

# Estuaries 101

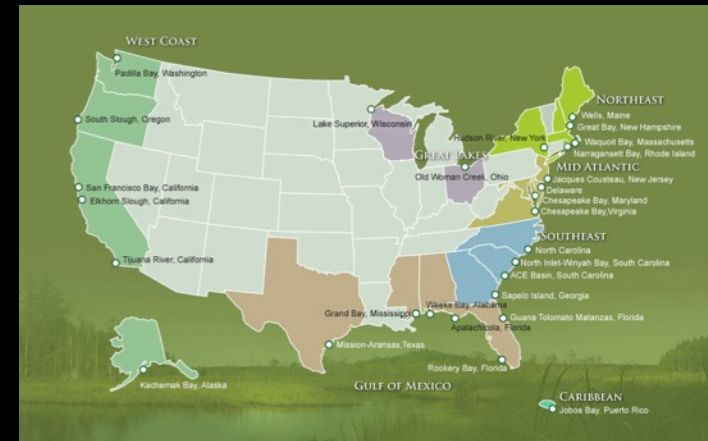
Jeff Crooks

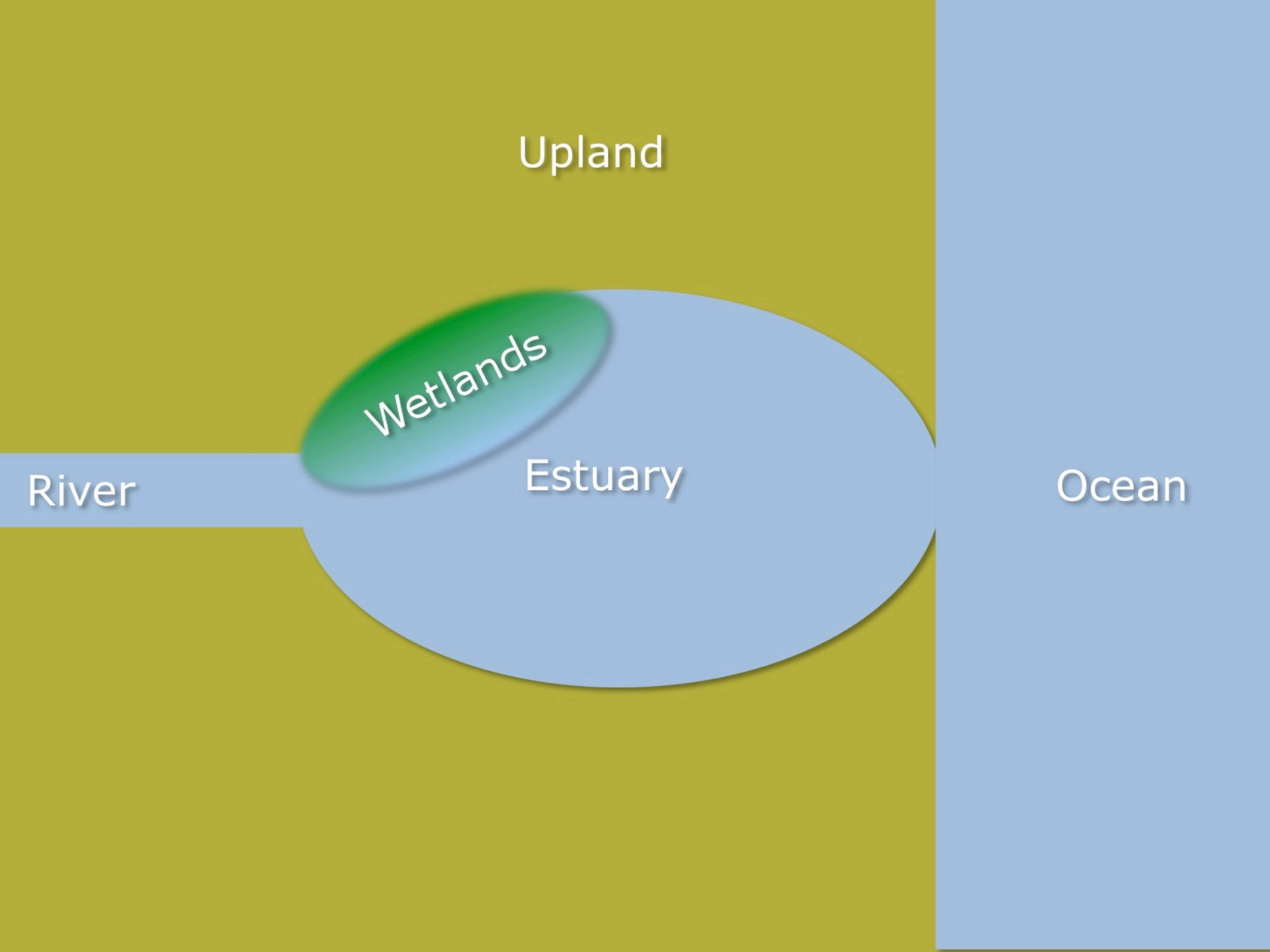
Tijuana River National Estuarine Research Reserve  
and the  
Southwest Wetlands Interpretive Association

# National Estuarine Research Reserve System

## National Oceanic & Atmospheric Administration

- ◆ Federal – State Partnerships
- ◆ 29 Reserves established by the Coastal Zone Management Act
- ◆ Provide long-term protection of reserve resources for research
- ◆ Enhance awareness and understanding of estuarine areas, and provide suitable opportunities for education and interpretation
- ◆ Protect areas that contribute to typological and biogeographical balance of the system





Upland

Wetlands

River

Estuary

Ocean



Beach, dune, channel, salt marsh habitats



Riparian & freshwater habitats

Coastal mesas



Upland transition



# Distribution and Loss of Coastal Wetlands



# Values of Wetlands

- Economic (direct and indirect)
- Recreation and aesthetics
- Habitat / nursery
  - Threatened species
  - Harvested species
- Water storage and filtration
- Environmental buffering
- Global carbon cycle

TABLE 1.1. Estimated Relative Economic Values per Hectare of Services Provided by the World's Ecosystems

Ecosystem Type	US\$ ha <sup>-1</sup> yr <sup>-1</sup>
Estuaries	22,832
Swamps/floodplains	19,580
Coastal sea grass/algae beds	19,004
Tidal marsh/mangrove	9,990
Lakes/rivers	8,498
Coral reefs	6,075
Tropical forests	2,007
Coastal continental shelf	1,610
Temperate/boreal forests	302
Open oceans	252

NOTE: From Constanza et al. (1997).

# Estuarine Gradients



## Horizontal

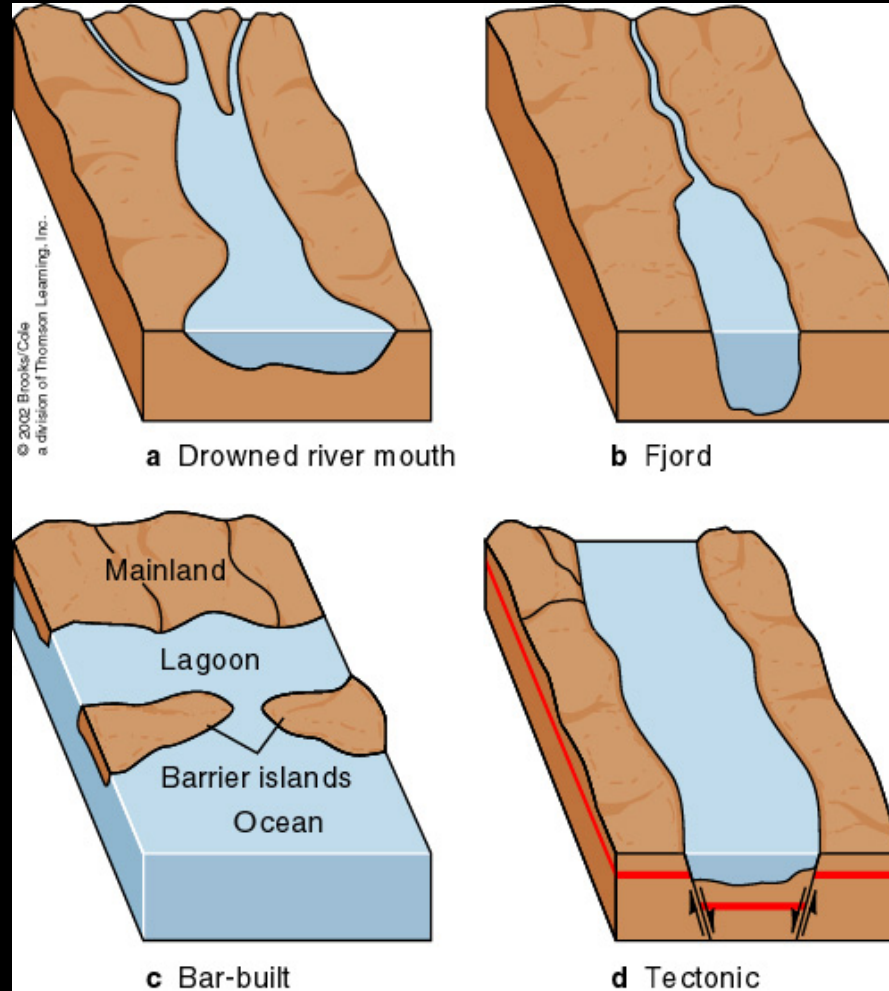
- Salinity
- Exposure
- Grain size
- Biota

## Vertical

- Tidal level
- Depth in sediment

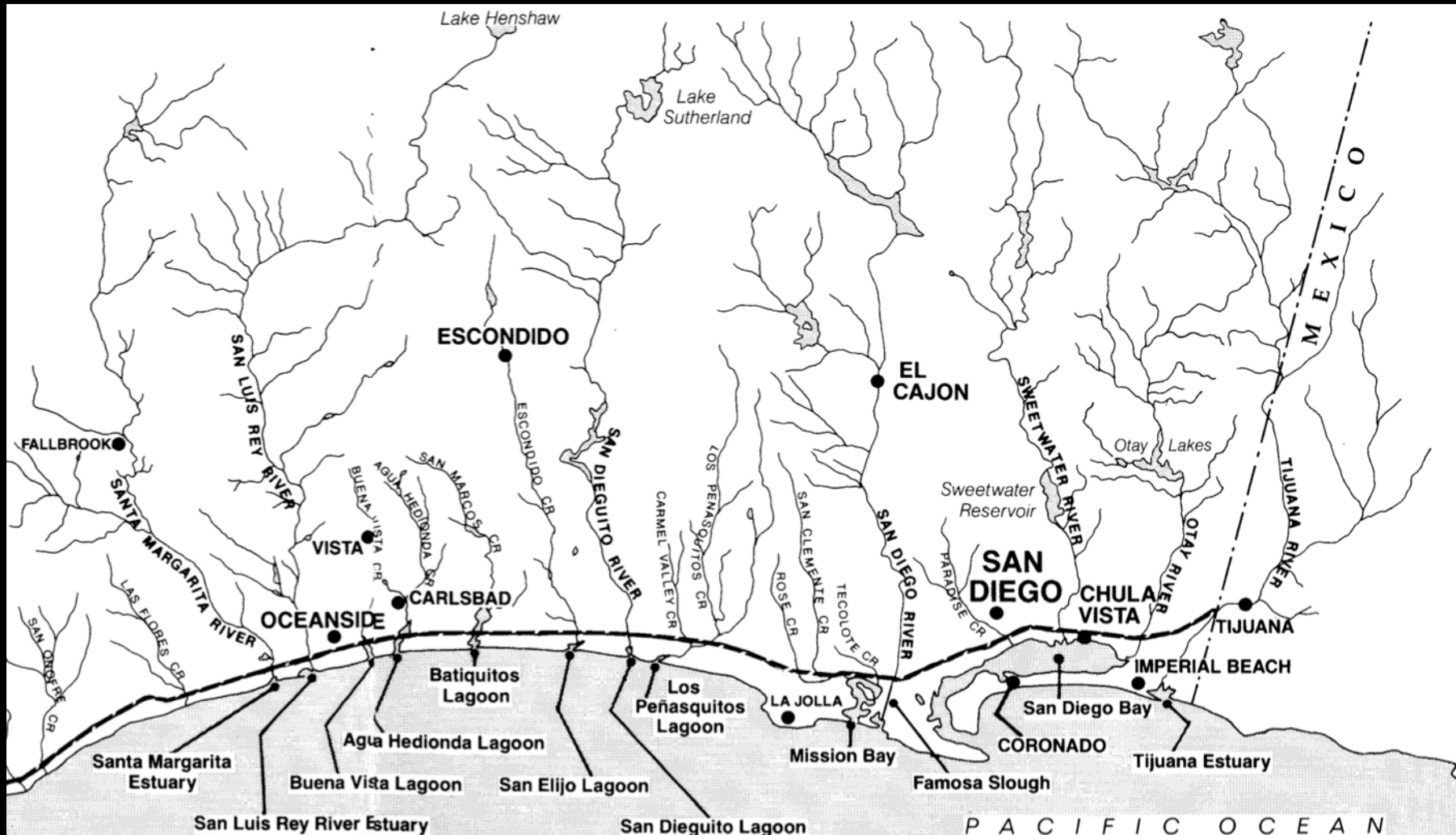
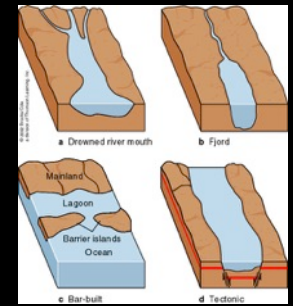
## Human Impact

# Estuarine Classification

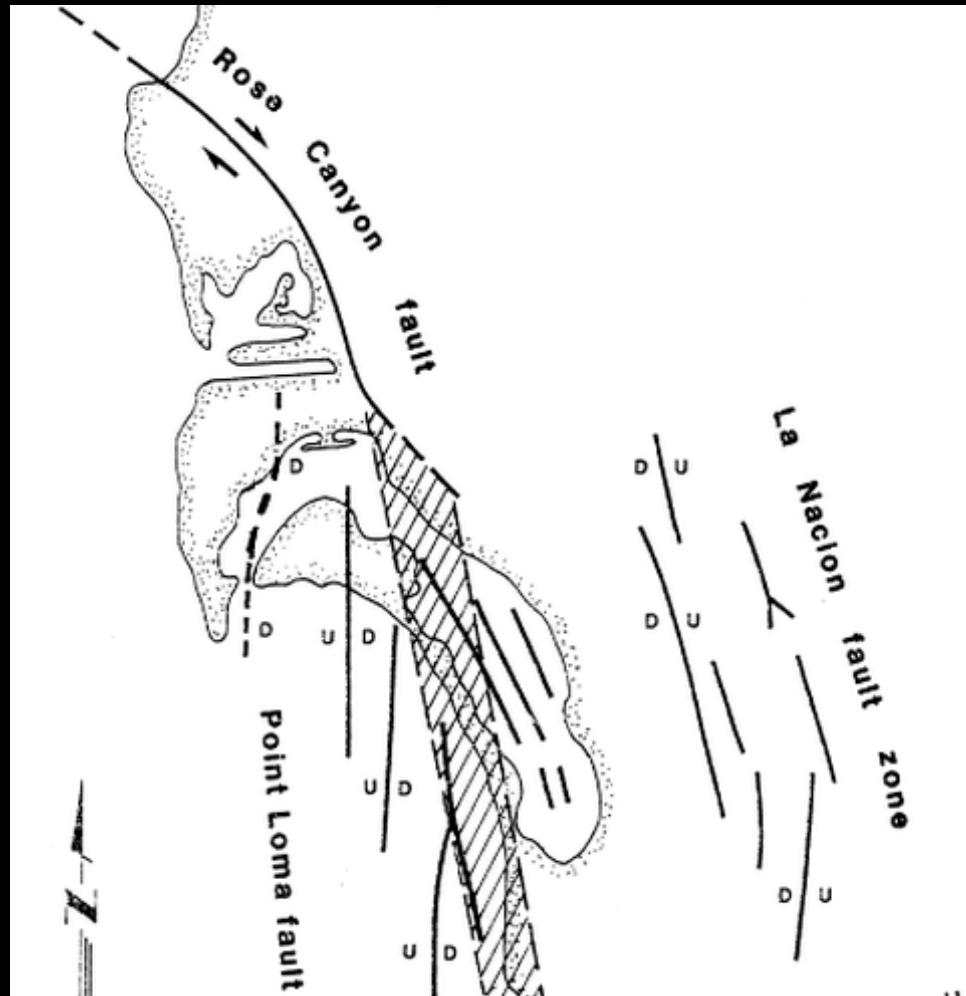
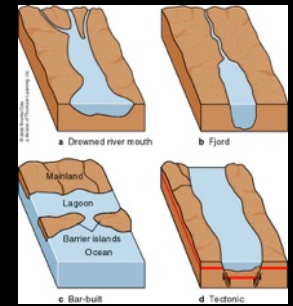




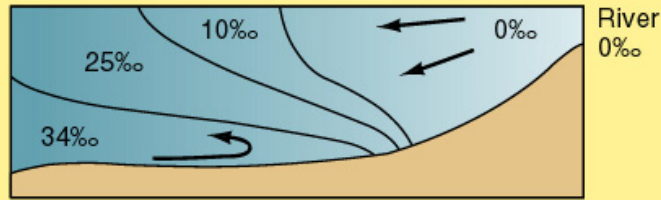
# Estuarine Classification



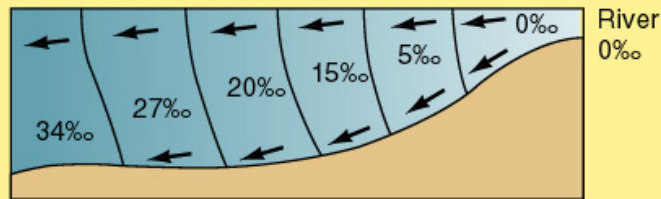
# Estuarine Classification



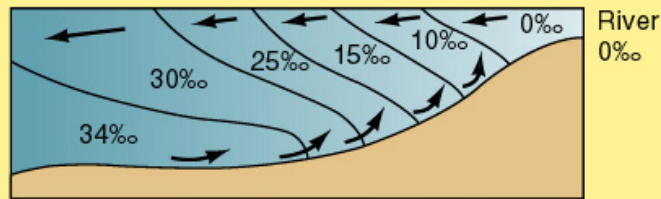
# Salinity Gradients



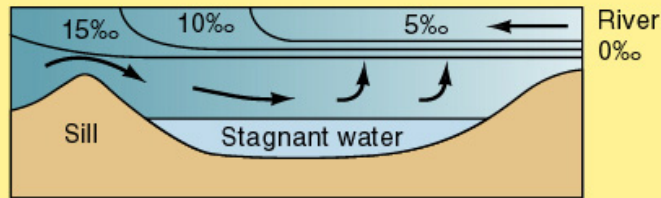
a Salt wedge estuary



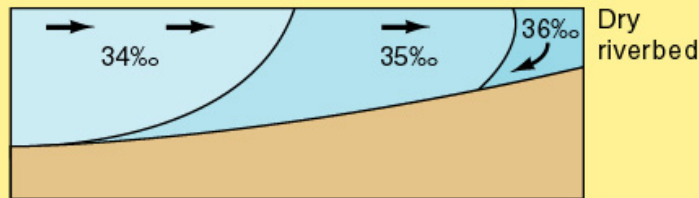
b Well-mixed estuary



c Partially mixed estuary

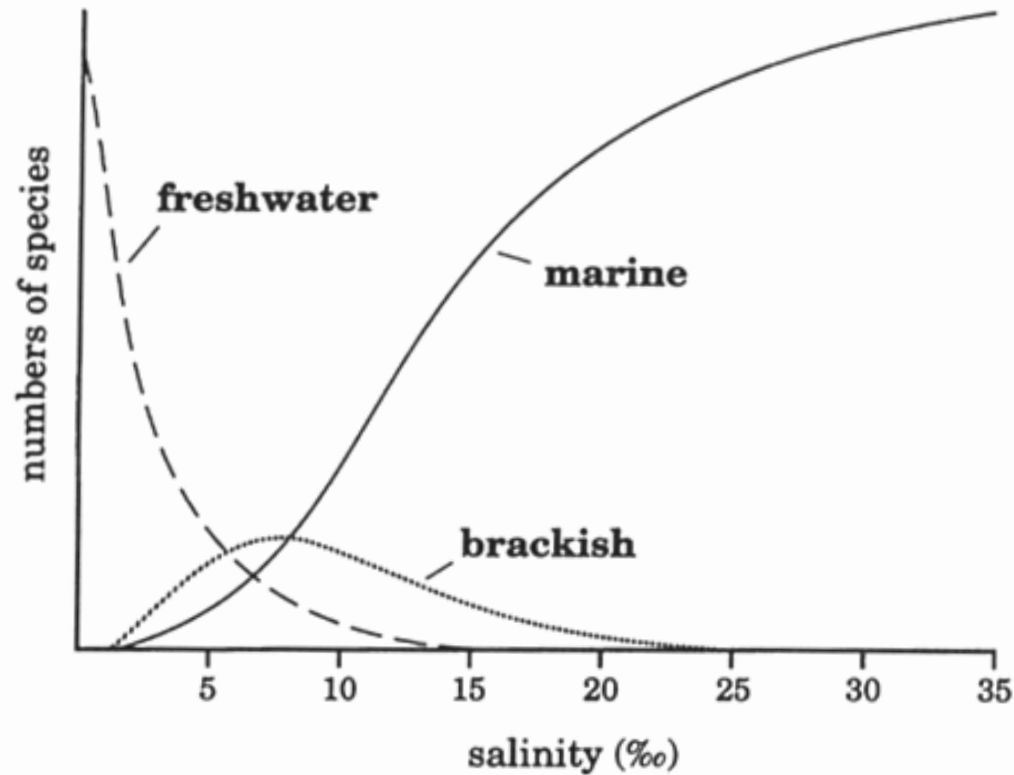


d Fjord estuary



e Reverse estuary

# Species Diversity Along a Salinity Gradient



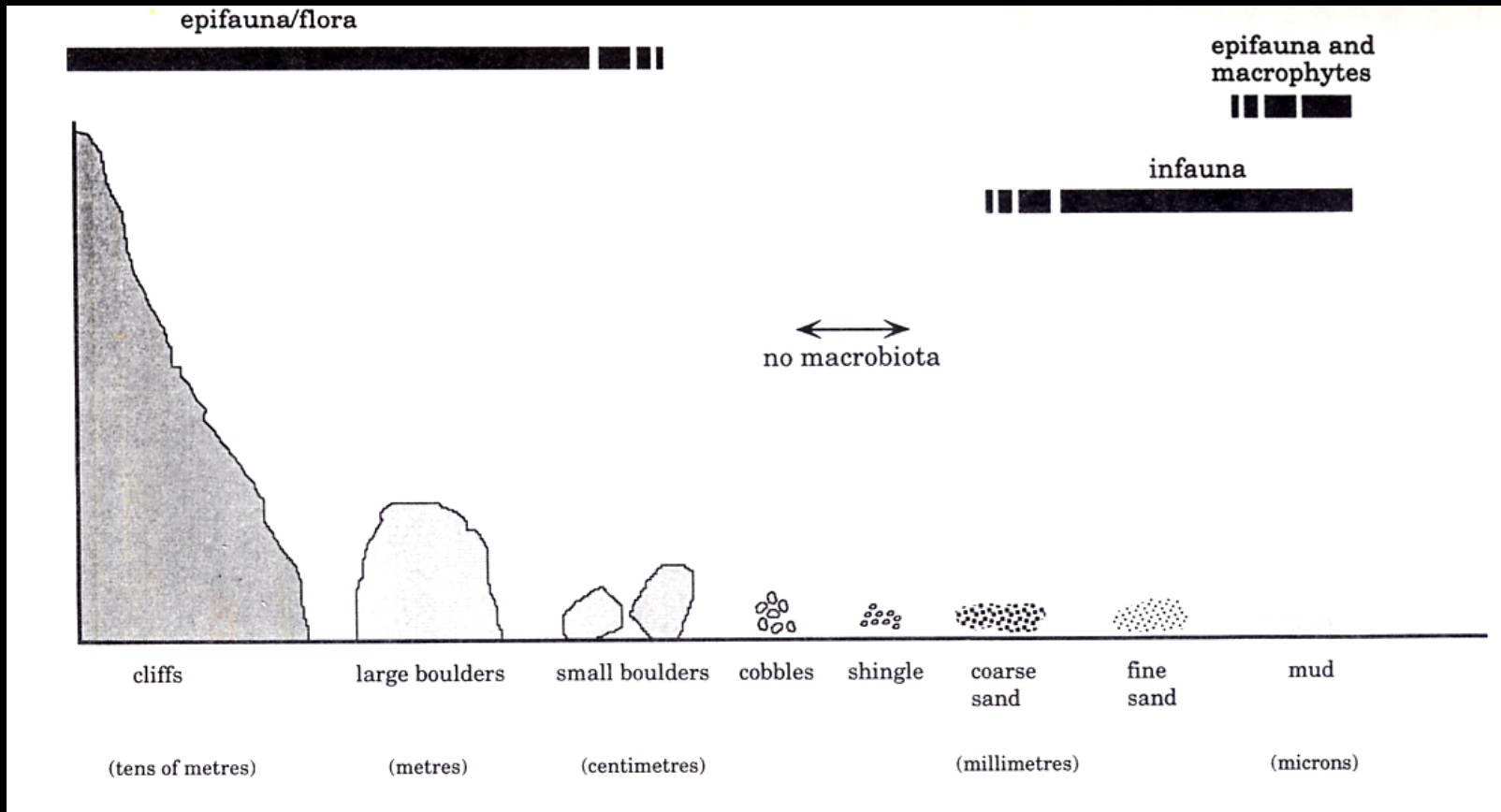
# Exposure and Sediment Characteristics



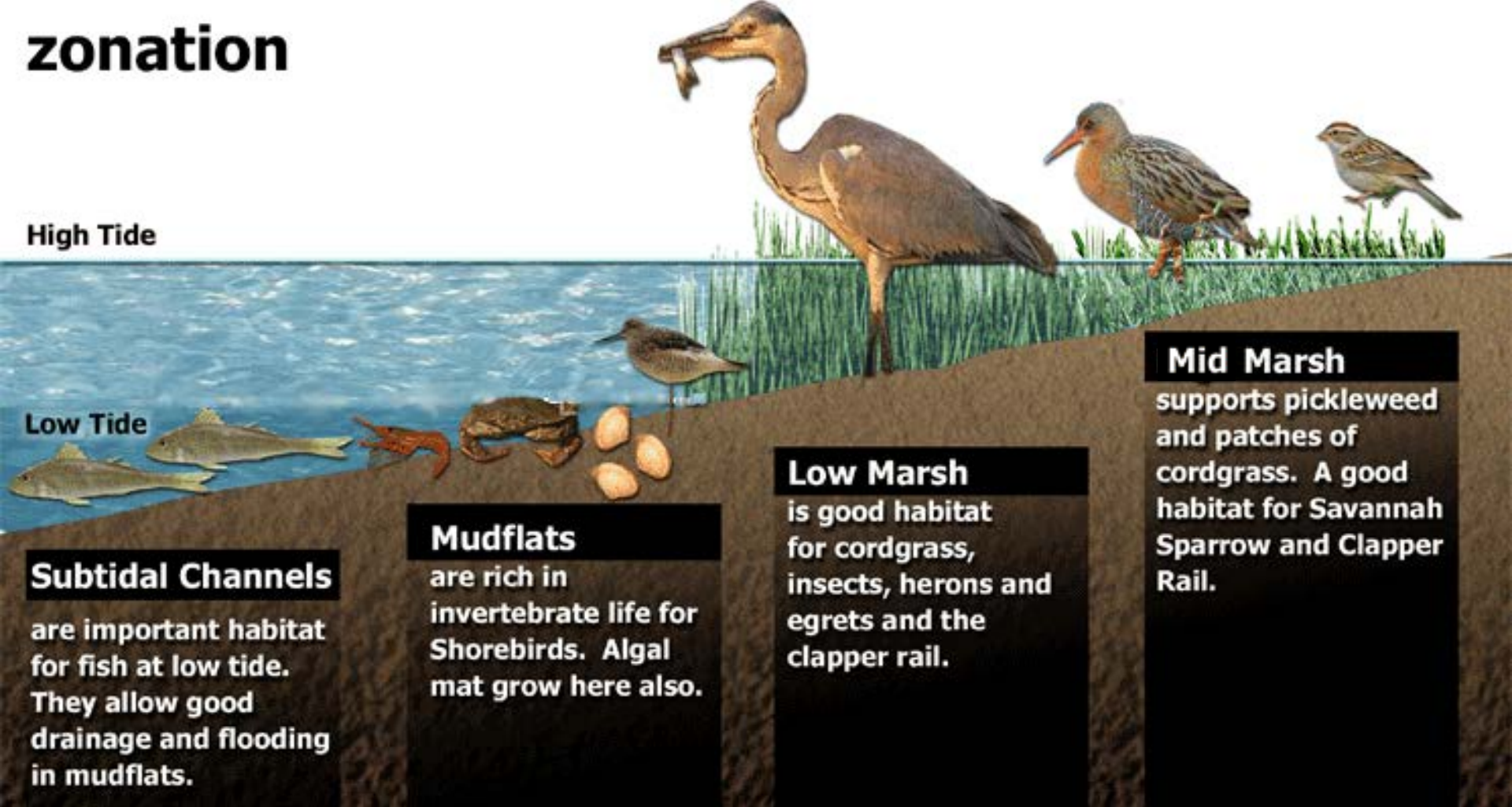


# Energy, Grain Size, & Biota

← wave energy →



# zonation



High Tide

Low Tide

## Subtidal Channels

are important habitat for fish at low tide. They allow good drainage and flooding in mudflats.

## Mudflats

are rich in invertebrate life for Shorebirds. Algal mat grow here also.

## Low Marsh

is good habitat for cordgrass, insects, herons and egrets and the clapper rail.

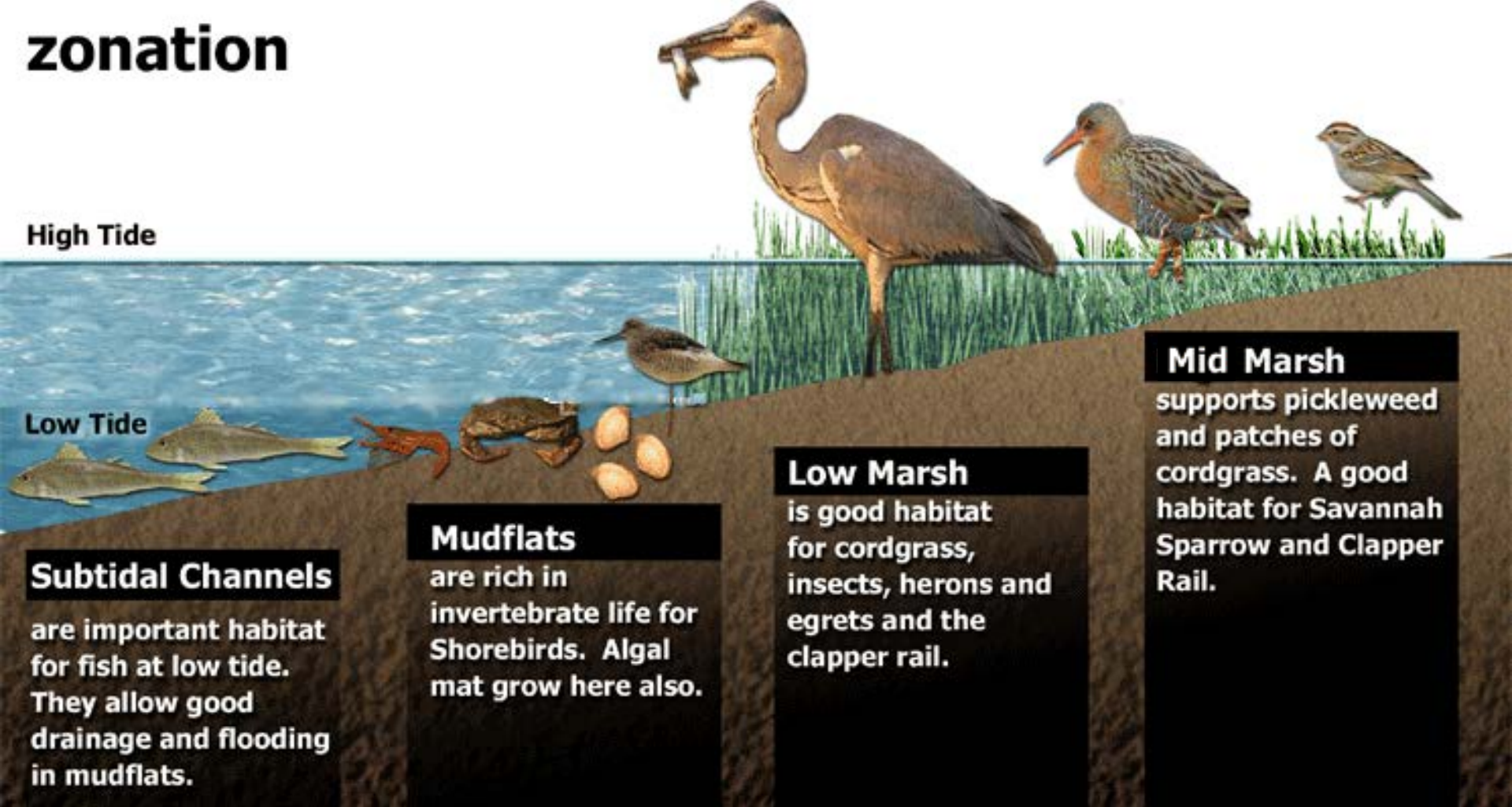
## Mid Marsh

supports pickleweed and patches of cordgrass. A good habitat for Savannah Sparrow and Clapper Rail.

# Zonation patterns in southern California estuaries



# zonation



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Low Tide

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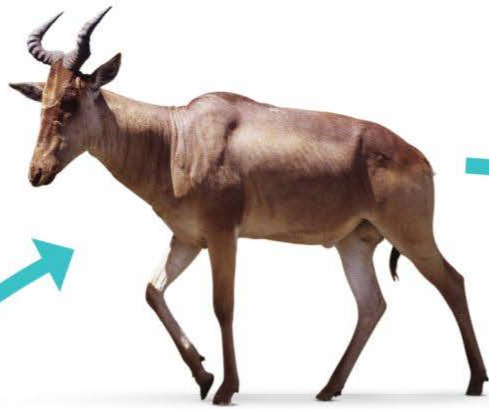
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# Zonation patterns in southern California estuaries

**CO<sub>2</sub>**  
Respiration



**CO<sub>2</sub>**  
Respiration



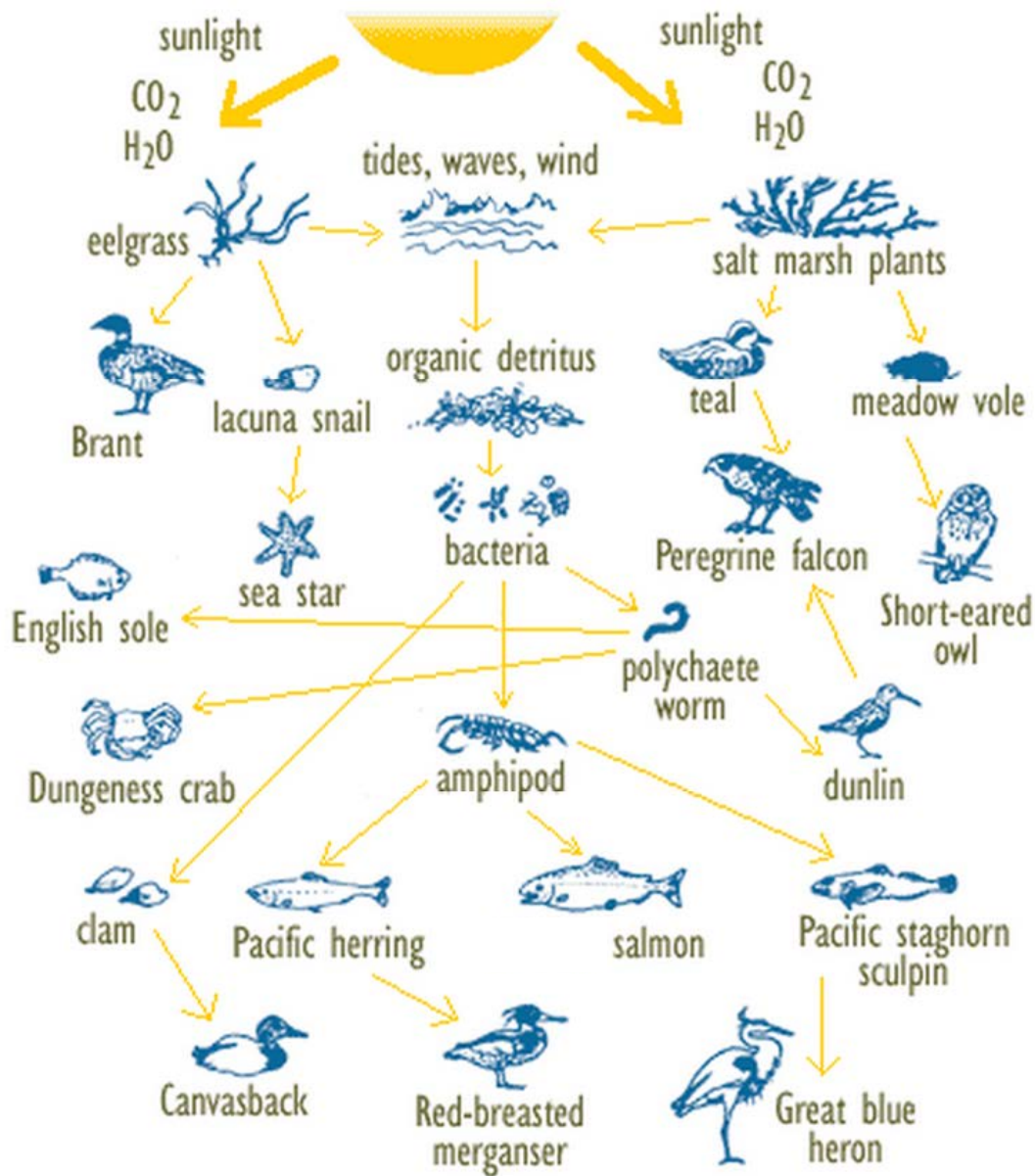
# Food Chain

**CO<sub>2</sub>**  
Photosynthesis

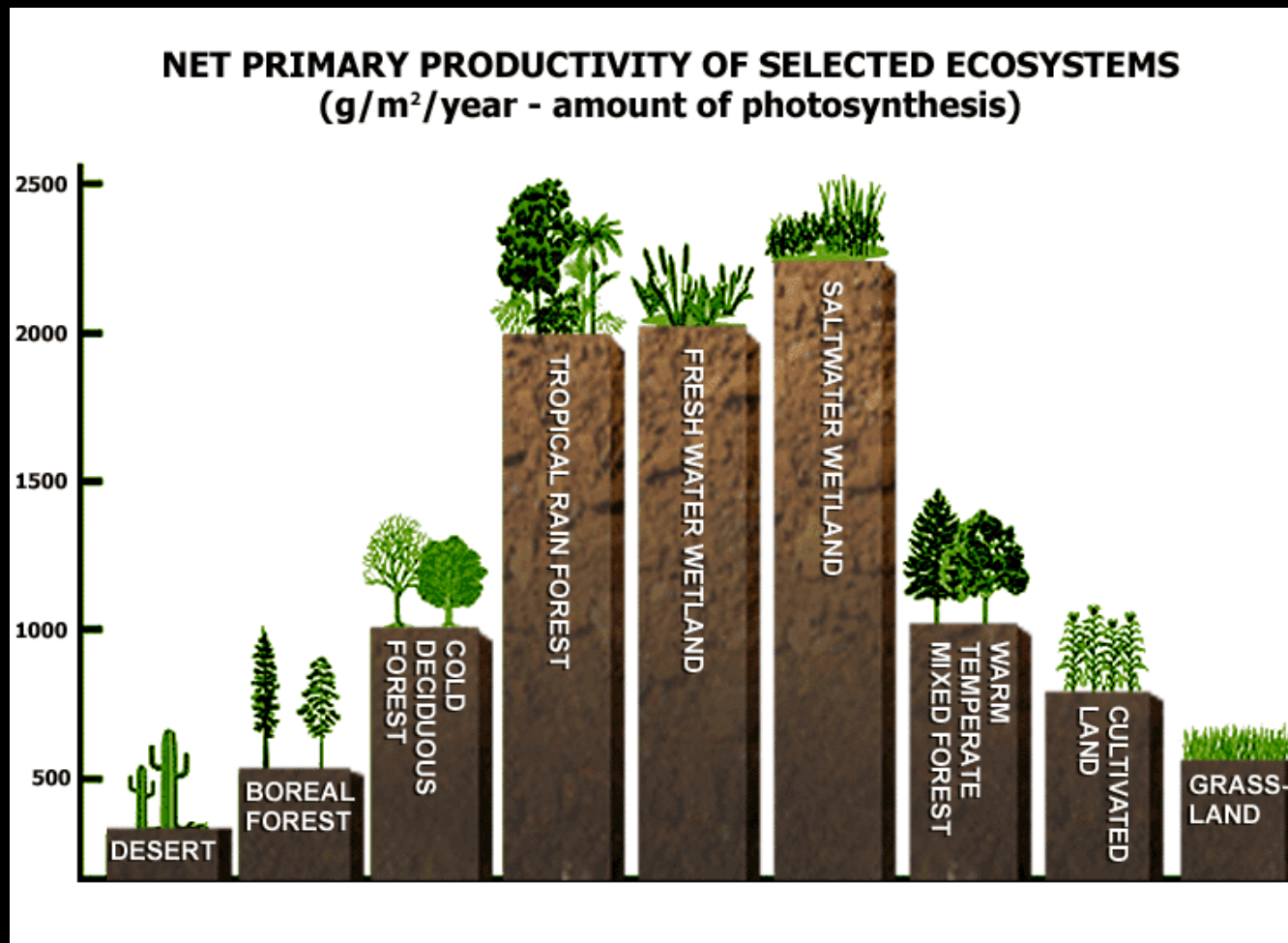


# Salt Marsh Food Web

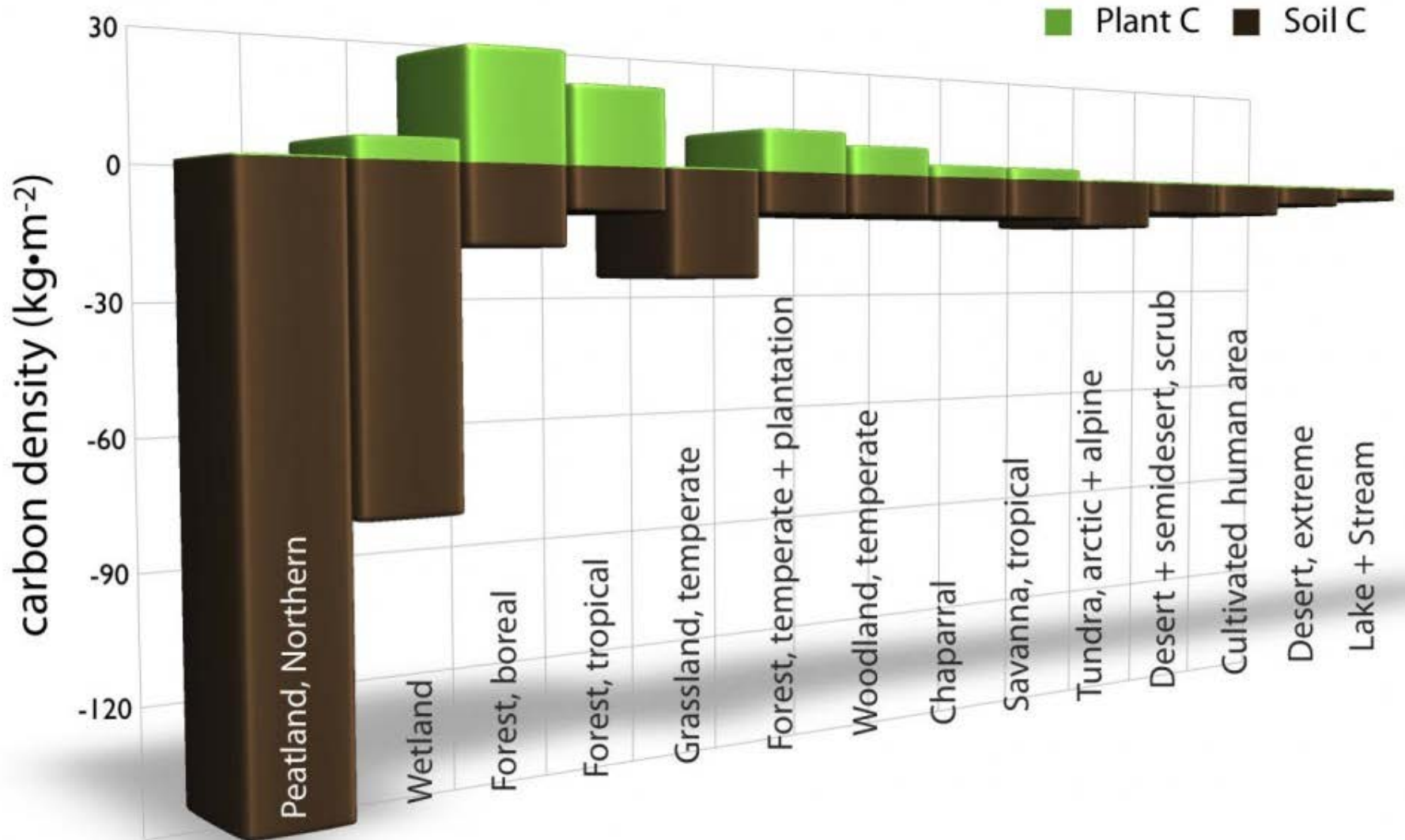
Detritus-based



# Productivity of Saltmarshes



# Aboveground vs. Belowground Carbon



(after Amthor et al. 1998)

# Carbon Sequestration

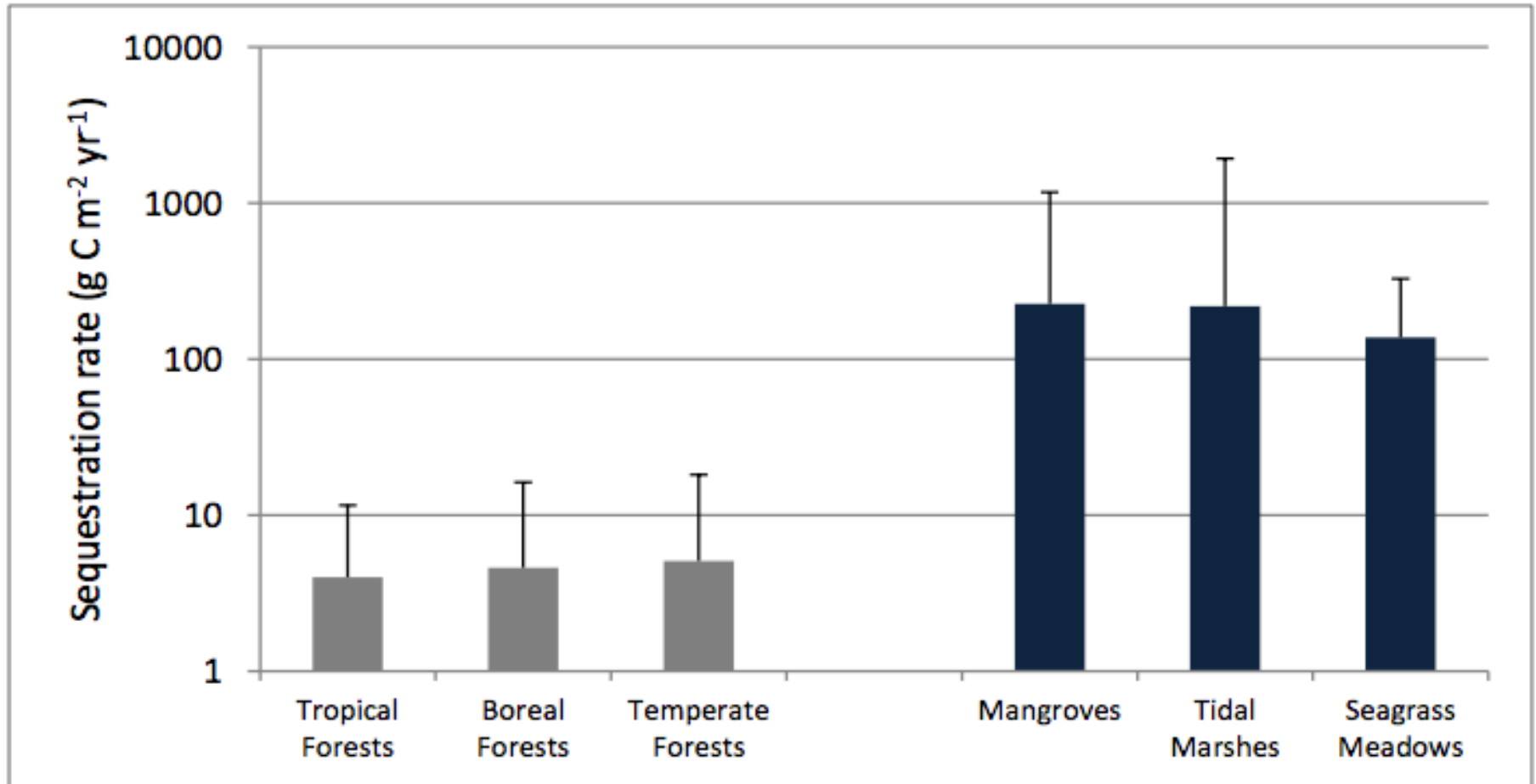


Figure 1. Annual mean carbon sequestration rates for blue carbon habitats per unit area compared to terrestrial forest habitats (error bars indicate maximum rates of accumulation). The annual sequestration rate of a given ecosystem is the quantity of  $\text{CO}_2$  removed from the atmosphere and/or ocean and trapped in natural habitats (Modified from McLeod et al. 2011).

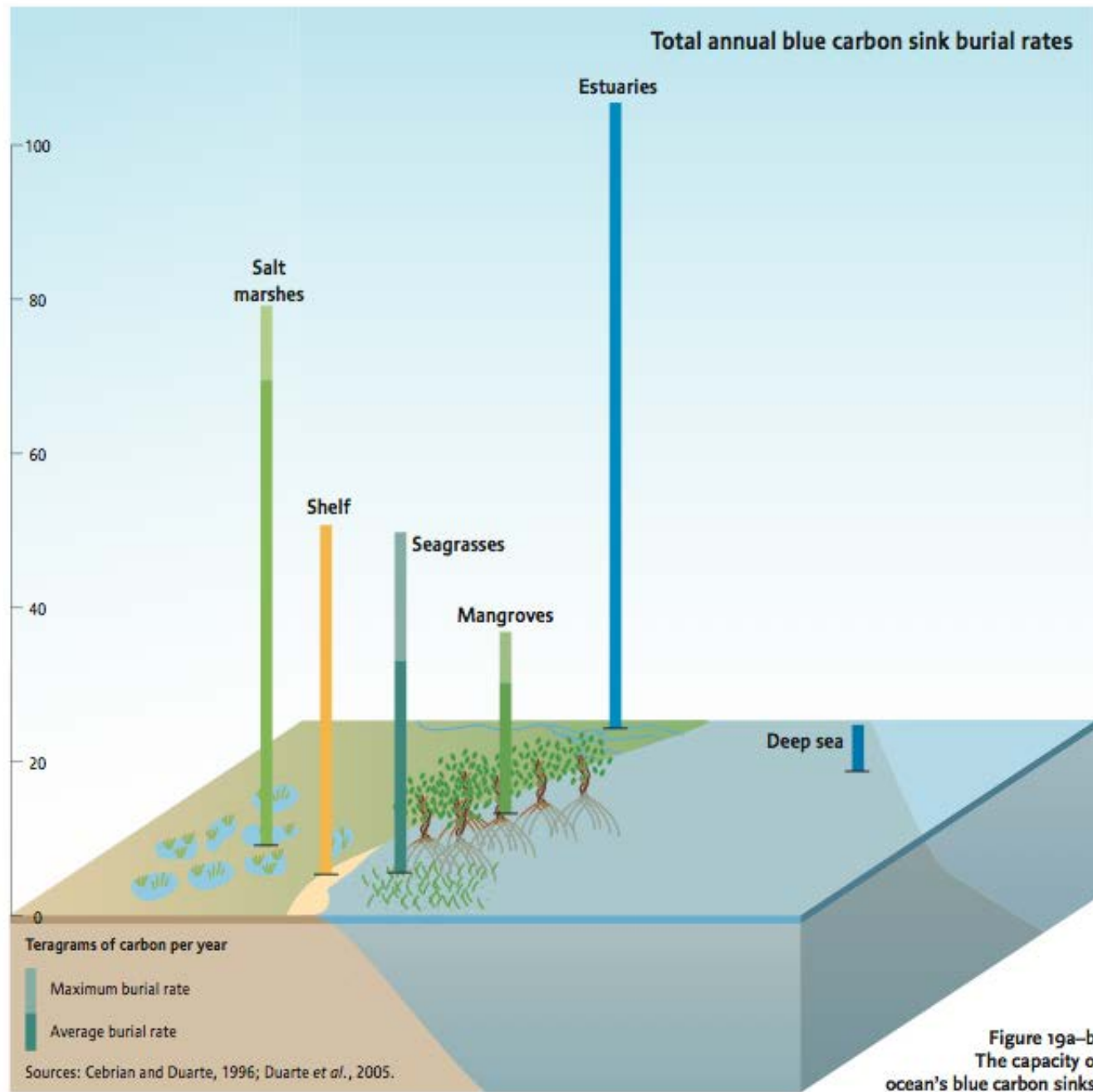
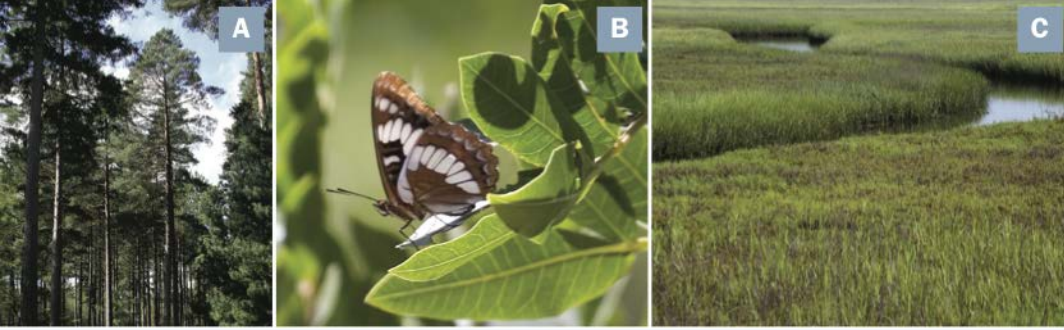
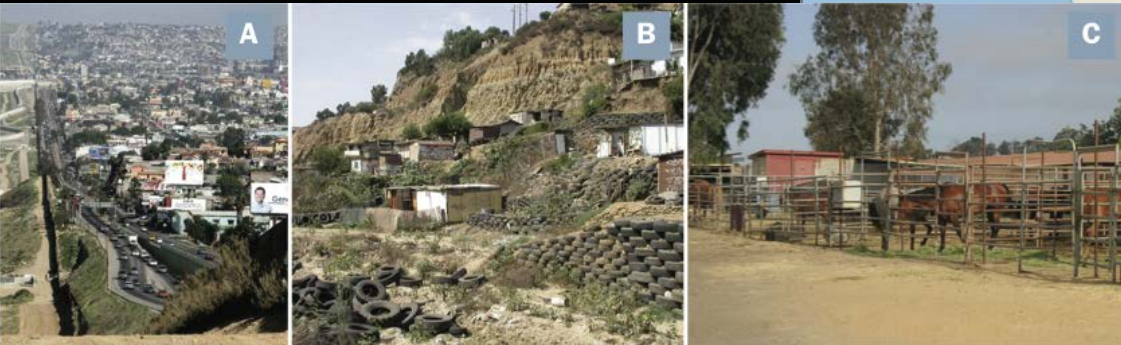


Figure 19a-b:  
The capacity of  
ocean's blue carbon sinks.



Diverse binational watershed with varied habitats: A) pine forest B) riparian habitat C) salt marsh

# Tijuana River Watershed

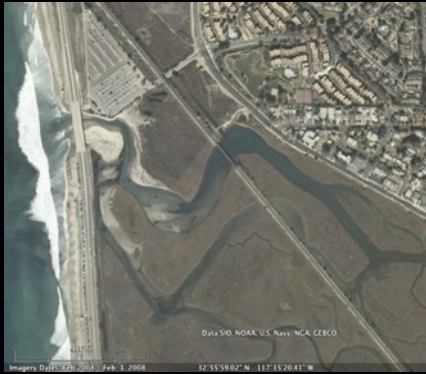


Current land uses in the watershed include: A) urban areas B) semi-urban development C) ranches in the Valley



# Threats

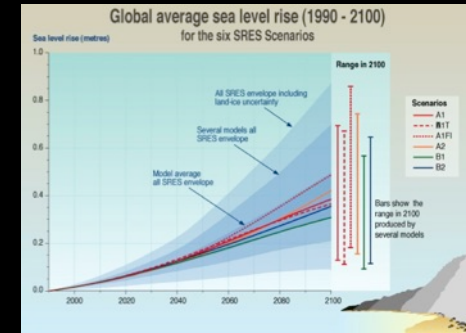
## Habitat Degradation



## Overexploitation



## Invasive Species



## Climate Change

## Sediment Loading



## Pollutants & Trash



## Hydrology



# Adaptive Management

Adaptive management is an iterative process of optimal decision-making in the face of uncertainty, with an aim to reducing that uncertainty over time via research and monitoring\*

\*from Wikipedia

# Adaptive Management – Invasive Species



atmosphere • climate • oceans  
organization • education • **newsroom** • search • home

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[Archive of Spotlight Feature Articles](#)

## **Invasion and Impacts of Tamarisk in Tijuana Estuary Salt Marshes, and Ecosystem Recovery After Its Removal**



(Left) Tamarisk in bloom. Photo: Jil M. Swearingen, USDI National Park Service

(Right) Reserve Research Coordinator Jeff Crooks points to tamarisk growing along the Tijuana River banks. Photos: Christina Johnson, California Sea Grant

# Adaptive Restoration



## Oneonta Tidal Linkage

This 2 acre excavation improves tidal circulation to 200 acres of vulnerable salt marsh.



## Model Marsh

The 20-acre Model Marsh Project was constructed in an area of former salt marsh that had filled through a series of natural and man-made events. Approximately 100,000 cubic yards of soil were excavated to create a now-thriving marsh plain with tidal channels.

## TETRP

Planning for the second phase of the Tijuana Estuary Tidal Restoration Program began in 2002.



## Visitor Center

Designed by noted architect Rob Quigley, and winner of a coveted Orchid award, the Visitor Center houses nature exhibits, an audio-visual room, offices, a library and classroom space for the center's education program. The Visitor Center welcomes more than 16,000 visitors a year.

City of Imperial Beach



## Goat Canyon Quarry Restoration

Soil from the Model Marsh excavation was used to reconstruct an abandoned quarry. The slopes have been revegetated with native coastal upland species.



## Goat Canyon Enhancement Project

Flood-born sediment has buried more than 30 acres of marsh since the mid-1980's. The construction of sediment management basins in 2003 will protect future projects in the TETRP restoration area.

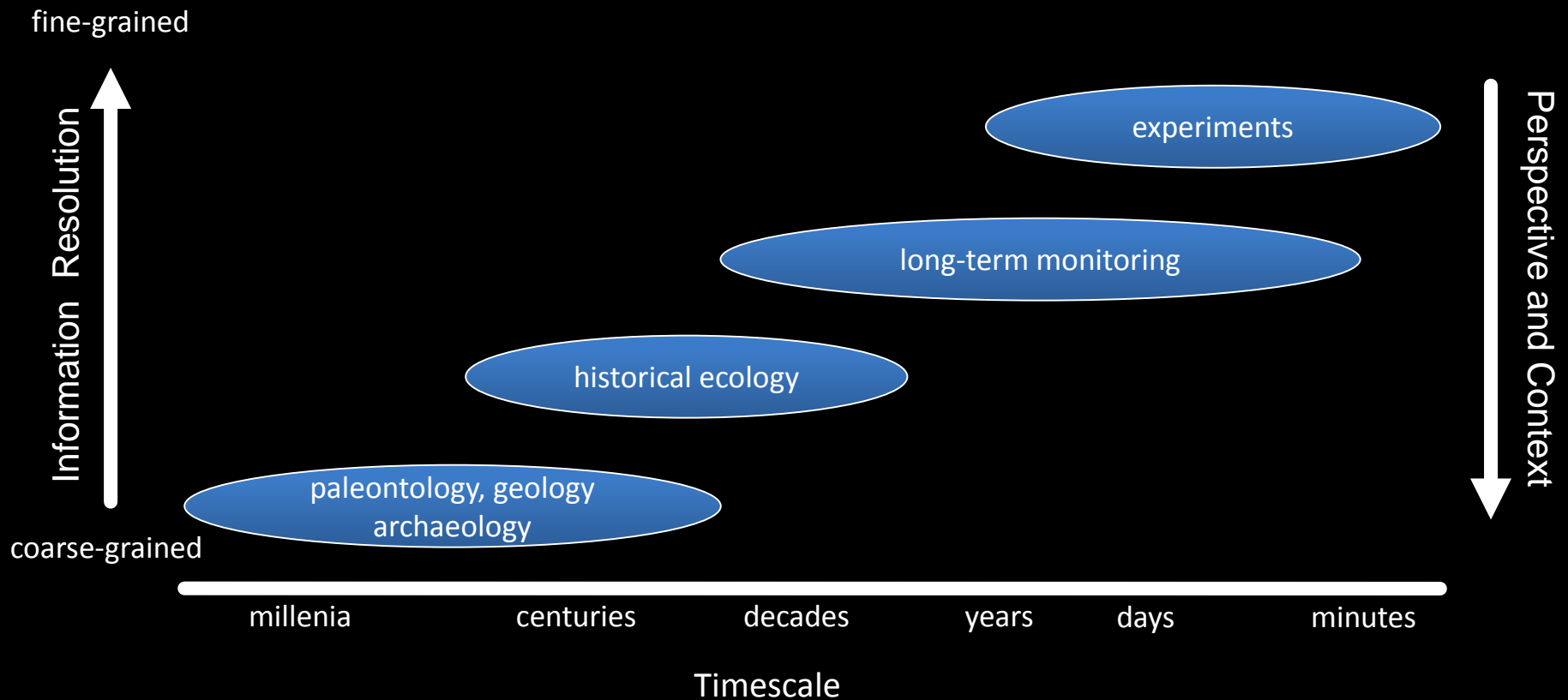


## Goals

- Re-create lost habitat and control invasive species
- Increase tidal prism and ability to export sediments
- Beneficially use excavated material
- Conduct research to steer future actions



# Science-Based Ecosystem Management - Sources of Information



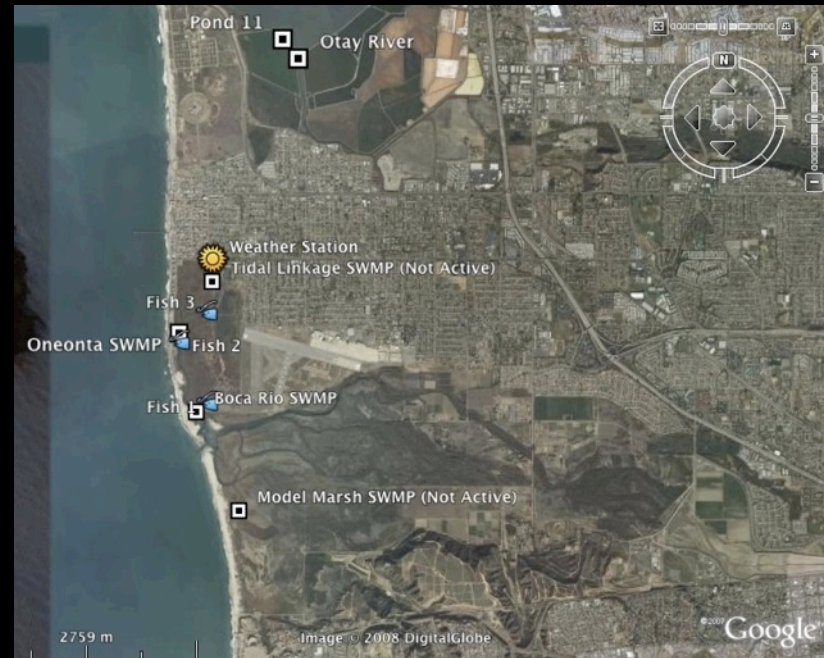
# Ecosystem Monitoring:

## Assessing “Vital Signs” and Fostering Adaptive Management

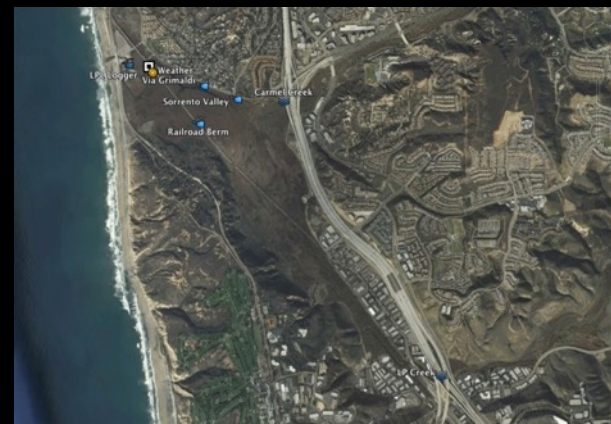
PERL and TRNERR

- Water: Temperature, Salinity, Dissolved Oxygen, Turbidity, pH, Depth
- Nutrients / Chlorophyll a
- Weather: Temperature, Humidity, Wind, Rainfall, Barometric Pressure, Light
- Topography / Bathymetry
- Soil Salinity
- Vegetation
- Invertebrates
- Fish
- Birds

South  
San Diego  
Bay



Tijuana  
River  
Estuary



Los  
Peñasquitos  
Lagoon

# SWMP

- Water Quality
  - Data sondes
    - 2 to 4 week deployments
    - Record salinity, temperature, dissolved oxygen, pH, turbidity, chlorophyll
    - Data from the sonde is uploaded and goes to the Central Data Management Office for QA/QC
    - Once data has been approved for the public it is available to download at <http://cdmo.baruch.sc.edu/>



# Boca Rio



# Oneonta Slough



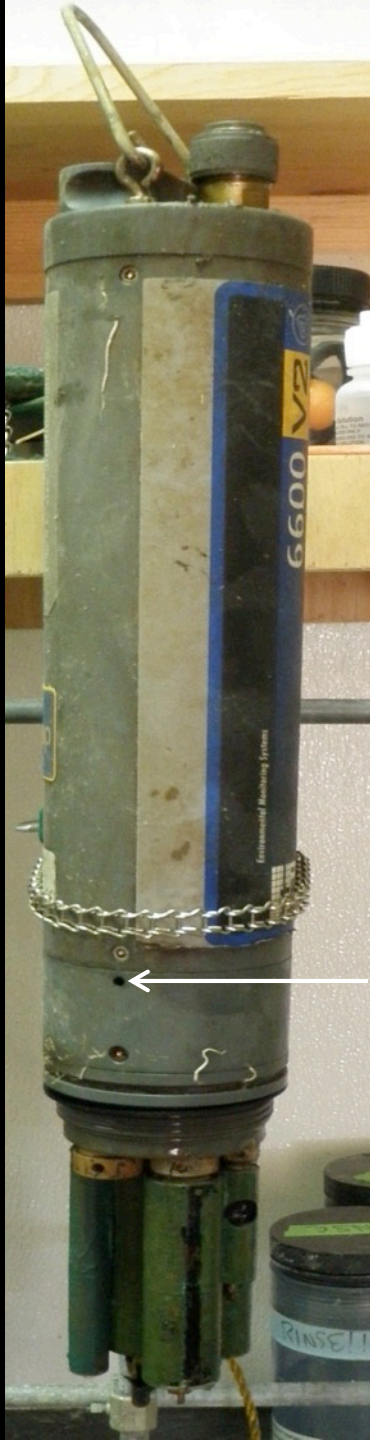
# South Bay



# Pond Eleven



# DataSonde Sensors

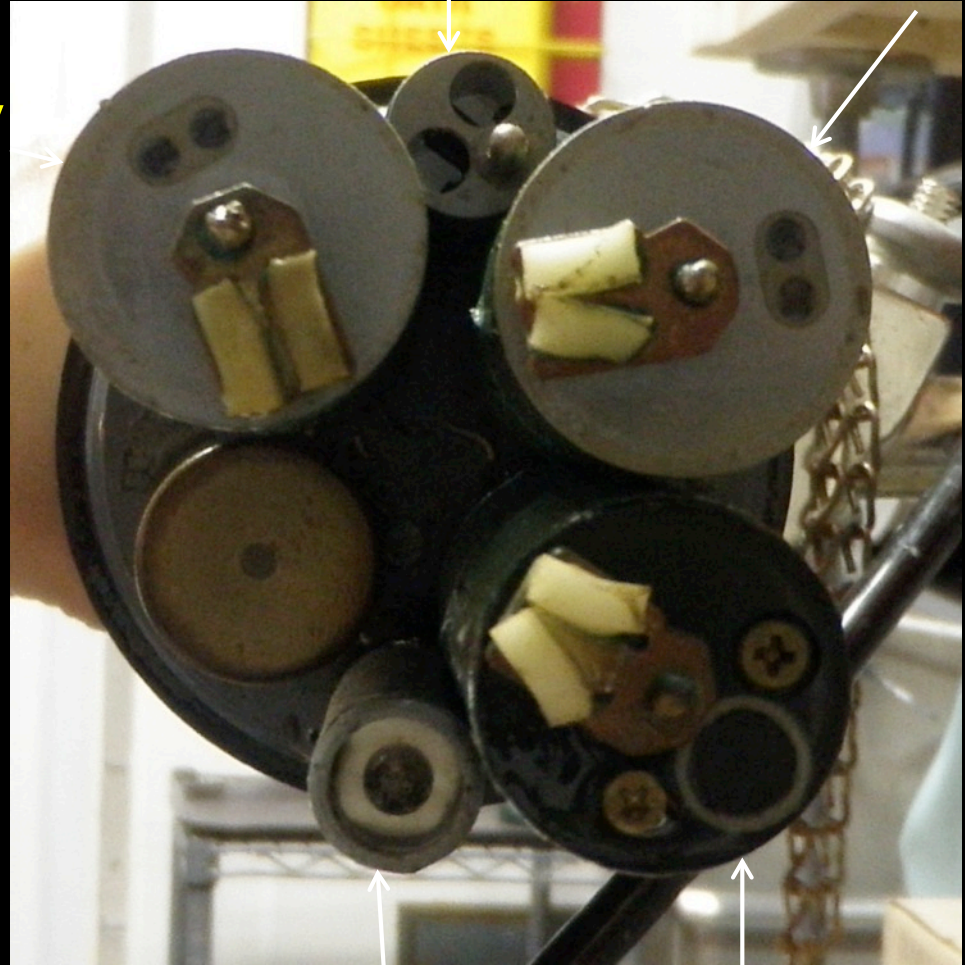


Turbidity

Depth

Conductivity/Temperature

Chlorophyll



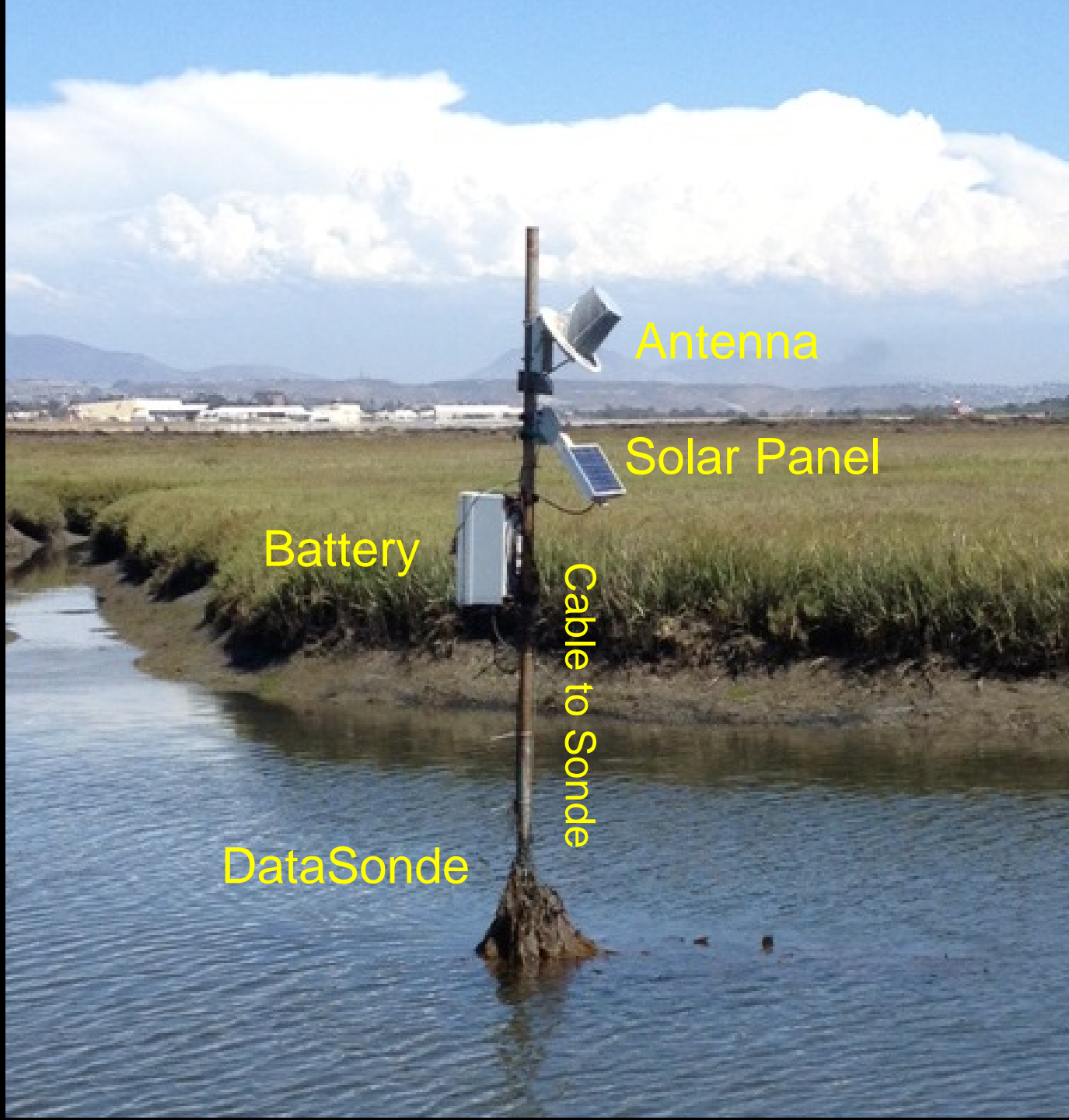
pH

Dissolved Oxygen



- Two sondes designated per site
  - Continuous data recording
  - Equipment failure – can take a day to a month for repairs





Antenna

Solar Panel

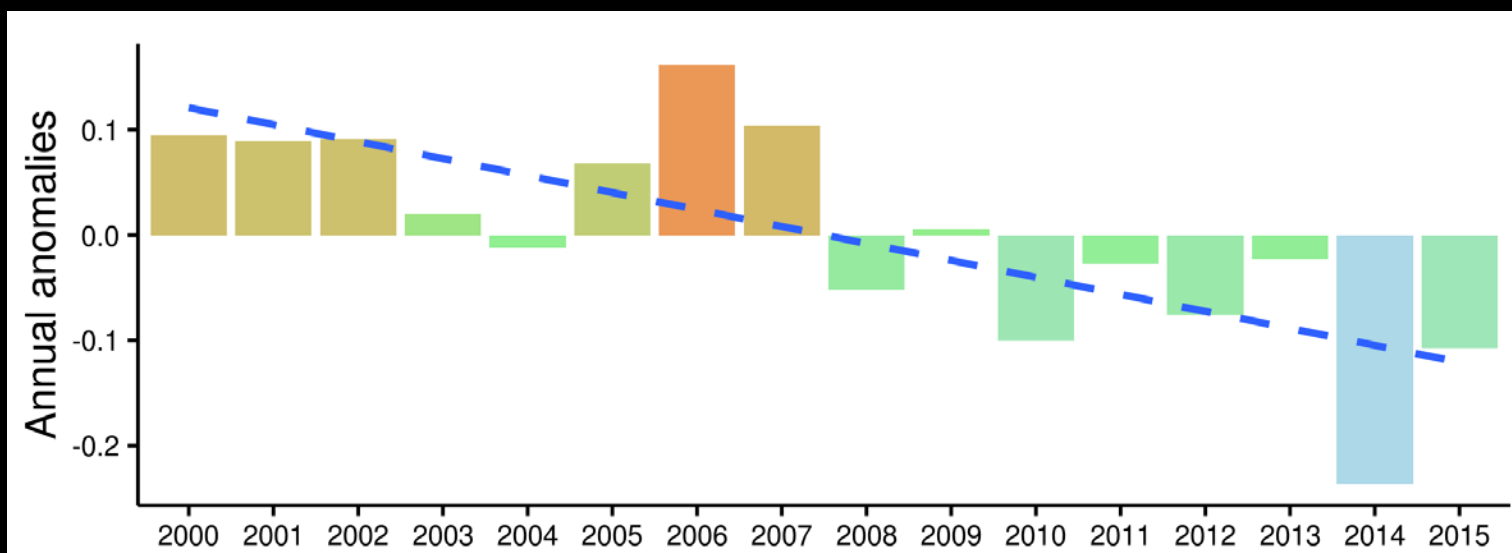
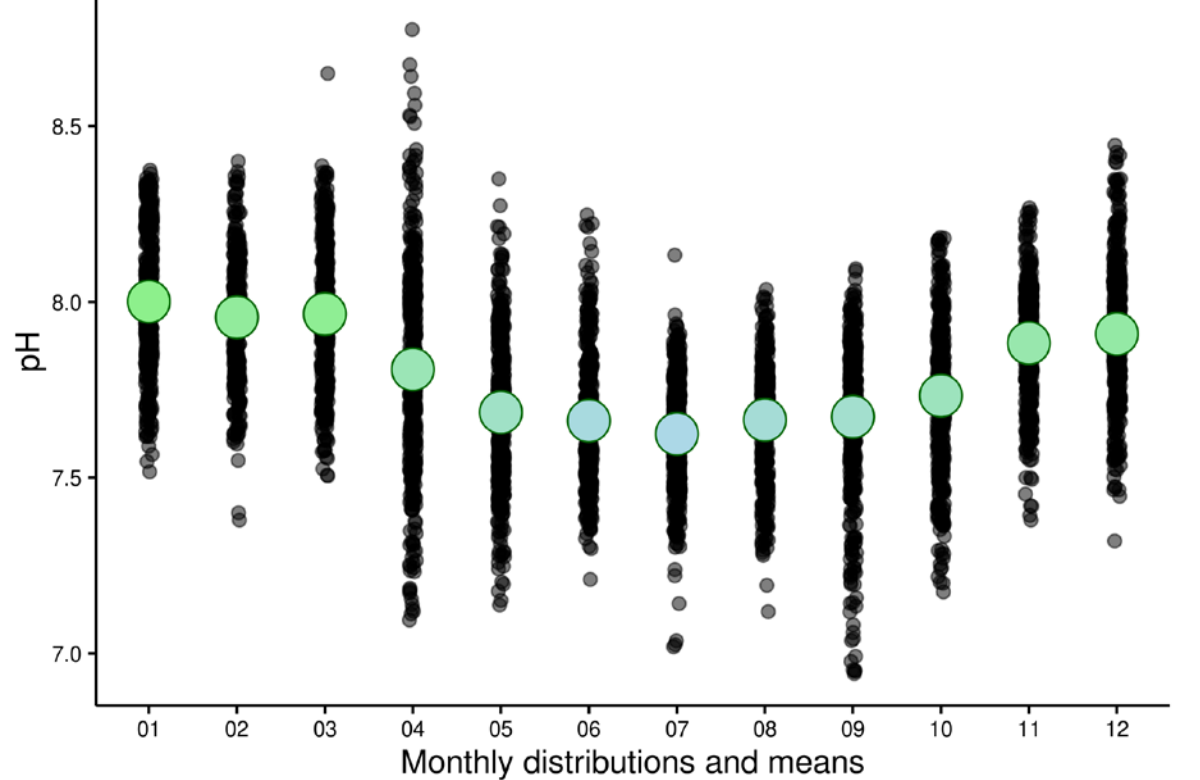
Battery

Cable to Sonde

DataSonde

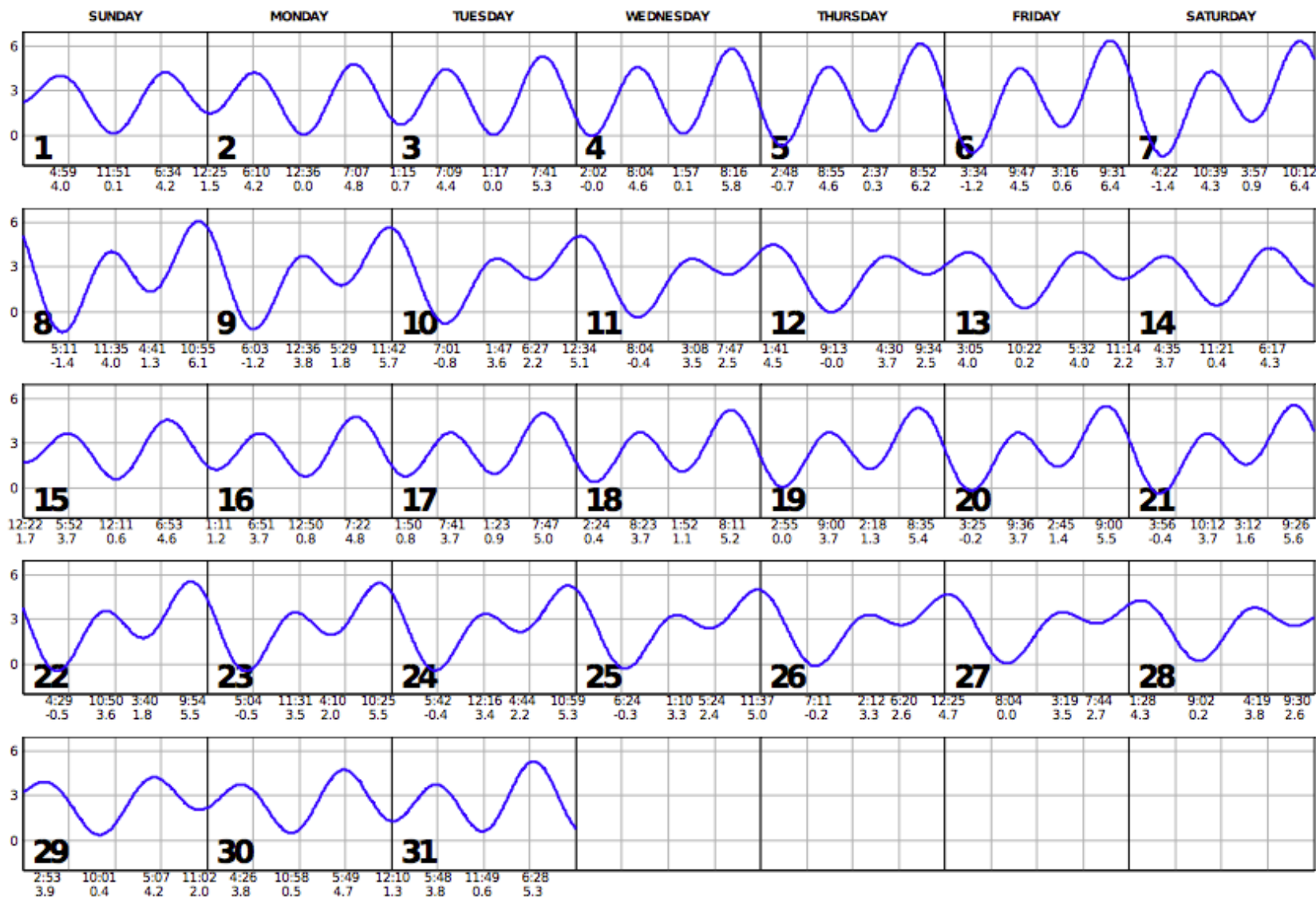






# May 2016

## Tide Predictions for Scripps Institution of Oceanography Pier



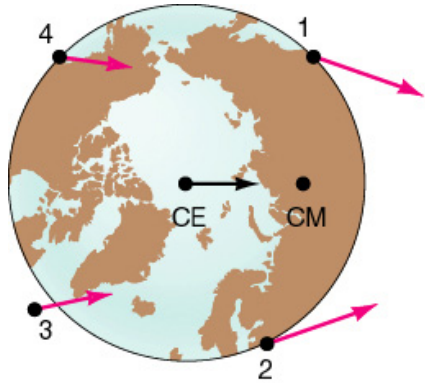
DISCLAIMER: These tides are predicted estimates only - actual tides will vary somewhat.

Enjoy the calendar, use it with caution and at your own risk.

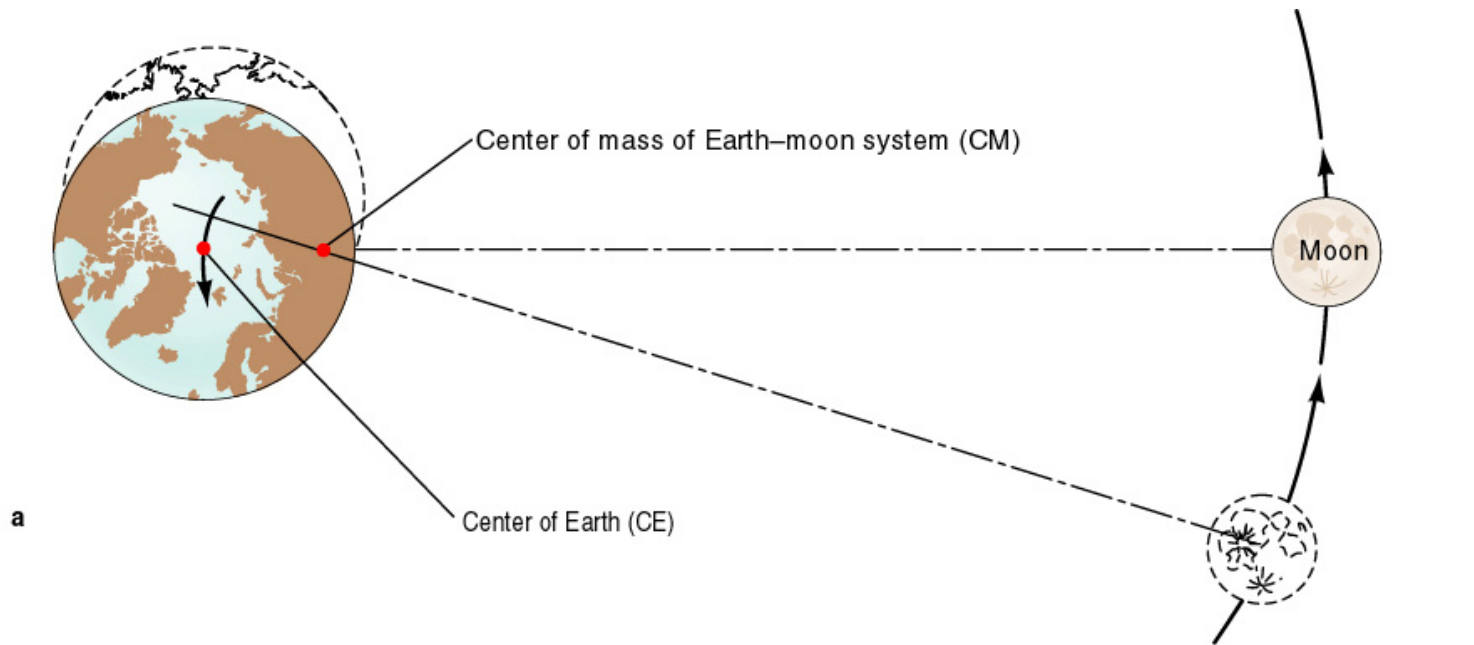
©2012 - Ed Parnell

# Gravity

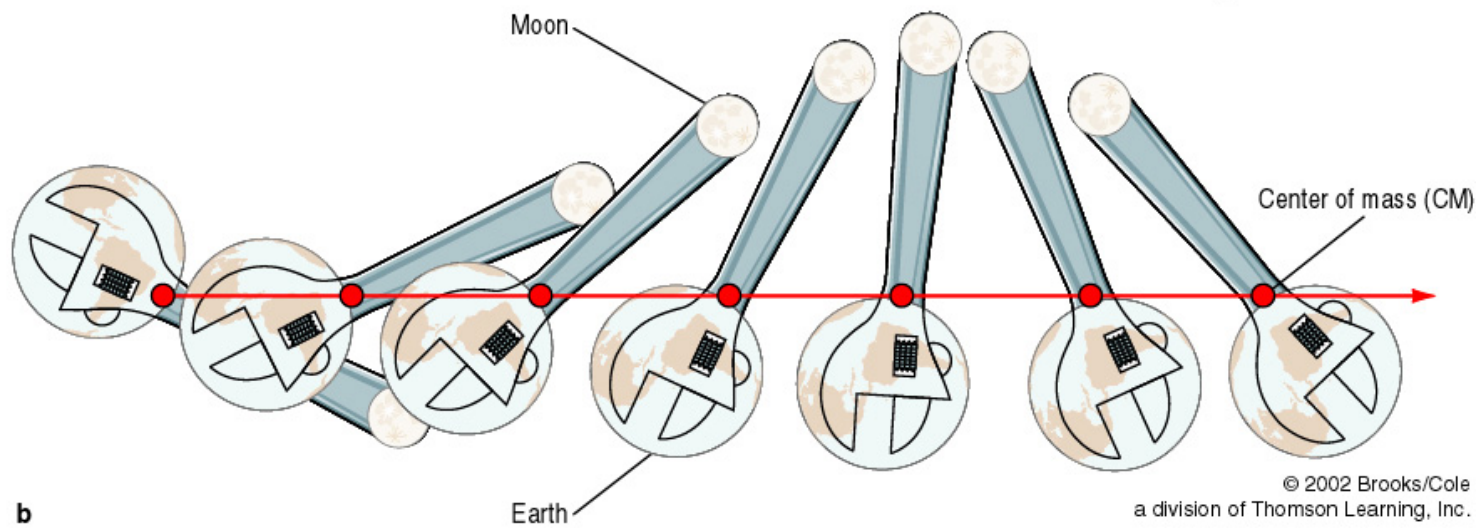
© 2002 Brooks/Cole  
a division of Thomson Learning, Inc.



CE = Center of Earth  
CM = Center of mass



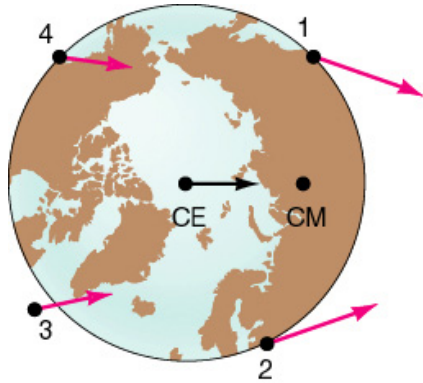
**a**



**b**

# Gravity

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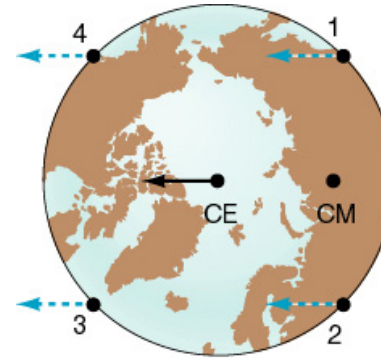


CE = Center of Earth  
CM = Center of mass



# Inertia

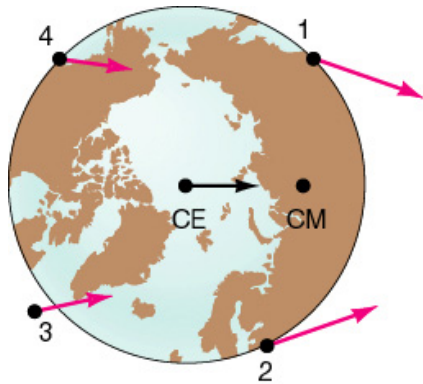
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a division of Thomson Learning, Inc.



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# Gravity

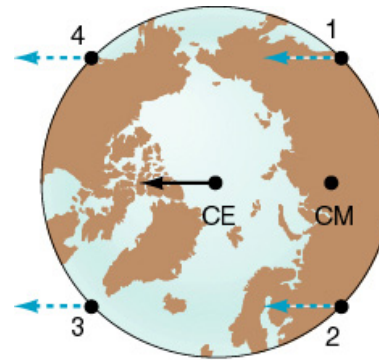


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# Inertia



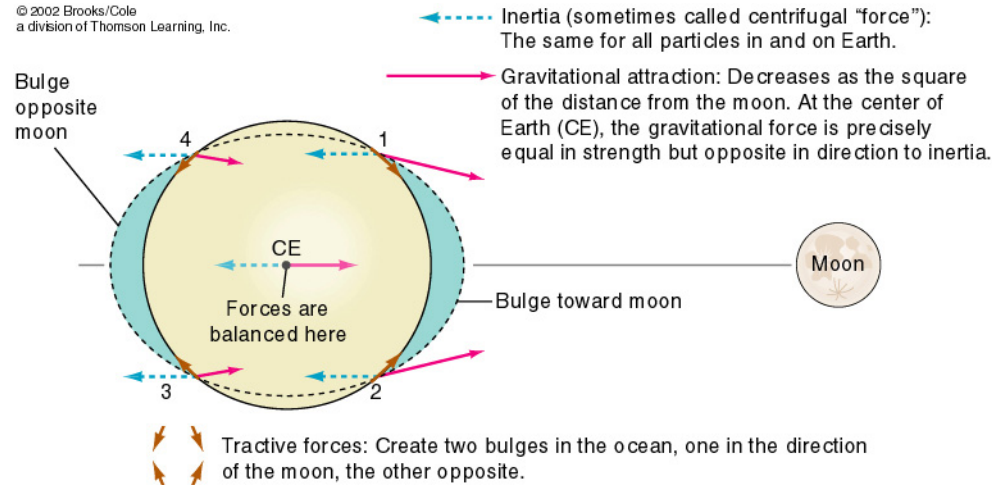
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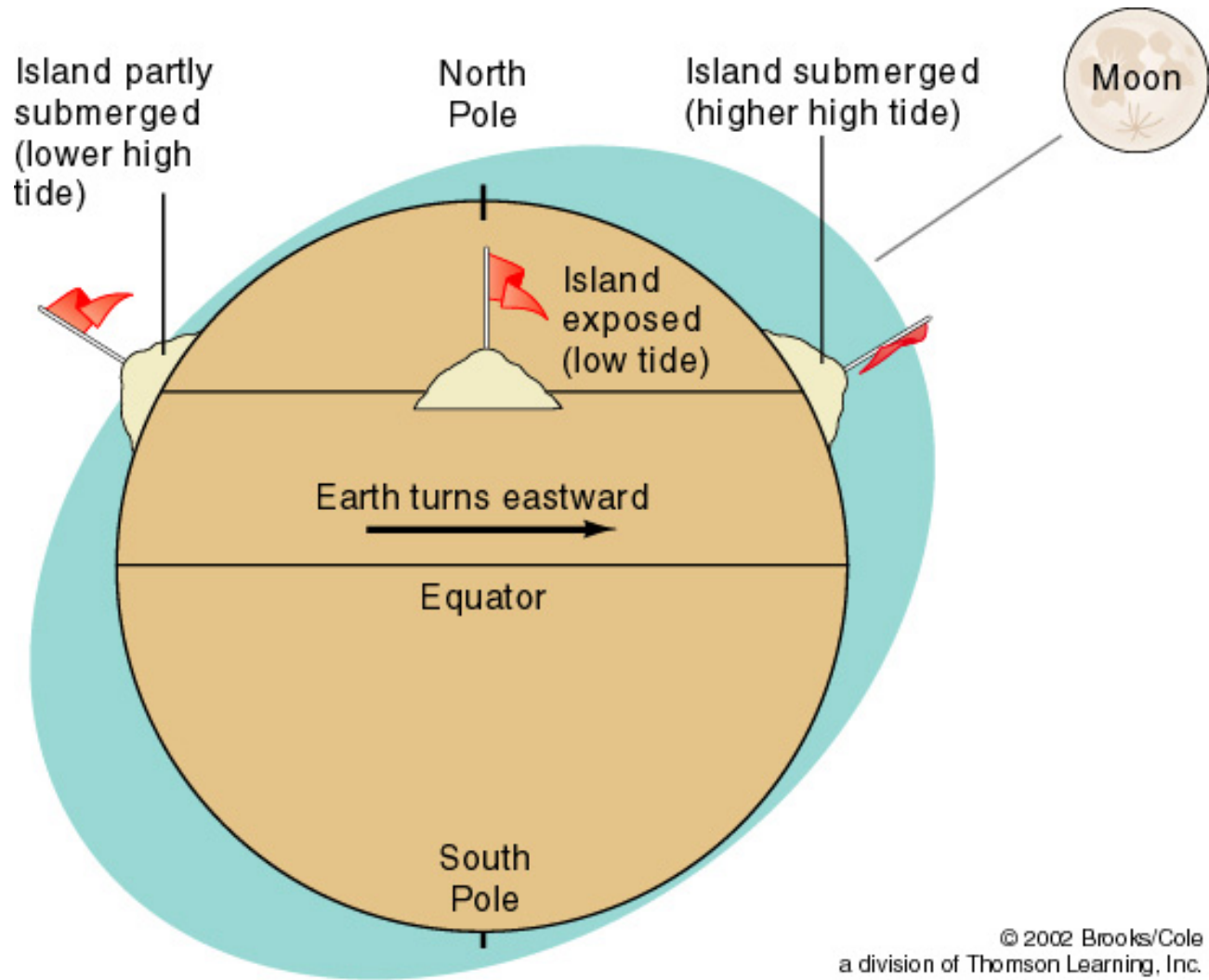
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# Difference Between the Two

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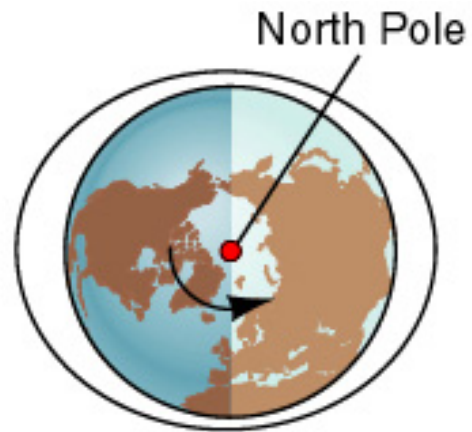
The two forces that can move the ocean are balanced only at the center of Earth (point CE). Elsewhere the net imbalance is a small force that causes ocean water to converge into two equal "bulges," as shown.







Moon



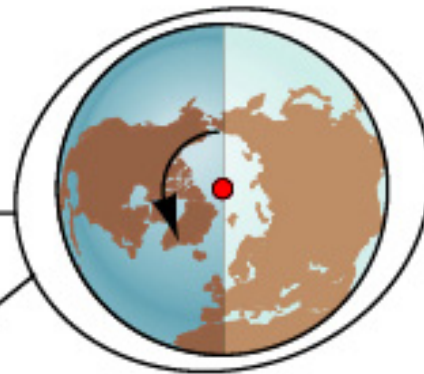
High tide  
0000 (midnight)

**a**



Moon  
moves

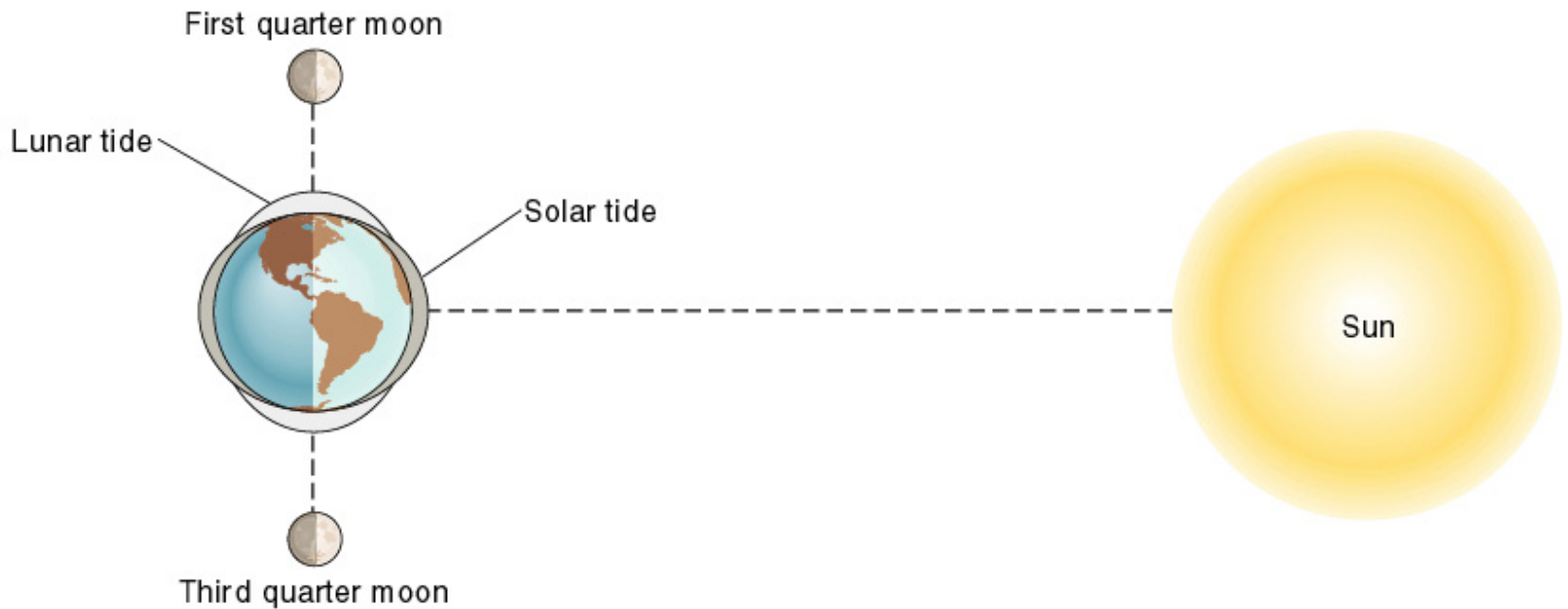
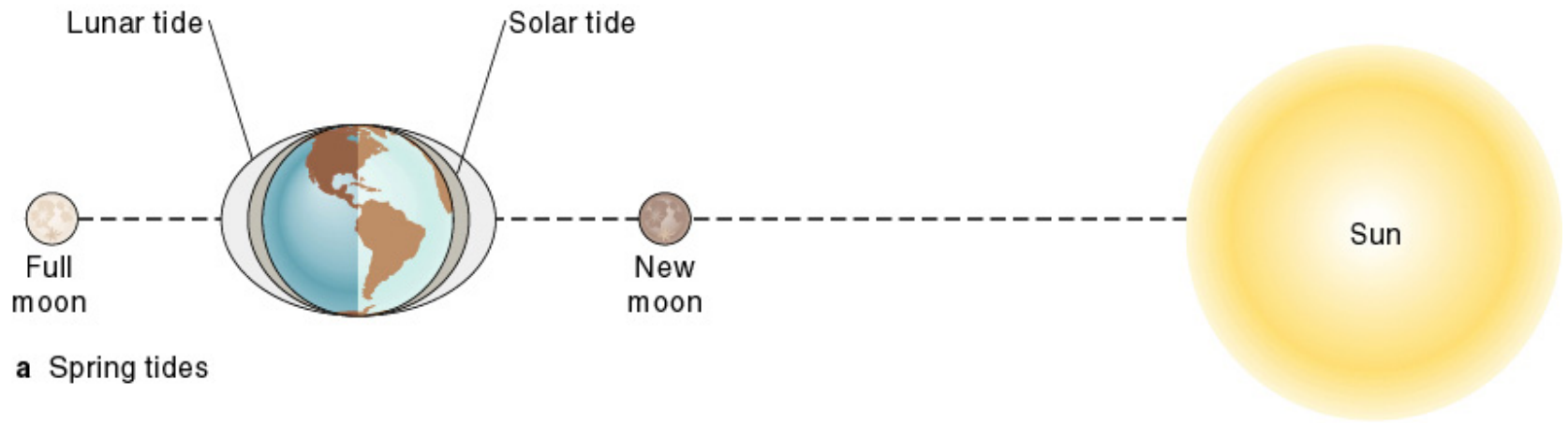
24 hr



High tide  
0050 (12:50 A.M.)

24 hr 50 min

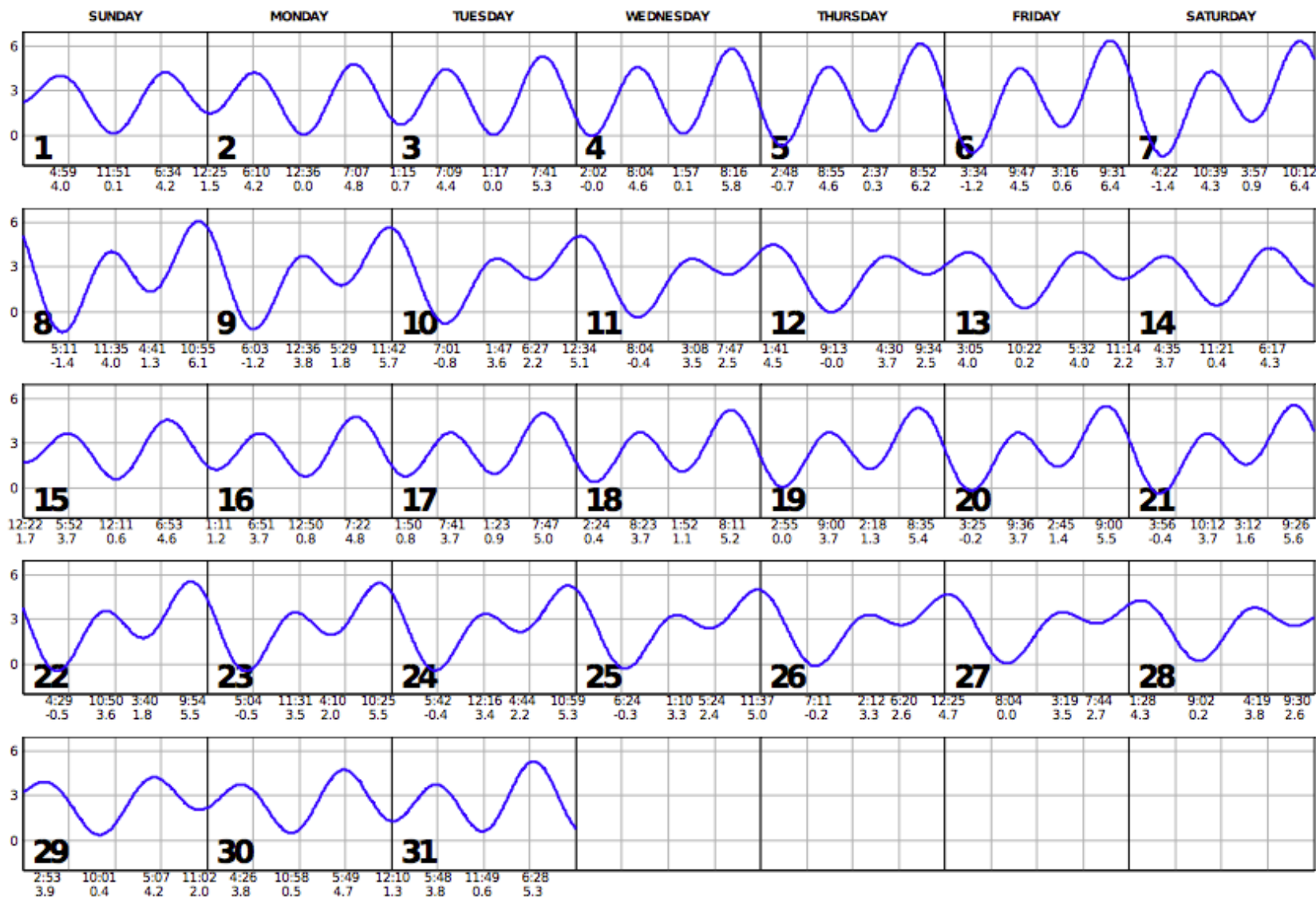
**b**



**b Neap tides**

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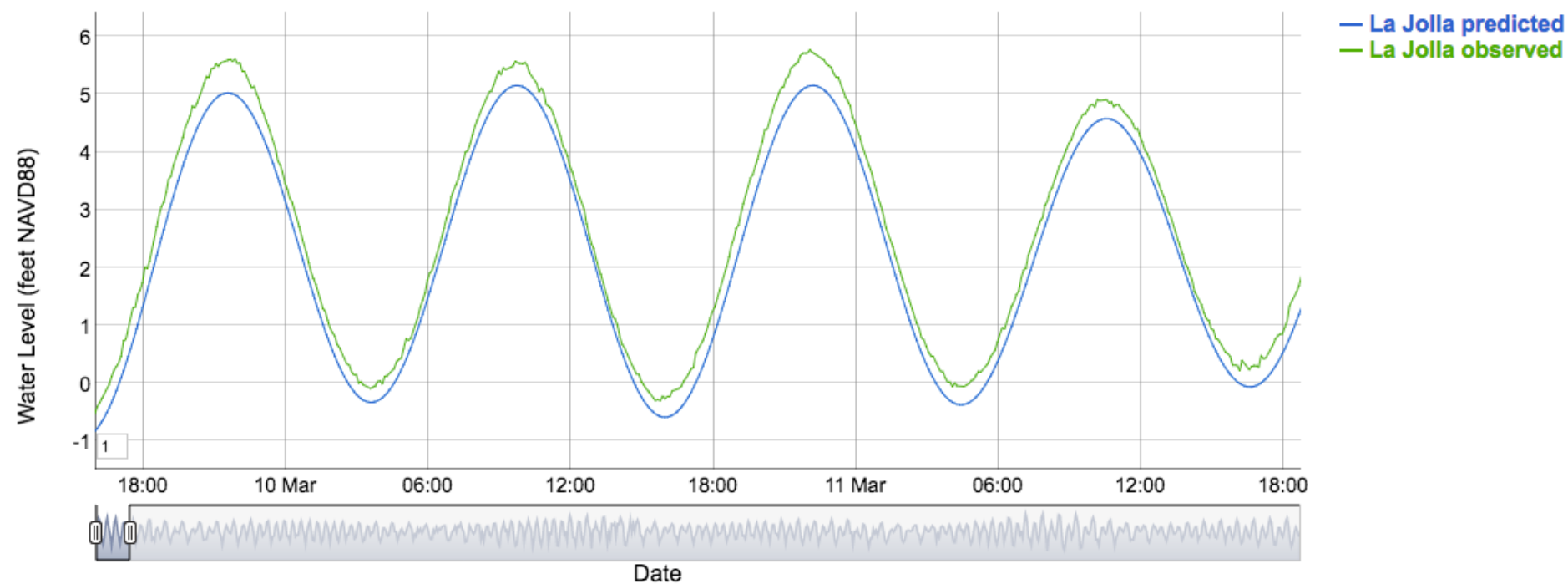
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Enjoy the calendar, use it with caution and at your own risk.

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## TRNERR Oneonta Slough station water levels with NOAA La Jolla

All data is preliminary and has not undergone any QAQC procedures



### Show Series:

- NOAA at La Jolla (predicted)
- NOAA at La Jolla (observed)
- TRNERR Oneonta Slough

### Chart Options:

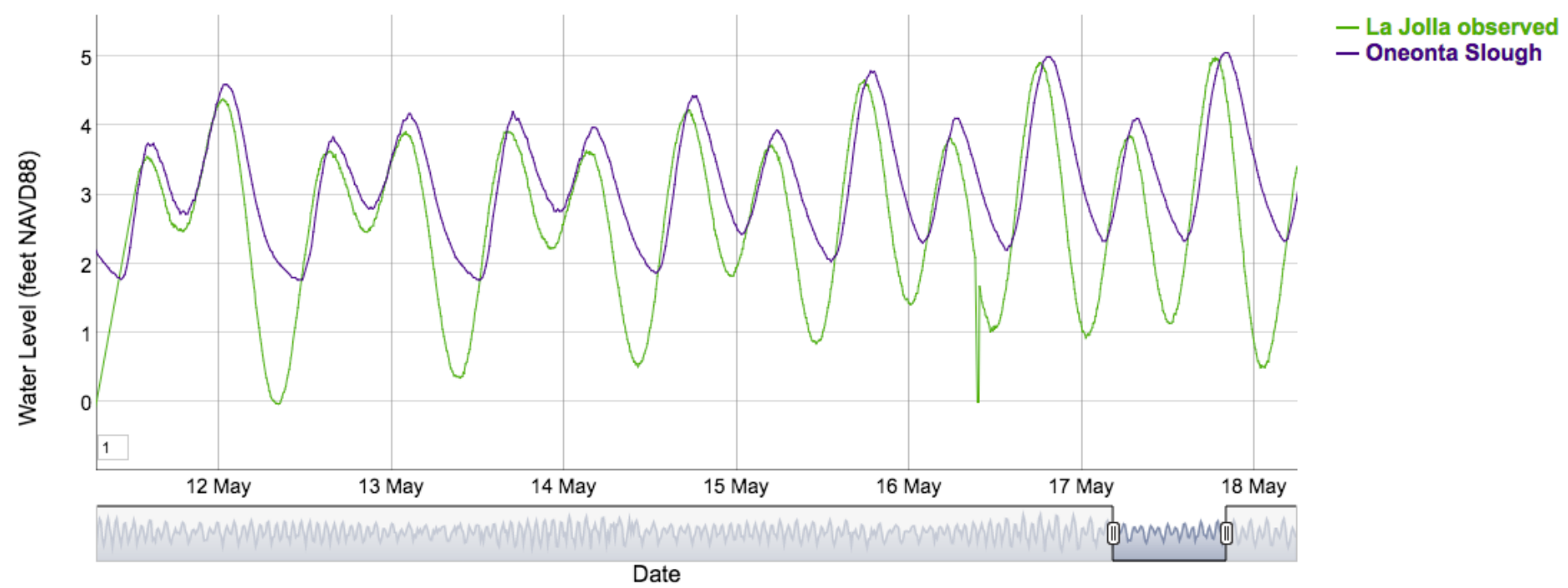
- Connect points  
(caution also connects missing data)

### NOTES:

- All times are Pacific Standard Time
- La Jolla is sampled at 6 min intervals
- TRNERR station at 15 min intervals

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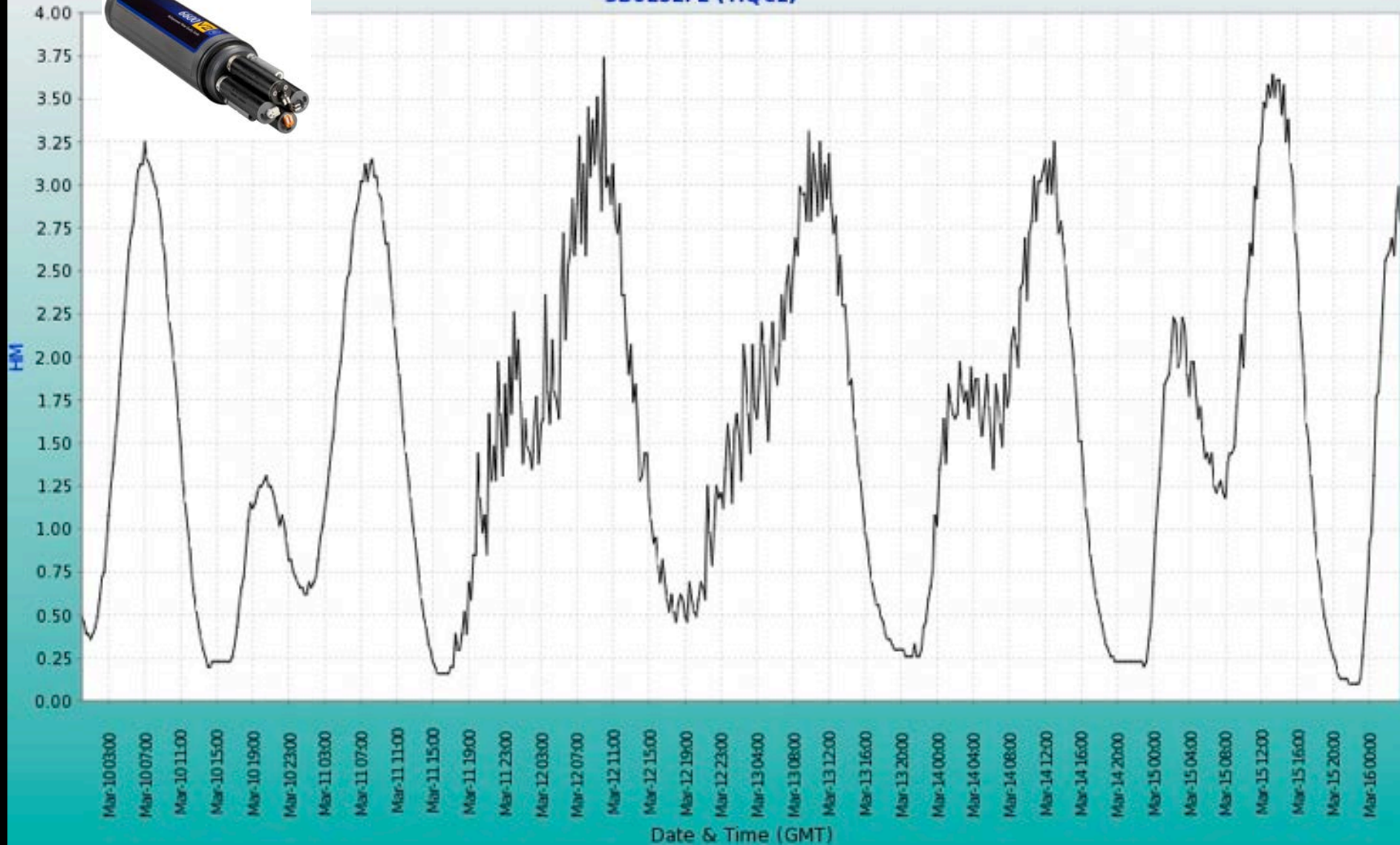
- NOTES:**
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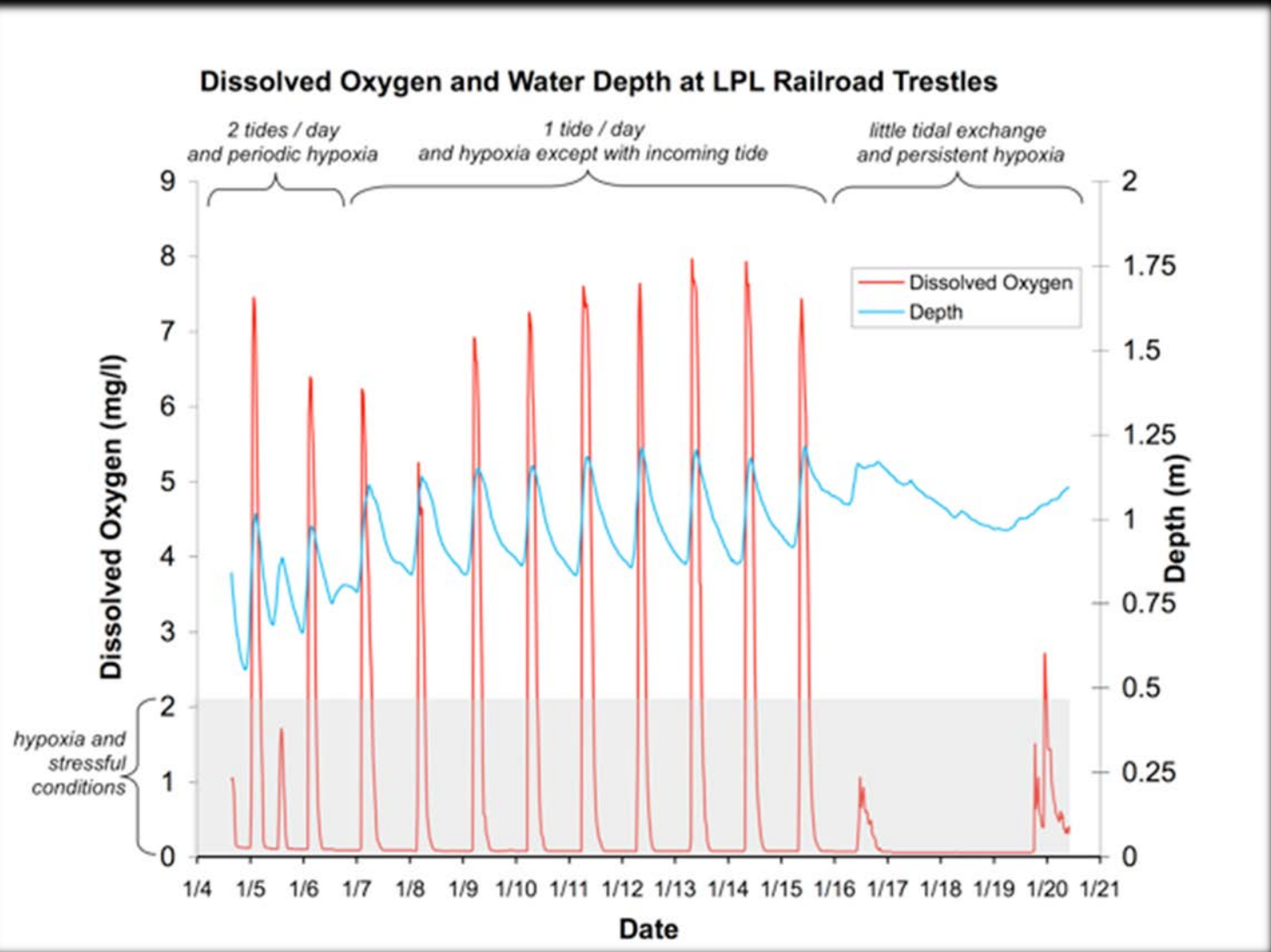
# Water Levels – March 2011

## NERRS WATER QUALITY SITE AT TIJUANA RIVER IN IMPERIAL

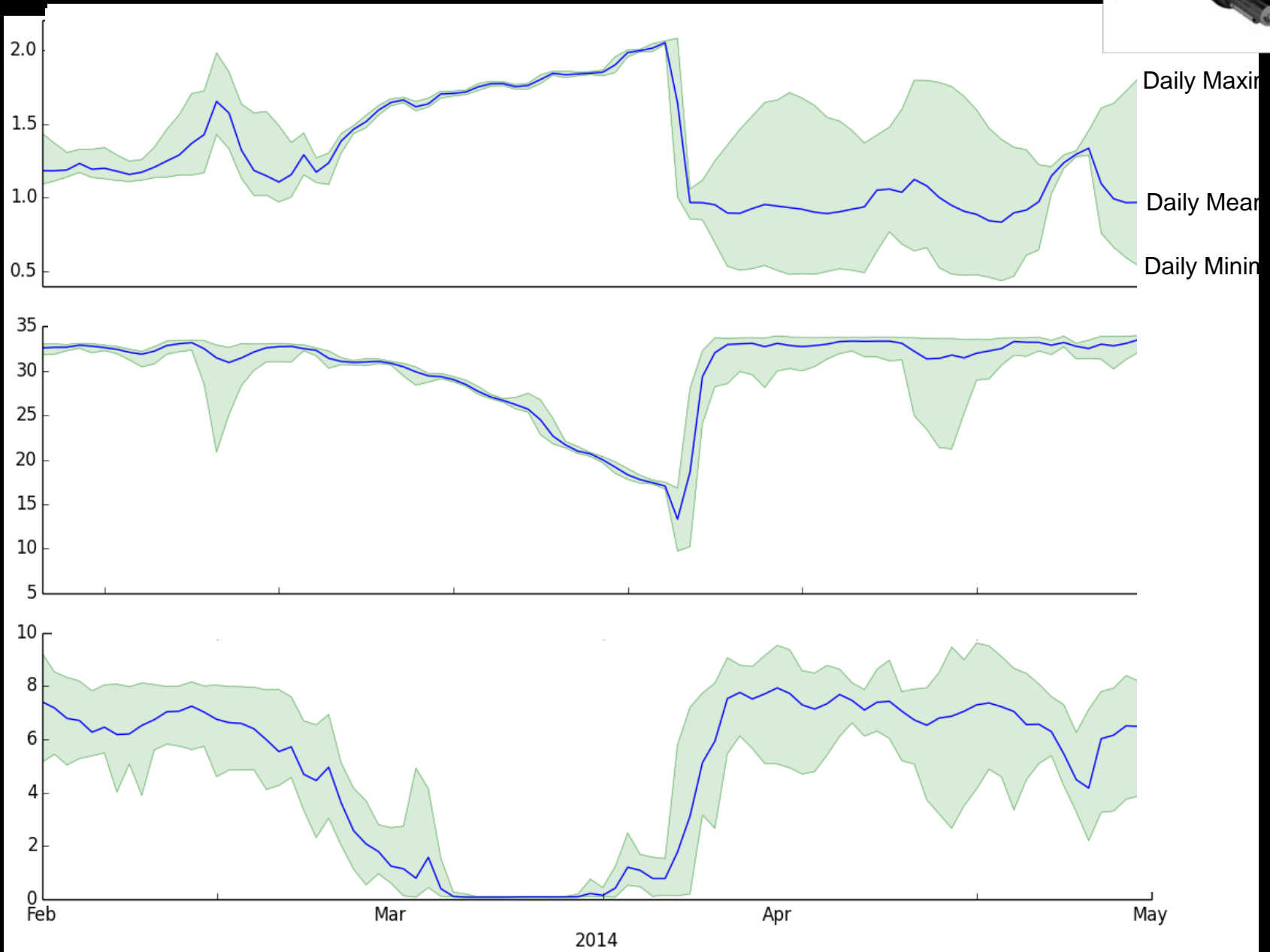
3B0252F2 (TIQC1)



# Onset of Mouth Closure and Low-Oxygen Conditions







# Fish Kill – October 2005



Data Export System Powered By The Centralized Data Management Office

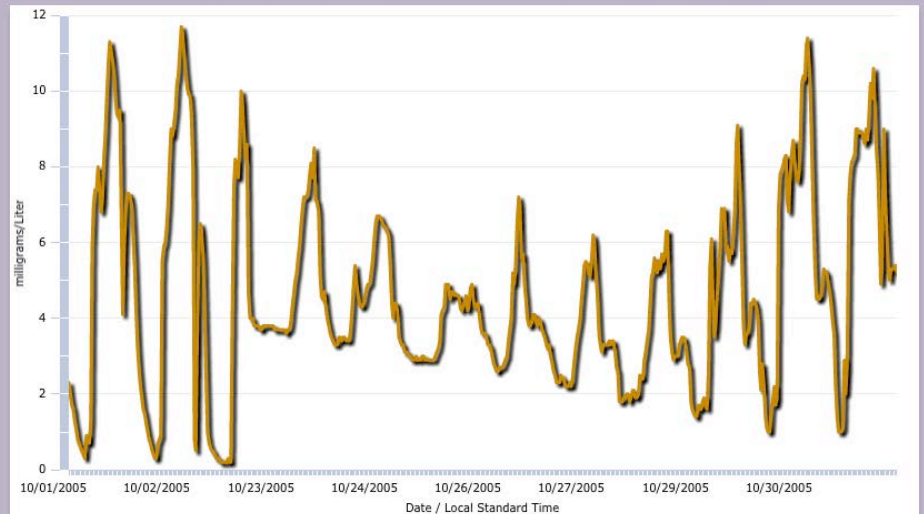
Choose Reserve Choose Sampling Station View or Download Data Submit Info Complete!

Yearly Files  Export Data  Graph Data  Current Conditions

Choose how you would like to select your dates:  Custom Dates (Enter below)  Preselected Options (24 hours, etc.)

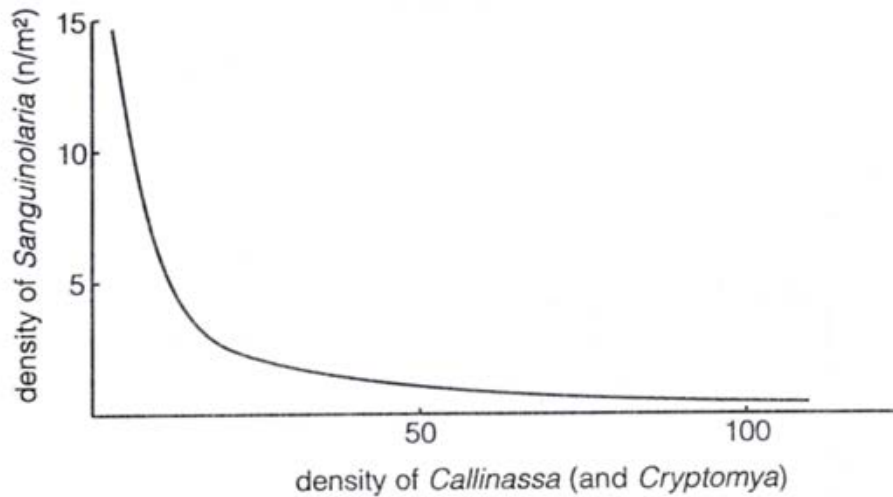
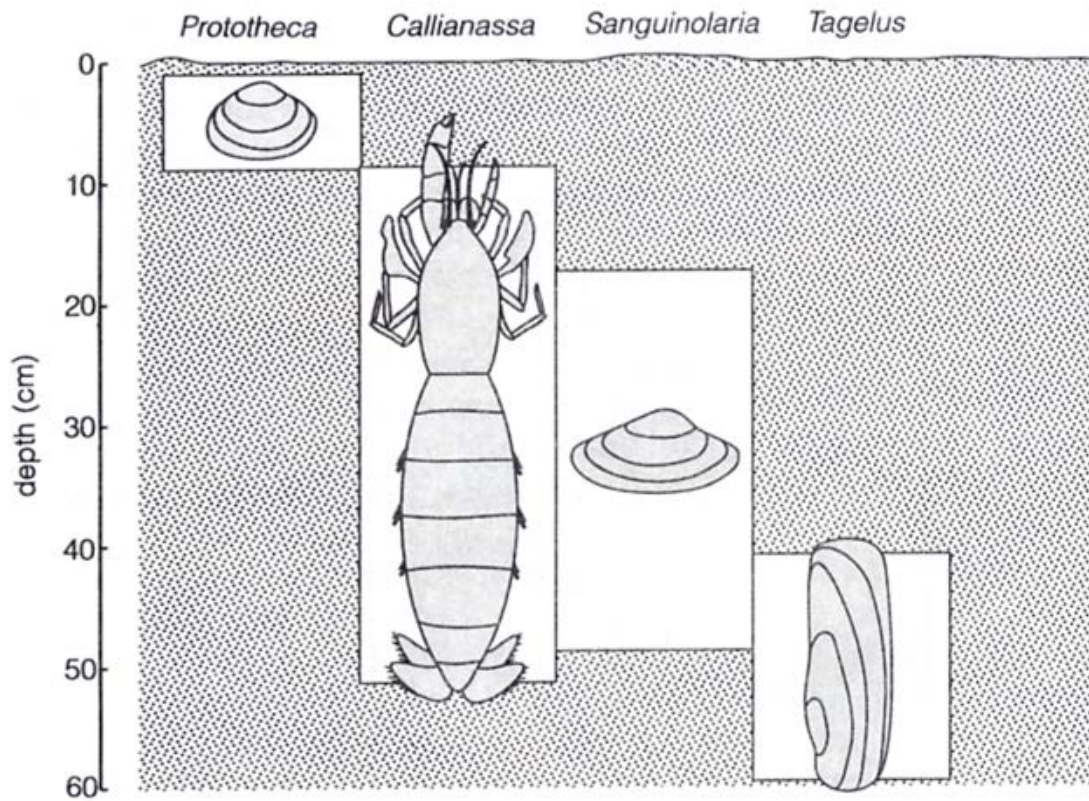
From: 10/01/2005 To: 10/31/2005 Parameter: Dissolved Oxygen (mg/L) Graph!

Tijuana River - Oneonta Slough - Dissolved Oxygen concentration in milligrams per Liter From: 10/01/2005 To: 10/31/2005



## Oxygen Depletion





**Three-dimensional zonation patterns in soft substrates**