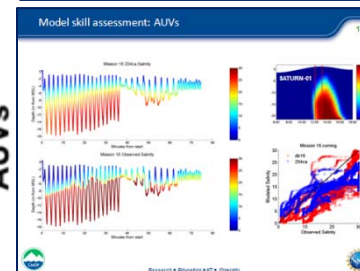
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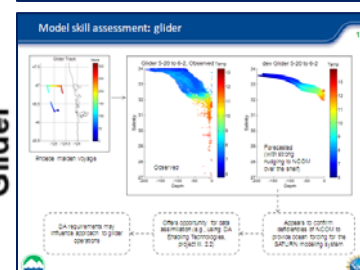
Metrics



AUVs

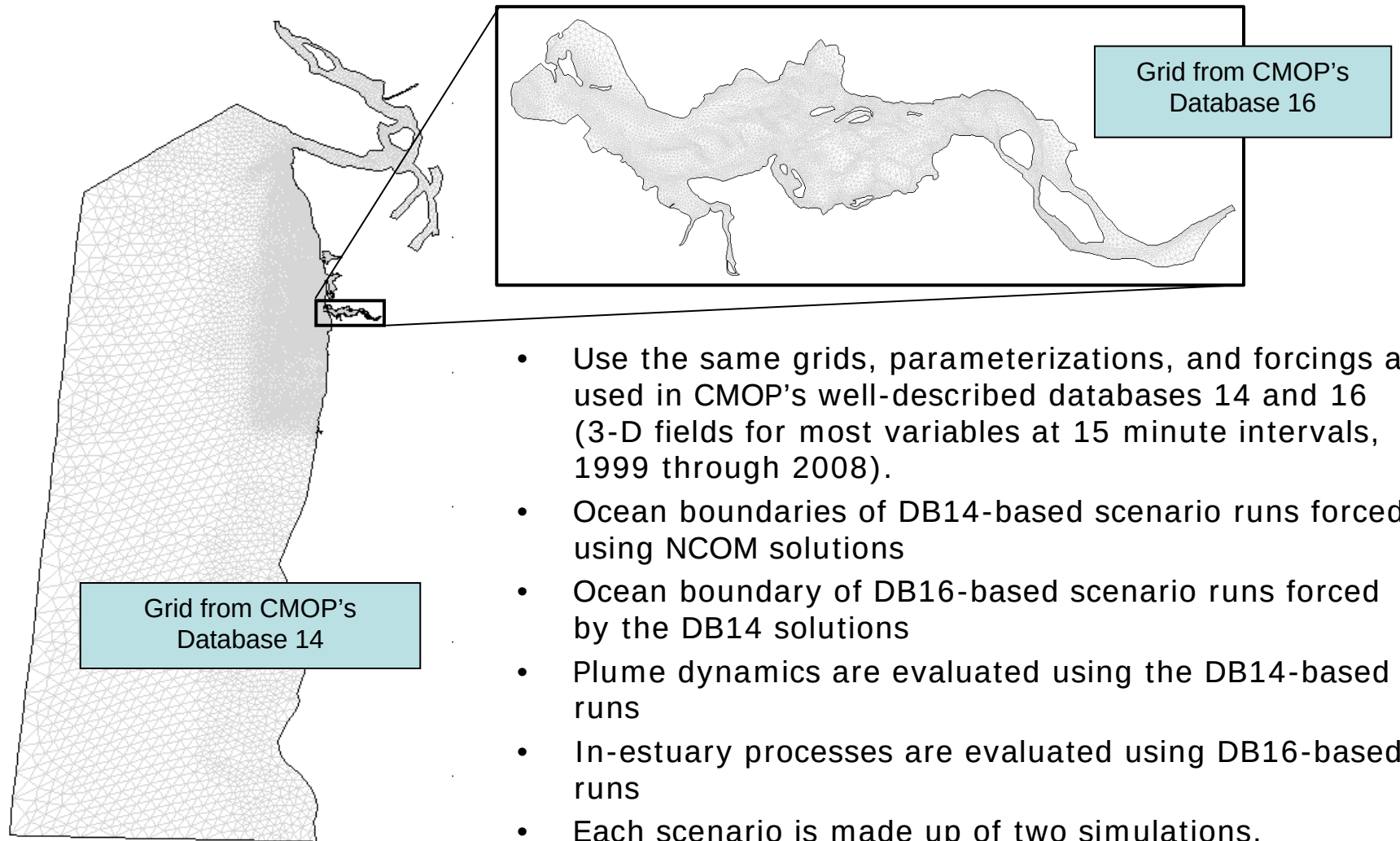


Glider



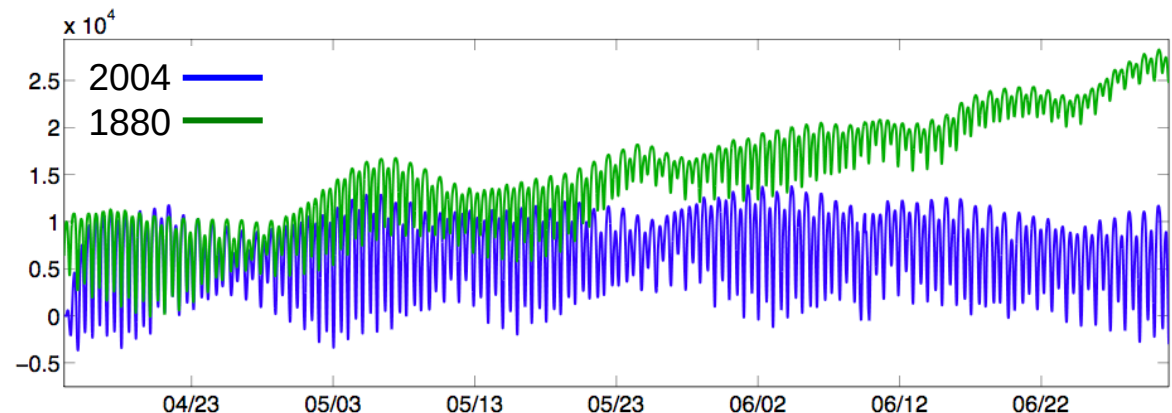
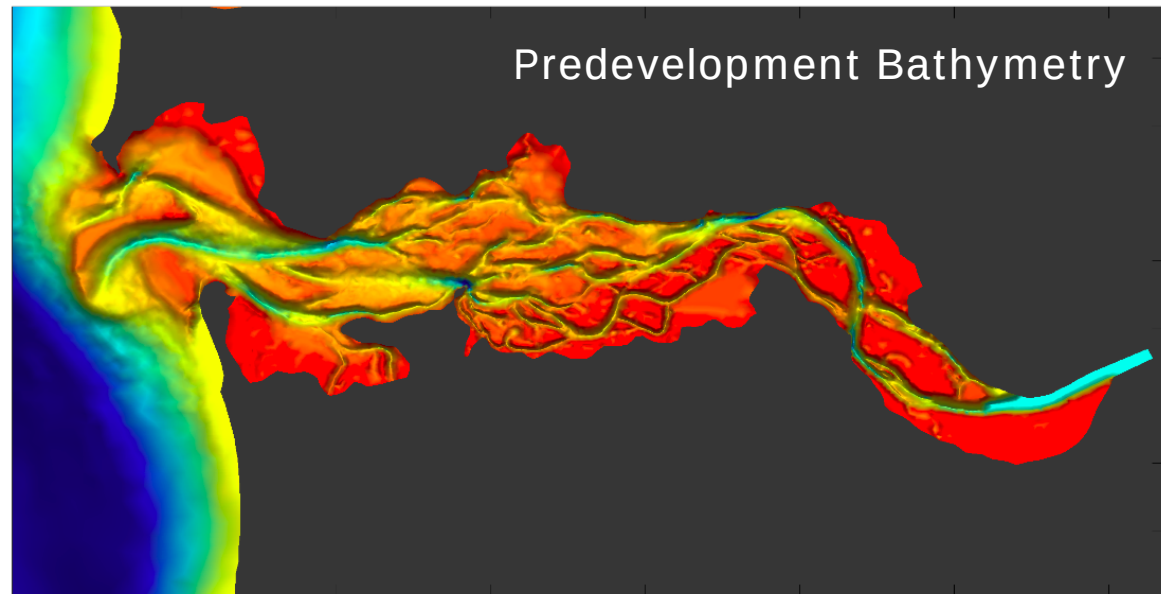
Emerging technologies:

- Sigma profiler
- RiverRad
- Non-hydrostatic SELFE



- Use the same grids, parameterizations, and forcings as used in CMOP's well-described databases 14 and 16 (3-D fields for most variables at 15 minute intervals, 1999 through 2008).
- Ocean boundaries of DB14-based scenario runs forced using NCOM solutions
- Ocean boundary of DB16-based scenario runs forced by the DB14 solutions
- Plume dynamics are evaluated using the DB14-based runs
- In-estuary processes are evaluated using DB16-based runs
- Each scenario is made up of two simulations, incorporating high and low flows through complete spring/neap cycles (5/1/99 – 5/31/99, and 8/1/01 – 8/31/01)

- Predevelopment (ca. 1880) bathymetry is estimated by Burke, Simenstad, and Jay using historical depth records and vegetation maps.
- The absence of dikes and jetties in the predevelopment grid allows for extensive floodplains
- Undammed Columbia River flow rates are estimated by Jay using historical records.
- All other forcings are identical to the control

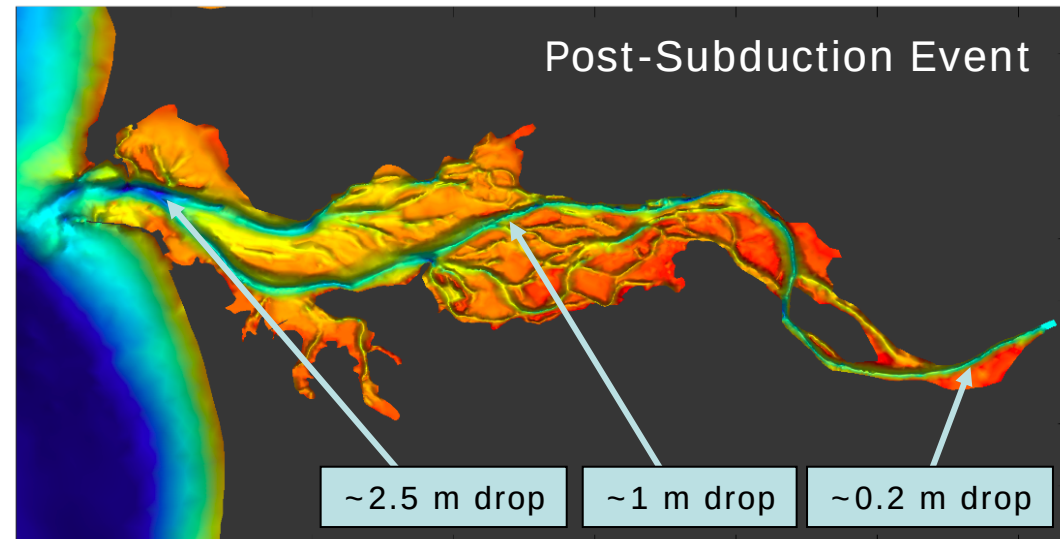
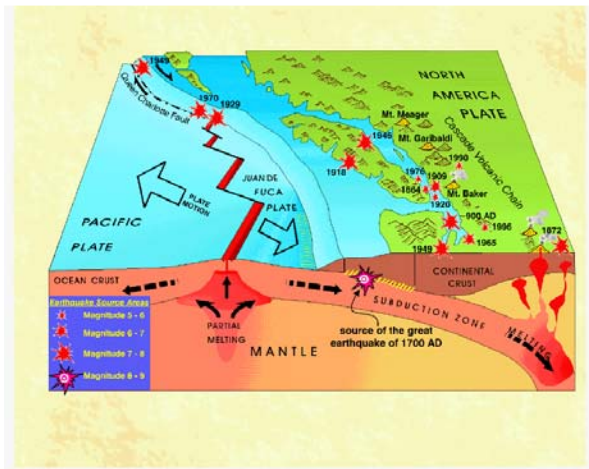
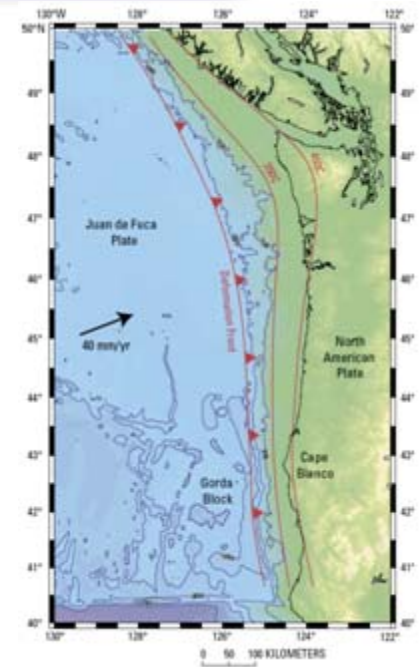


Late Spring River Discharge

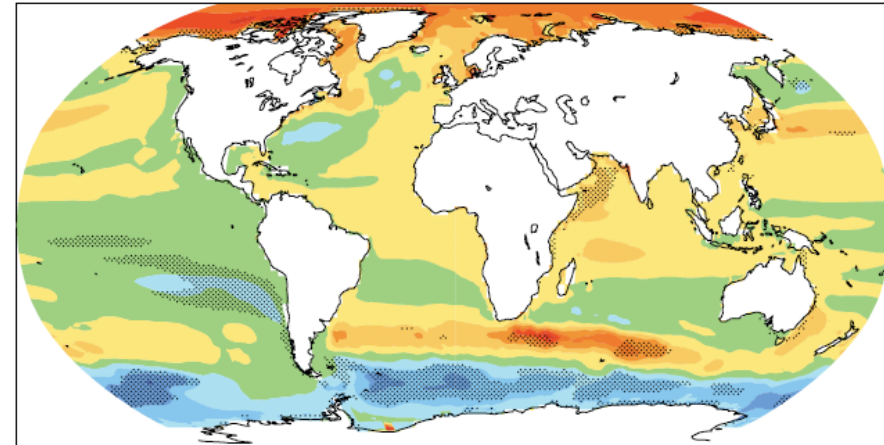
Subduction Scenario

30

- Work by George Priest and Rob Witter (DOGAMI), Christ Goldfinger (OSU) and Kelin Wang (Pacific Geoscience Cntr.) attempts to predict inundation patterns attributable to subsidence-driven tsunamis
- Continental margin isotherms are used to estimate the location and magnitude of subsidence likely after a sudden release of the interplate thrust
- Predicted magnitudes of subsidence are used to modify the control scenario's grid, altering the depths of the nodes and adding new nodes in newly flooded regions
- All other forcings are identical to the control

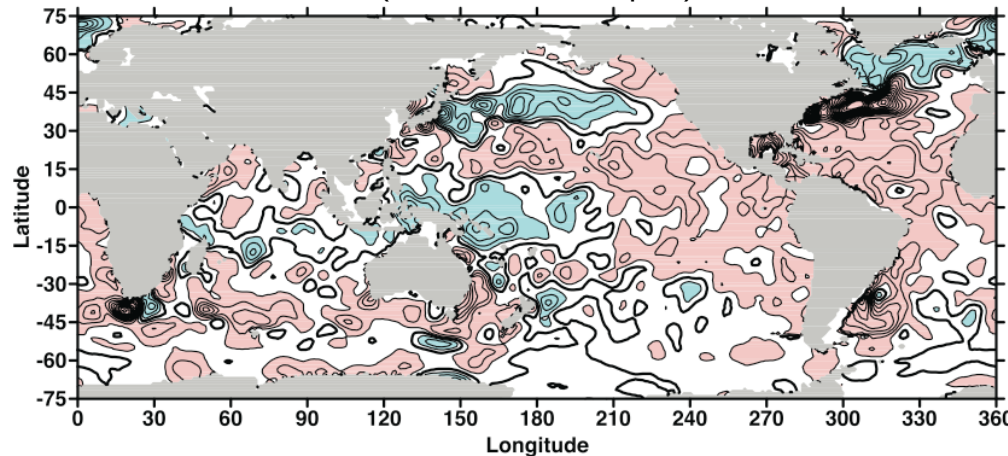


- The IPCC report details multiple impacts of climate change that will likely influence processes in the Columbia River estuary and plume
- Currently assembling the forcing data necessary for this scenario



Difference From Mean Predicted Sea-Level Change
(from the IPCC report)

Warming Trends In The Surface Ocean
(from the IPCC report)

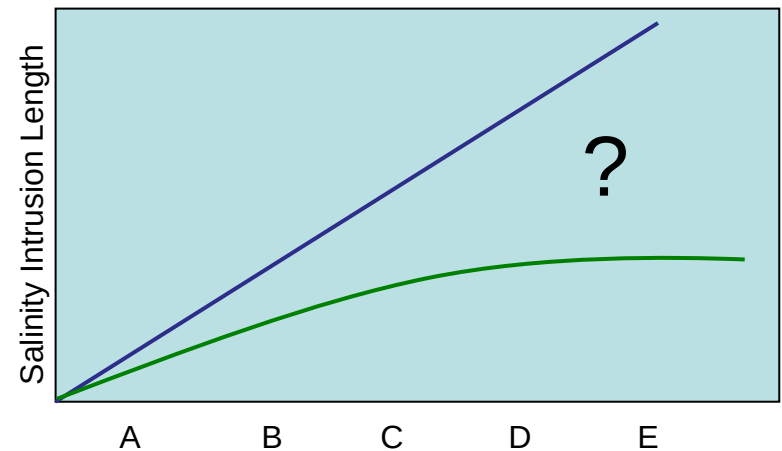
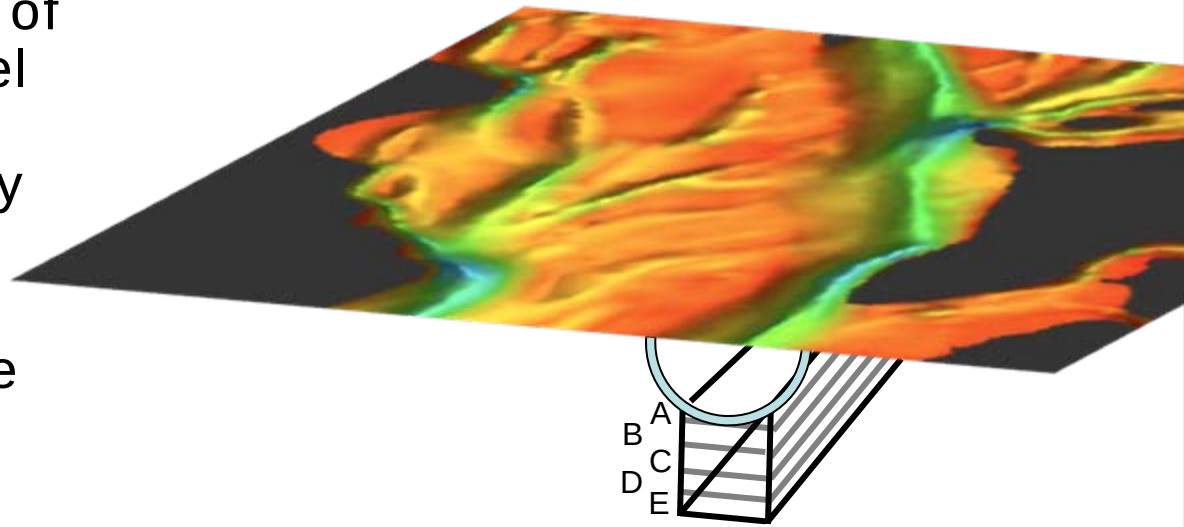


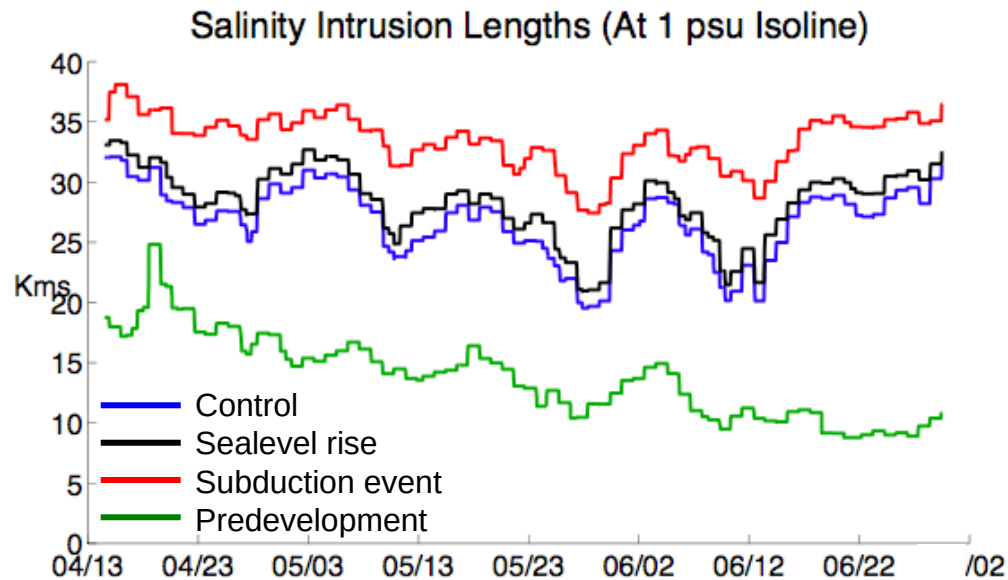
- Will maintain the control grid but will alter ocean boundary salinities and temperatures, upstream boundary fluxes and temperatures, all atmospheric forcings, and sea-level

Channel Deepening Scenario

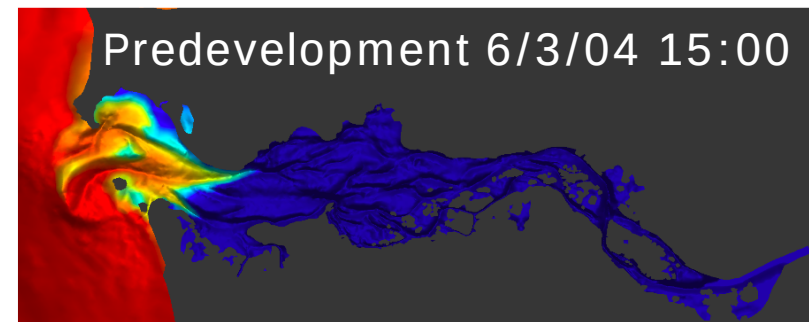
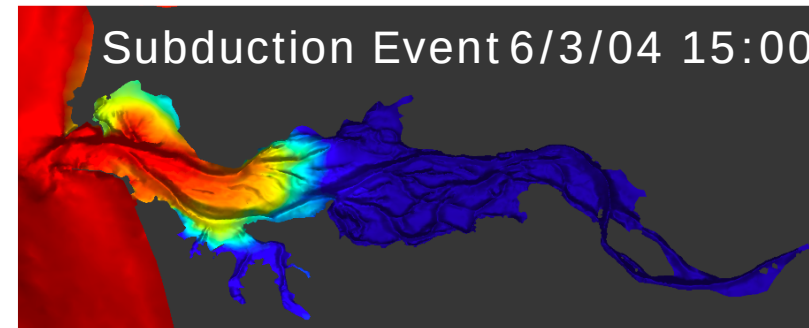
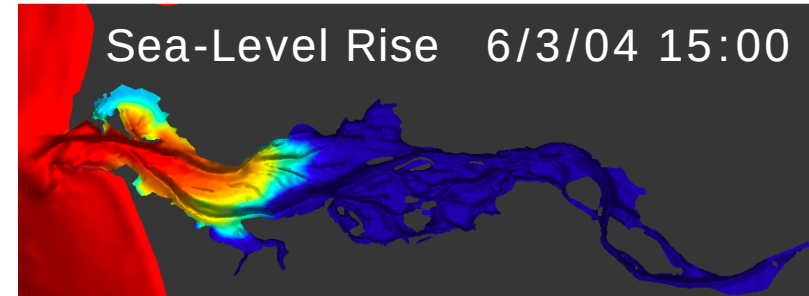
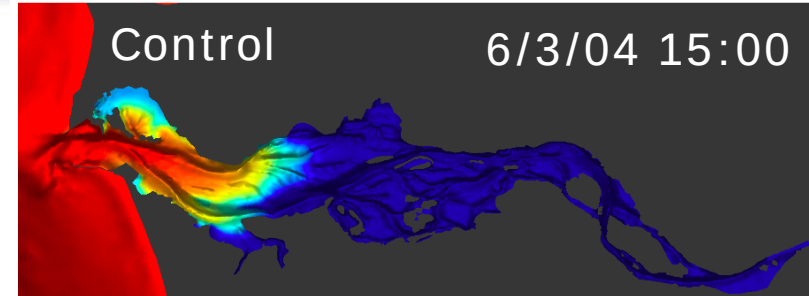
32

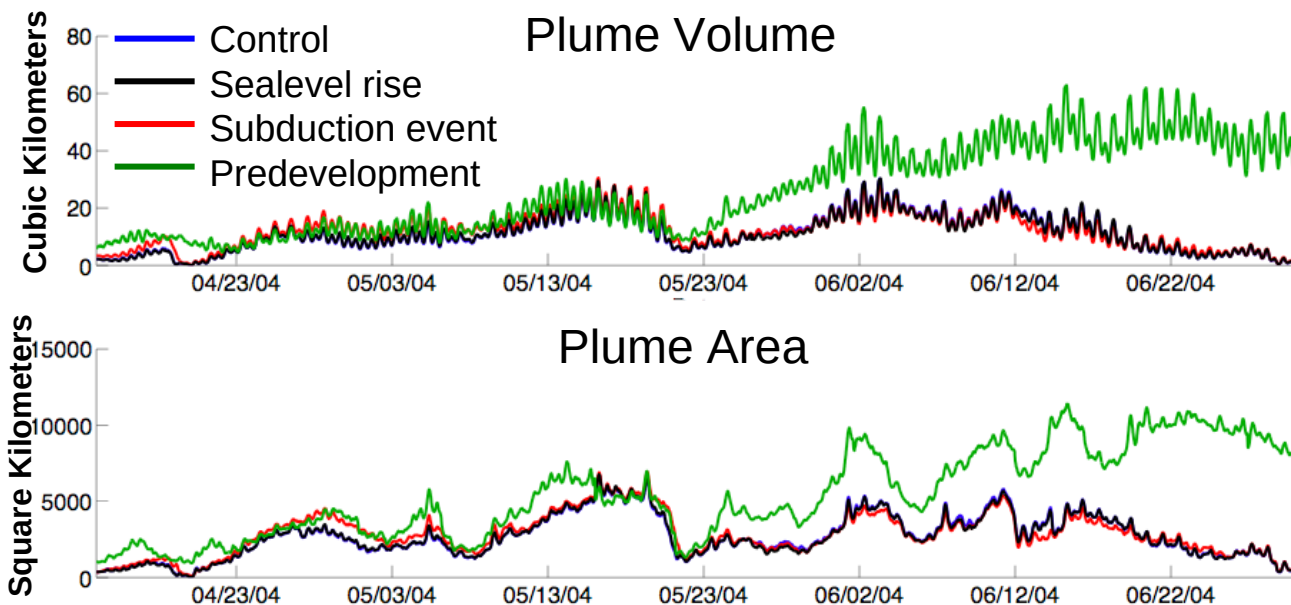
- Incremental deepening of the navigational channel may influence several processes in the estuary and plume
- How do these effects respond with successive increases in channel depth?
- 4 channel depths will be simulated and compared with the control (12m): 10m, 11m, 13m, and 14m.
- The only modifications to the control run will be the depths of those nodes compromising the channel



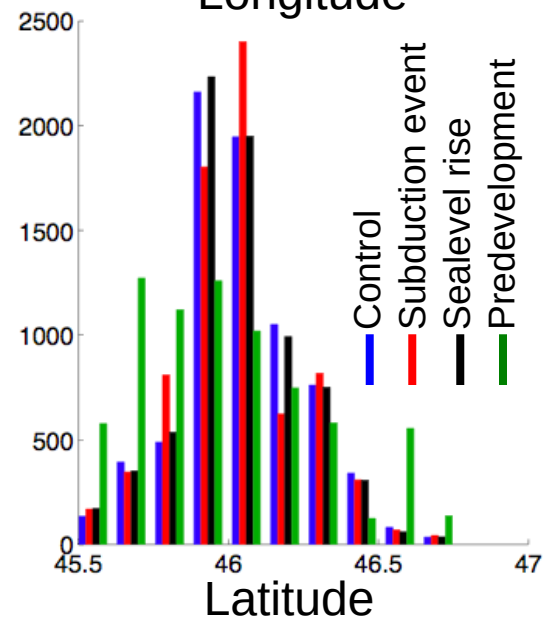
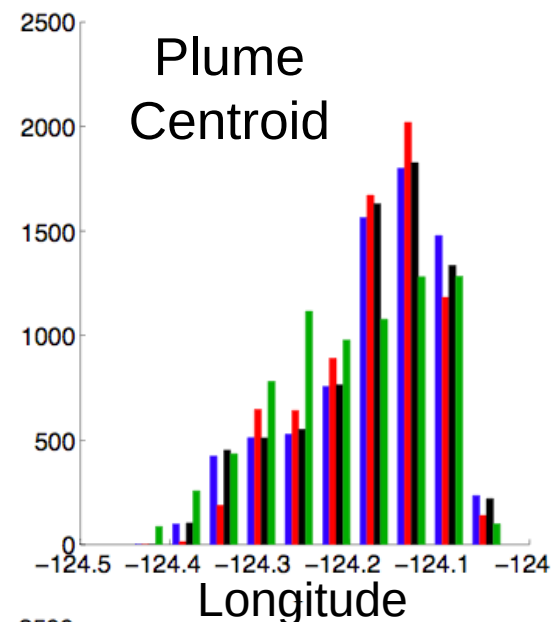


- SIL's in the sealevel rise simulation were slightly longer than the control
- The strongest SIL response was displayed by the predevelopment run, but the subduction run moved significant salt up-estuary - often as far as Cathlamet and Gray's Bay
- The predevelopment bathymetry does appear to influence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





- Predevelopment plume significantly larger, and positioned further south, than all others
- Sealevel rise has relatively little impact on plume processes, but the subduction run produces a slight northward and eastward shift in the plume centroid position
- 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



Analysis: Physical Habitat Opportunity

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Habitat Criteria

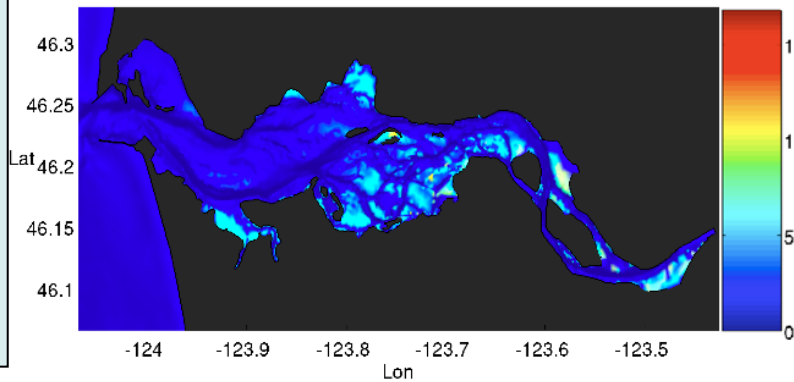
Depth (m)
 $0.1 < Z < 2.0$

Salinity (psu)
 $0 < S < 5$

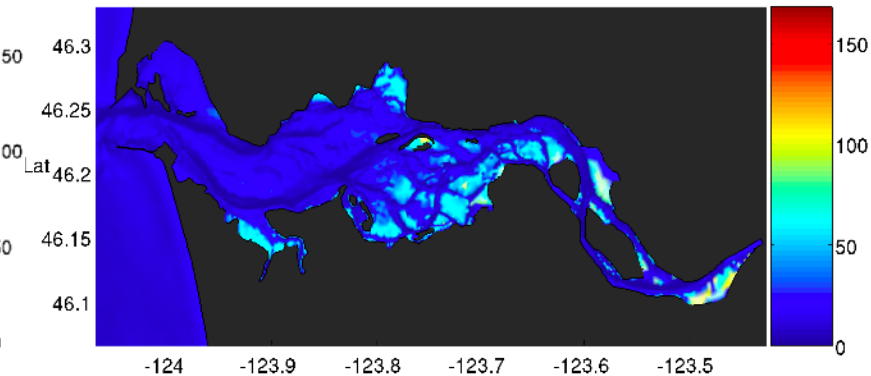
Temp (C)
 $0 < T < 19$

Velocity (m/s)
 $0.0 < U < 0.3$

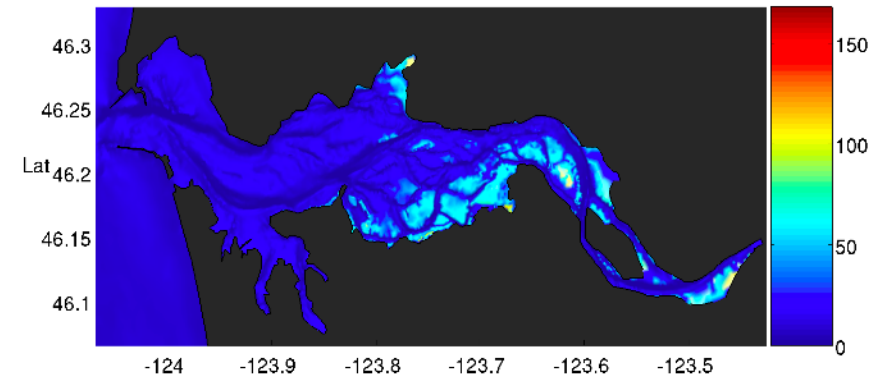
Mean Weekly PHO For Control Run



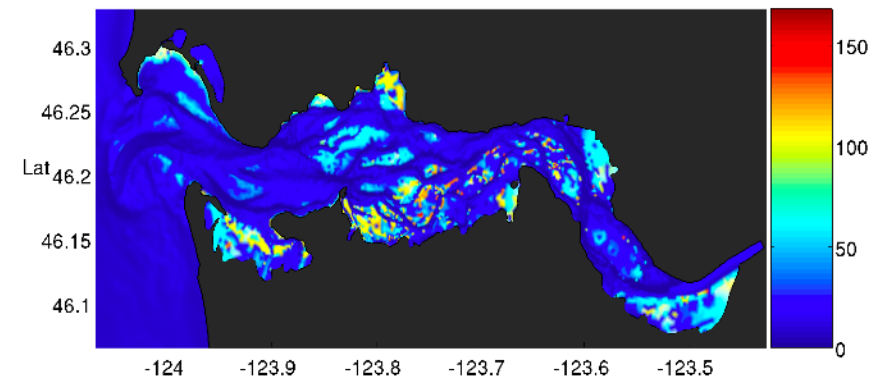
Mean Weekly PHO For Sealevel Rise Run



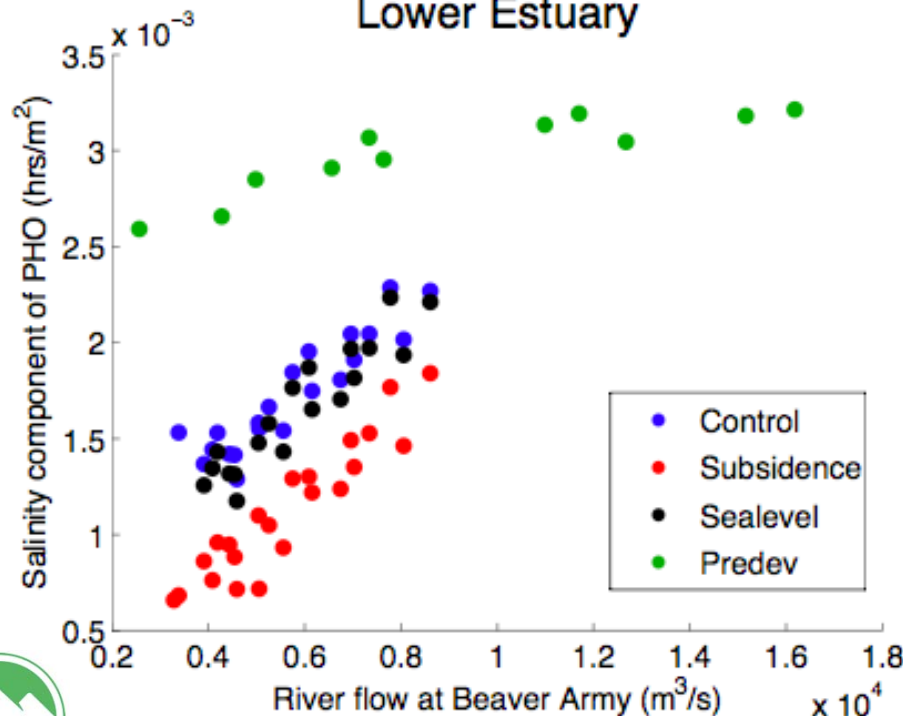
Mean Weekly PHO For Post-CSZ Run



Mean Weekly PHO For Predev Run

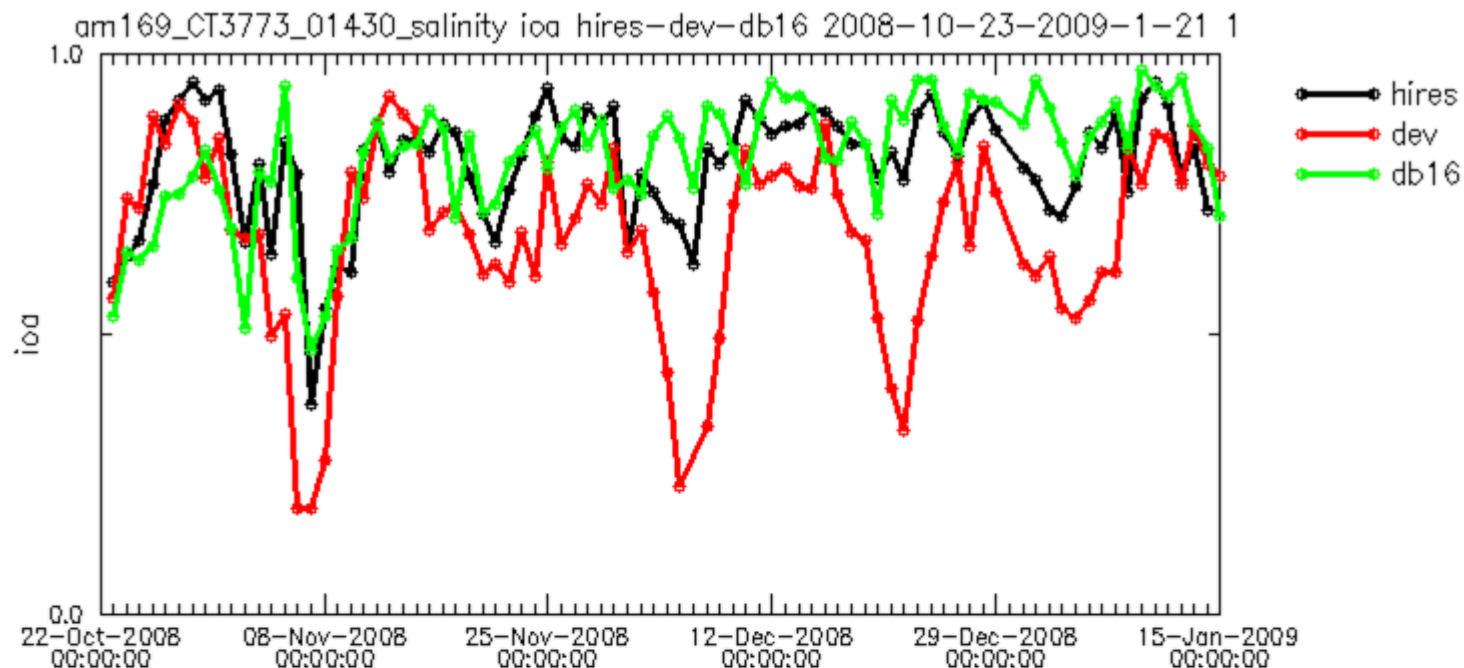


Lower Estuary

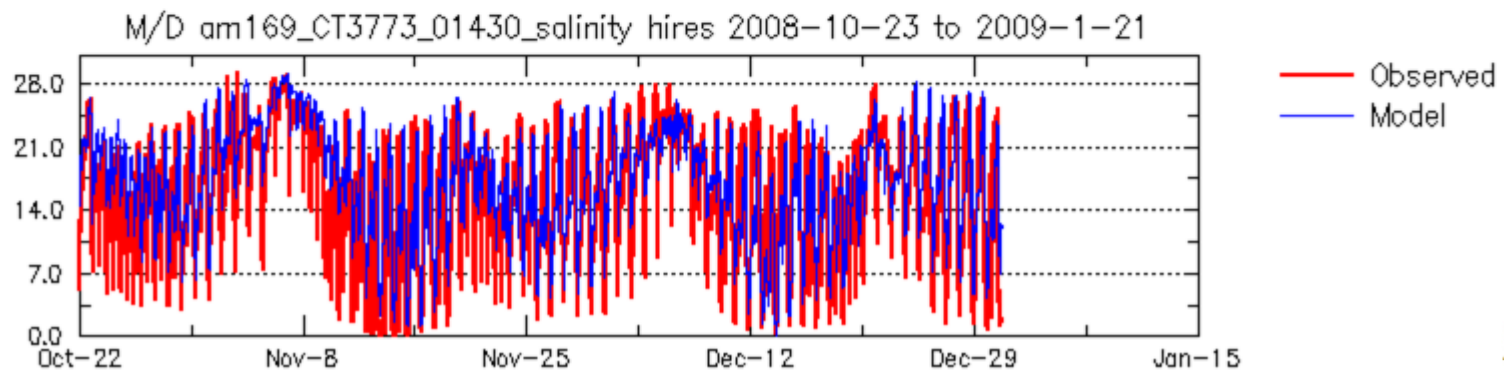


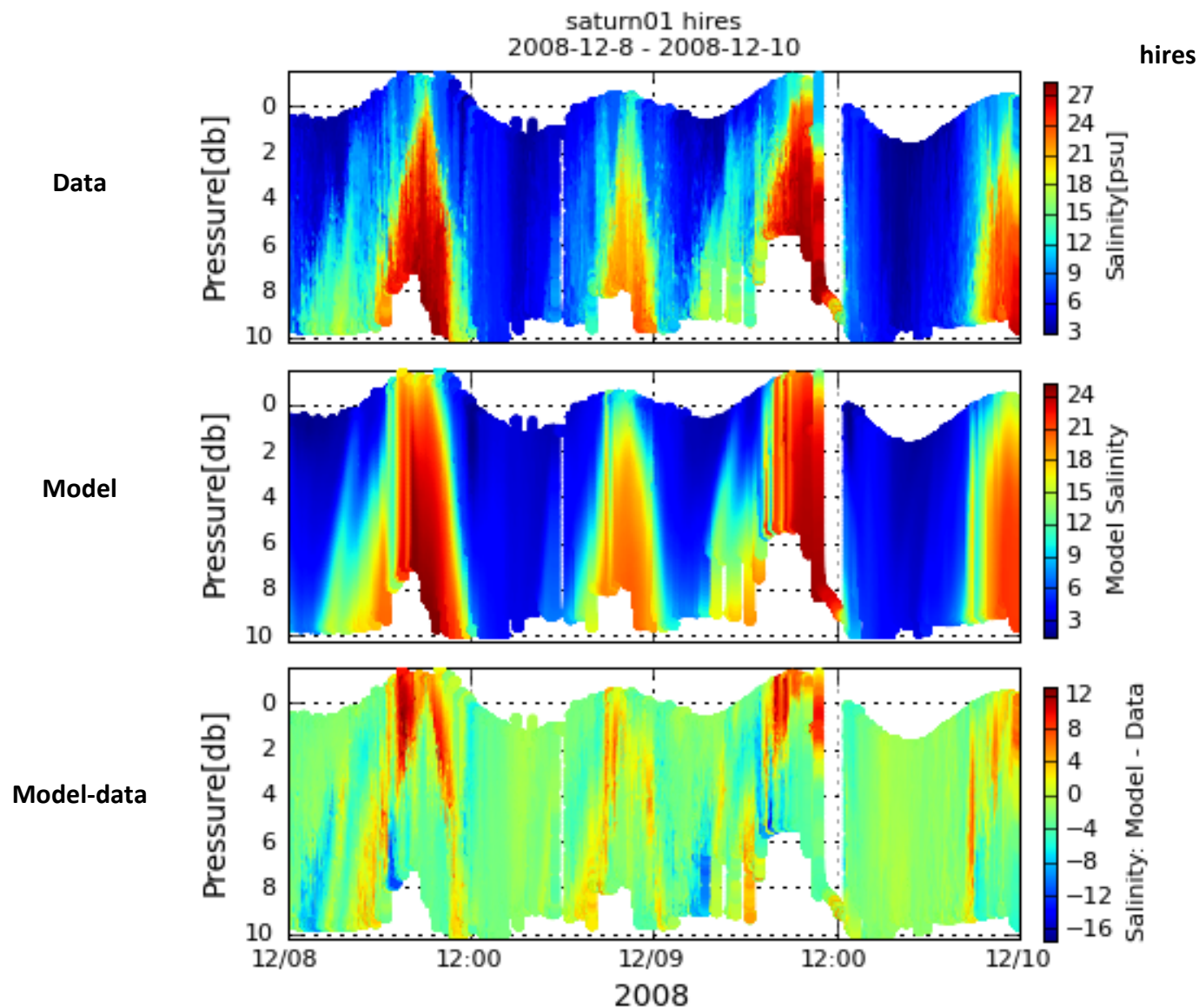
Model skill assessment: Stations

36



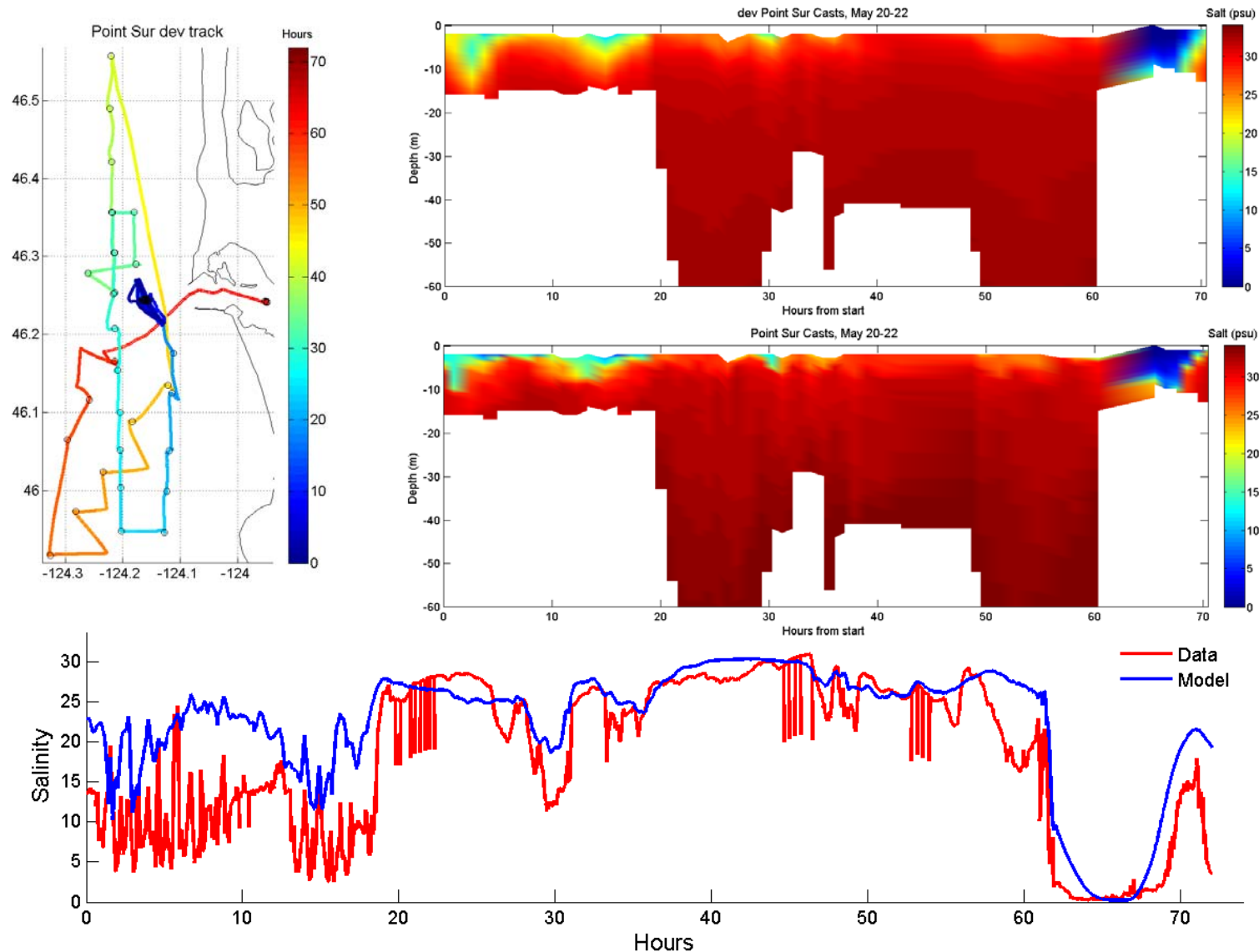
[\[ACE/gr plot file\]](#) [\[CSV data file\]](#)



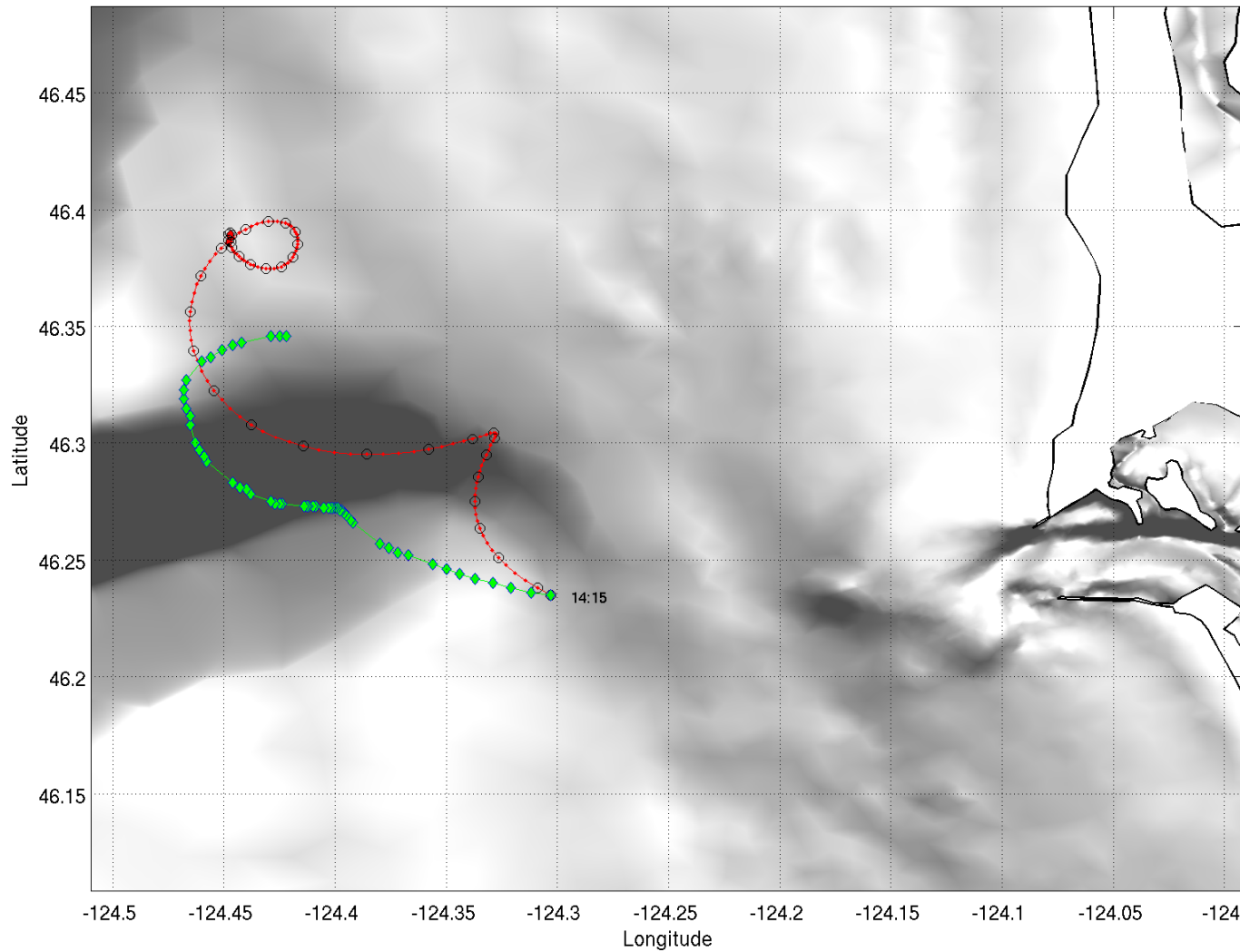


Model skill assessment: Vessels

38

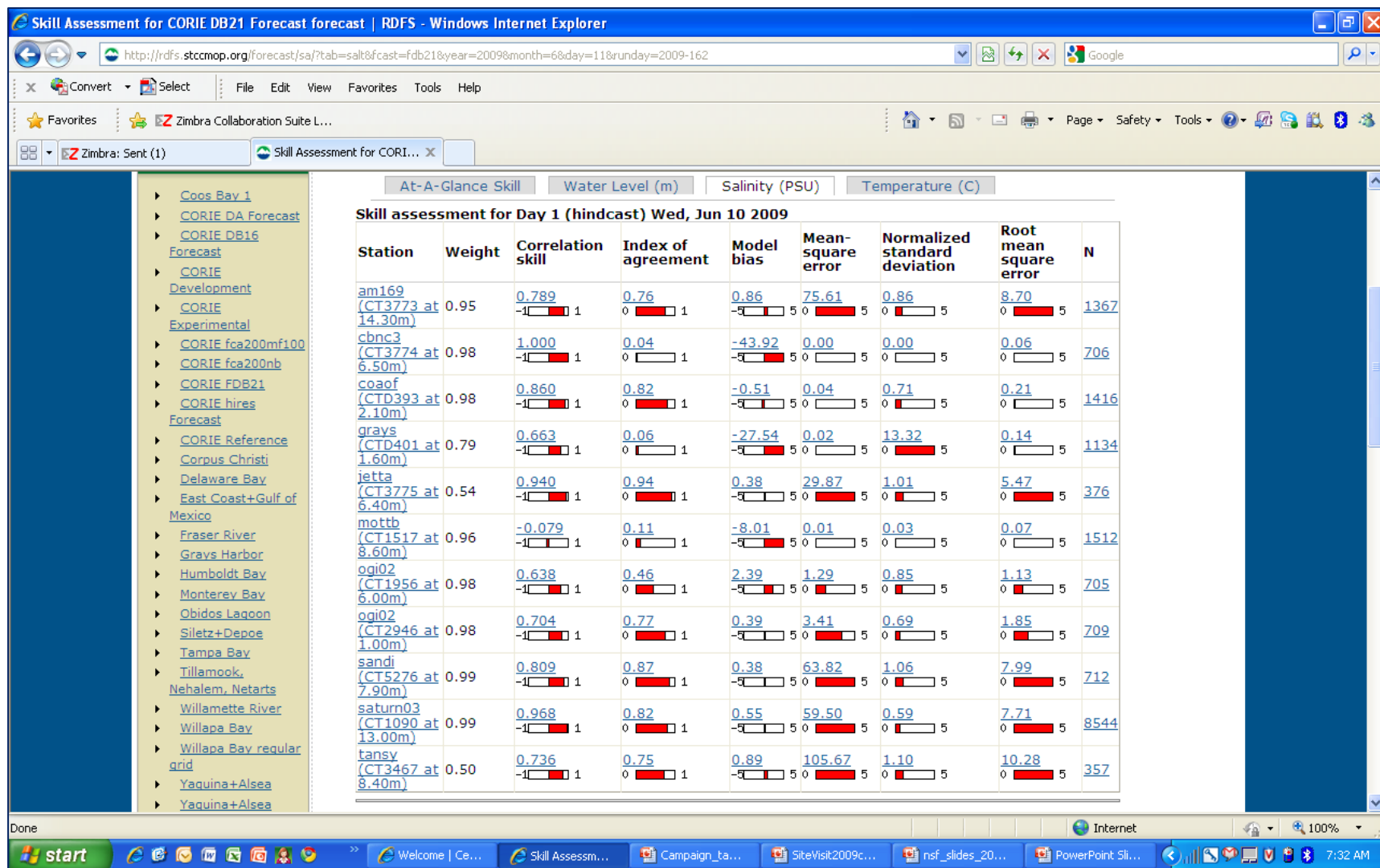


Projected Drifter Trajectory For 5/17 Deployment



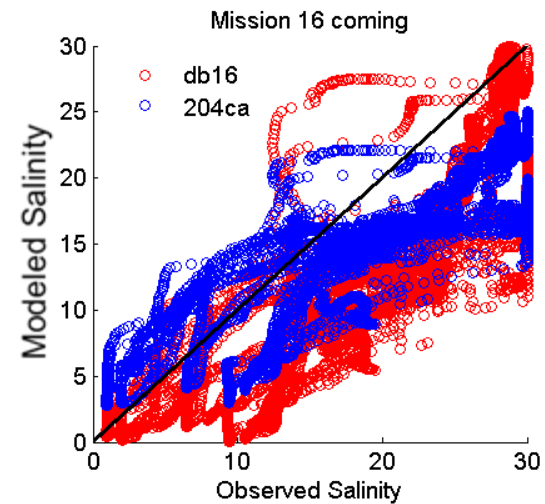
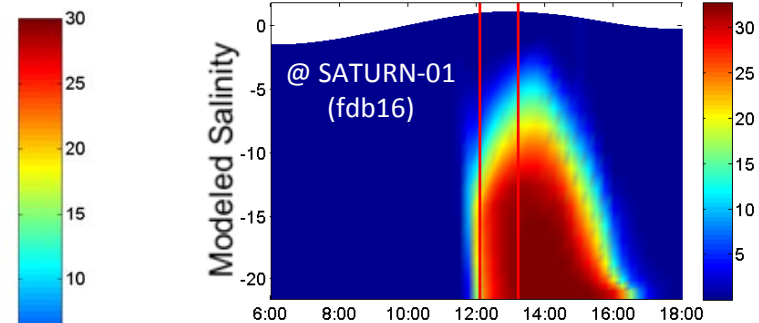
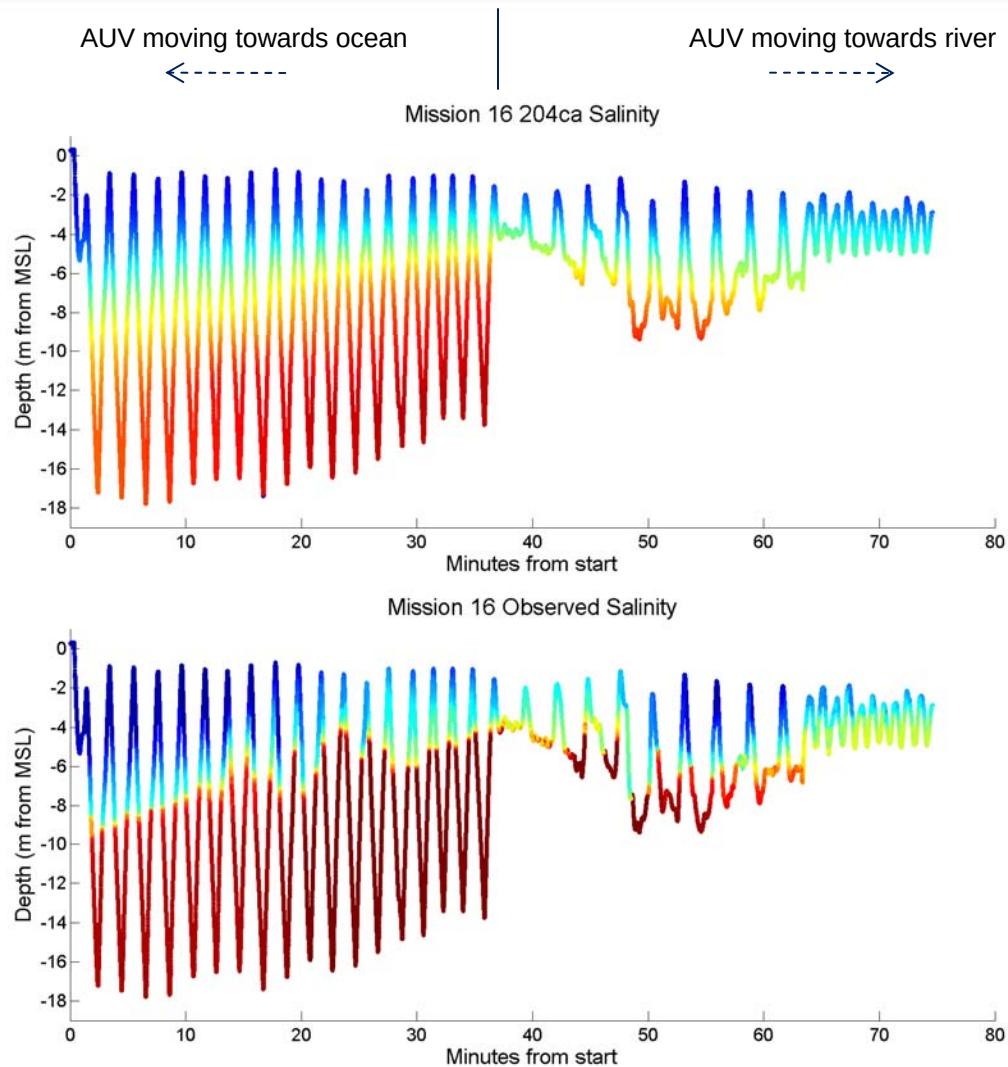
Model skill assessment: Metrics

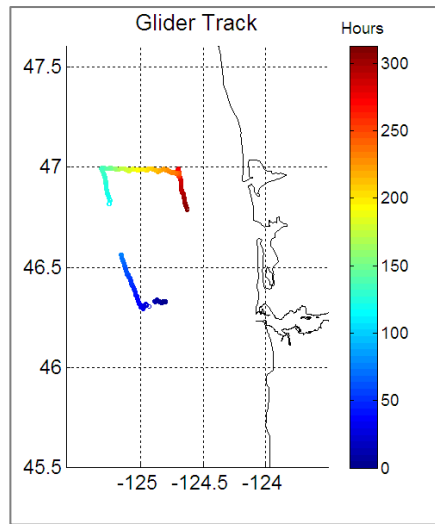
40



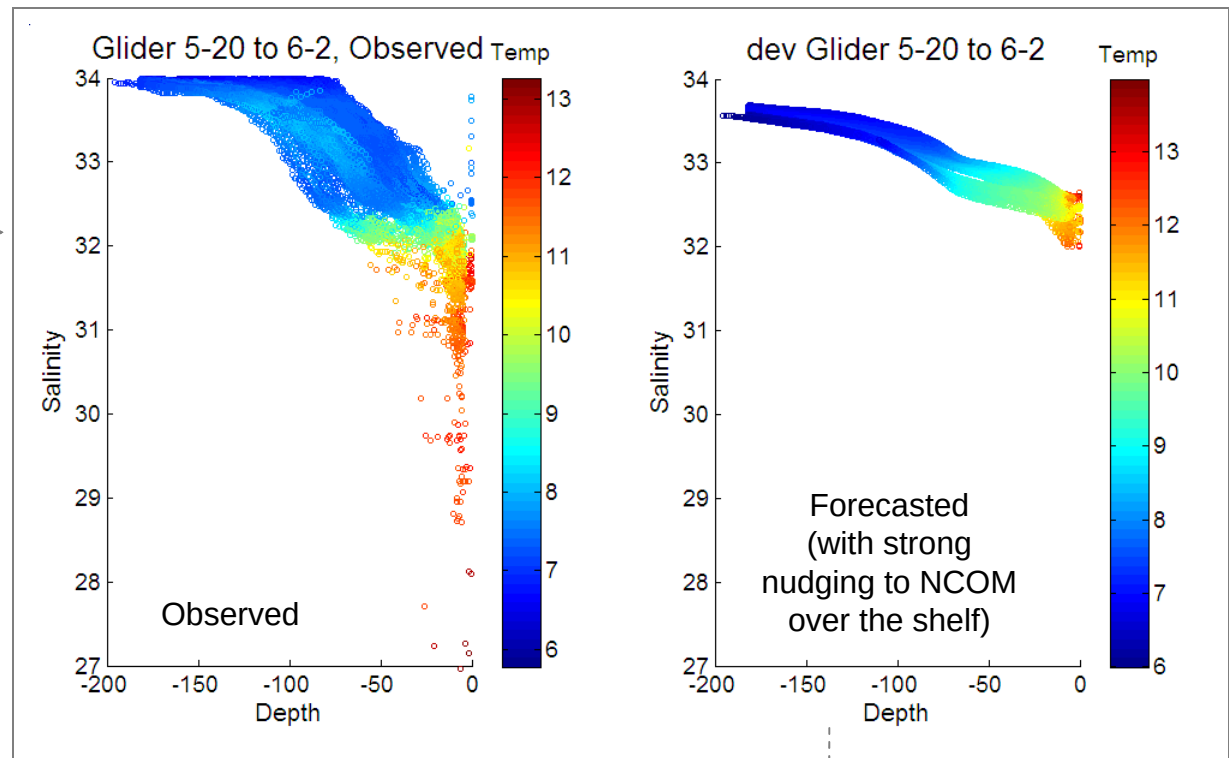
Model skill assessment: AUV's

41





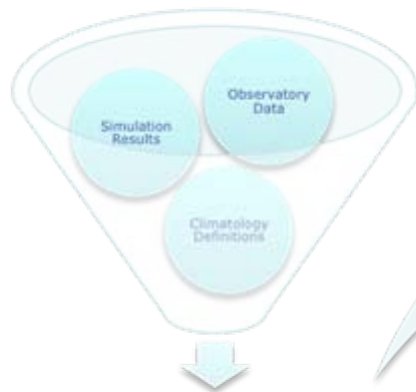
Phoebe maiden voyage



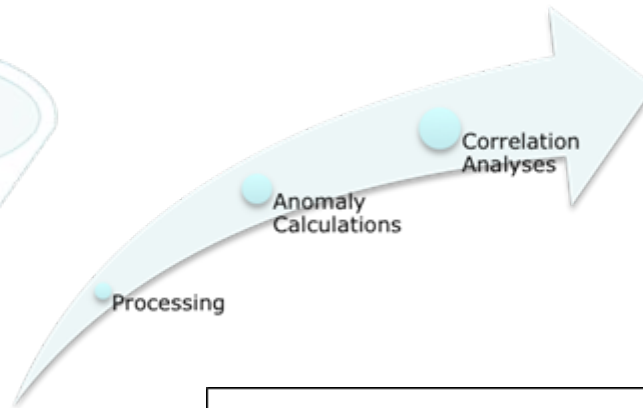
DA requirements may influence approach to glider operations

Offers opportunity for data assimilation (e.g., using DA Enabling Technologies, project III. 2.2)

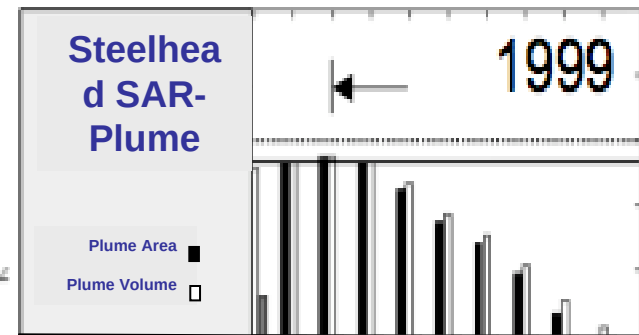
Appears to confirm deficiencies of NCOM to provide ocean forcing for the SATURN modeling system



Climatology Archive



1.0
0.8
0.6
0.4
0.2
0.0



Columbia River Climatologies and Climatology Overlays

This page is under construction. It constitutes a reading (and temporary archive) for various climatologies and climatology overlays being computed for the extended Columbia River.

IMAGES (see also: data)

- Coastal Upwelling Index (42 K)

[metadata]
1: Climatology
2: Overlays 1988, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008
Anomalies: daily, weekly, monthly, seasonally, yearly
January, February, March, April, May, June, July, August, September, October, November, December

- Coastal Upwelling Index (43 K)

[metadata]
1: Climatology
2: Overlays 1988, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008
Anomalies: daily, weekly, monthly, seasonally, yearly
January, February, March, April, May, June, July, August, September, October, November, December

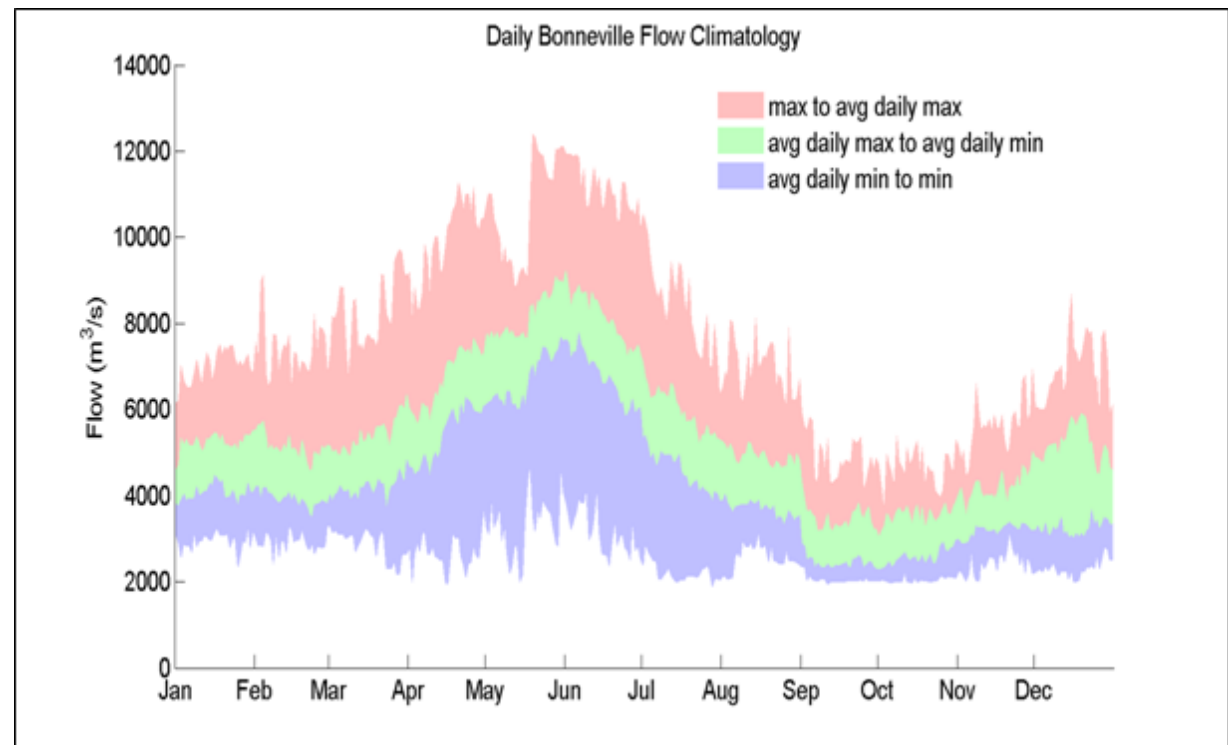
- Coastal Upwelling Index (48 K)

[metadata]
1: Climatology
2: Overlays 1988, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008
Anomalies: daily, weekly, monthly, seasonally, yearly
January, February, March, April, May, June, July, August, September, October, November, December

- Pacific Decadal Oscillation (PDO) Index

[metadata]
1: Climatology
2: Overlays 1988, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008
Anomalies: monthly, seasonally, yearly
January, February, March, April, May, June, July, August, September, October, November, December

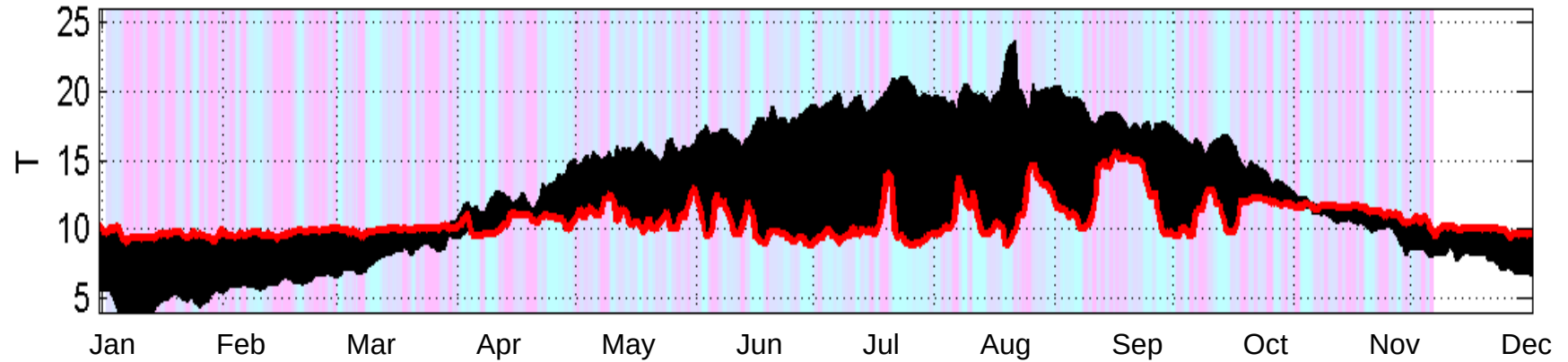
- Multivariate El Niño/Southern Oscillation Index (MEI)



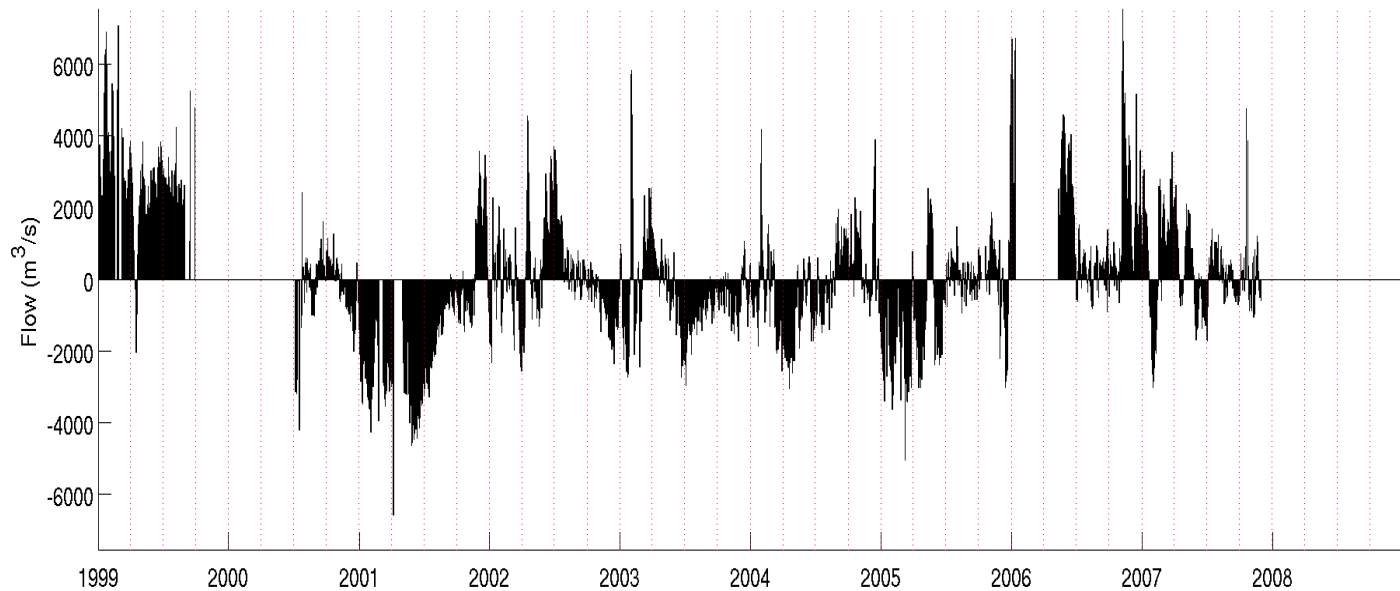
Hyde, N.



Seaton, C.



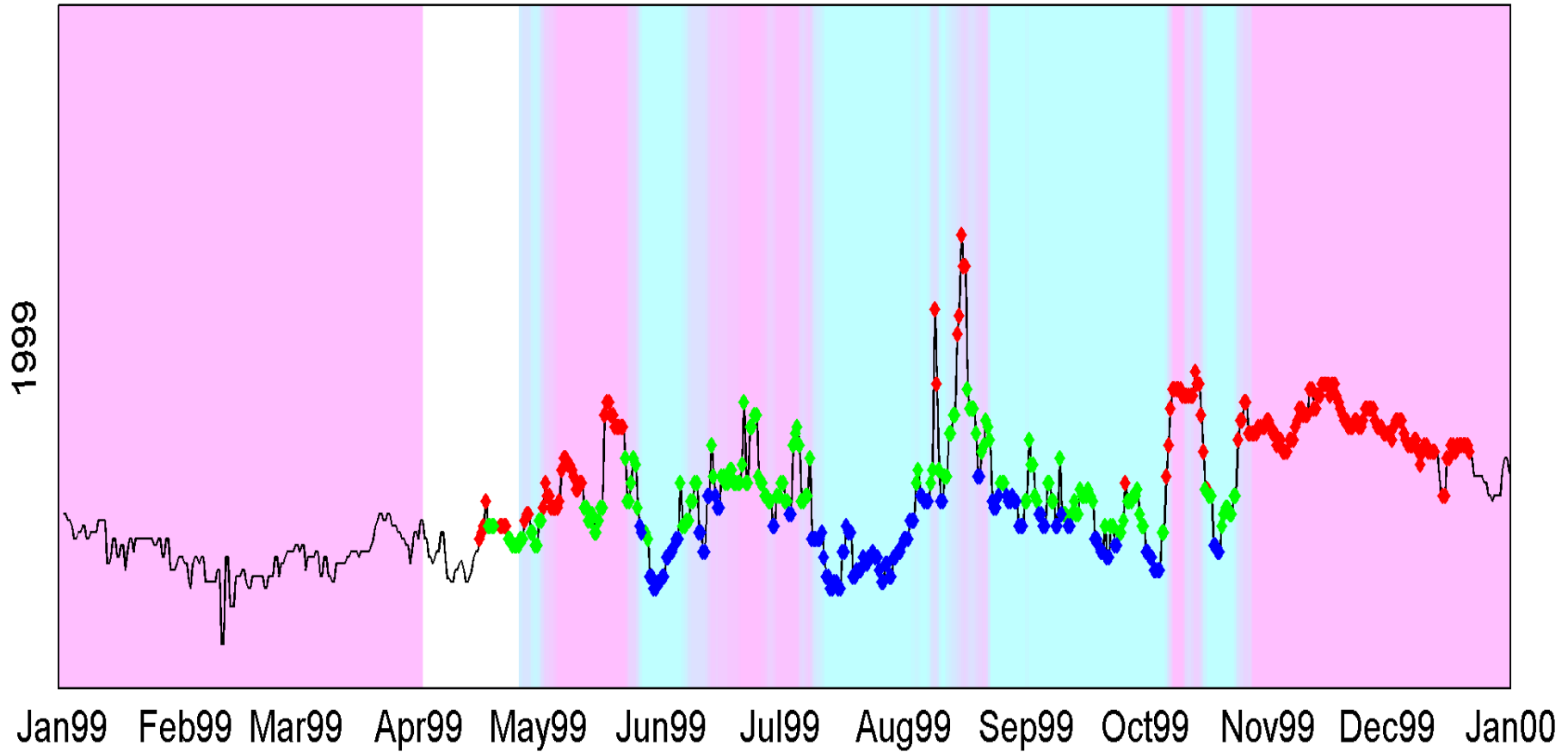
Daily Beaver Army Flow Anomalies



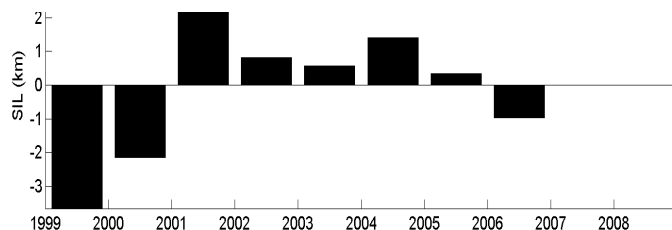
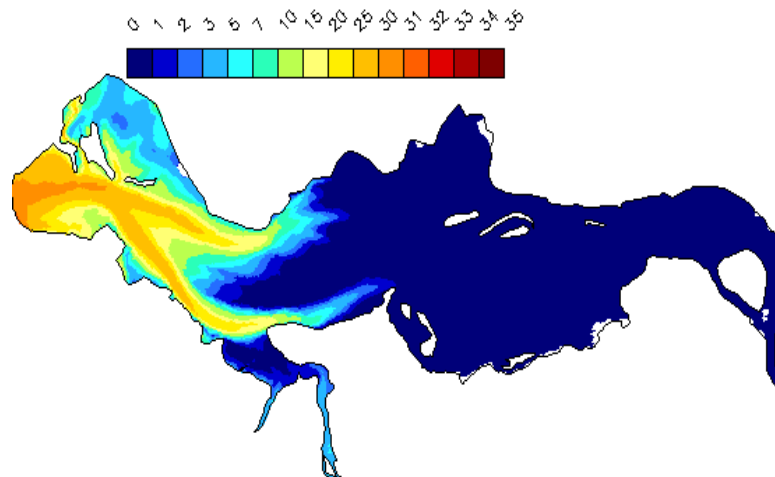
based on data from USGS



Seaton, C.



Average Bottom Salinity: 1999-2006 (DB16)

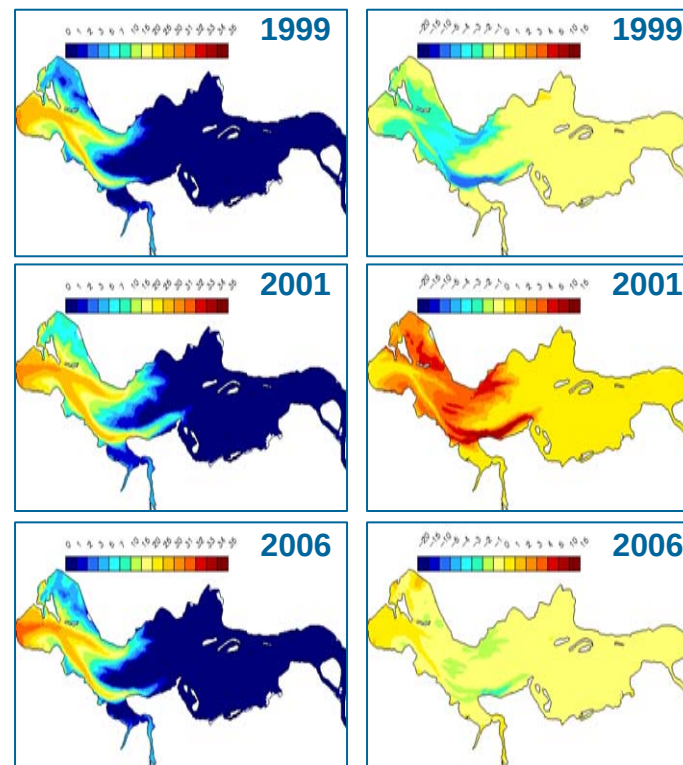


Annual Salinity Intrusion Anomaly (DB16)

May

Climatology

Anomaly



Turner, P.

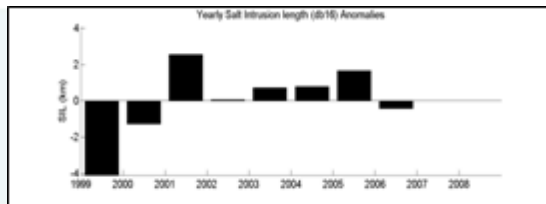
- Residence time
- River flow rates
- Coastal Upwelling Index (CUI)
- Plume Metrics
 - Volume
 - Area
 - Average width
 - Centroid position
- ENSO
- Pacific Decadal Oscillation (PDO)
- Salinity Intrusion Length (SIL)
- Salmonid Physical Habitat Opportunity (PHO)



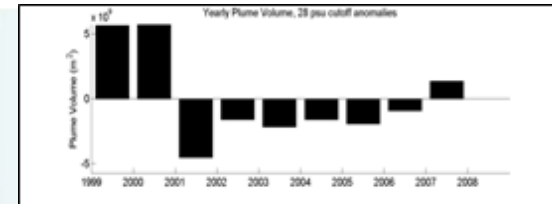
Anomaly Calculations

48

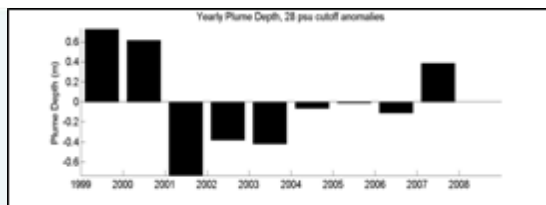
Salinity
Intrusion



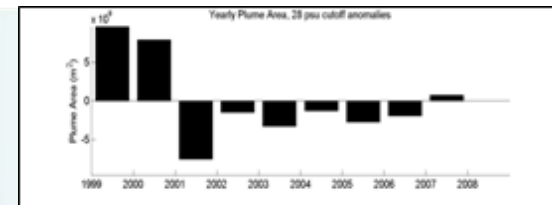
Plume
Volume



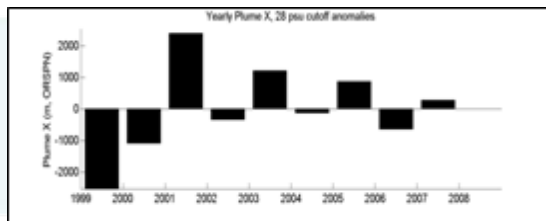
Plume
Thickness



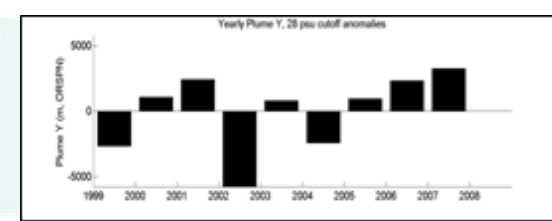
Plume
Area



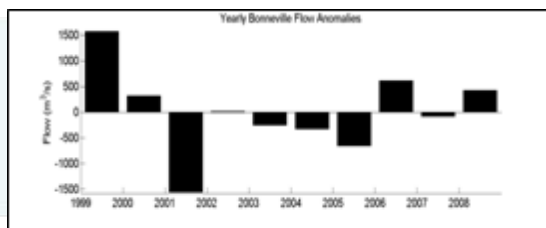
X-
Centroid



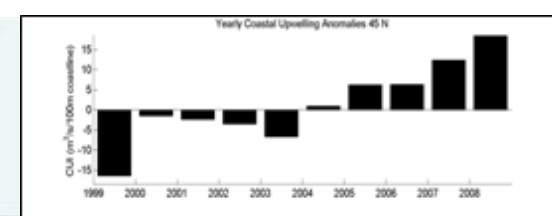
Y-
Centroid



Bonneville
Flows



Upwelling
(CUI)



1999
2000
2001
2002
2003
2004
2005
2006
2007
2008

1999
2000
2001
2002
2003
2004
2005
2006
2007
2008



Correlation Analyses

49

Marked juvenile steelhead (*Oncorhynchus mykiss*) were released at Jones Beach

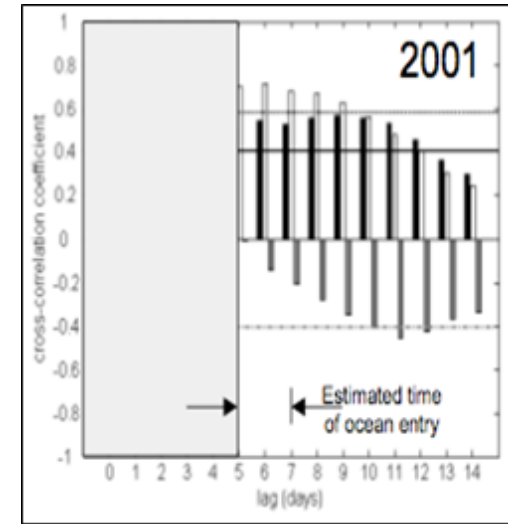
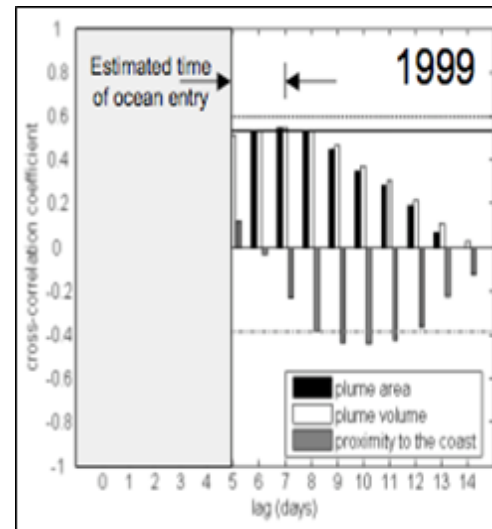
Returning adults were sampled and checked for tags

The resulting dataset was used to produce a time series of Smolt-to-Adult ratios (SAR), which was compared to variabilities in Columbia River processes

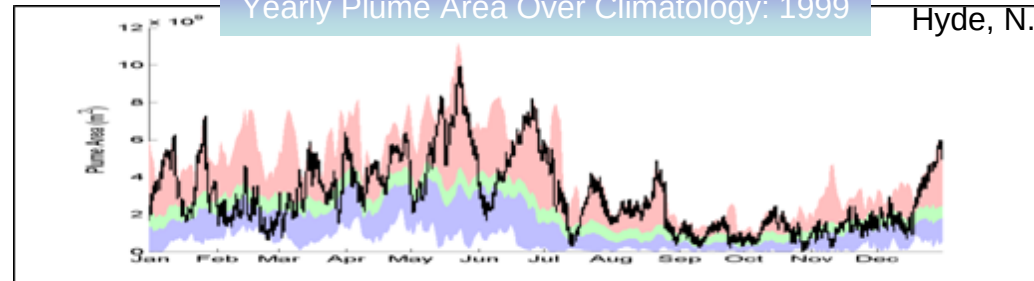
Conclusion: SAR is positively correlated with the size of the Columbia River Plume. Steelhead juveniles are more likely to successfully return as adults if they are released during conditions that produce large plumes (high flow, and/or upwelling periods)



Burla, M.

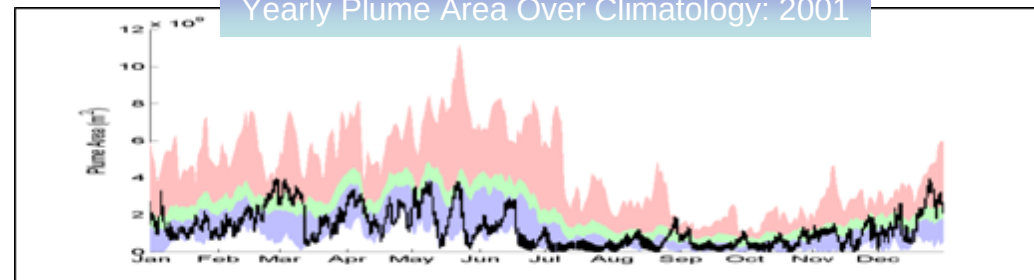


Yearly Plume Area Over Climatology: 1999



Hyde, N.

Yearly Plume Area Over Climatology: 2001



- Residence time
- River flow rates
- Coastal Upwelling Index (CUI)
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 - Volume
 - Area
 - Average width
 - Centroid position
- ENSO
- Pacific Decadal Oscillation (PDO)
- Salinity Intrusion Length (SIL)
- Salmonid Physical Habitat Opportunity (PHO)

