Hyoxia in the nearshore coastal waters of South Carolina along the Grand Strand

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CCA SOUTH CAROLINA COASTAL CONSERVATION ASSOCIATION

SECOORA Southeast Coastal Ocean Observing Regional Association

SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES

D H E C PROMOTE PROTECT PROSPER Ocean and Coastal Resource Management

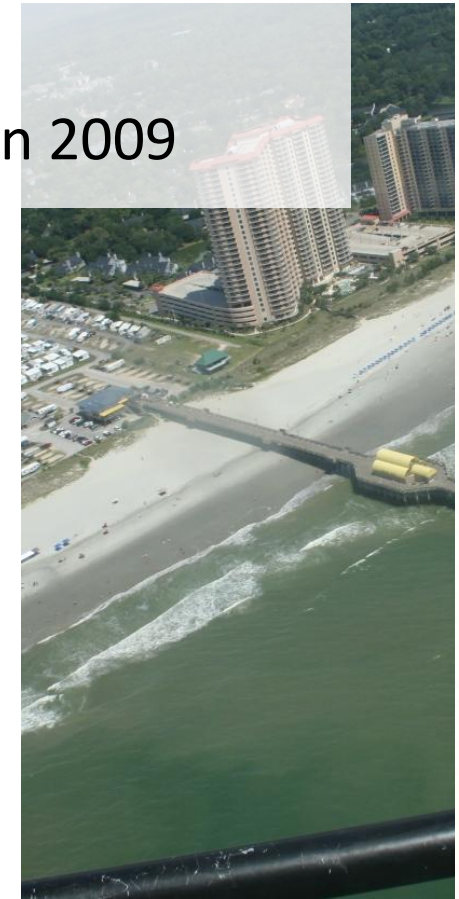
BURROUGHS & CHAPIN CENTER COASTAL CAROLINA UNIVERSITY FOR MARINE & WETLAND STUDIES

Sea Grant S.C. Sea Grant Consortium

APACHE Family Campground & Pier Myrtle Beach, SC

Hypoxia observations

- July 2004
  - Shallow waters !
  - Sandy beaches !
  - Non-estuarine !
- Sondes in the water by 2006
- Anoxia in 2009



The Sun News | Myrtle Beach, S.C. | Friday, August 21, 2009
TheSunNews.com

Dissolved oxygen problem reemerges

GREGG HOLSHOUSER
OUTDOORS COLUMNIST

Brady Simpson, a resident of Surfside Beach, had a feeling something unusual was going on last week when he observed flounder swimming up to the surface near the breakers at the Surfside Pier.

Simpson, an employee of the pier, also noted that lifeguards had come into the tackle shop to buy dip nets in order to return flounder they had found trapped in tidal pools along the beach to the ocean.

Let's flash back to mid-to-late July of 2004, when anglers on piers, particularly along the south end of the Grand Strand, were astounded when flounder suddenly were being caught in unprecedented numbers.

For about two weeks, the strange flounder catches continued and other species rare to the piers, such as puffers and ribbonfish, also were caught.

Officials from the South Carolina Department of Natural Resources and a contingent from Coastal Carolina University investigated and discovered there were very low levels of dissolved oxygen (DO) in the ocean water along the surf — the likely cause of the highly unusual catches.

The situation helped spur the establishment of a data station at the Apache Pier on the north

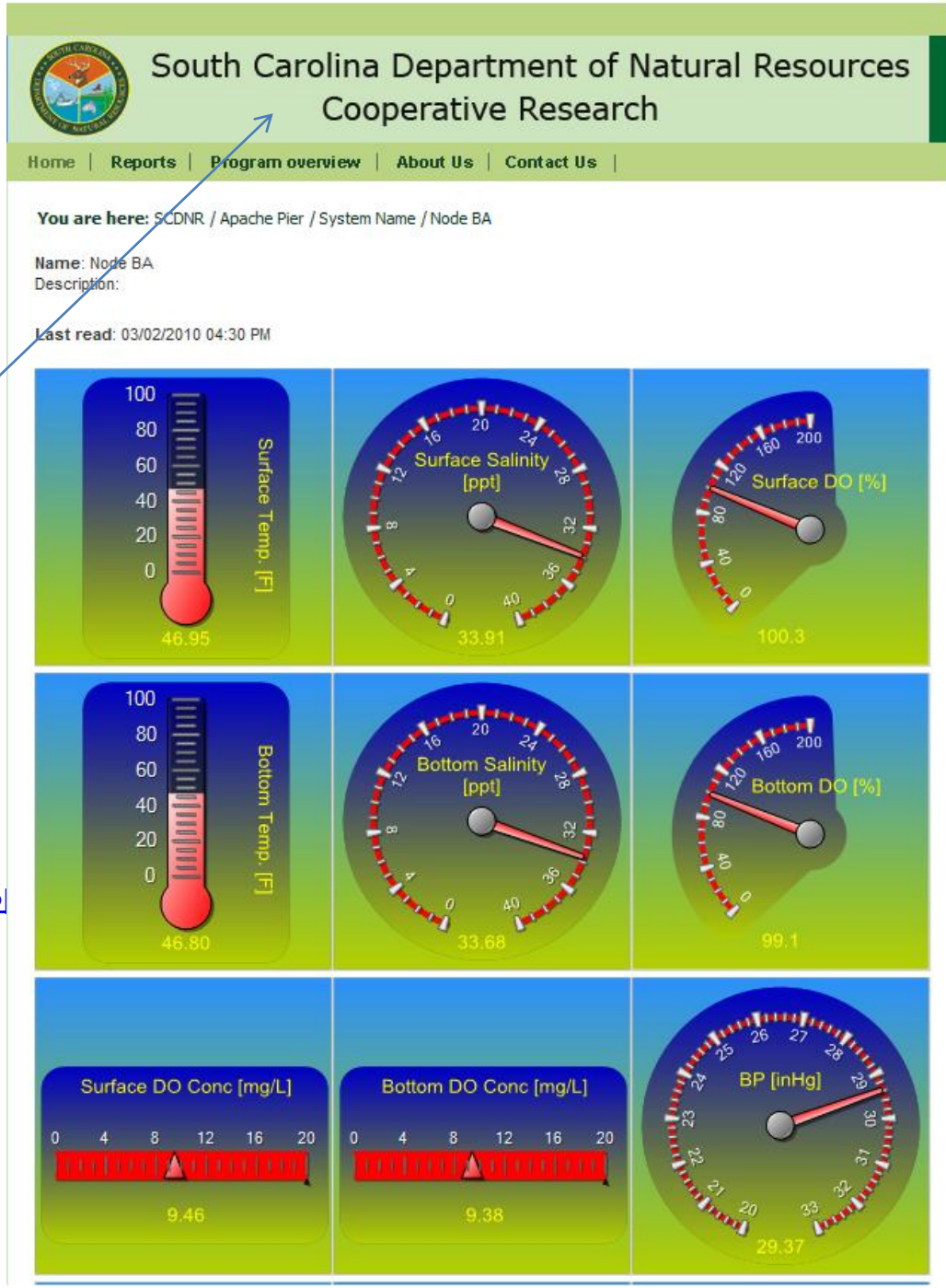
Tr Gerald Holshouser *For The Sun News*

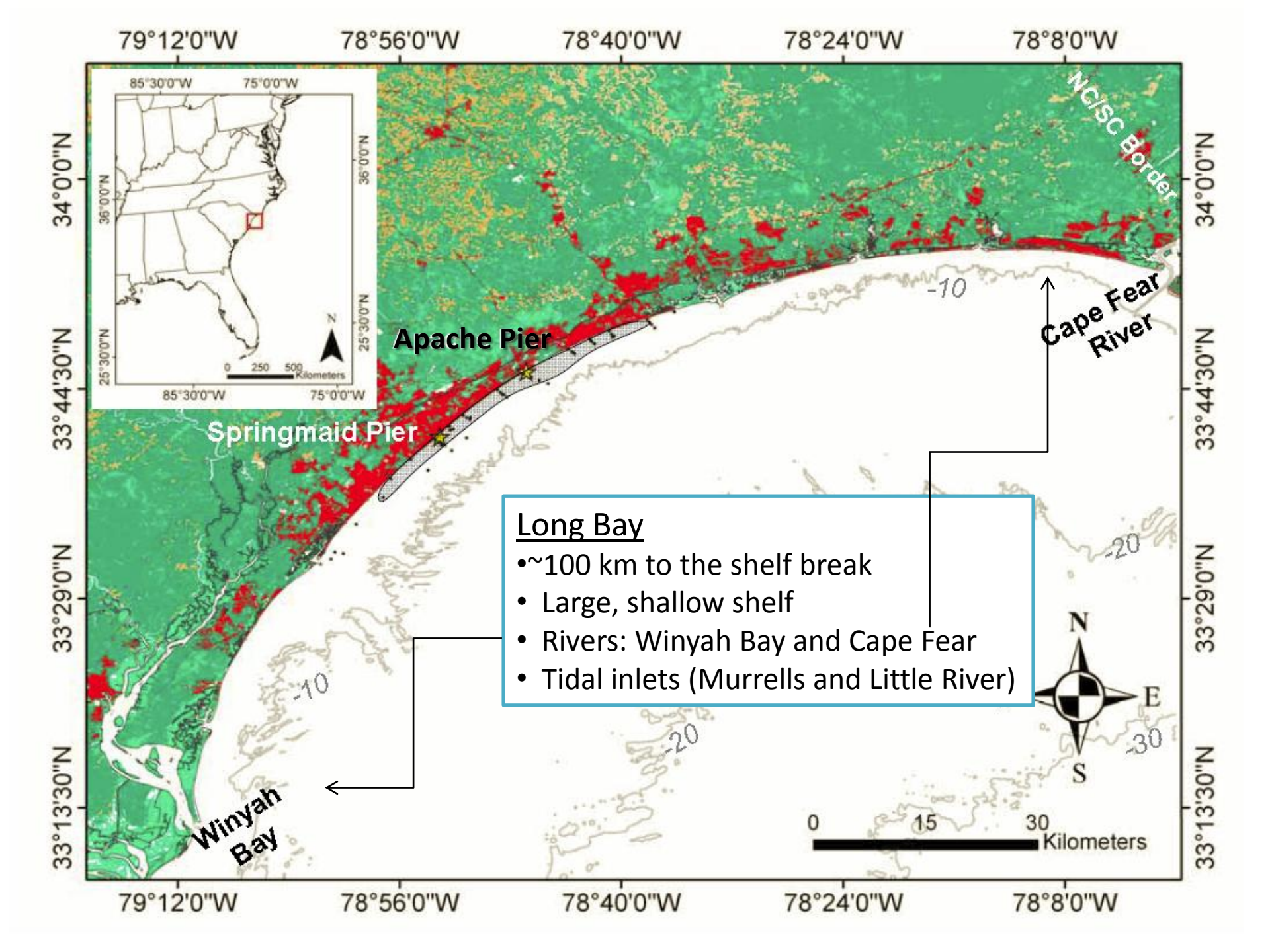
Donnie Robertson of Roanoke, Va., displays a pair of flounder he caught off The Pier at Garden City on Tuesday afternoon.

Why Apache Pier?

- Low DO constrained to water depths of 5 to 10 m
- Site of Low DO in 2004
- Fishing resource
  - SC DNR Fishing Coop

- Some data from mid depths at Springmaid pier at south end
  - Aug 06 thru Dec 07
  - http://nautilus.baruch.sc.edu/CSV/Springmaid_DO/

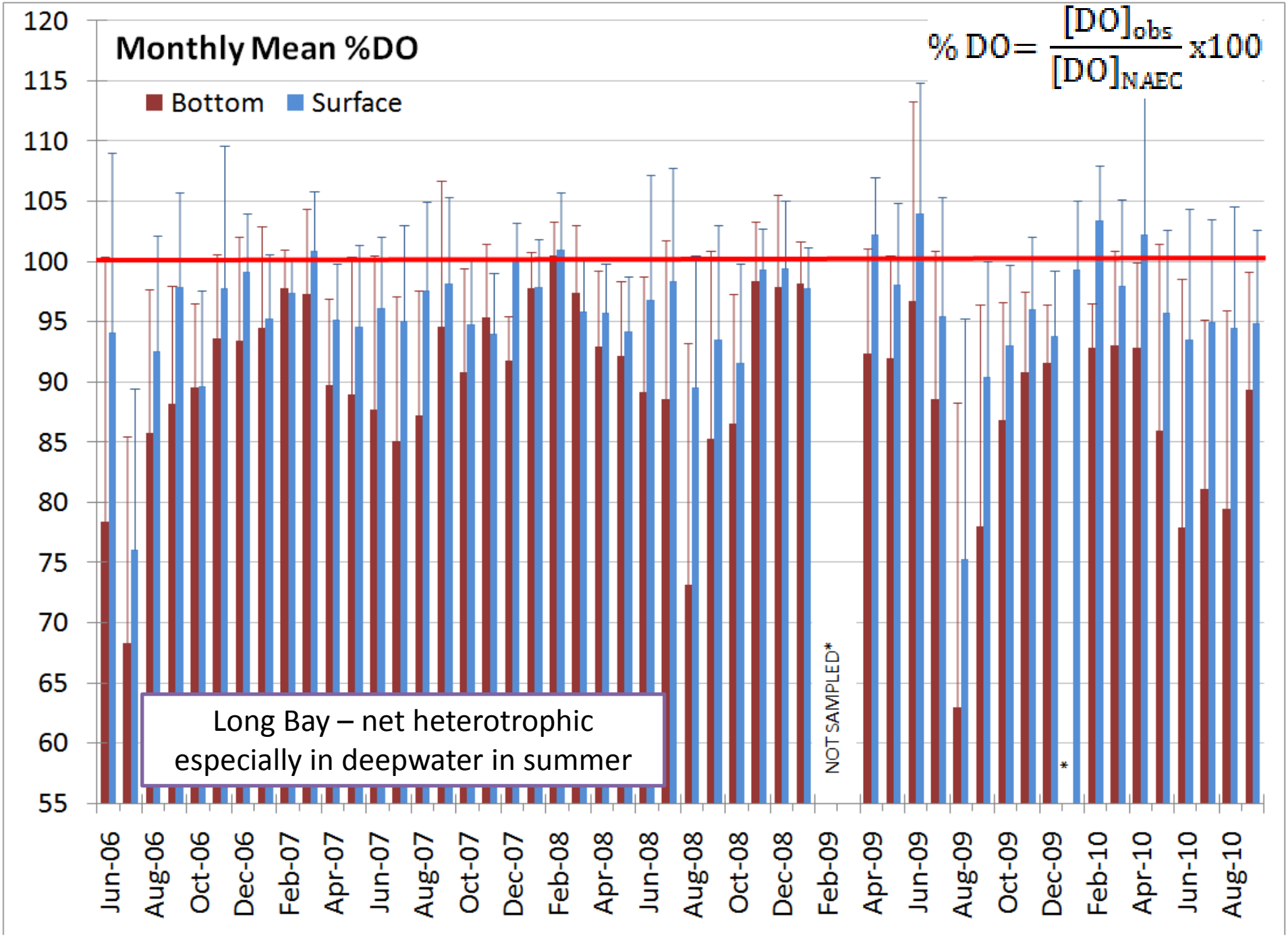


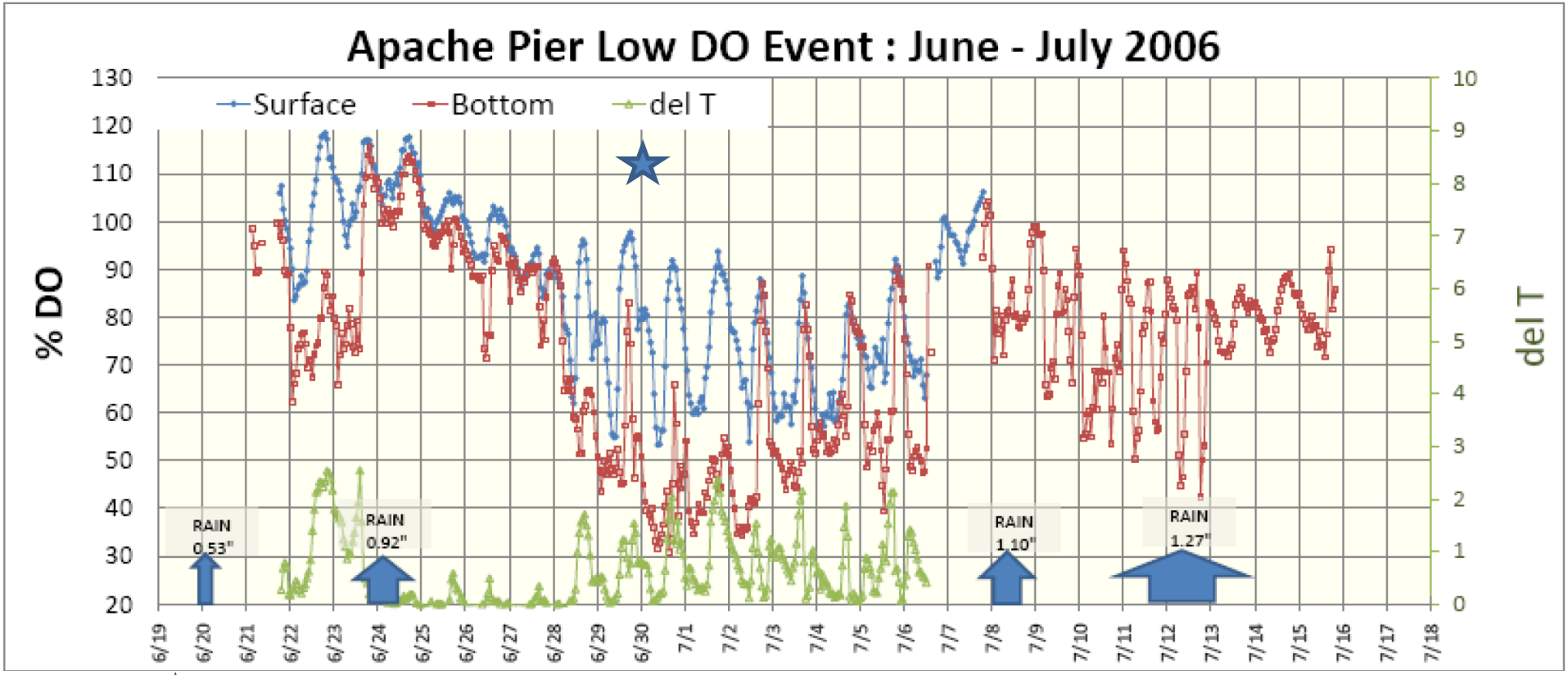

79°12'0"W
78°56'0"W
78°40'0"W
78°24'0"W
78°8'0"W
34°0'0"N
33°44'30"N
33°29'0"N
33°13'30"N
85°30'0"W
75°0'0"W
36°0'0"N
25°30'0"N
0 250 500 Kilometers
N
NC/SC Border
Apache Pier
Springmaid Pier
Cape Fear River
Winyah Bay
-10
-20
-30
Long Bay
•~100 km to the shelf break
• Large, shallow shelf
• Rivers: Winyah Bay and Cape Fear
• Tidal inlets (Murrells and Little River)
N
E
S
0 15 30 Kilometers

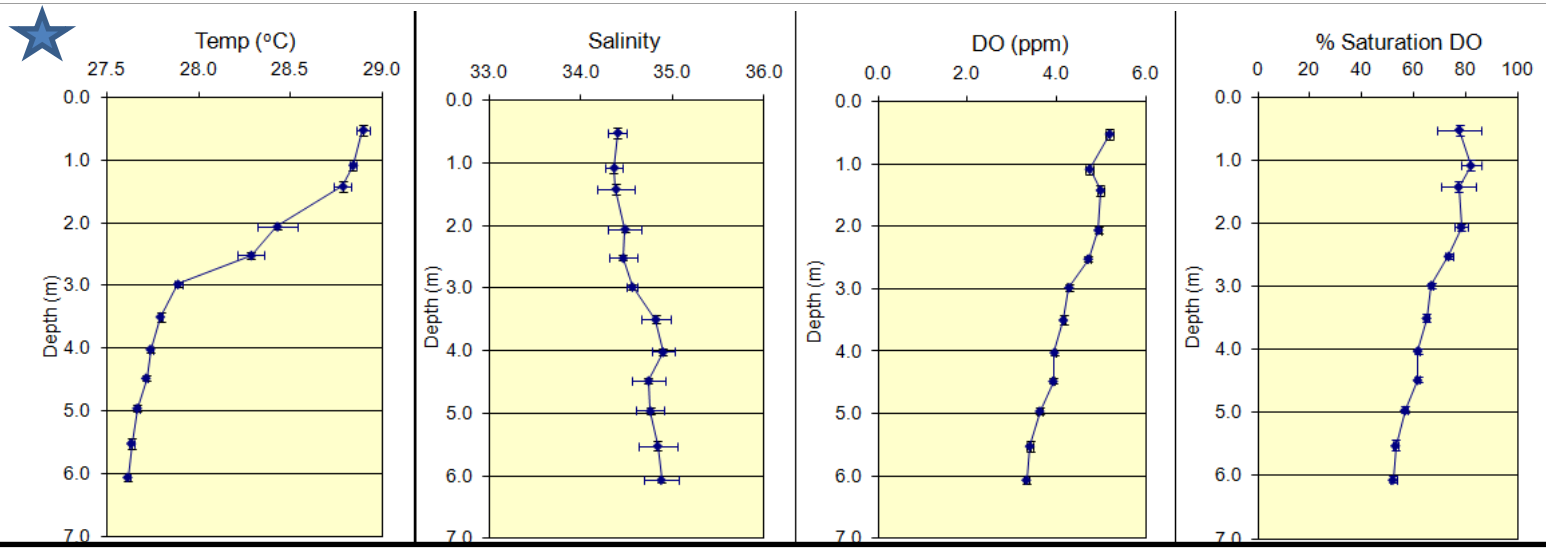
Dataset

- Time Scales (n = 4 y)
  - Seasonal
  - Diel
  - Interannual
    - Anoxia in 2009
- Spatial Scales
  - Apache
    - Surface water
    - Deep water
  - Other piers

YSI 600R Datasondes


Monthly Mean %DO
$\%\,DO = \frac{[DO]_{obs}}{[DO]_{NAEC}} x100$
Bottom
Surface
120
115
110
105
100
95
90
85
80
75
70
65
60
55
Long Bay – net heterotrophic especially in deepwater in summer
NOT SAMPLED*
*
Jun-06
Aug-06
Oct-06
Dec-06
Feb-07
Apr-07
Jun-07
Aug-07
Oct-07
Dec-07
Feb-08
Apr-08
Jun-08
Aug-08
Oct-08
Dec-08
Feb-09
Apr-09
Jun-09
Aug-09
Oct-09
Dec-09
Feb-10
Apr-10
Jun-10
Aug-10

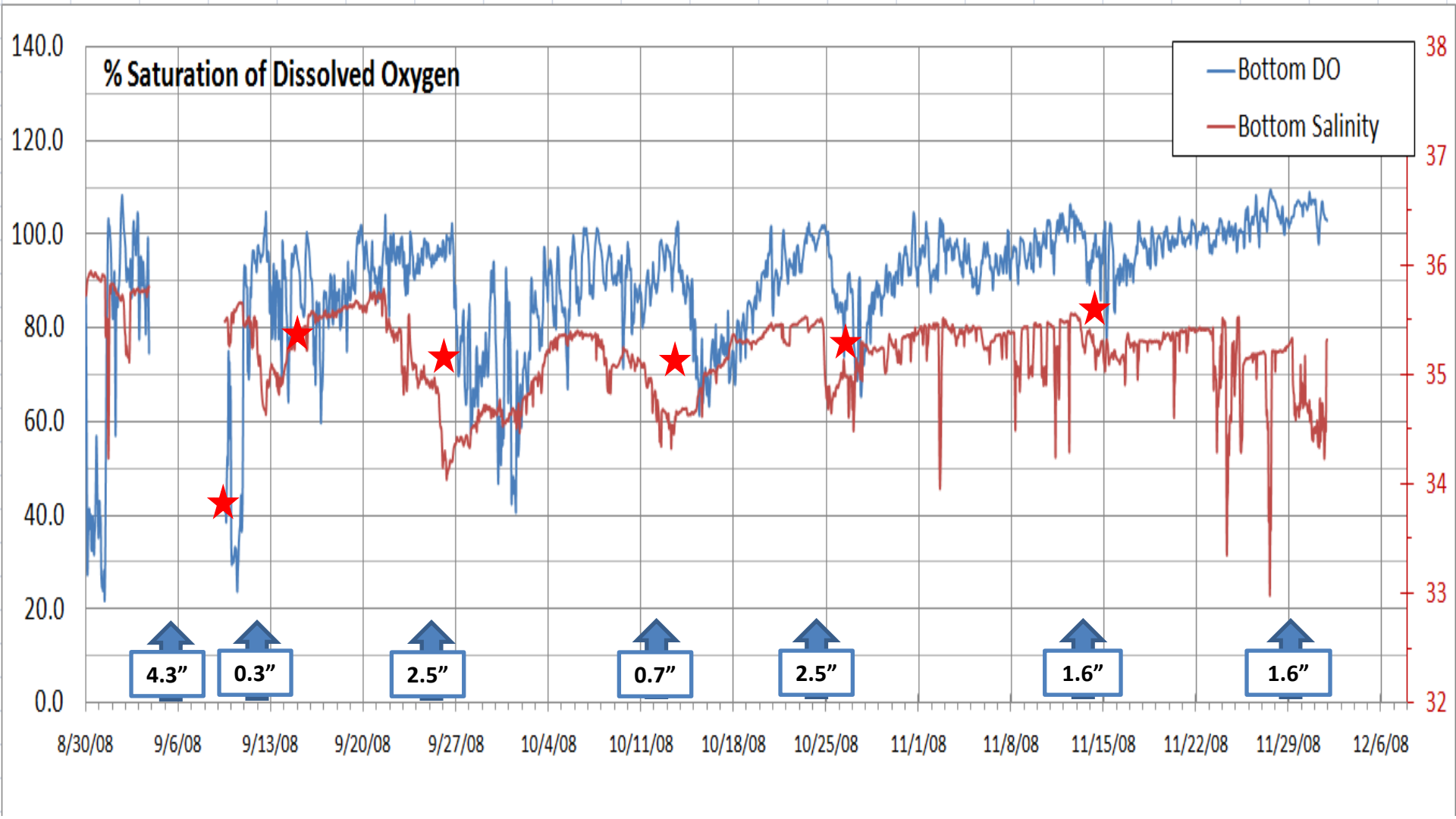


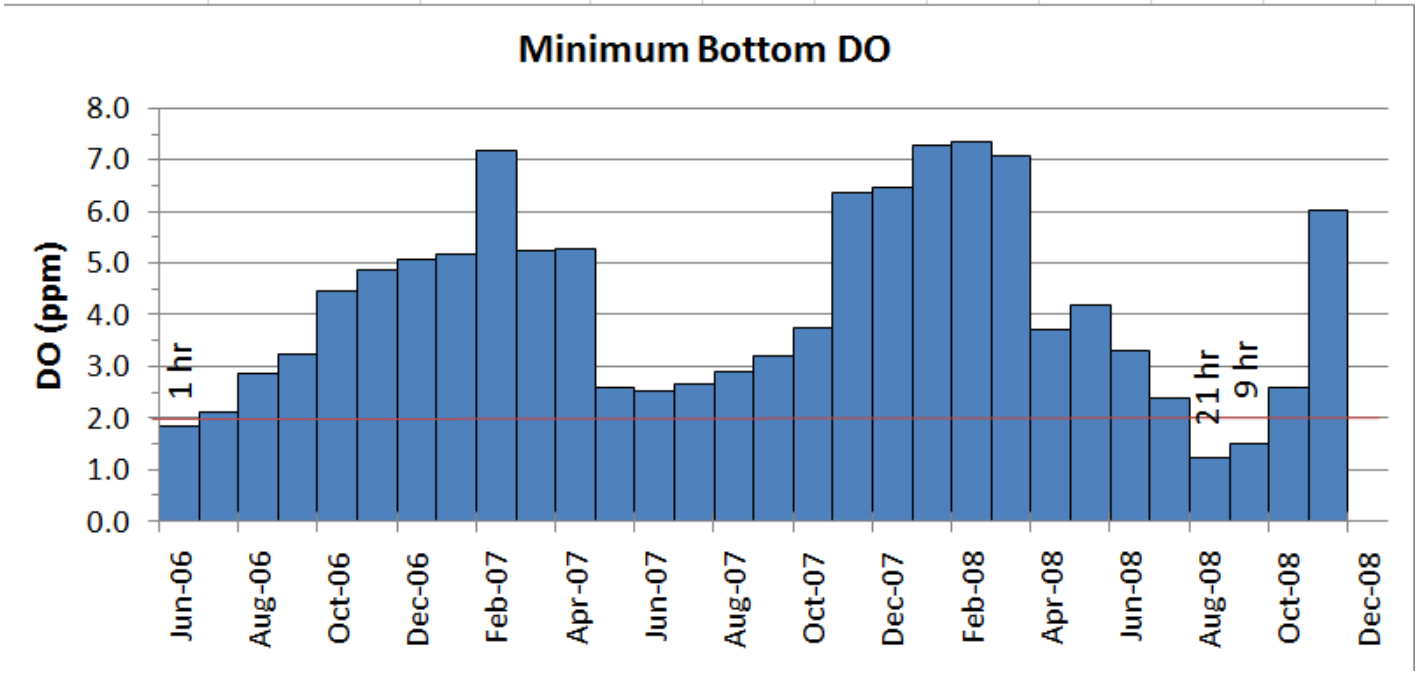


Southwesterly winds → Upwelling → Cold saline water migrates onshore → Frontal condition

Rain in late summer 2008

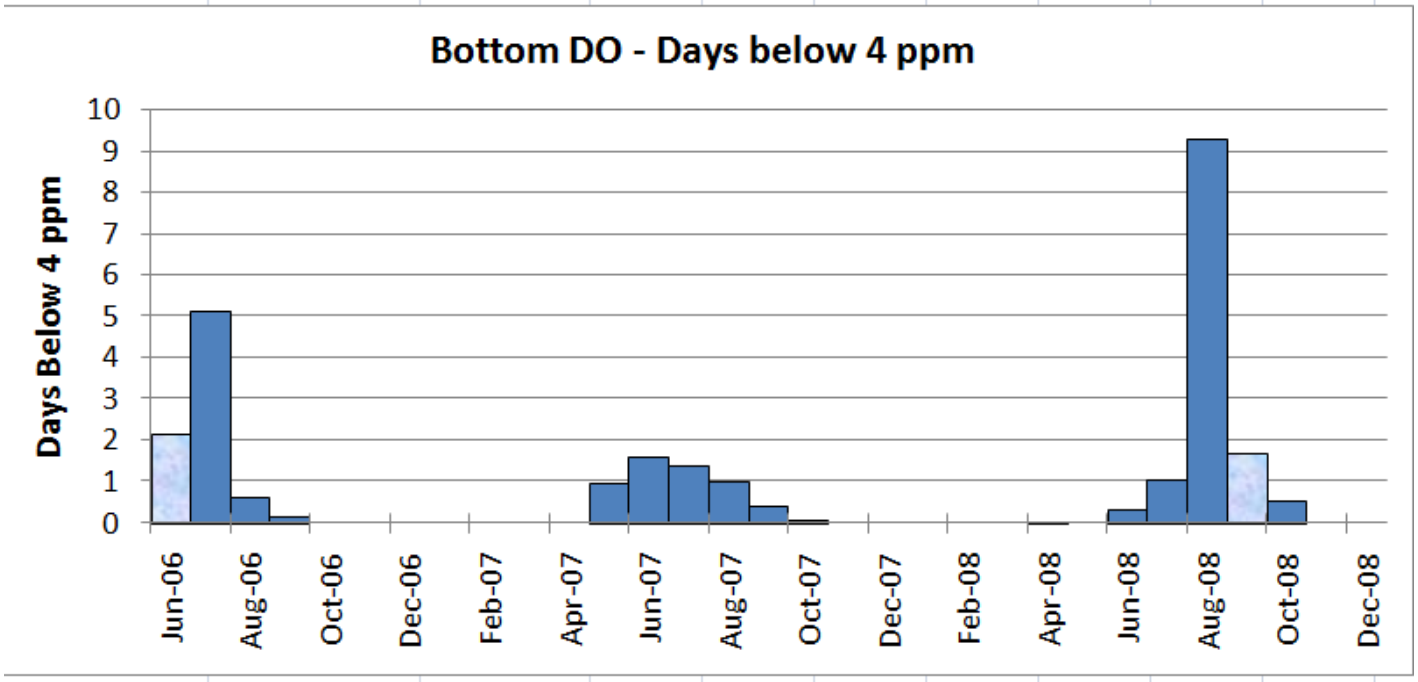
Min DO = 1.4 ppm





2006-2008

Springmaid Pier
July-Aug 2006
Minima: 1.8 to 2.1 ppm
30% < 4 ppm

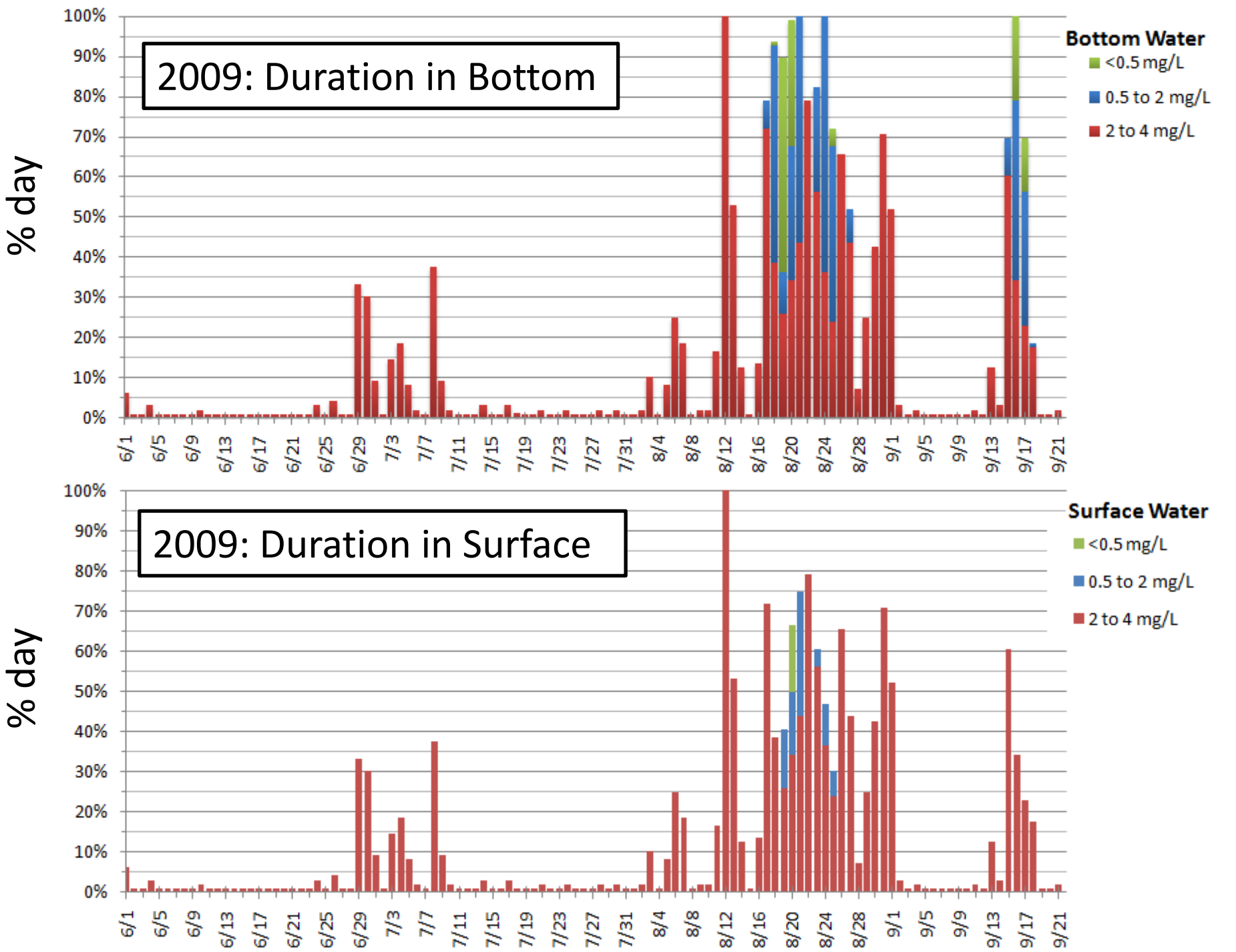


<u>Hypoxia (< 2 ppm)</u>

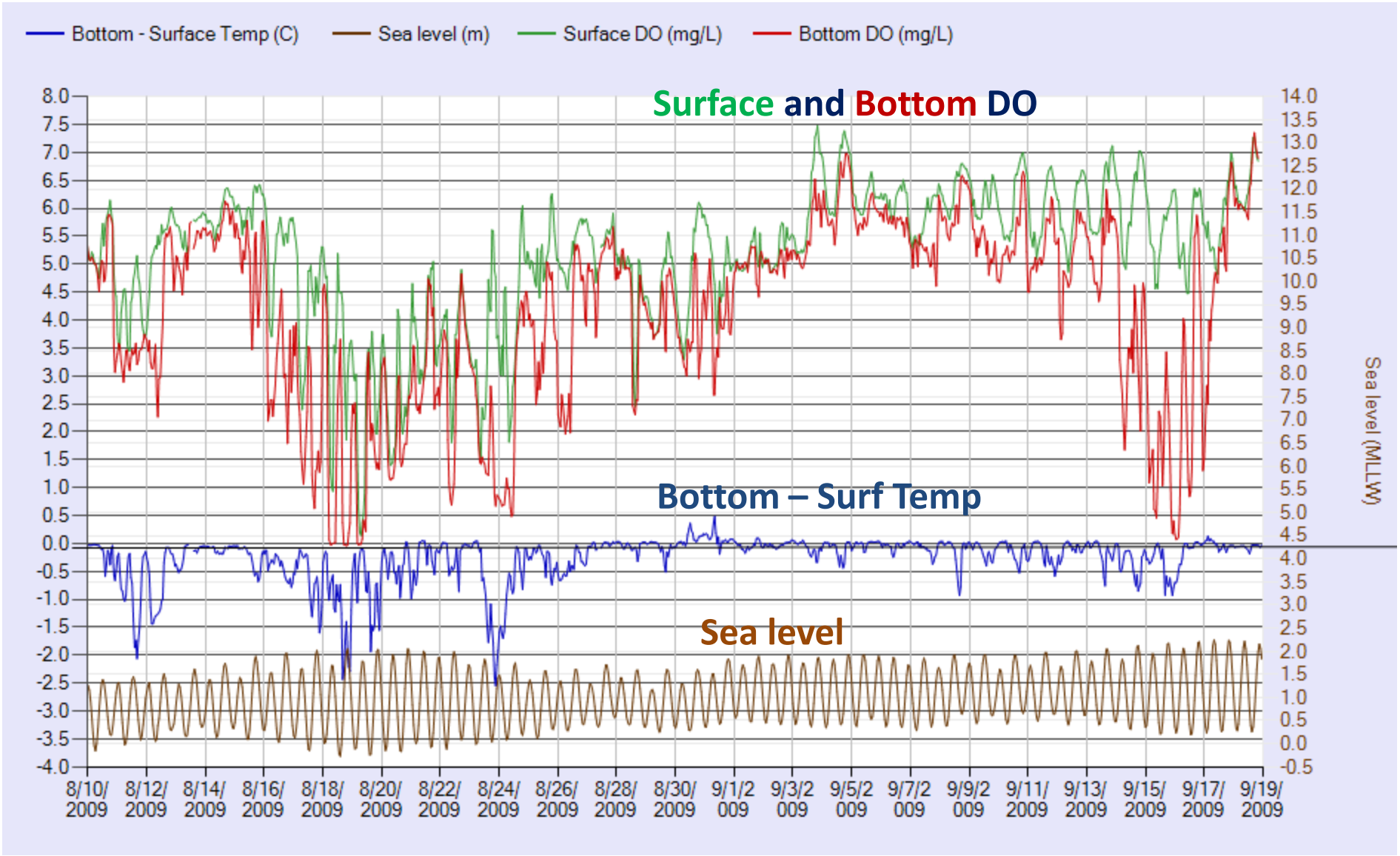
- Long Island & Diaz (< 3 ppm)
- NEEA and NCCR (< 5 ppm) = FAIR

<u>Fish Stress</u>

- < 5 ppm
- 60% saturation

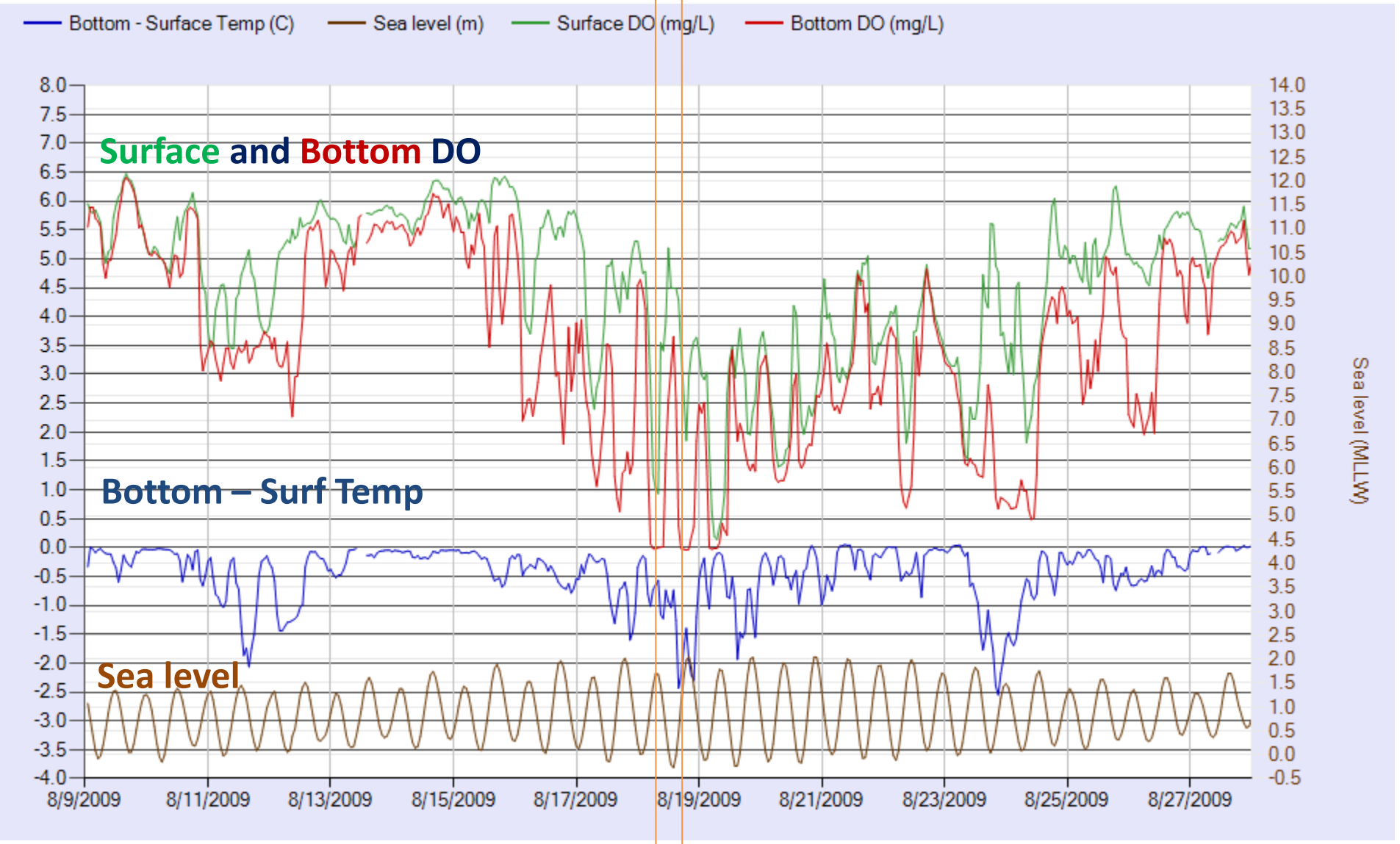

2009: Duration in Bottom
% day
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
6/1
6/5
6/9
6/13
6/17
6/21
6/25
6/29
7/3
7/7
7/11
7/15
7/19
7/23
7/27
7/31
8/4
8/8
8/12
8/16
8/20
8/24
8/28
9/1
9/5
9/9
9/13
9/17
9/21
Bottom Water
<0.5 mg/L
0.5 to 2 mg/L
2 to 4 mg/L
2009: Duration in Surface
% day
Surface Water
<0.5 mg/L
0.5 to 2 mg/L
2 to 4 mg/L

Two Hypoxic Events



Commonalities: Spring Tide, Frontal conditions (temperature stratification)

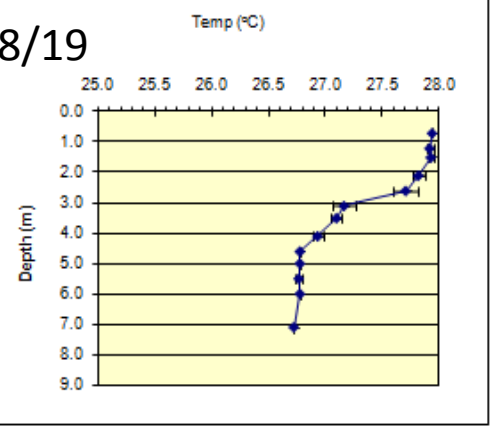
August Event - Anoxia

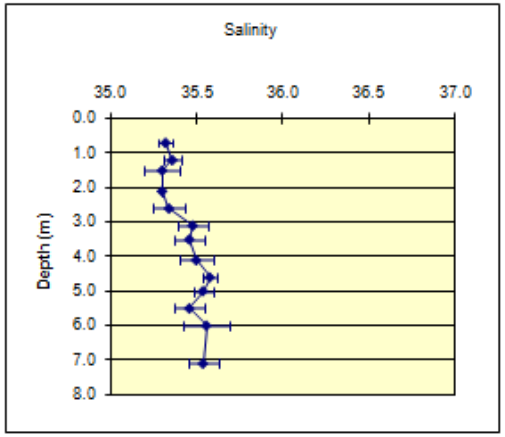


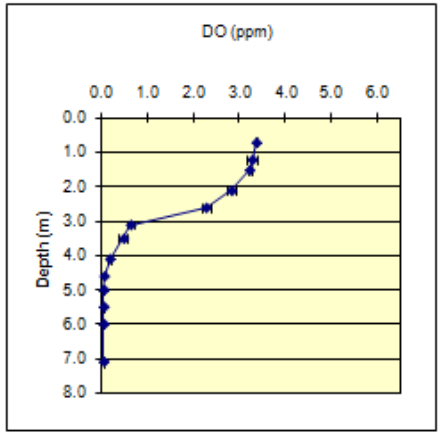
Sloshing with the tides. Note low surface DO

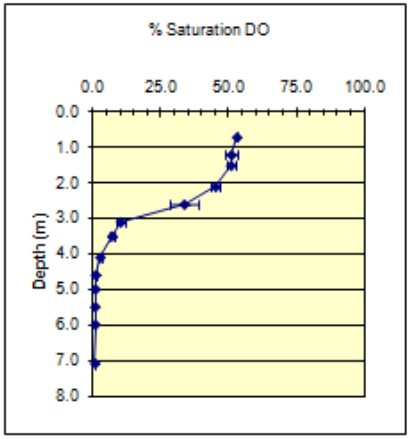
Apache Pier Time Series

8/19

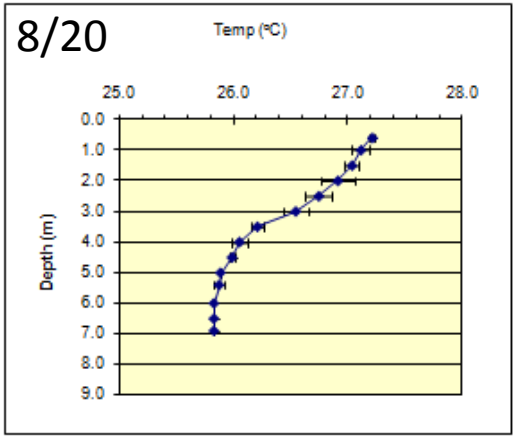


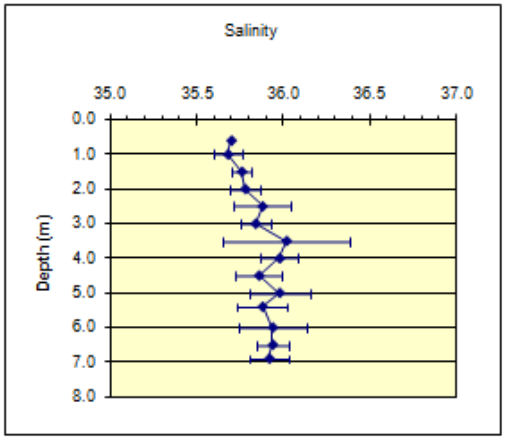


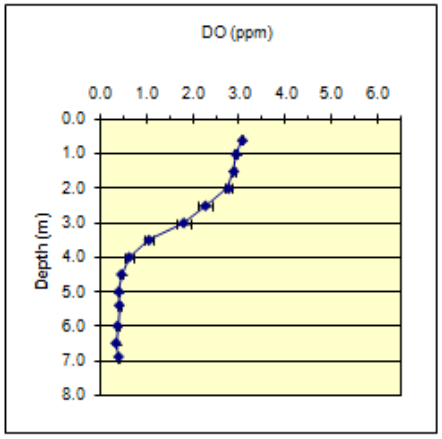


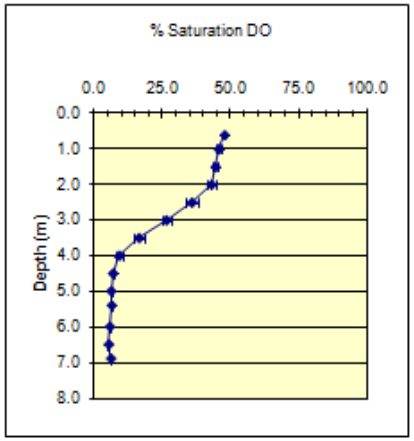


8/20

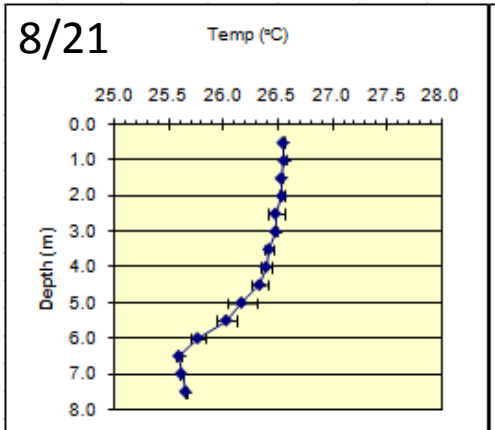


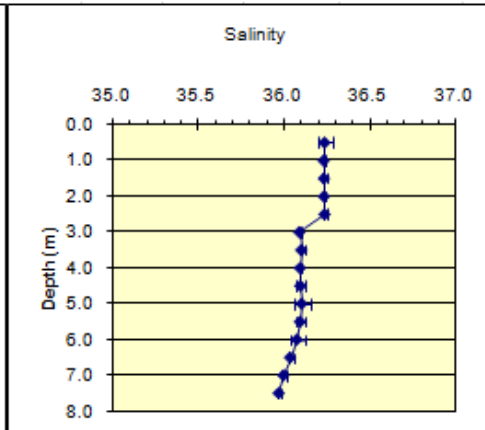


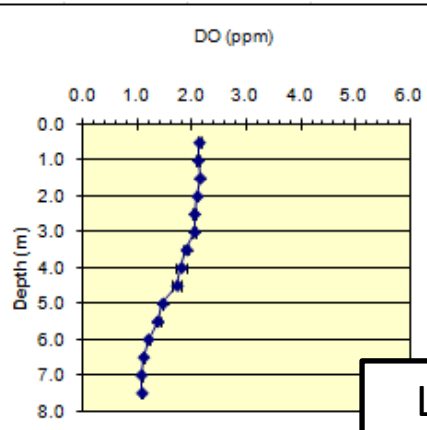


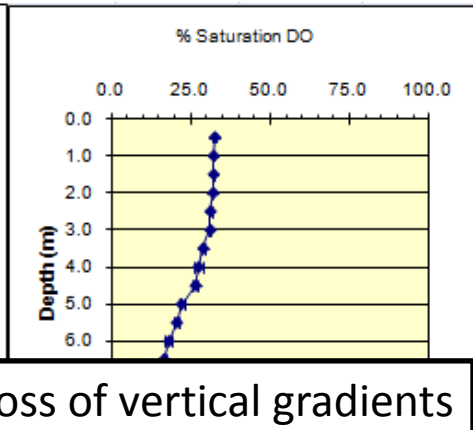


8/21









Loss of vertical gradients

Apache Pier Time Series

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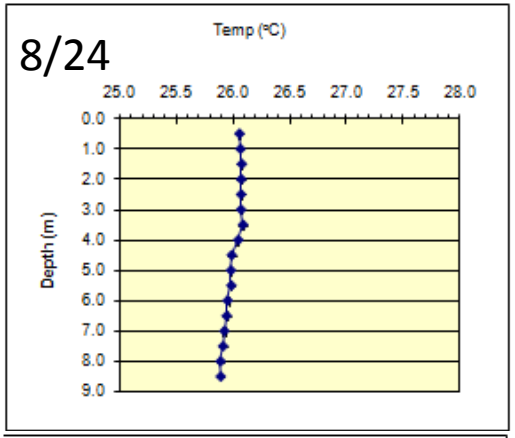
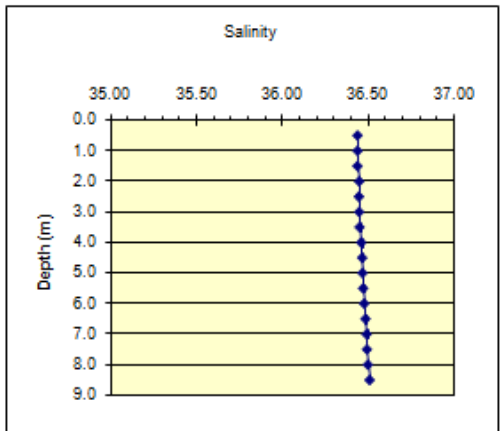
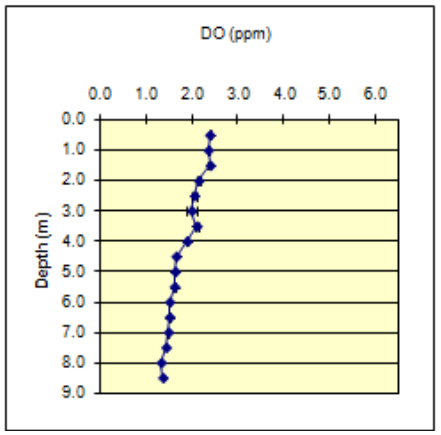
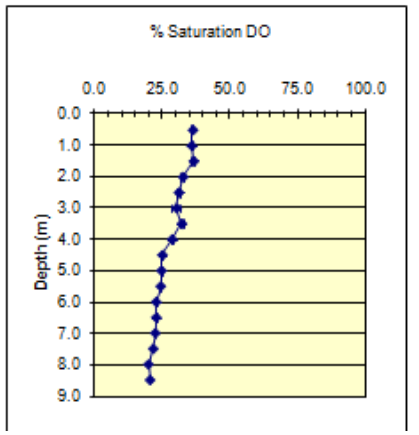
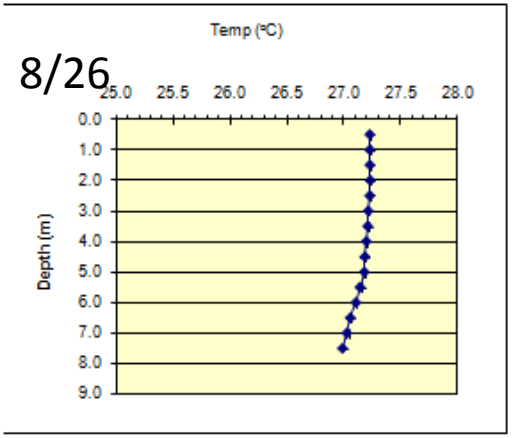


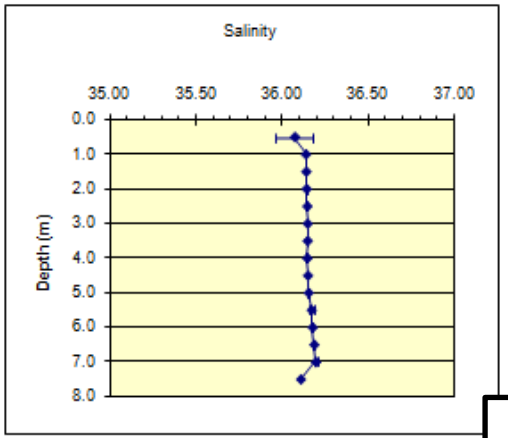


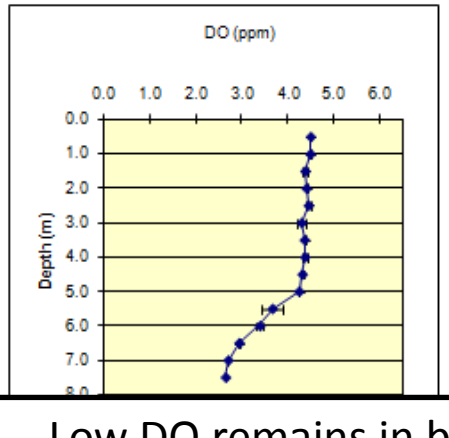


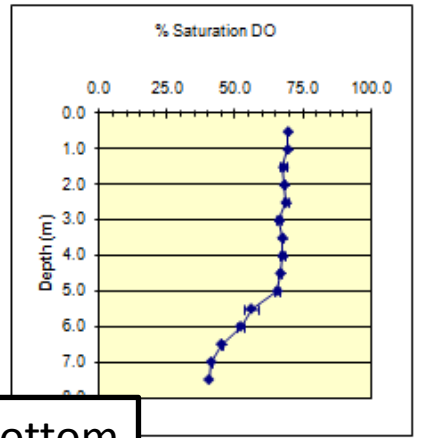


8/26



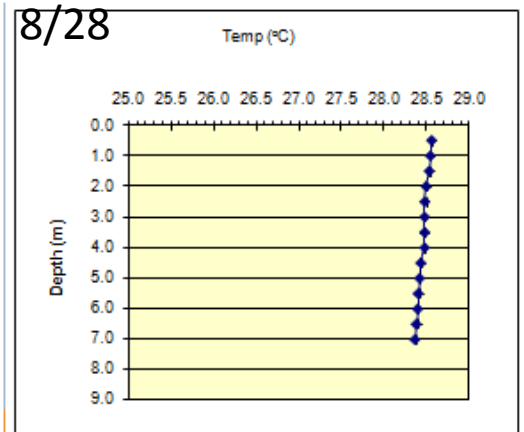


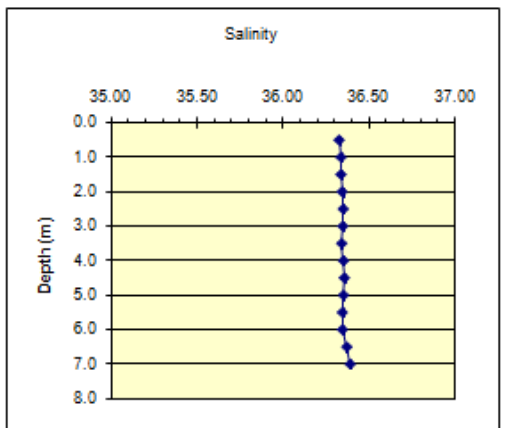


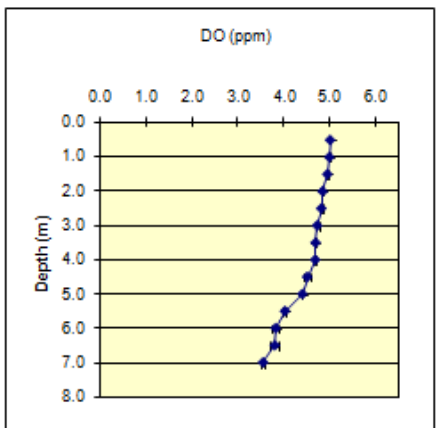


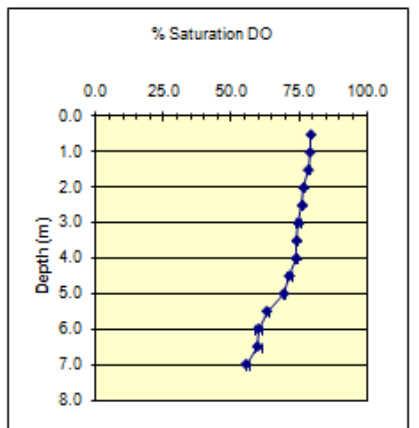
Low DO remains in bottom

8/28

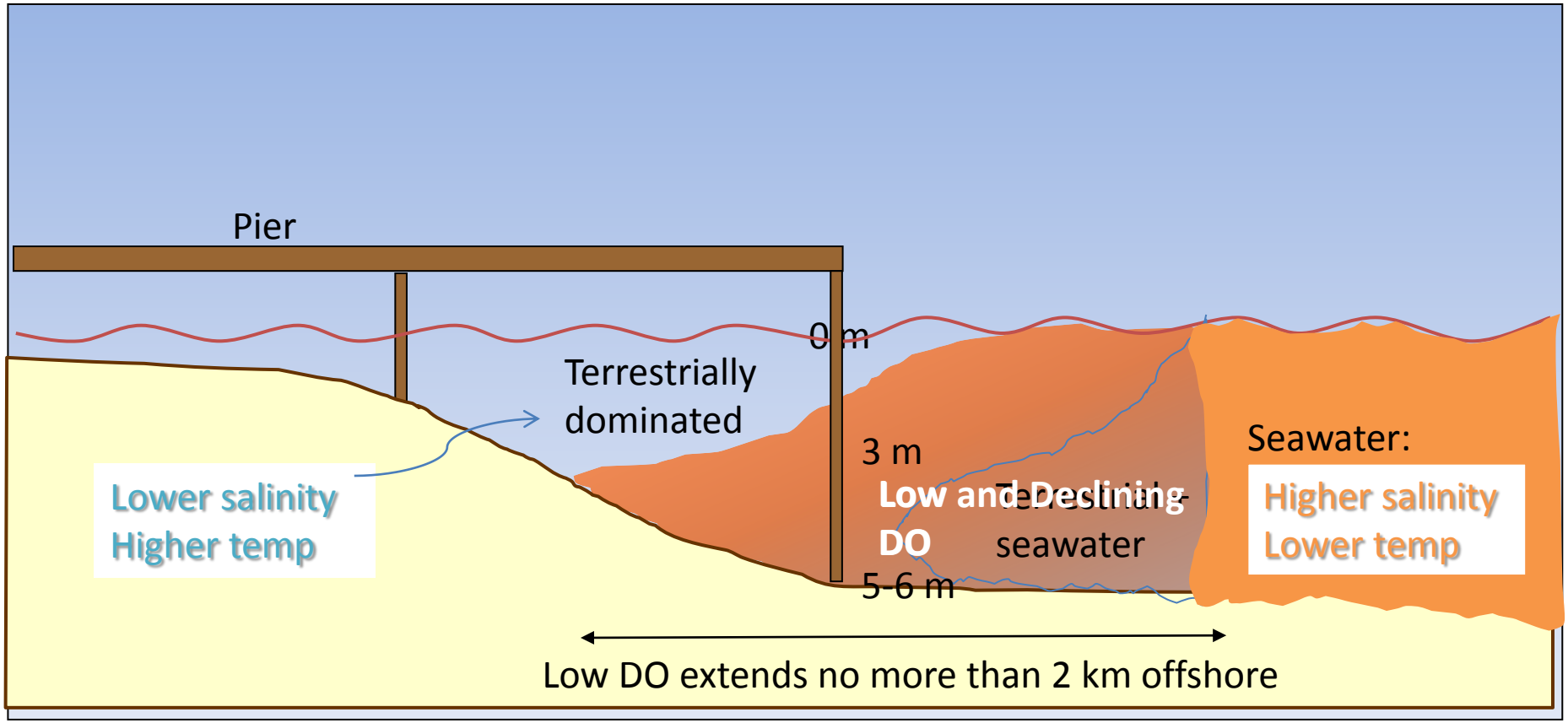


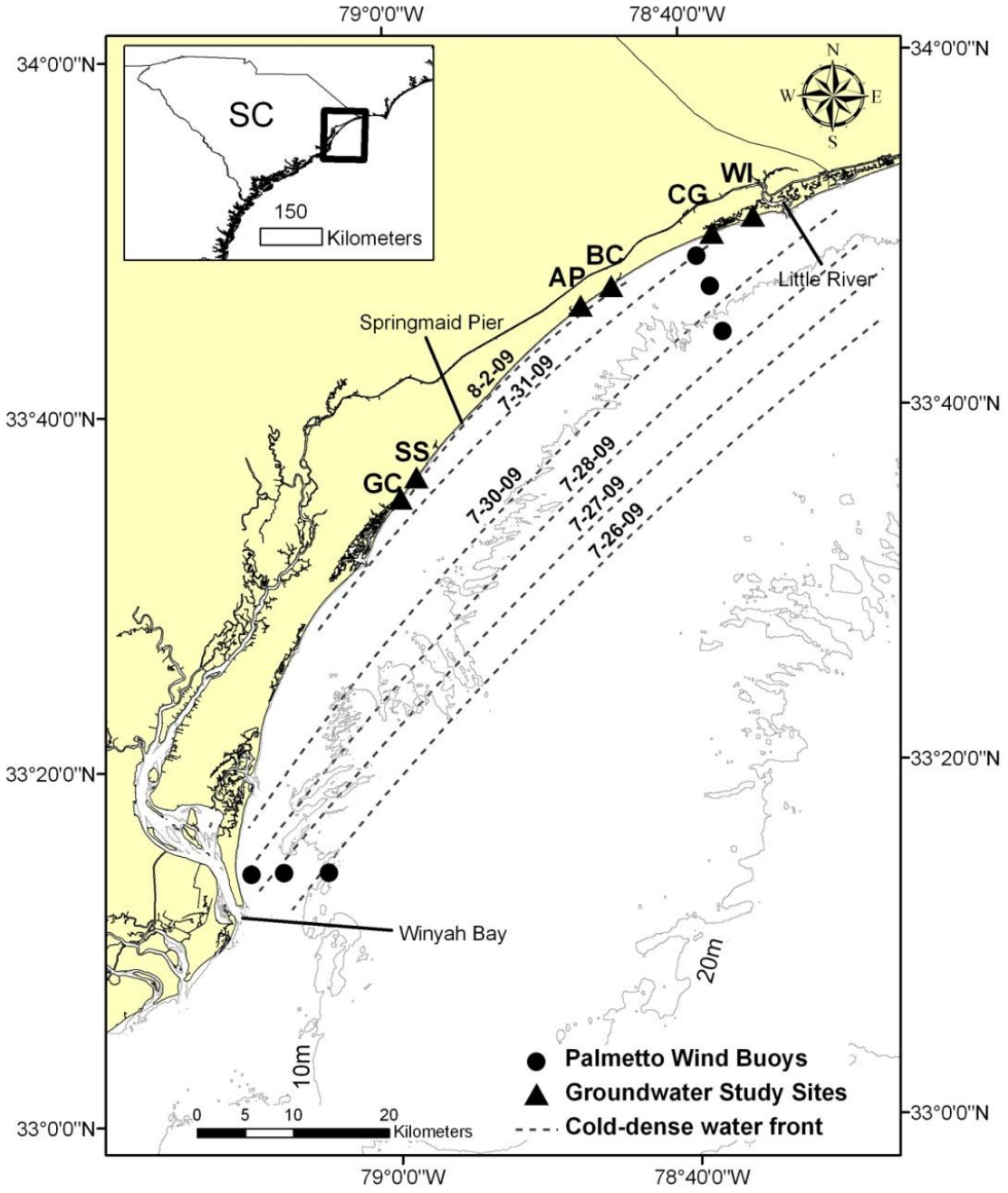






Low DO Events



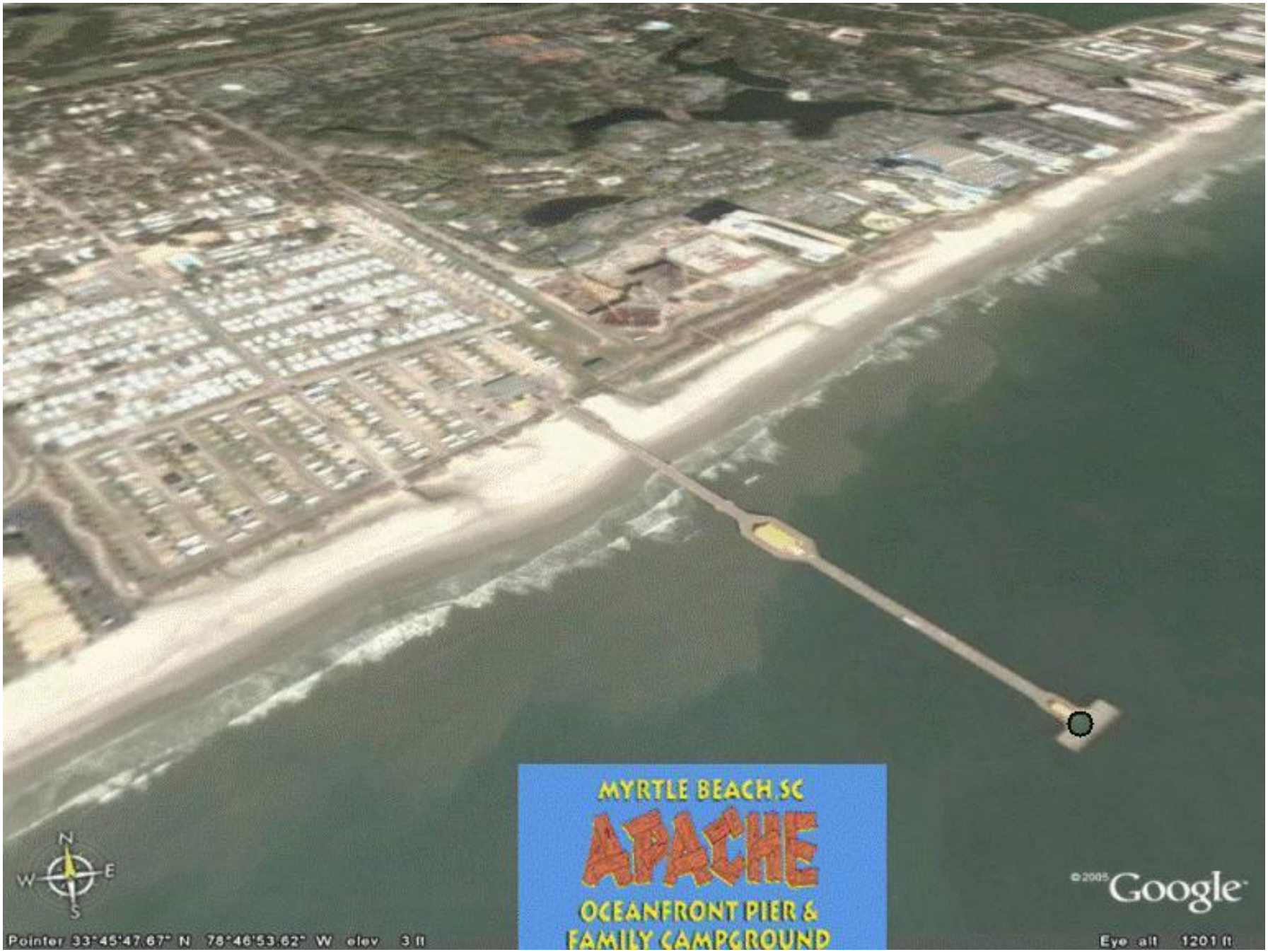


Buoys record onshore movement of cold, salty water mass

Source: Clay McCoy, SC Seagrant Consortium/CCU

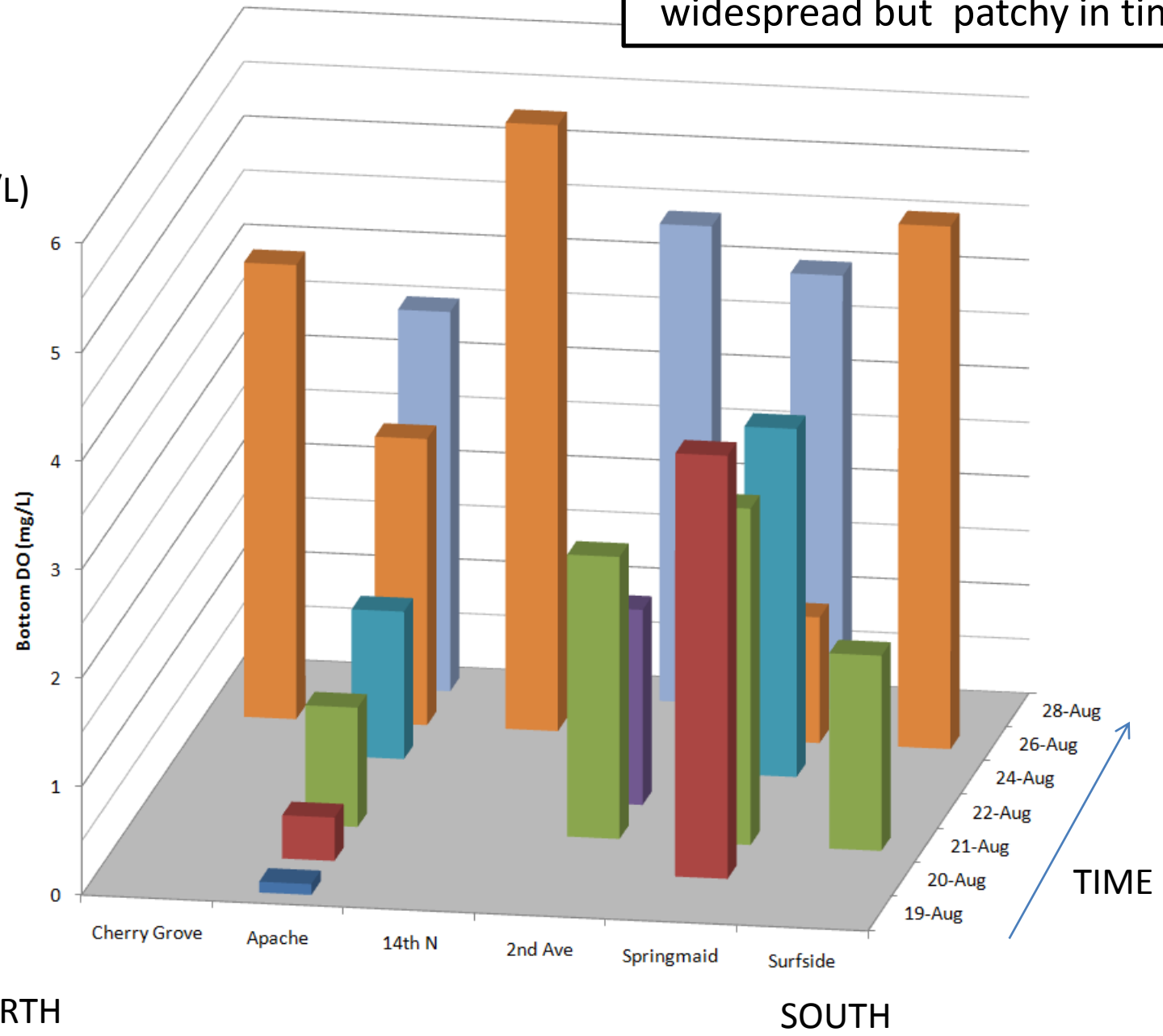
Blobs versus ribbons

Pollen in Apr 2010


MYRTLE BEACH, SC
APACHE
OCEANFRONT PIER &
FAMILY CAMPGROUND
N
W
E
S
Pointer 33°45'47.67" N 78°46'53.62" W elev 3 ft
©2005 Google
Eye alt 1201 ft

Hypoxic conditions geographically widespread but patchy in time and space

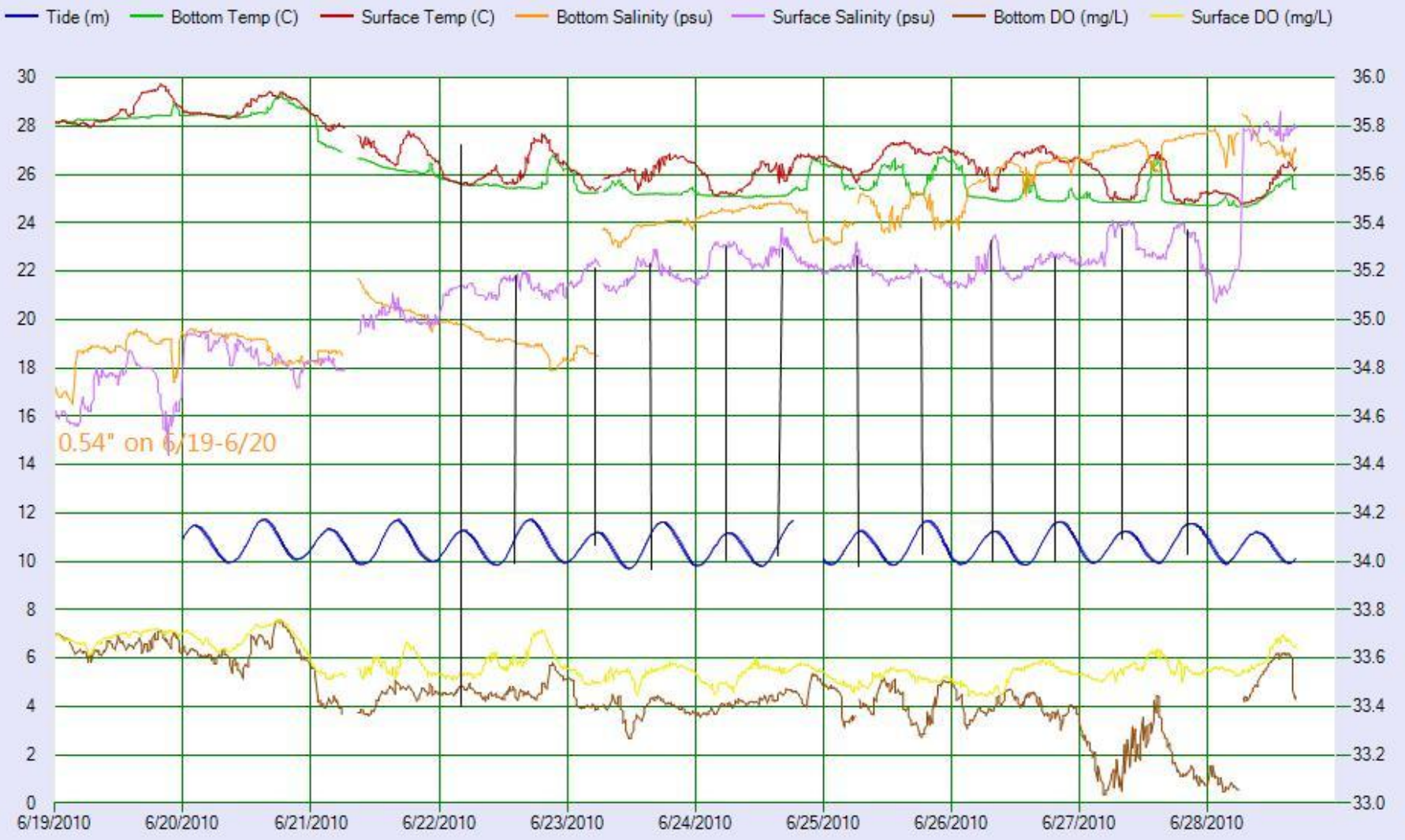
Bottom DO (mg/L)



NORTH

SOUTH

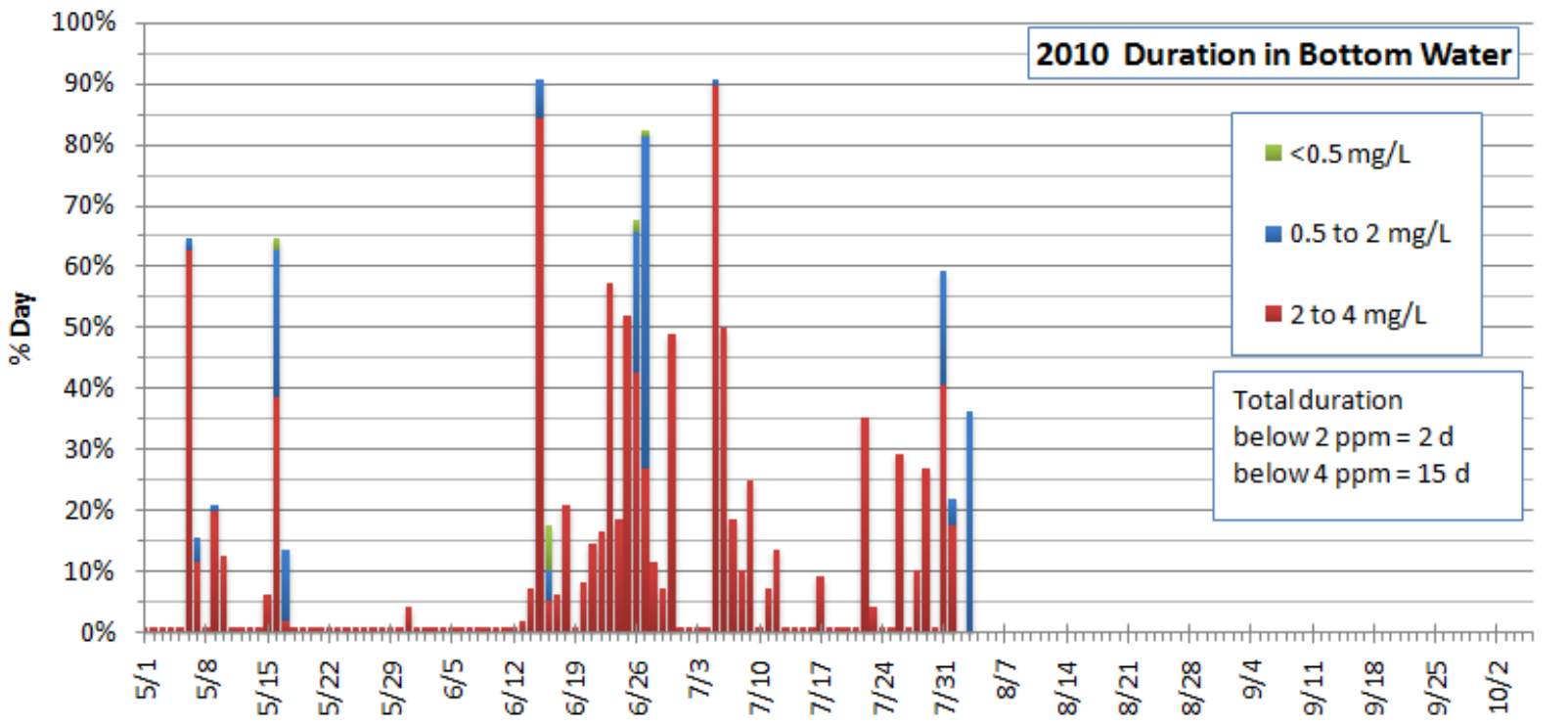
Example of instrusion of marine water coincident with low do

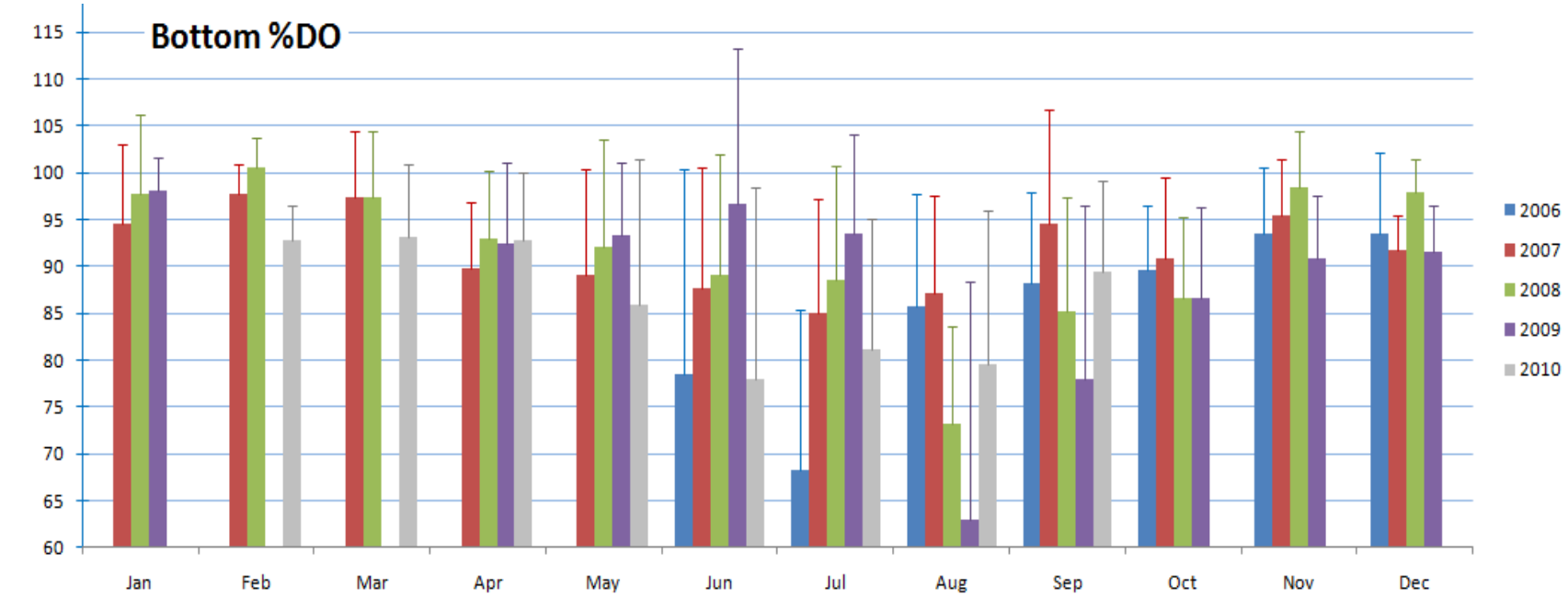


Conclusions

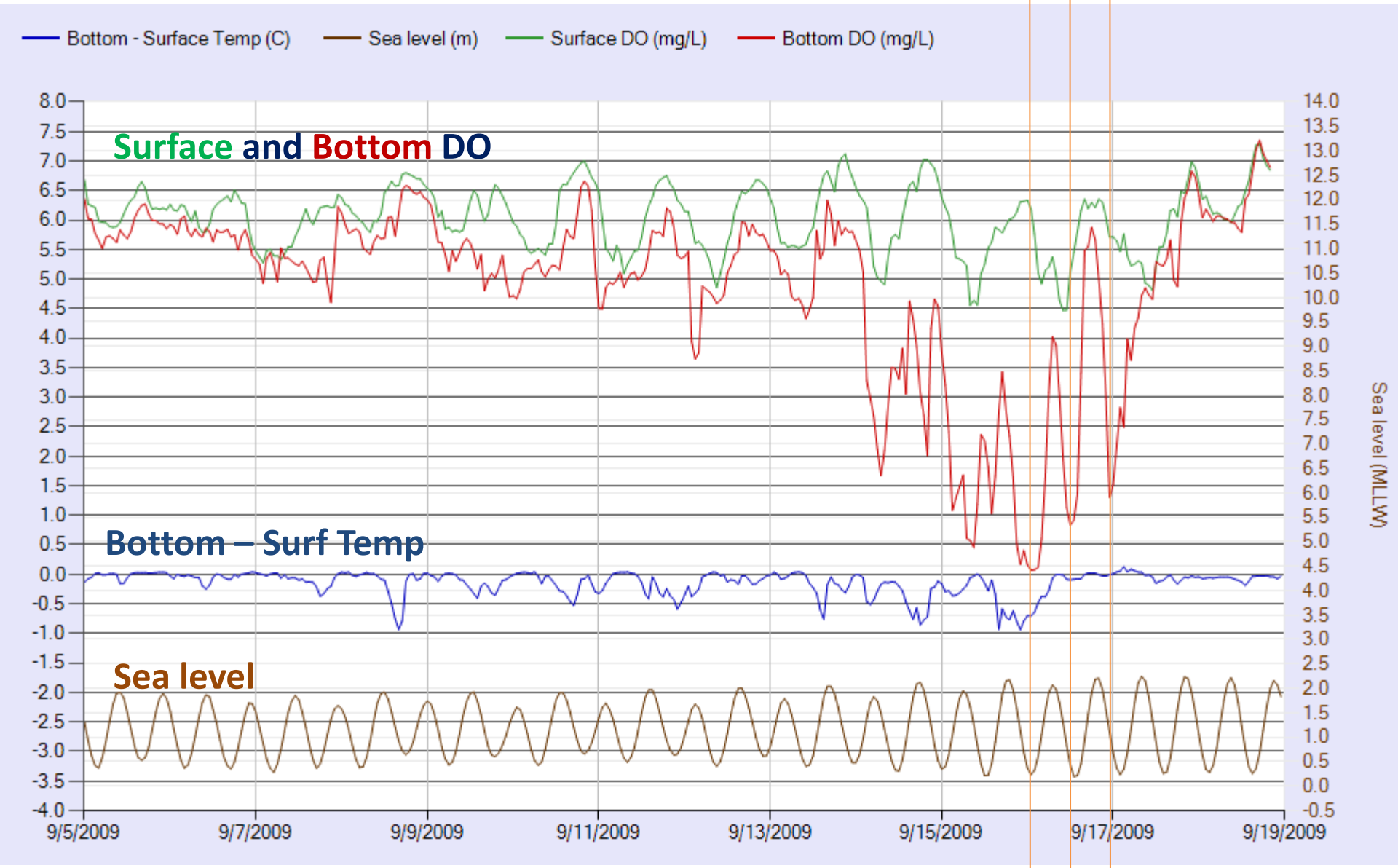
- Lots of temporal variability across multiple scales
- Terrestrial influences
  - Rain
- Marine influences
  - Low temp, high salinity water intrusions
- Tidal influences

- Need long-term dataset

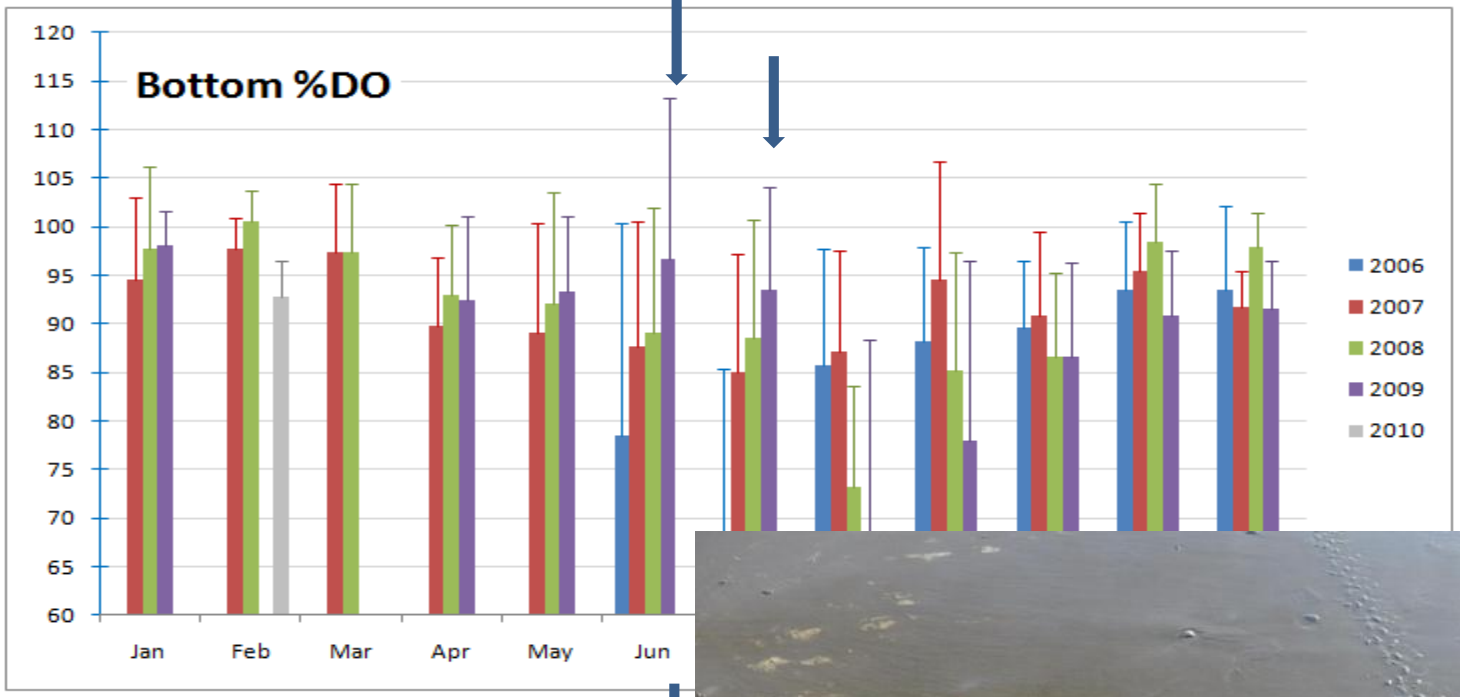

2010 Duration in Bottom Water
% Day
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
5/1
5/8
5/15
5/22
5/29
6/5
6/12
6/19
6/26
7/3
7/10
7/17
7/24
7/31
8/7
8/14
8/21
8/28
9/4
9/11
9/18
9/25
10/2
<0.5 mg/L
0.5 to 2 mg/L
2 to 4 mg/L
Total duration
below 2 ppm = 2 d
below 4 ppm = 15 d

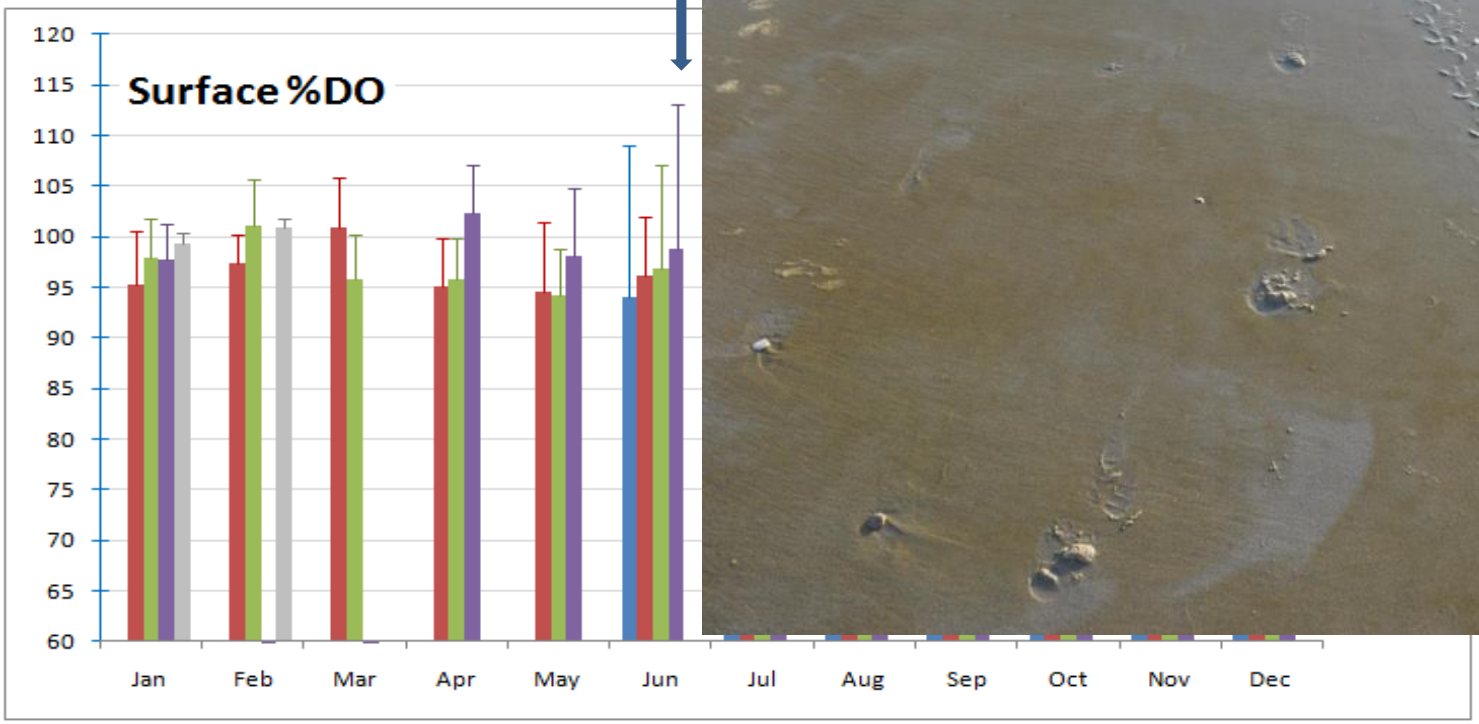

Bottom %DO
115
110
105
100
95
90
85
80
75
70
65
60
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2006
2007
2008
2009
2010

September Event



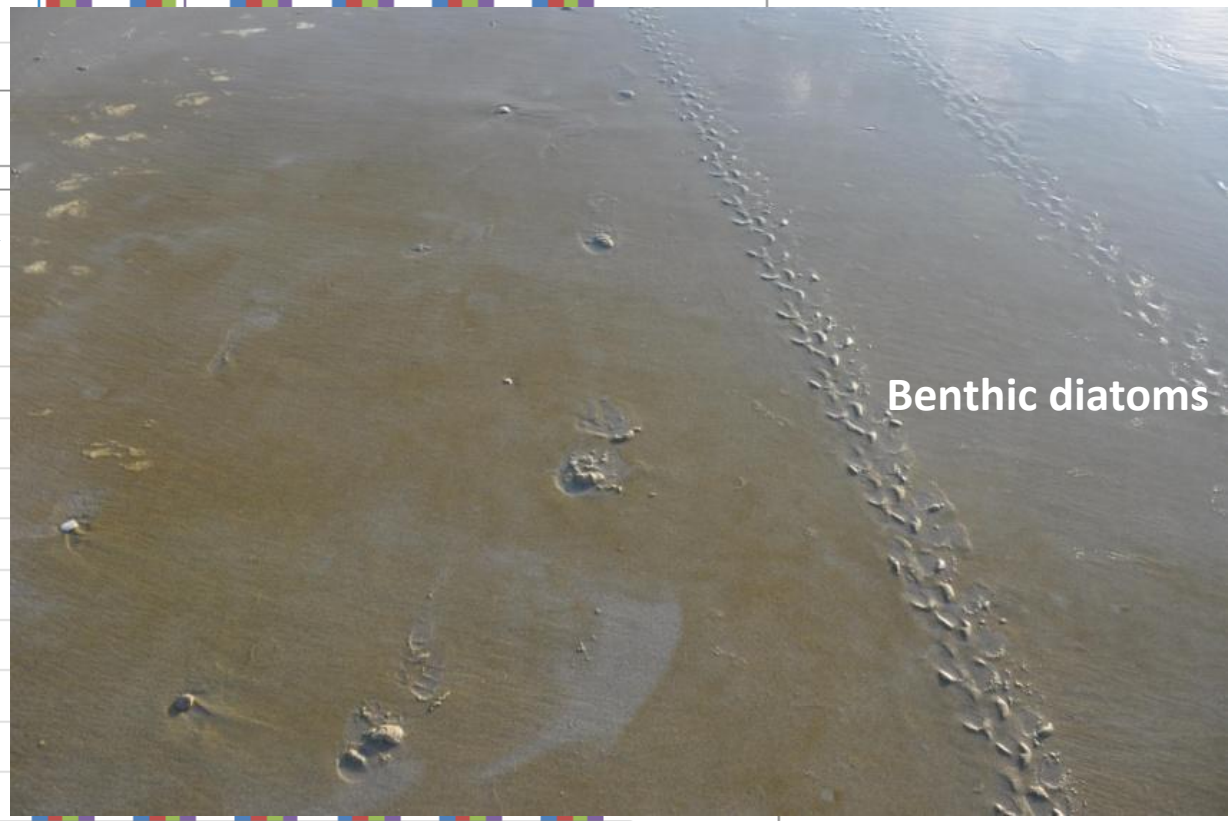
Sloshing with the tides but timing is different. Note higher surface DO



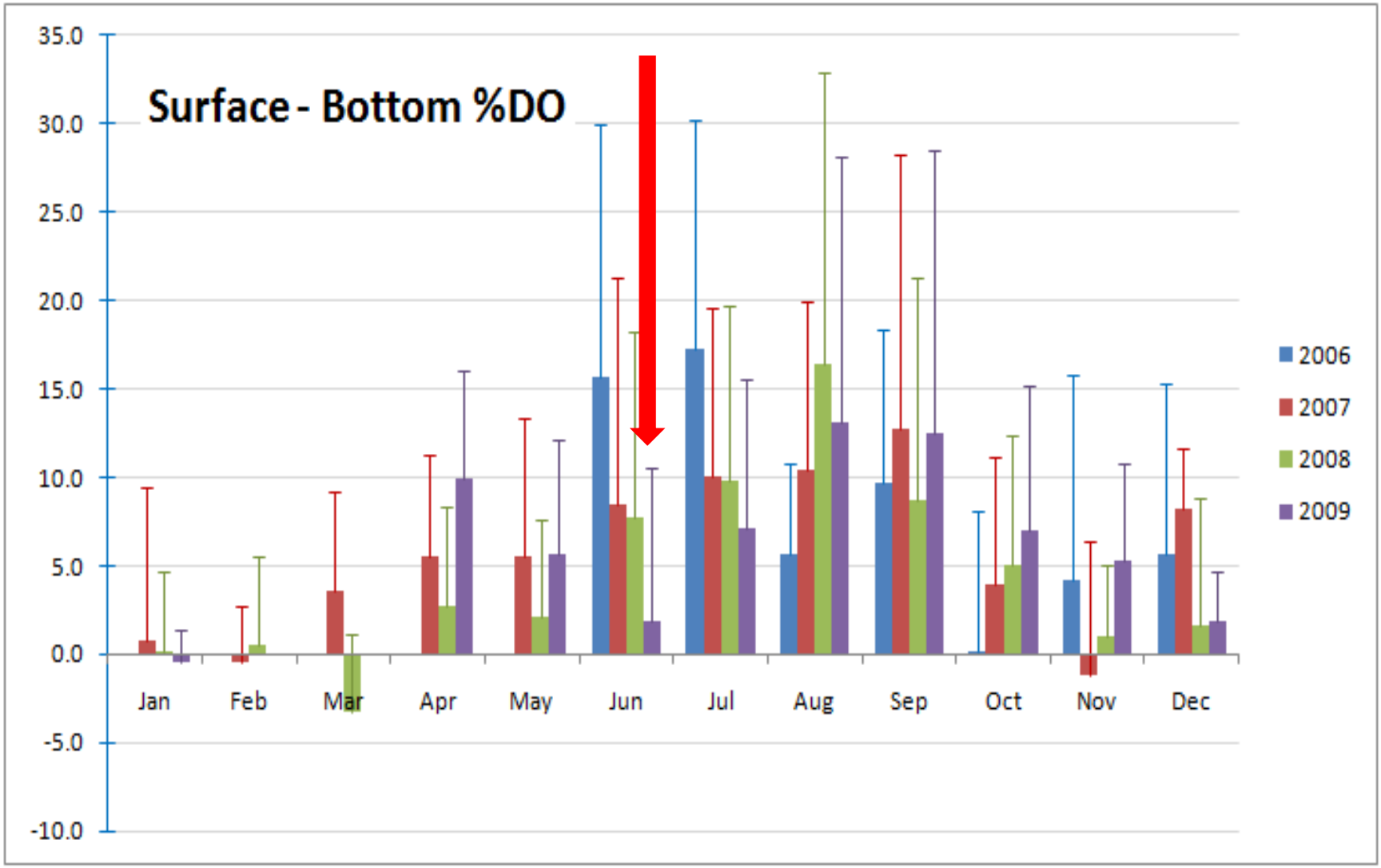


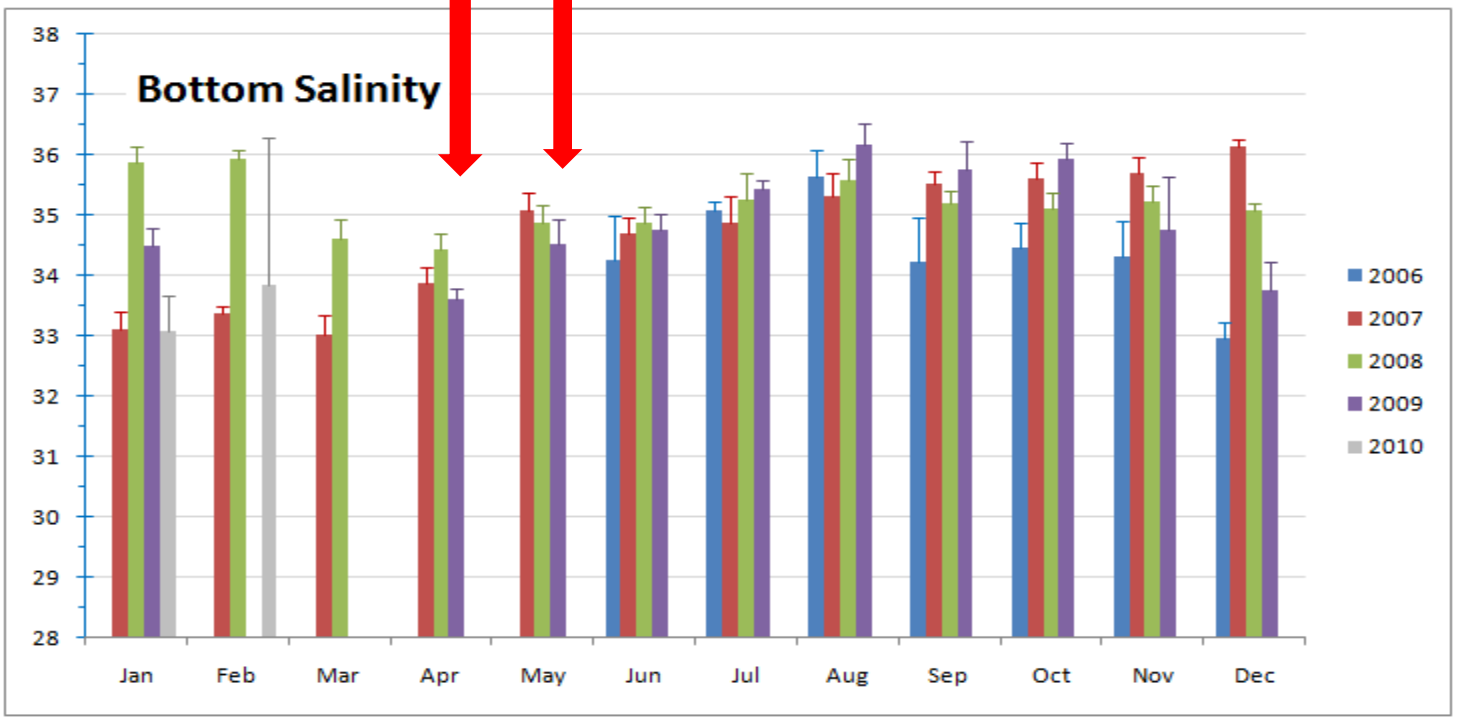
Bloom in Spring?

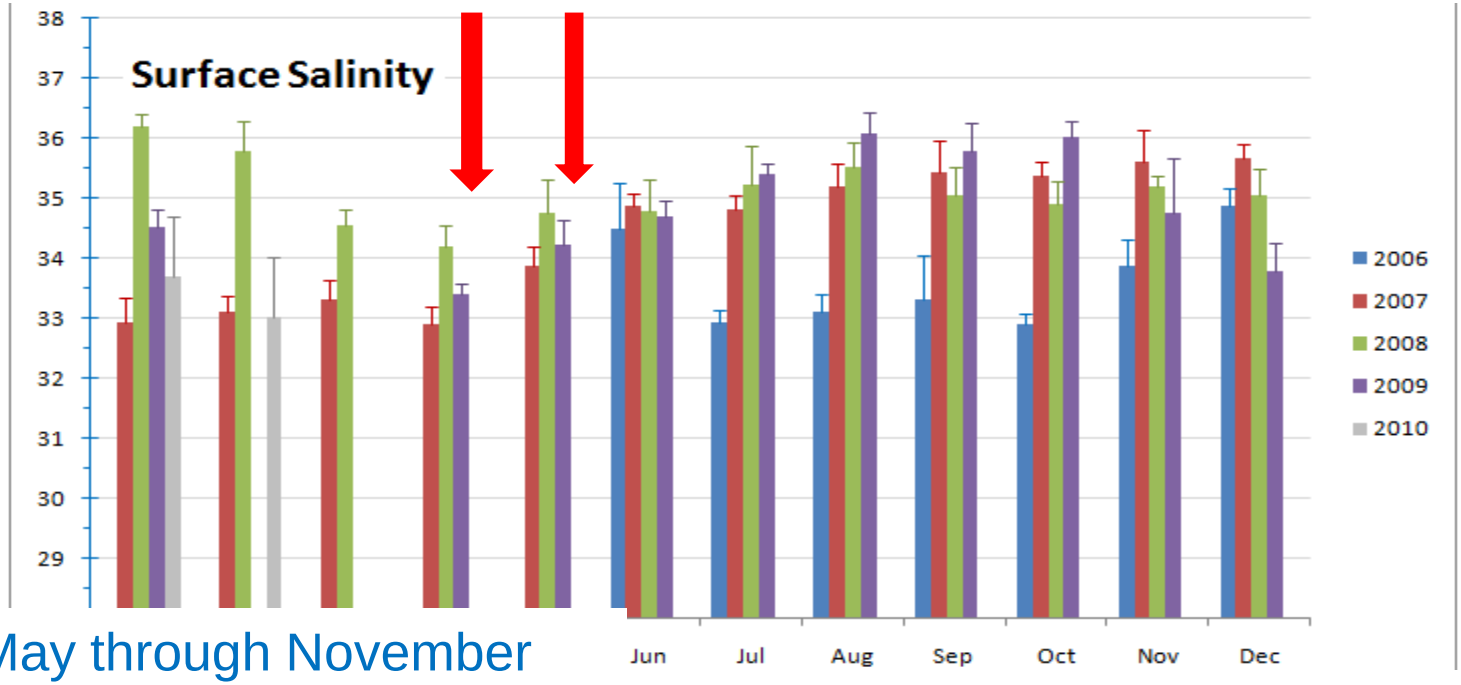
- Bottom: High %DO in May-Jul
- Surface: High %DO in Jun
- Large SD reflects diel oscillations



Hardly any Surface to Bottom difference in %DO in June 2009







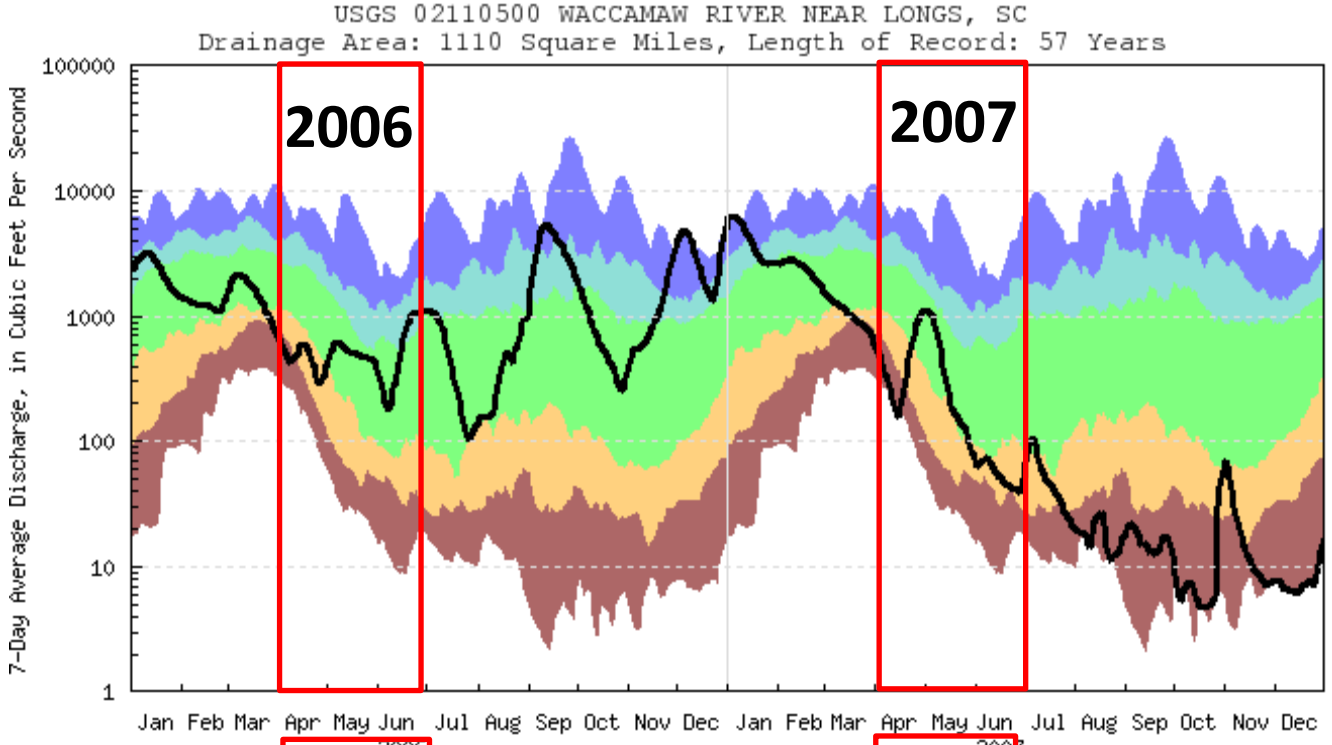
Salinities were low in April and May

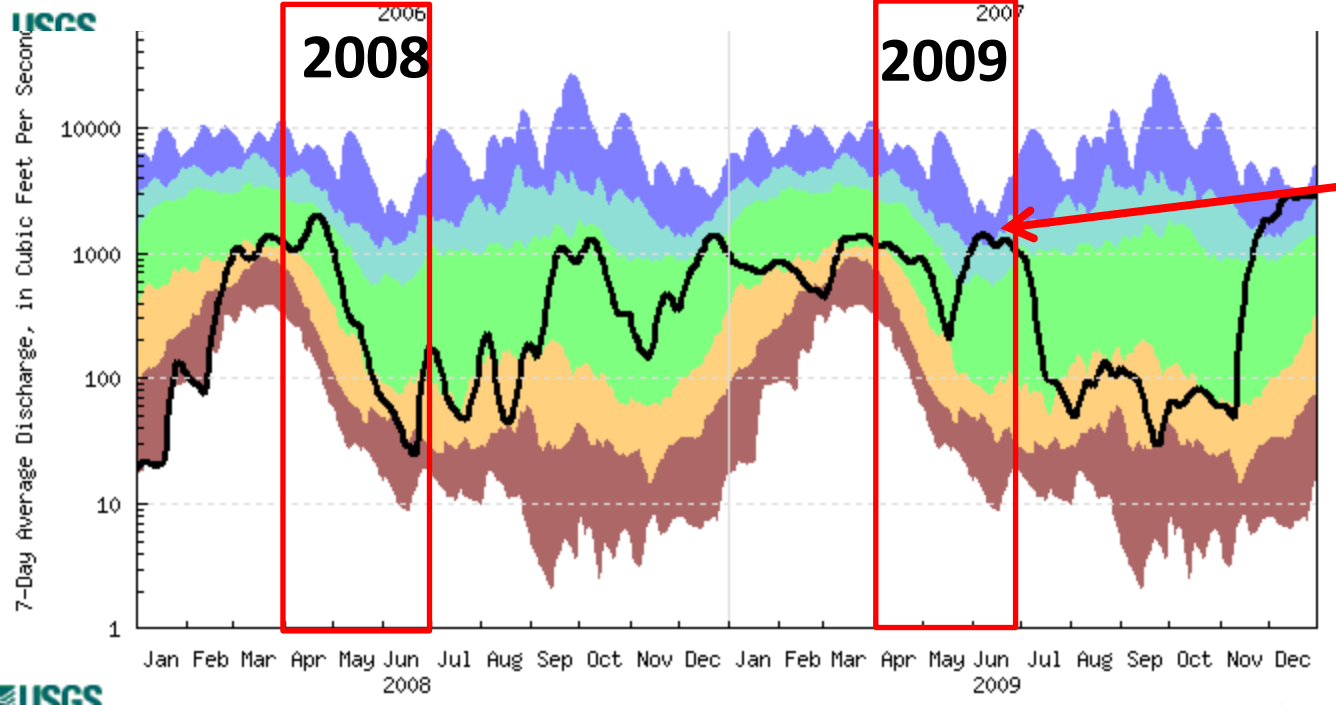
Not due to rainfall at the coast

2007 was an historic drought year. Salinity driven by lack of upwelling. Temperature is also reflective of upwelling.

May through November

2006: 28"



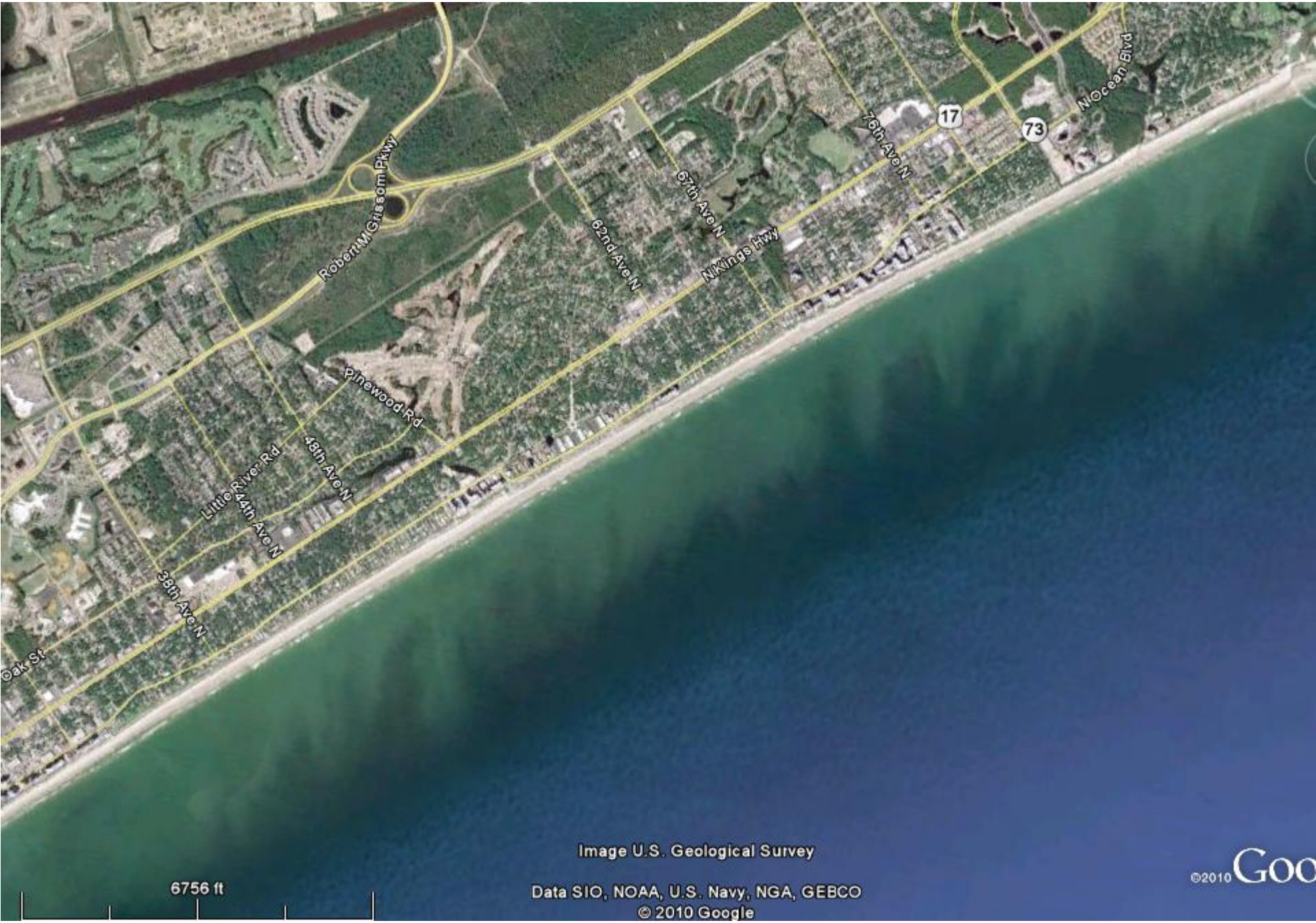


WaterWatch

USGS streamflow duration hydrographs

Explanation - Percentile classes					
lowest-10th percentile	10-24	25-75	76-90	90th percentile -highest	Flow
Much below normal	Below normal	Normal	Above normal	Much above normal	

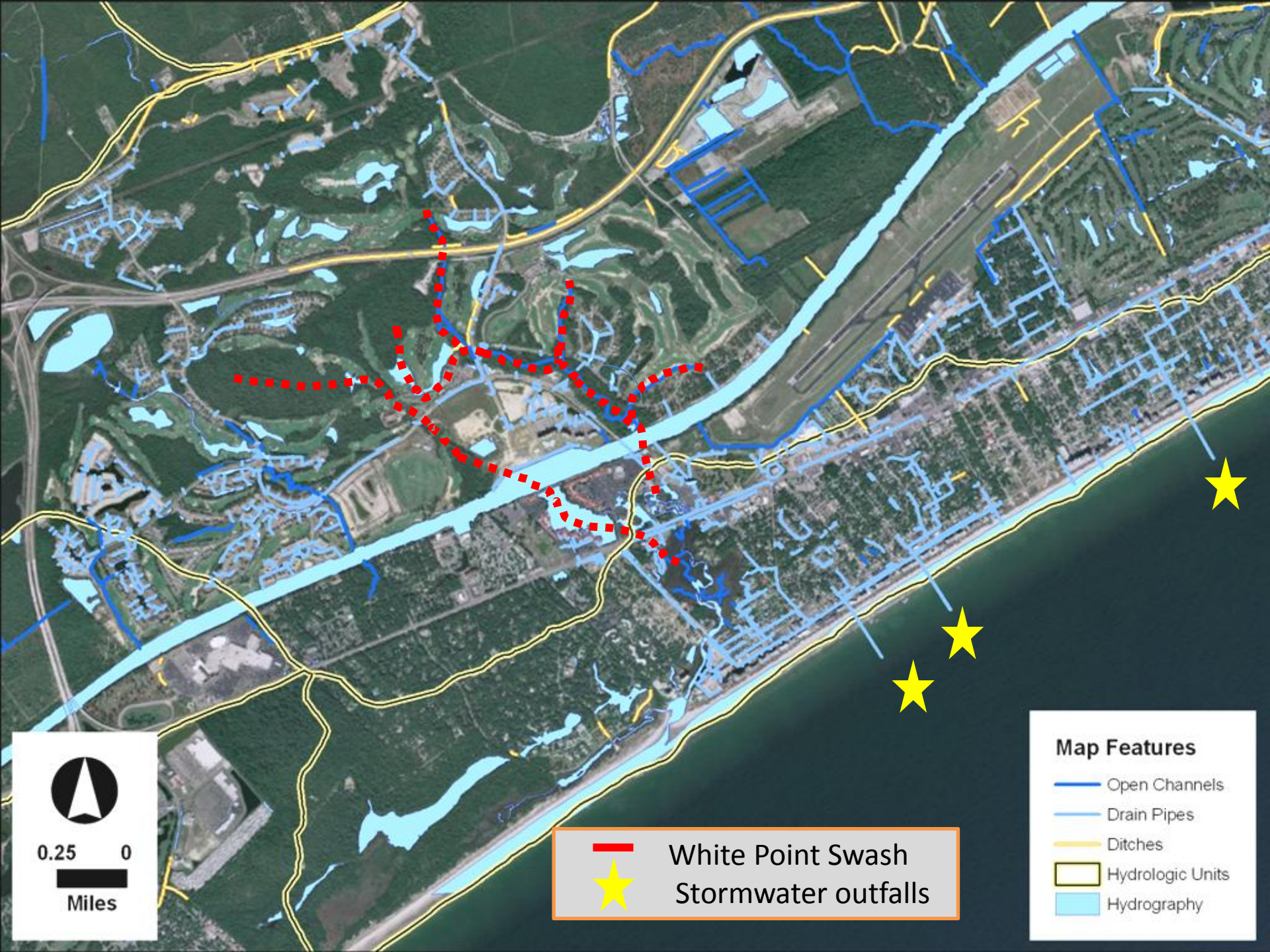
River flow in June 2009 was "Much above normal"


Robert M Grissom Pkwy
62nd Ave N
67th Ave N
76th Ave N
17
73
N Ocean Blvd
N Kings Hwy
Pinewood Rd
48th Ave N
Little River Rd
44th Ave N
38th Ave N
Oak St
Image U.S. Geological Survey
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2010 Google
6756 ft
©2010 Goo

Stormwater Pipes on the Beach Face

Tidal creeks (n = 14)
aka “Swashes”

White Point Swash


0.25
0
Miles
White Point Swash
Stormwater outfalls
Map Features
Open Channels
Drain Pipes
Ditches
Hydrologic Units
Hydrography