Fecal Coliform, Shellfishing, and Tidal Restoration in Wellfleet's Herring River

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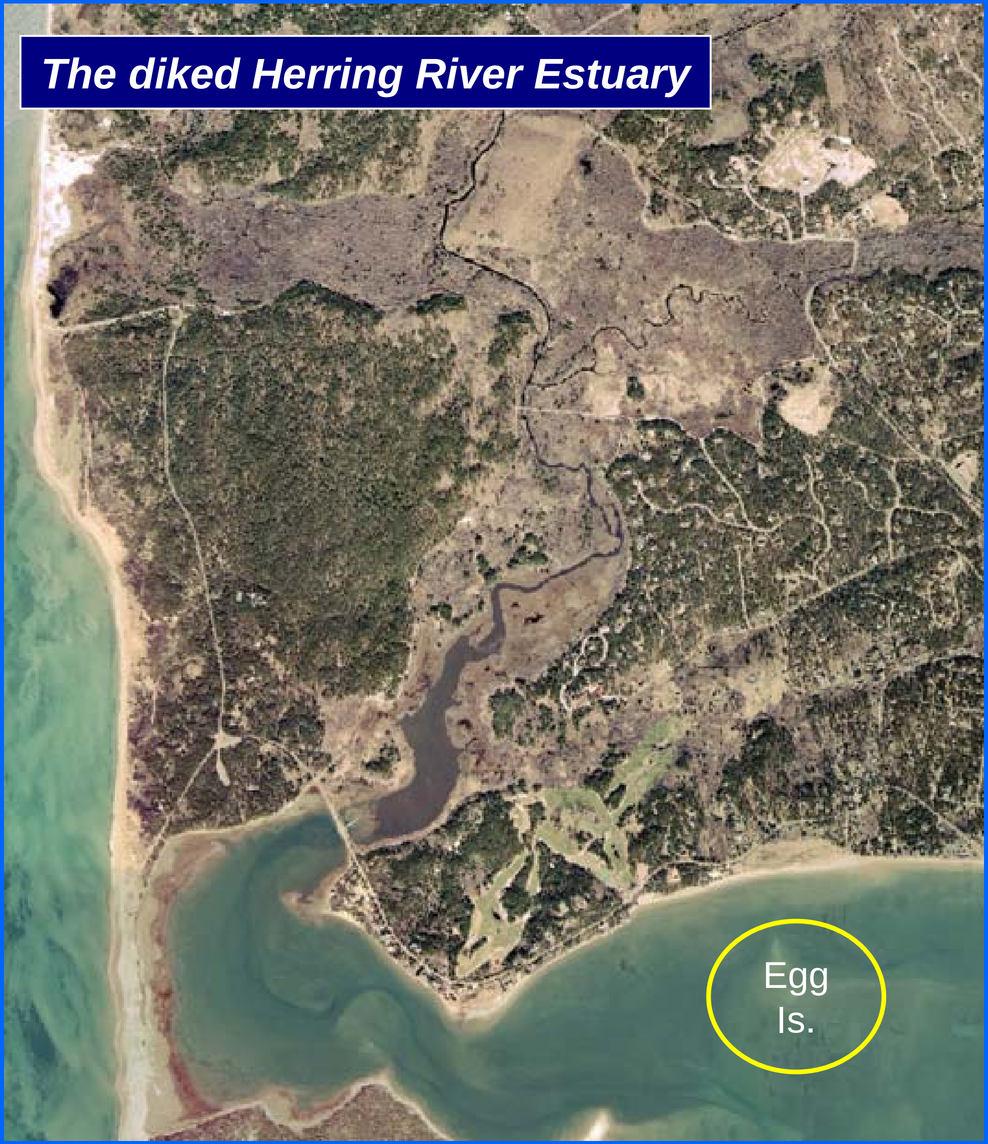
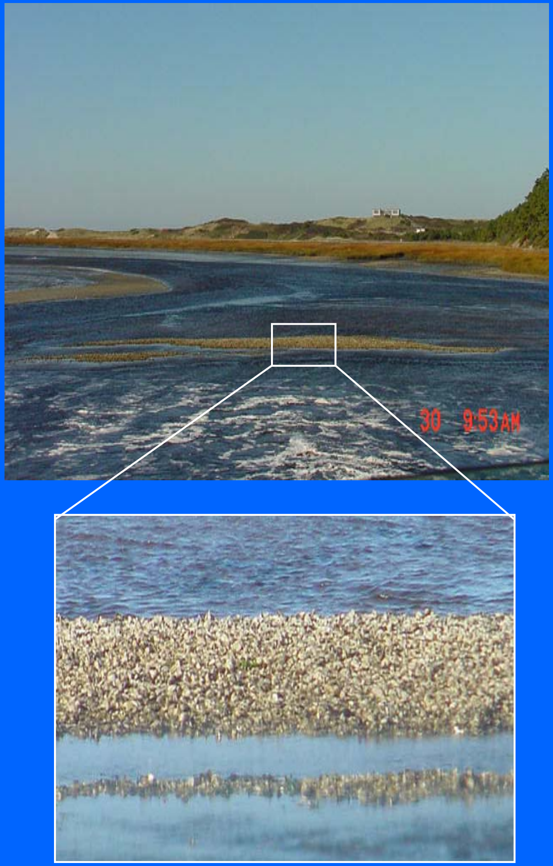
Since the state increased surveillance in the mid-1980s, the extensive oyster beds in the Herring River mouth have been closed to shellfishing due to fecal coliform (FC) contamination.

With current planning for tidal restoration, there is concern that changes in tidal flow could extend the FC problem onto aquaculture beds at Egg Island.



The Problem:



Oyster beds in river mouth

High FC has kept the area just above and seaward of the dike structure closed throughout the year, and the river mouth closed conditionally, after wet weather, and now seasonally, August through March.

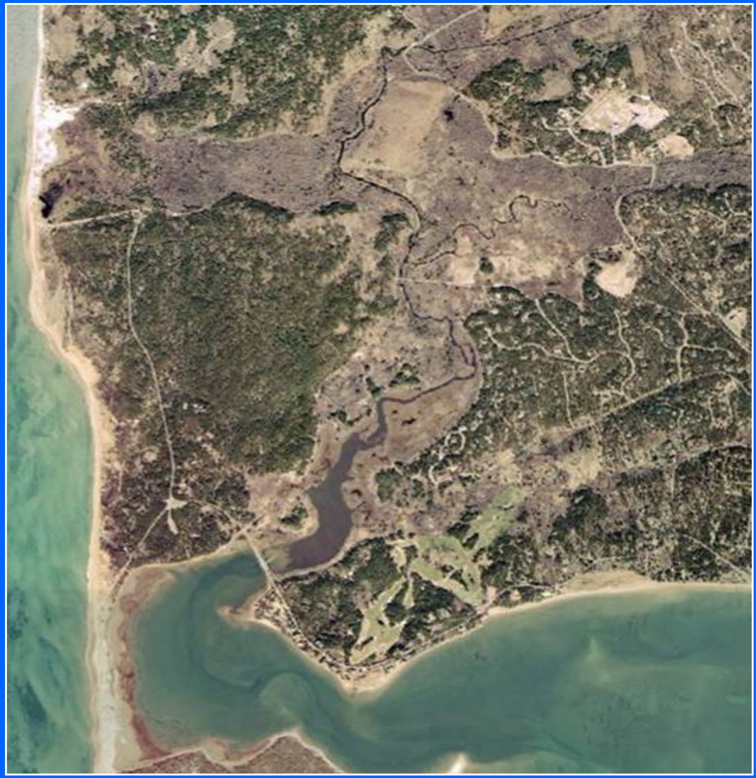
Bacteria Sources:

Septic leachate?

Wildlife?

Road runoff?

But little change in land use since 1961.



Potential ultimate sources for FC in the river are septic leachate, wildlife and road runoff. However, there are very few cesspools or septic systems near the river; few road crossings; and land use has changed little since 1961 because of incorporation of most of the flood plain into Cape Cod National Seashore. Wildlife within the river basin is probably the ultimate source of FC in the river water, but it's unlikely that wildlife use and input of FC has changed in many decades.

Study assumption:

The source of bacteria (probably wildlife) is unlikely to change, thus...

Study focus:

Water quality and hydrodynamic factors that affect coliform bacteria concentrations in the environment, the Herring River estuary.

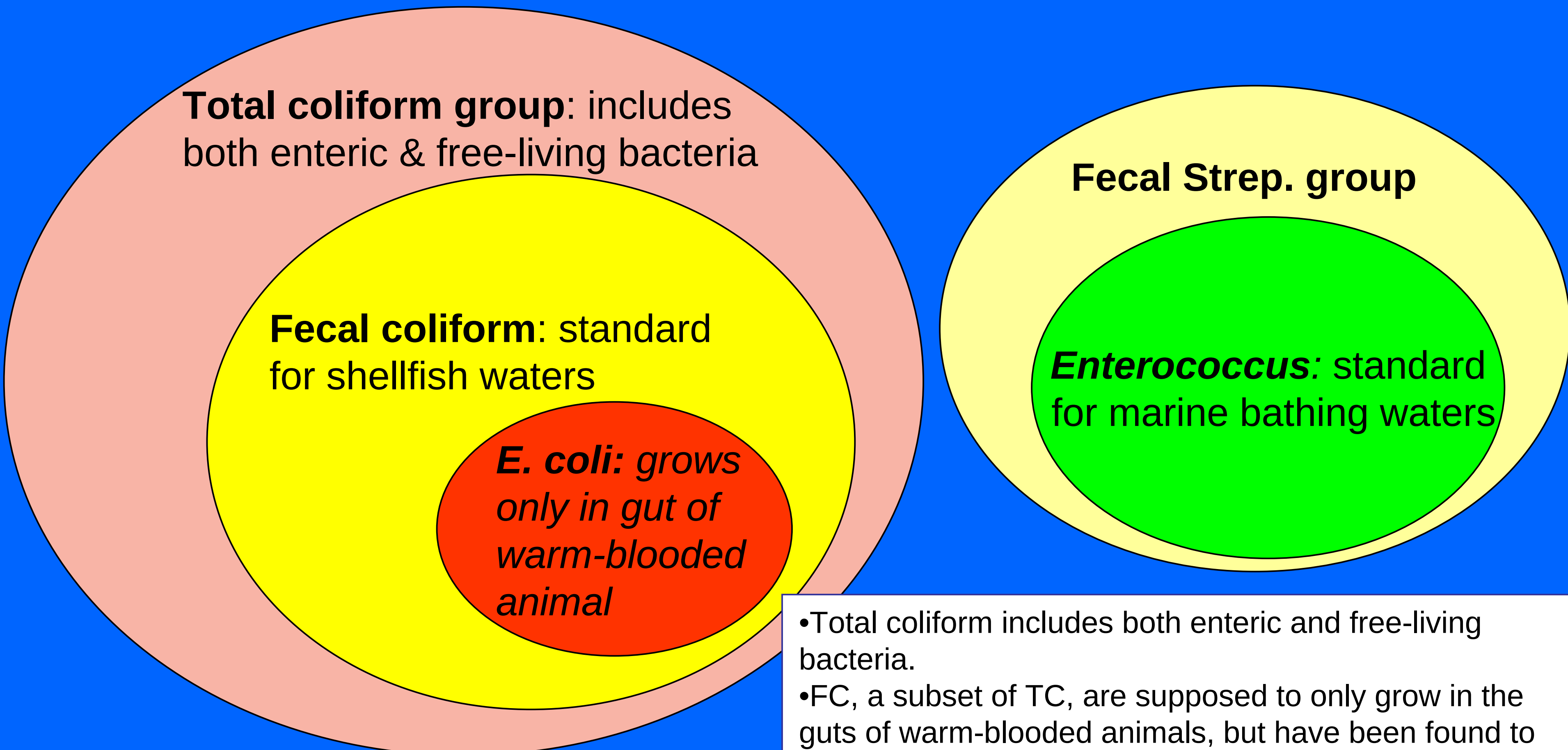
Specific questions:

- ***Where and when do public-health bacteria contaminate River surface waters?***

- ***How would restoration of tidal flow affect shellfish-water quality?***

Rather than studying sources, this study focused on bacteria survival and transport within the river.

Public Health Indicator Bacteria Used to Assess Microbiological Water Quality



•Total coliform includes both enteric and free-living bacteria.
•FC, a subset of TC, are supposed to only grow in the guts of warm-blooded animals, but have been found to grow in sediments; they are the standard for shellfish-growing waters.
•E. coli only grow in animal intestines.
•Enterococcus, a member of a different group (fecal Streptococcus.) are the standard for marine bathing waters.

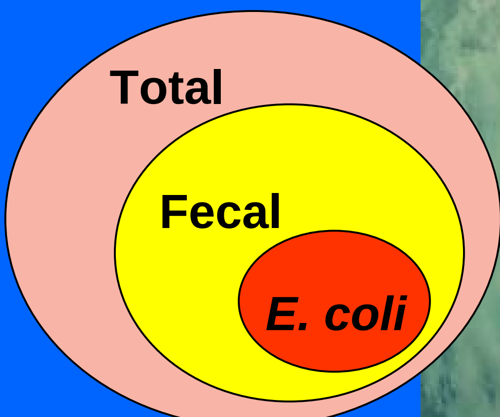
Factors extending coliform survival in the environment

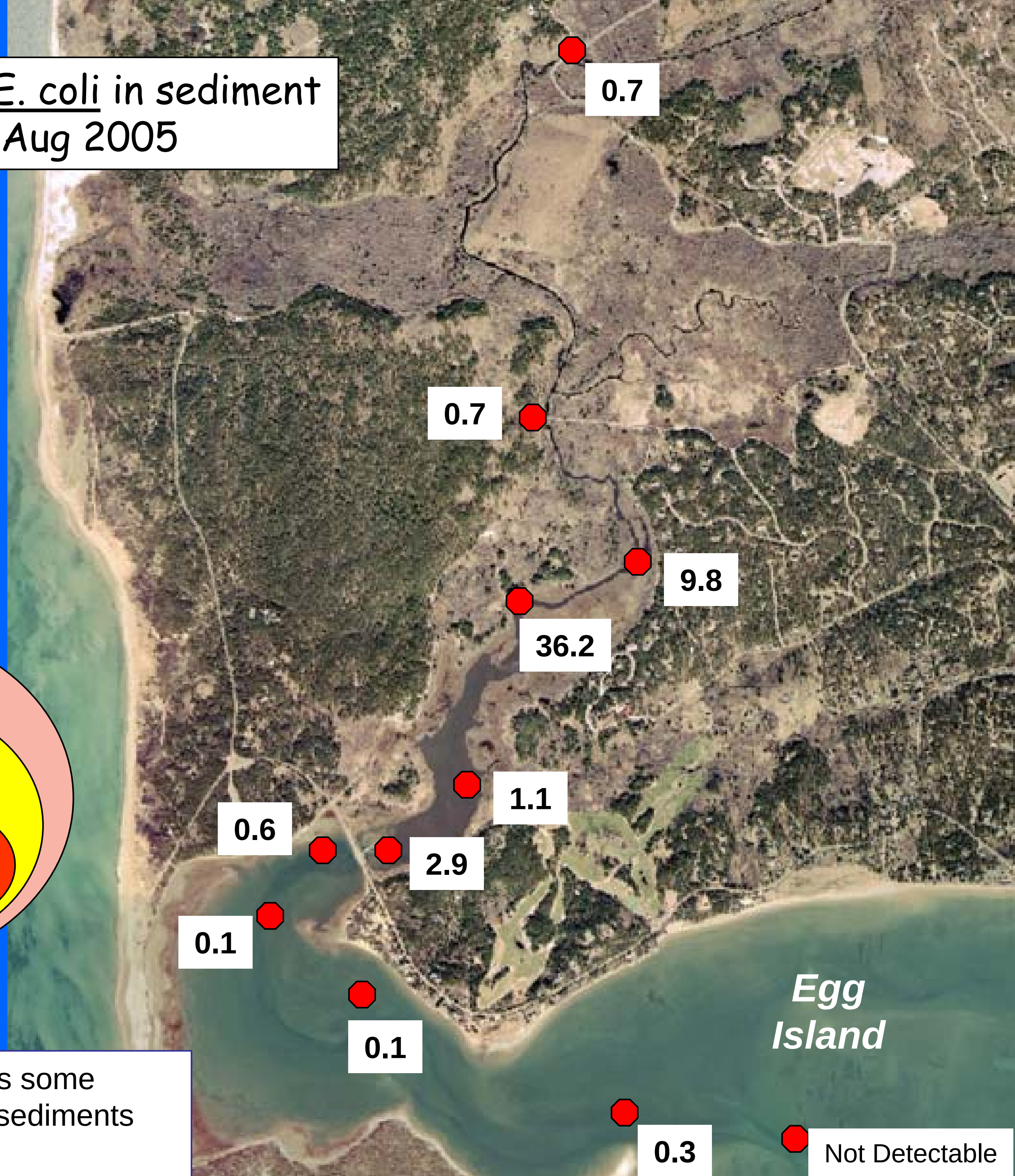
- Low salinity
- Low pH (high acidity)
- Low dissolved oxygen
- High sediment organic content

Current water quality in the diked Herring River favors coliform survival.

Herring River E. coli in sediment
9 & 16 Aug 2005

Data are E. coli per gram of dry sediment

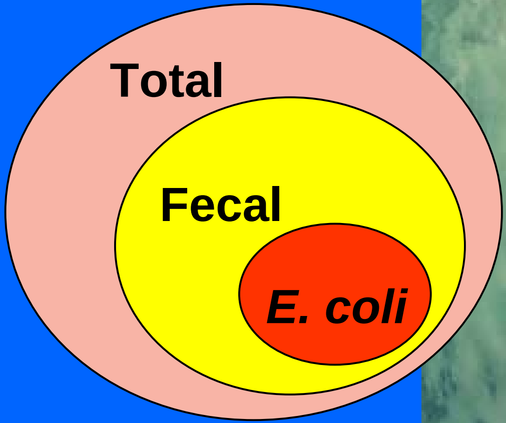


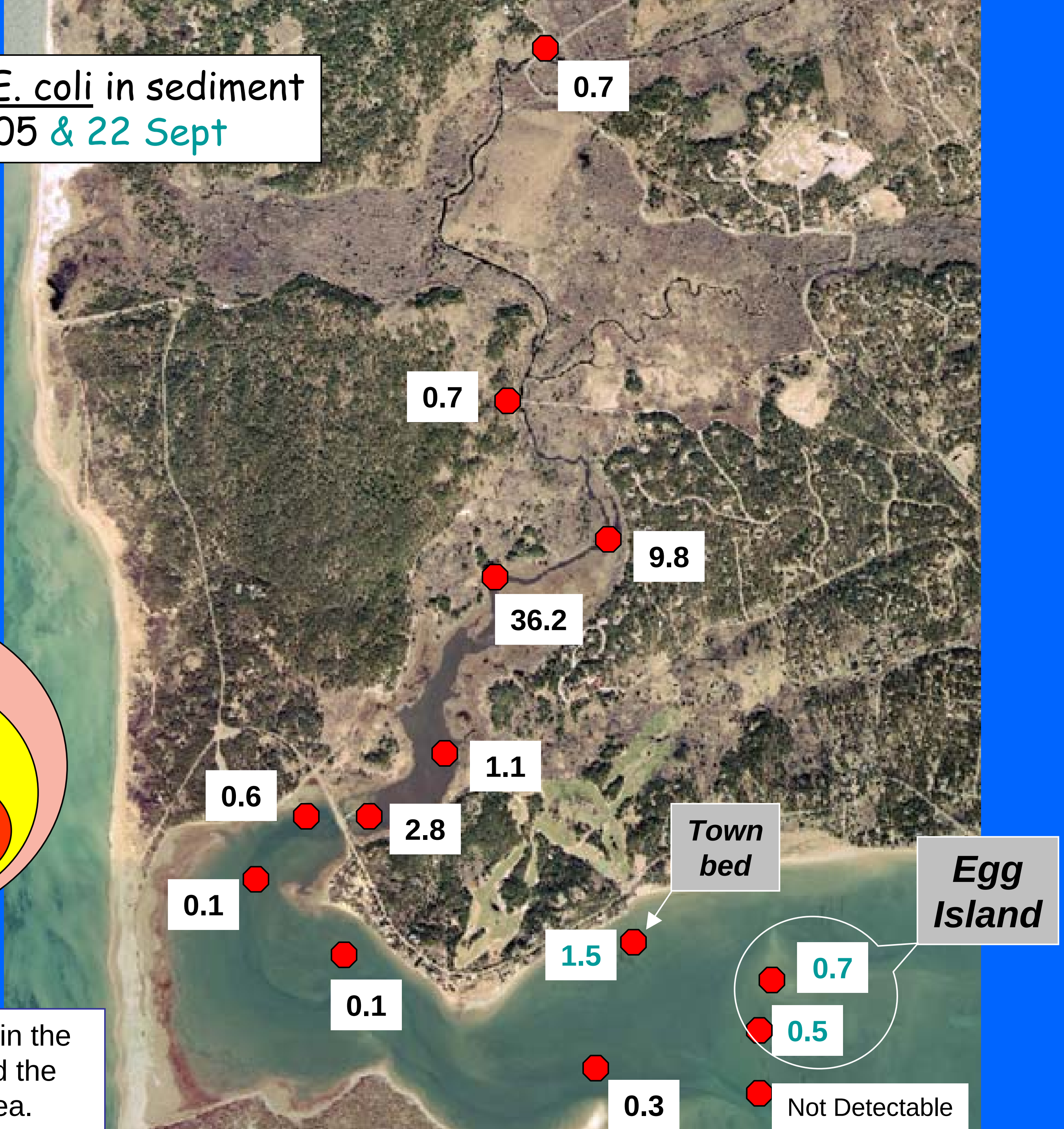


Sediment sampling shows some pockets of high E. coli in sediments above the dike structure.

Herring River E. coli in sediment
16 Aug 2005 & 22 Sept

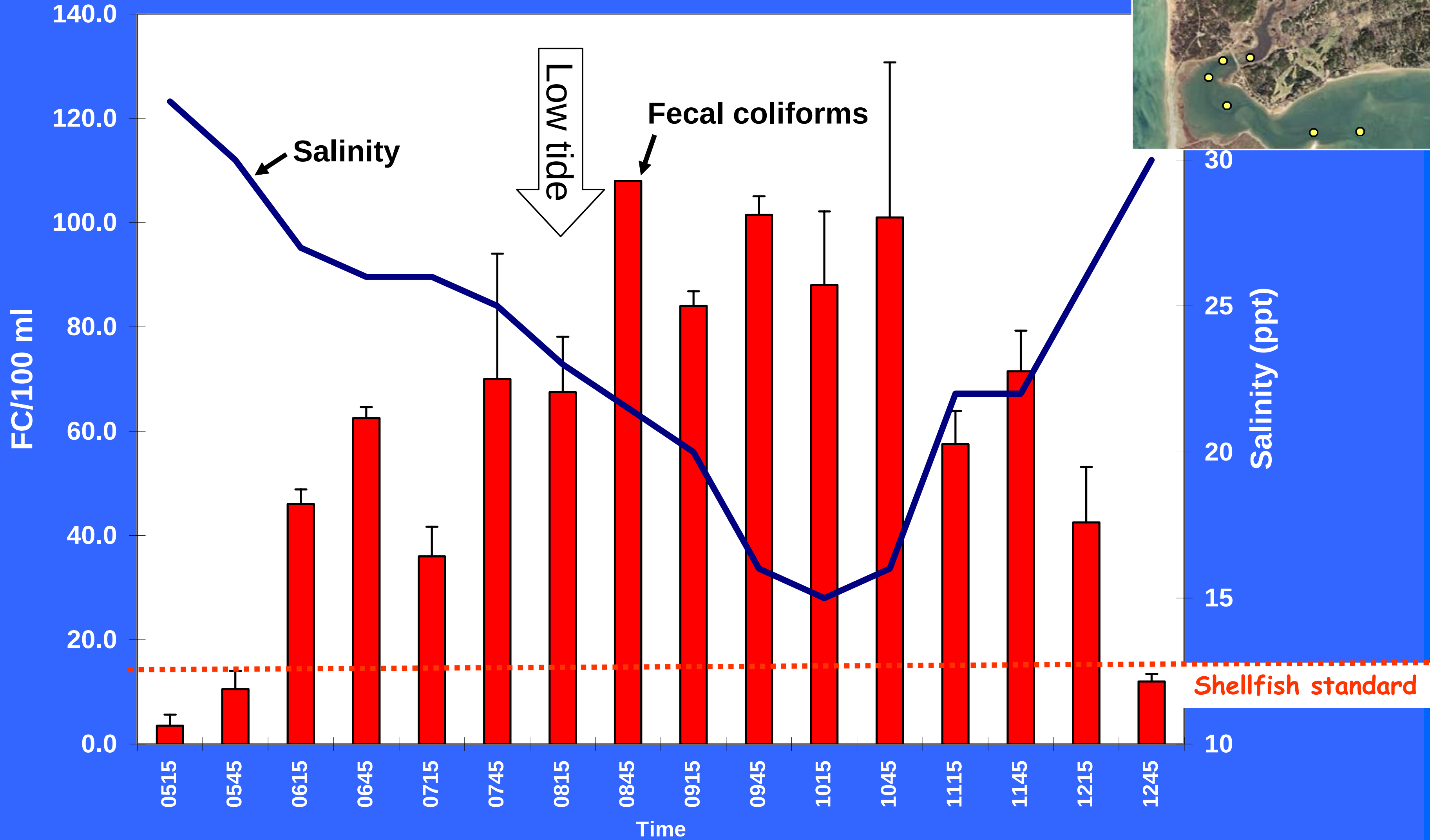
Data are E. coli per gram of dry sediment





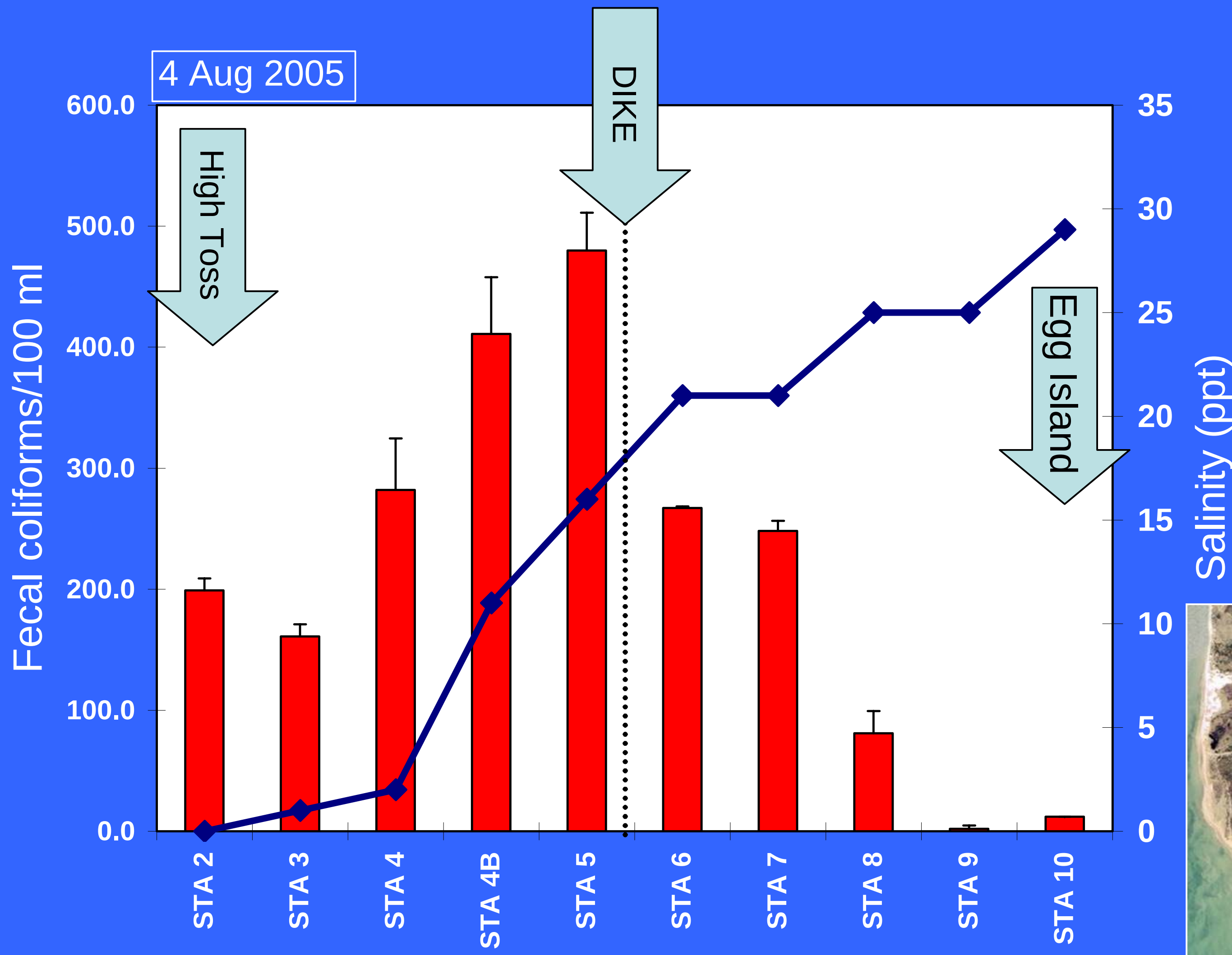
E. coli are also present, in the sediments of Egg I. and the Town propagation area.

River coliform and salinity through tidal cycle



Fecal coliform concentrations are inversely related to salinity in the river mouth, with highest concentrations at low tide and lowest concentrations at high tide. Concentrations exceed the 14 colonies/100 ml limit throughout low tide.

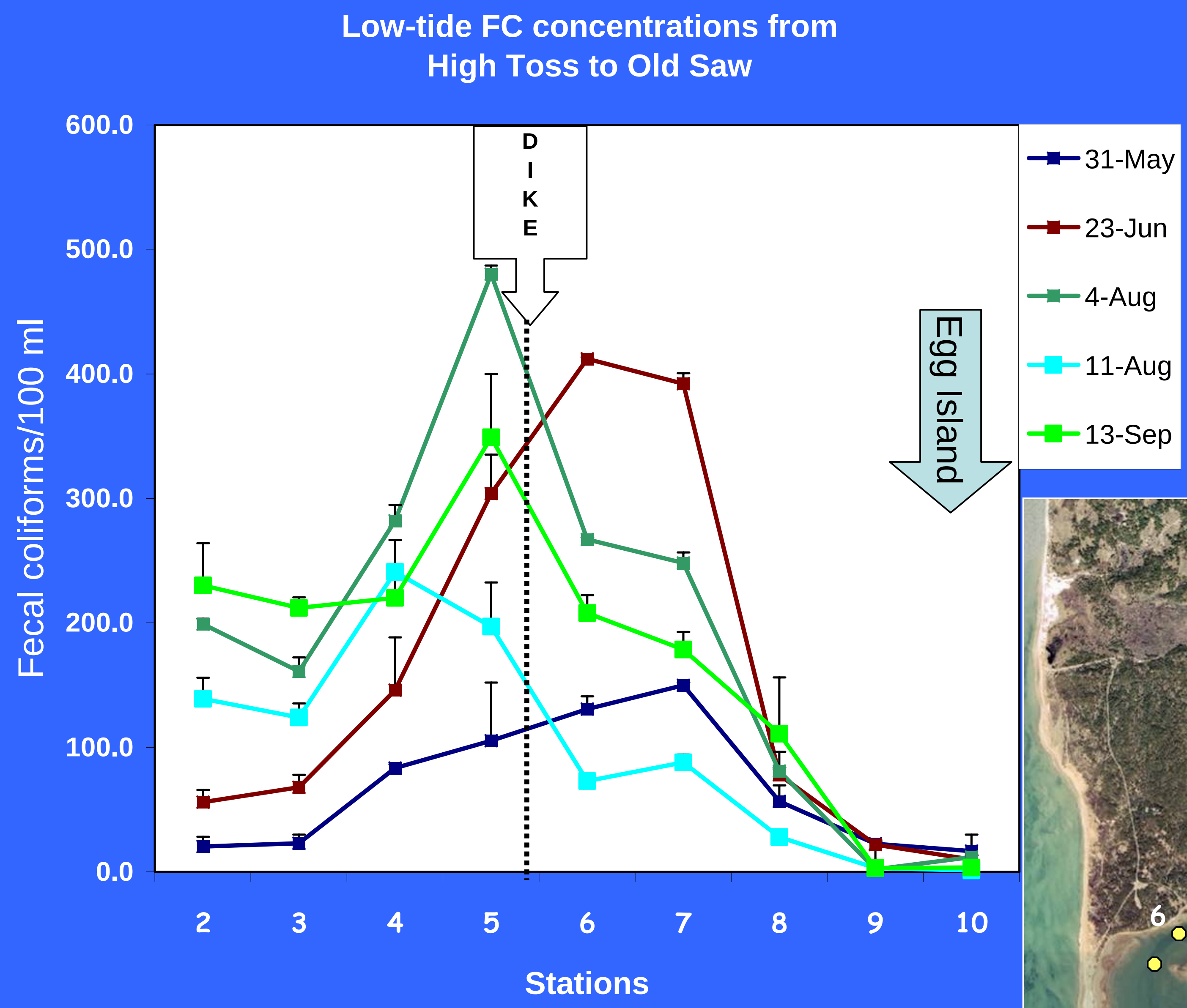
Low-tide coliform from High Toss to Egg Island



Note: Water-quality standard for shellfish waters is 14 FC per 100 ml.

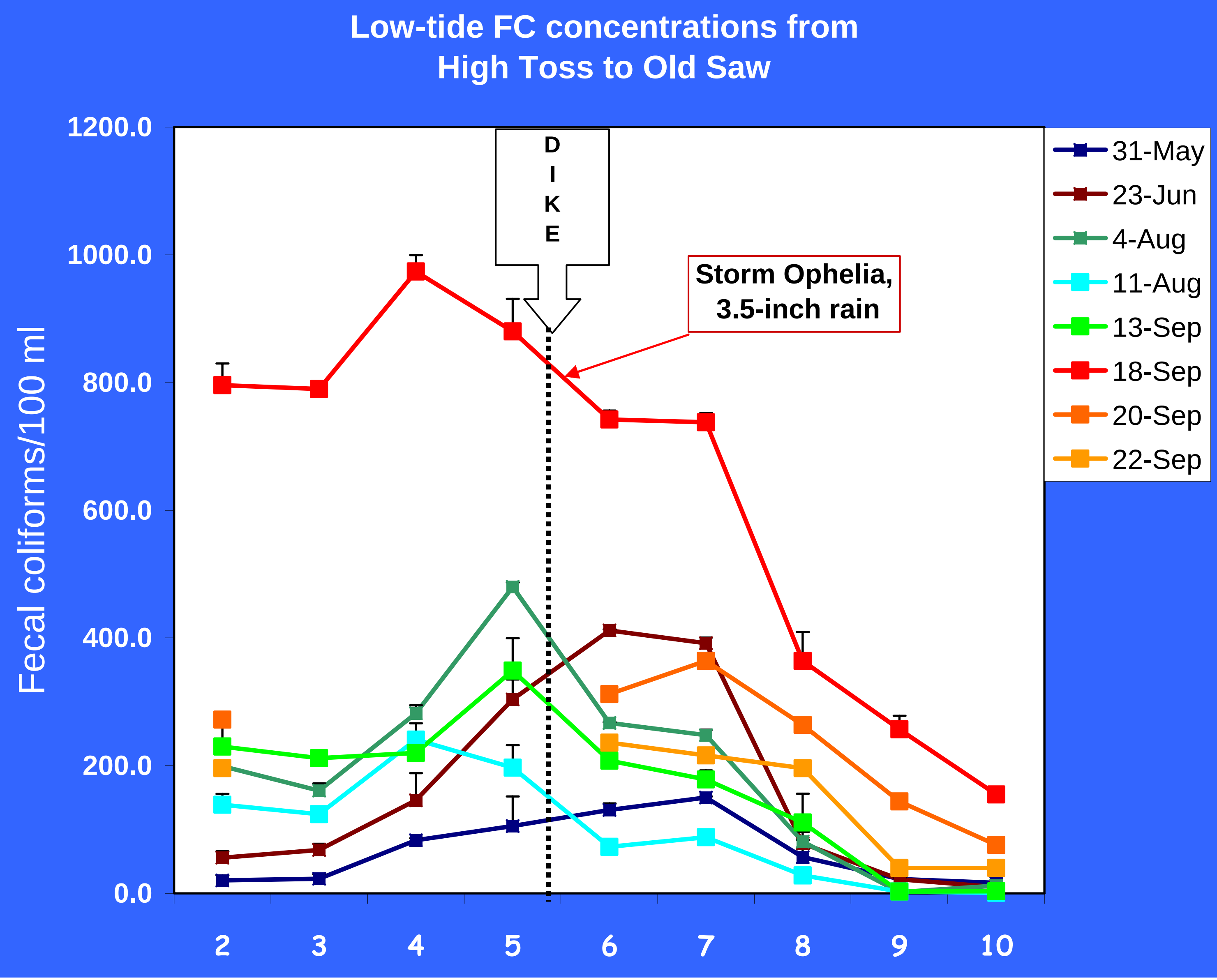
Sampling at 9 stations at low tide from High Toss Road to Egg I. always shows moderate FC in the freshwater river, high FC ~3000 ft just above and below the dike, and low FC in the channel between Great and Egg Islands, where salinity rarely drops below 25 ppt.

Low-tide fecal coliform along the river



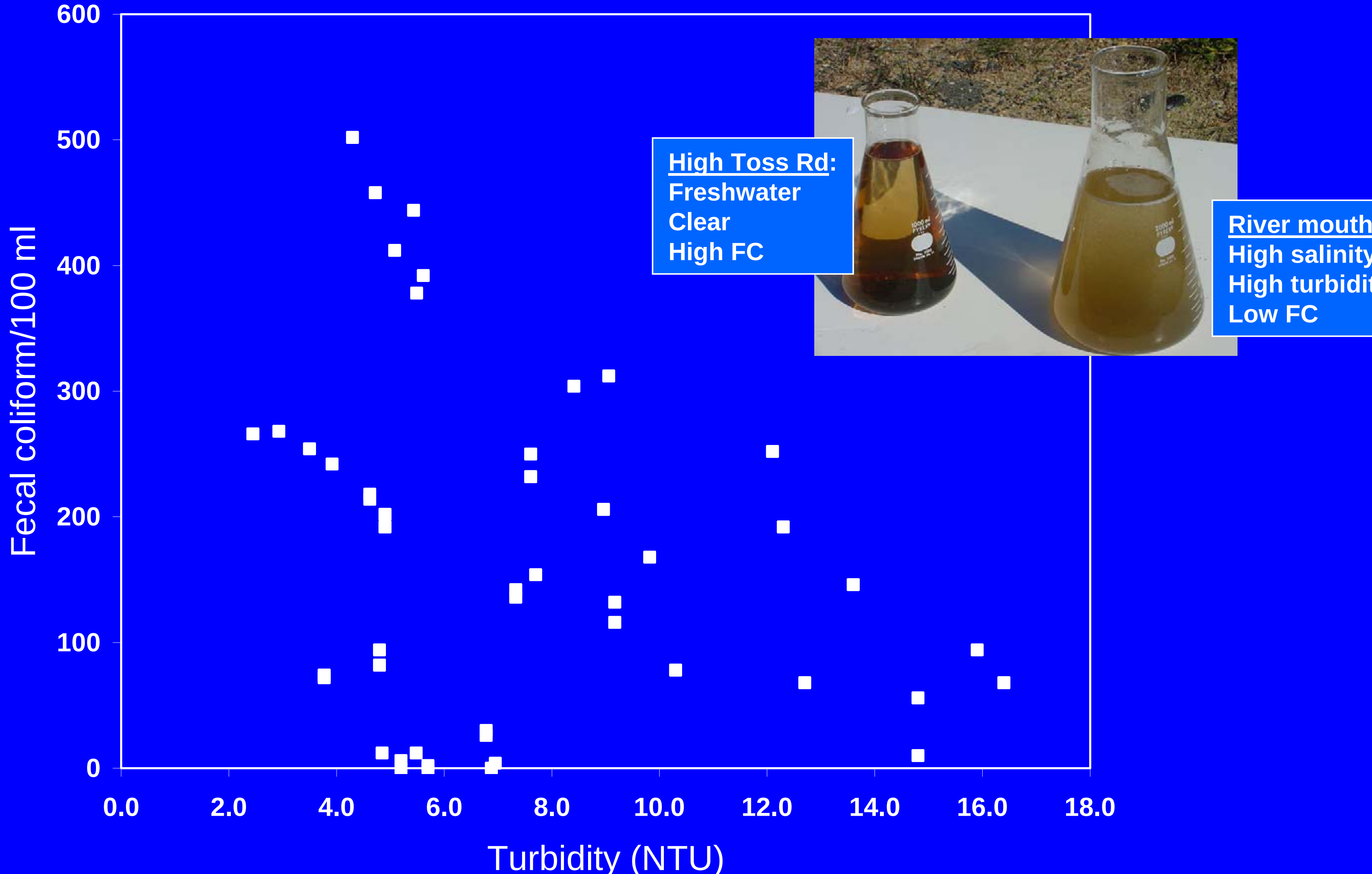
Repeated sampling throughout 2005 shows that Egg Island aquaculture beds are protected from FC by high-salinity Cape Cod Bay waters.

Low-tide fecal coliform after rain



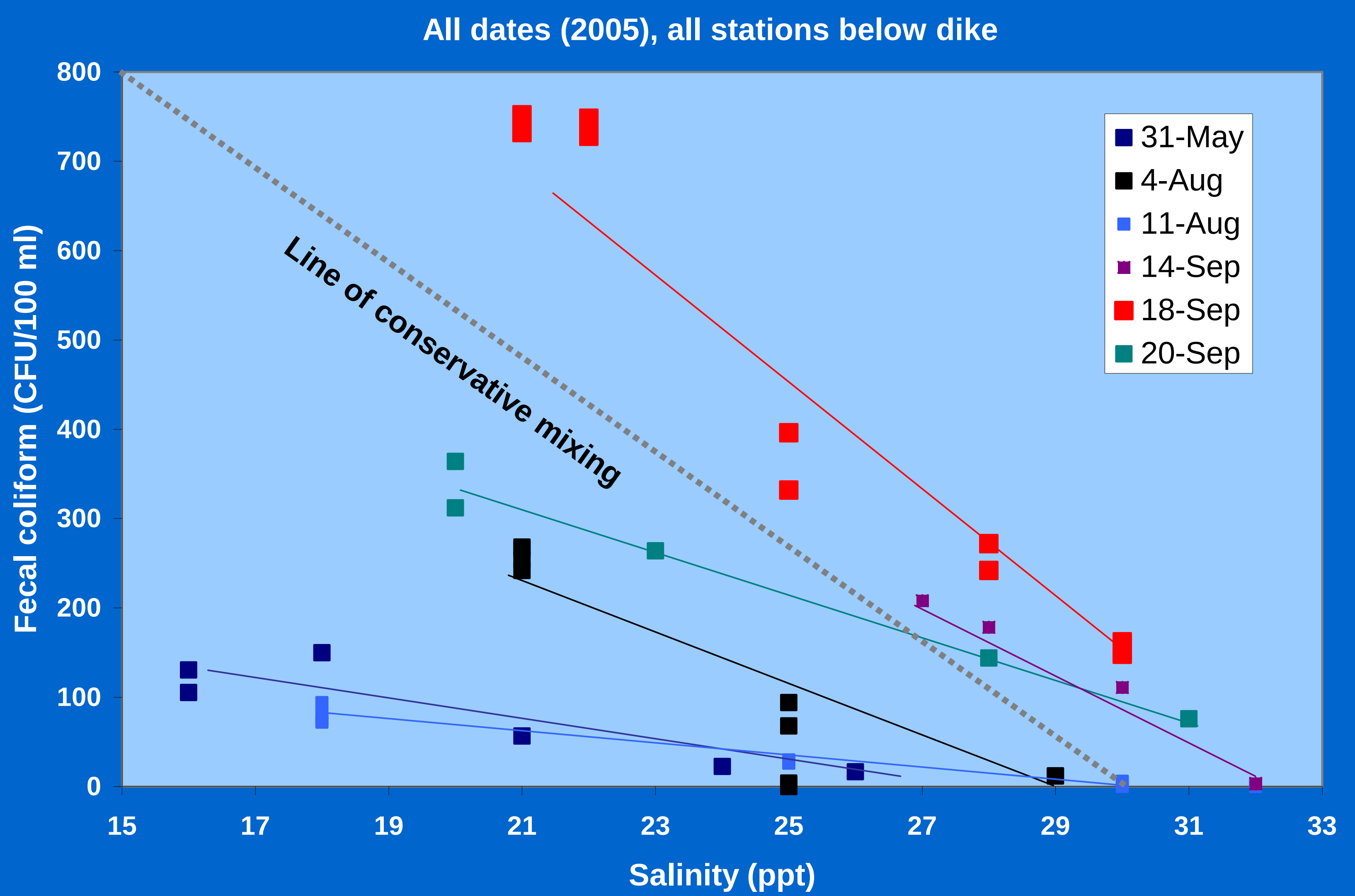
Under current tide-restricted conditions, large rain events increase FC throughout the lower river, even affecting the channel near Egg Island. Concentrations return to pre-storm water quality in about 4 days.
With the river unrestricted, the low-salinity, high-FC signal would be much weaker and shorter lived, see below.

Fecal coliform in Herring River is not caused by sediment resuspension



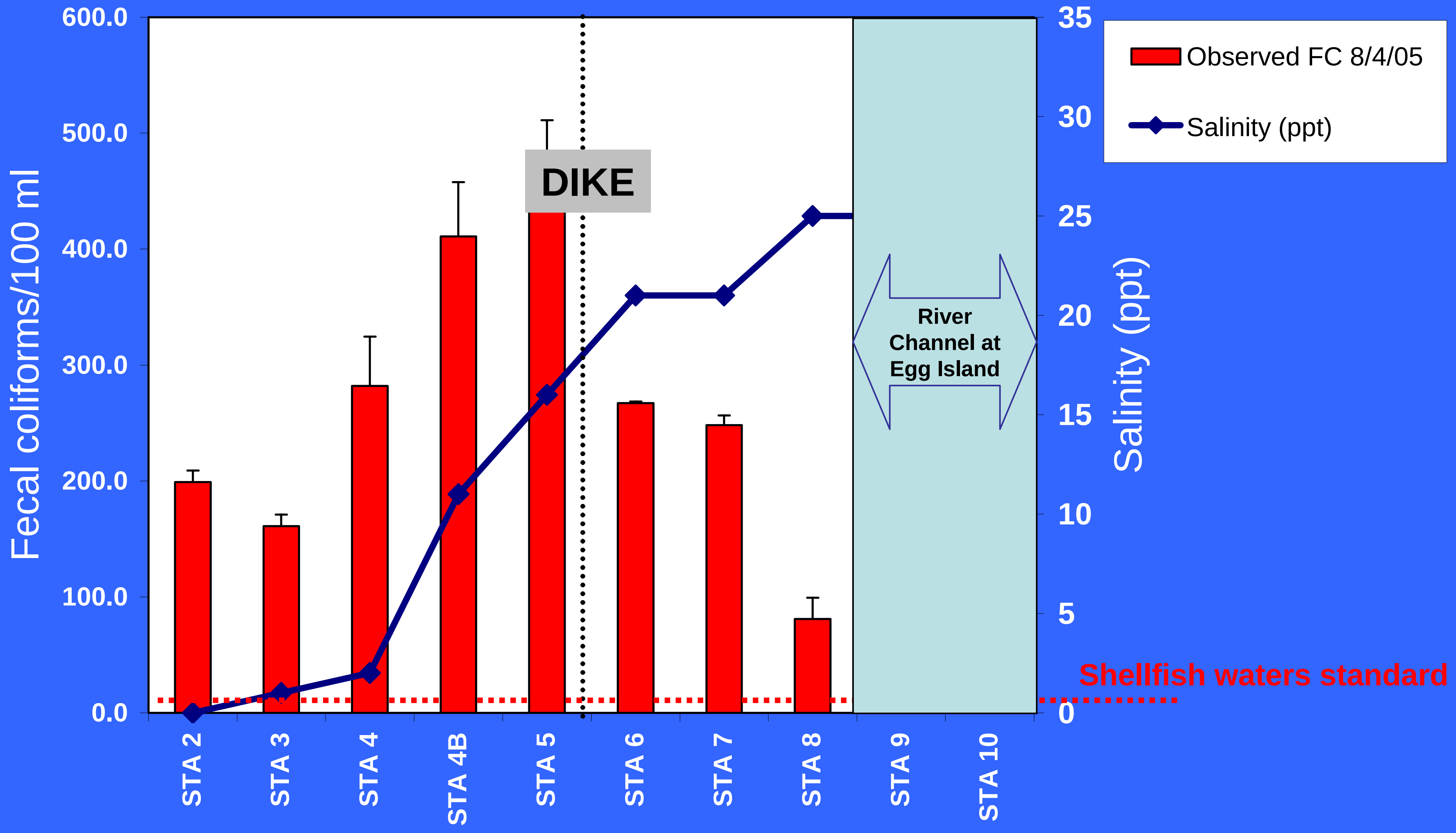
FC in the river is not caused by sediment resuspension. In fact, if anything, high FC occurs in the low-salinity river water, and not in the turbid water seen at the river mouth at low tide.

Fecal coliform in Herring River varies inversely with salinity



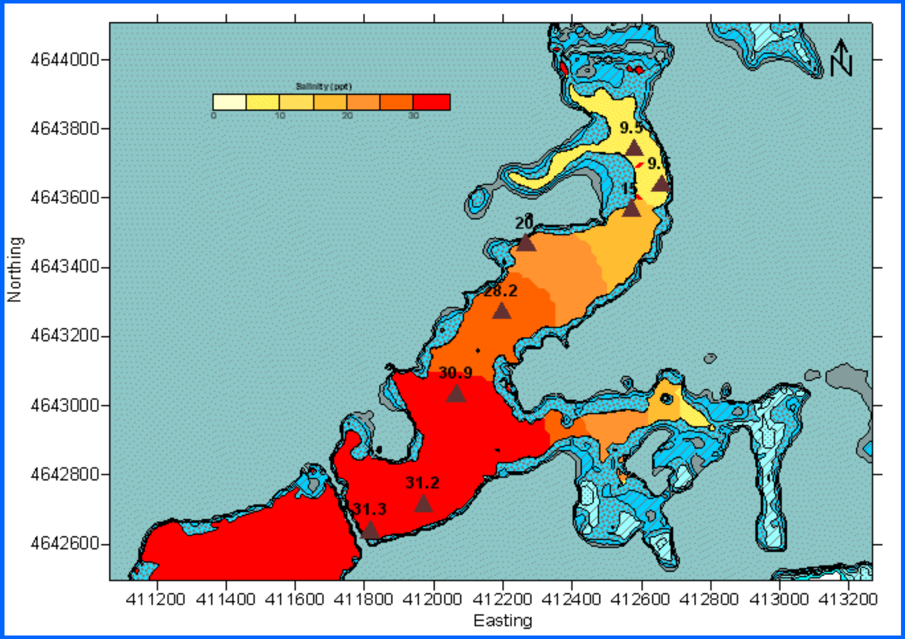
FC consistently decreased with increasing salinity for each sampling datePlus 14 CFU/100 ml t

Observed low-tide fecal coliform, 4 Aug 2005



Typical low-tide FC concentrations in the lower river in summer, plus 14 CFU/100 ml limit for shellfish-growing waters, showing how under current tide-restricted conditions, high-salinity bay waters only protect the most seaward stations during low tide.

Microbiological water quality and tide restoration



<u>Hydrodynamic modeling shows that tide restoration will affect FC through</u>:

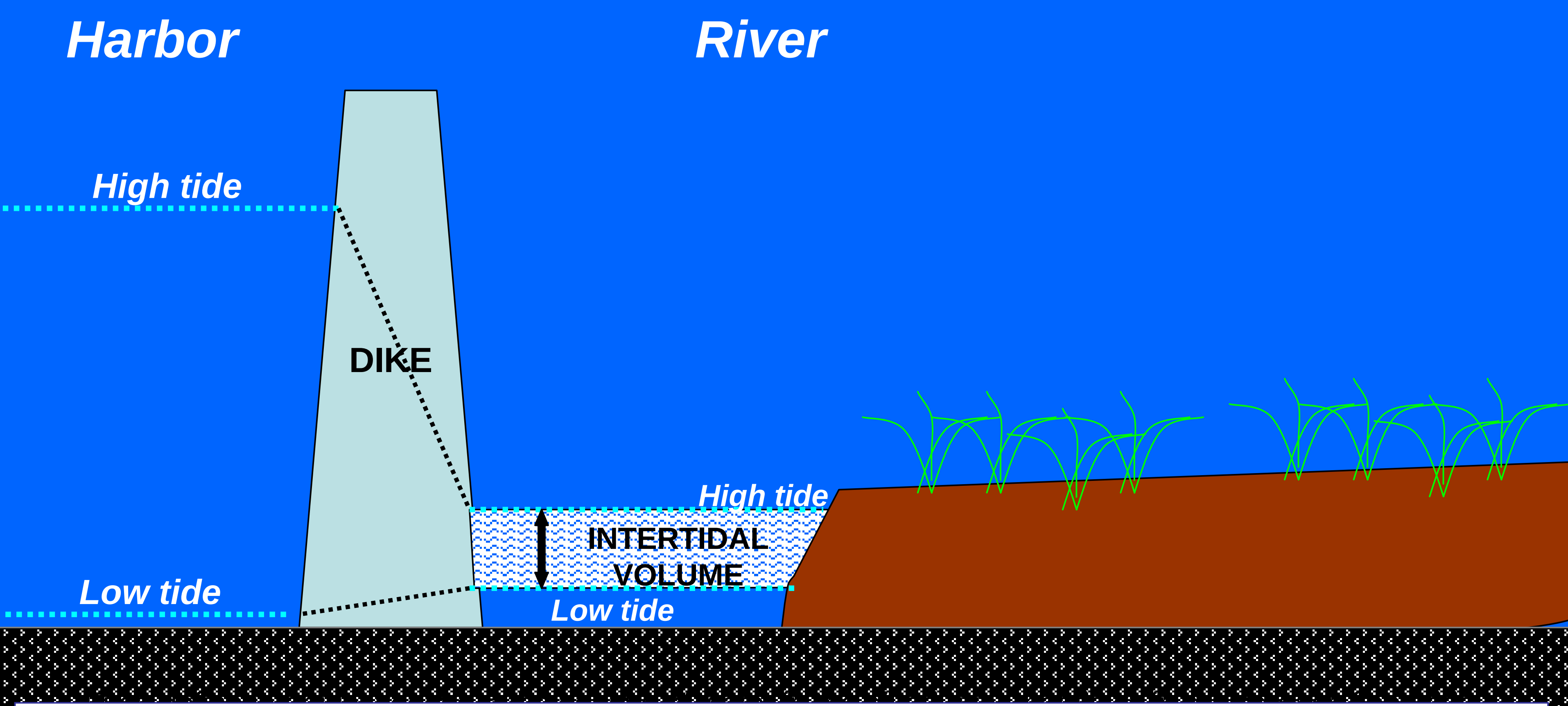
•Increased salinity

•Increased dissolved oxygen

•Increased pH

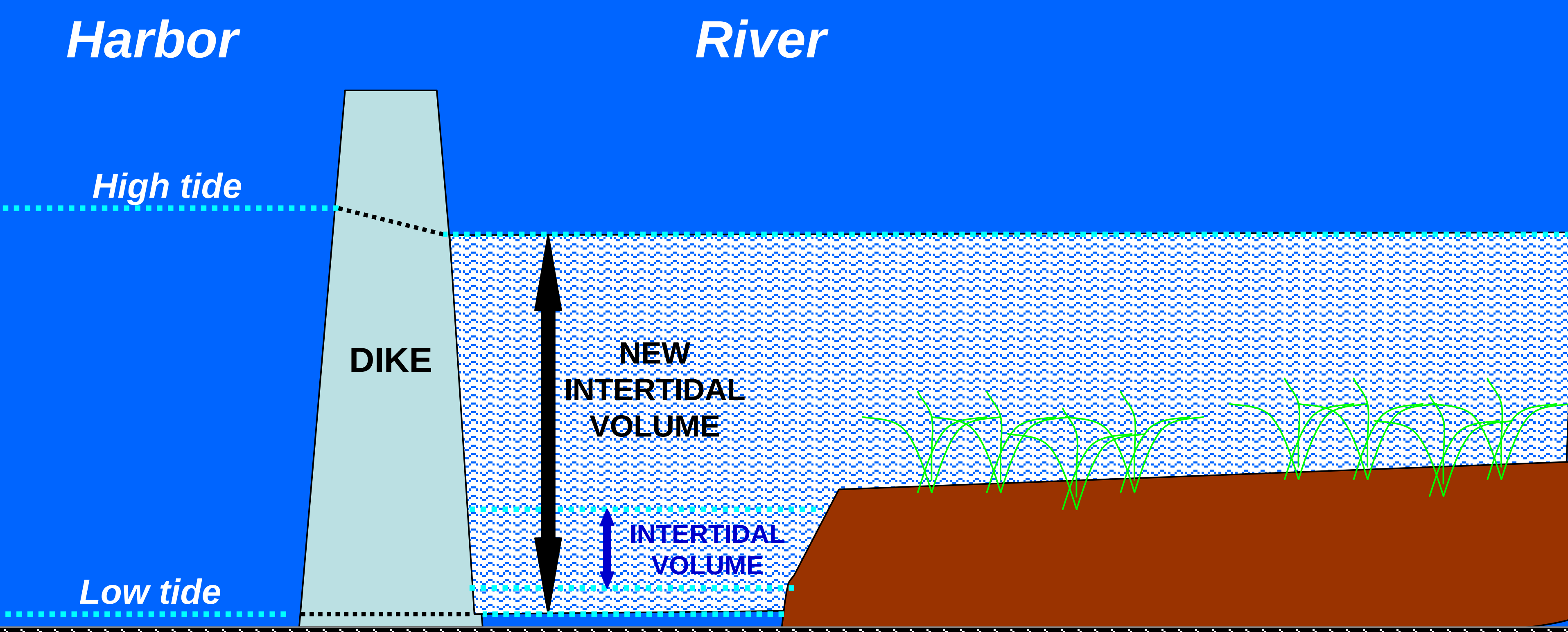
•Increased tidal flushing

Current restriction & intertidal volume



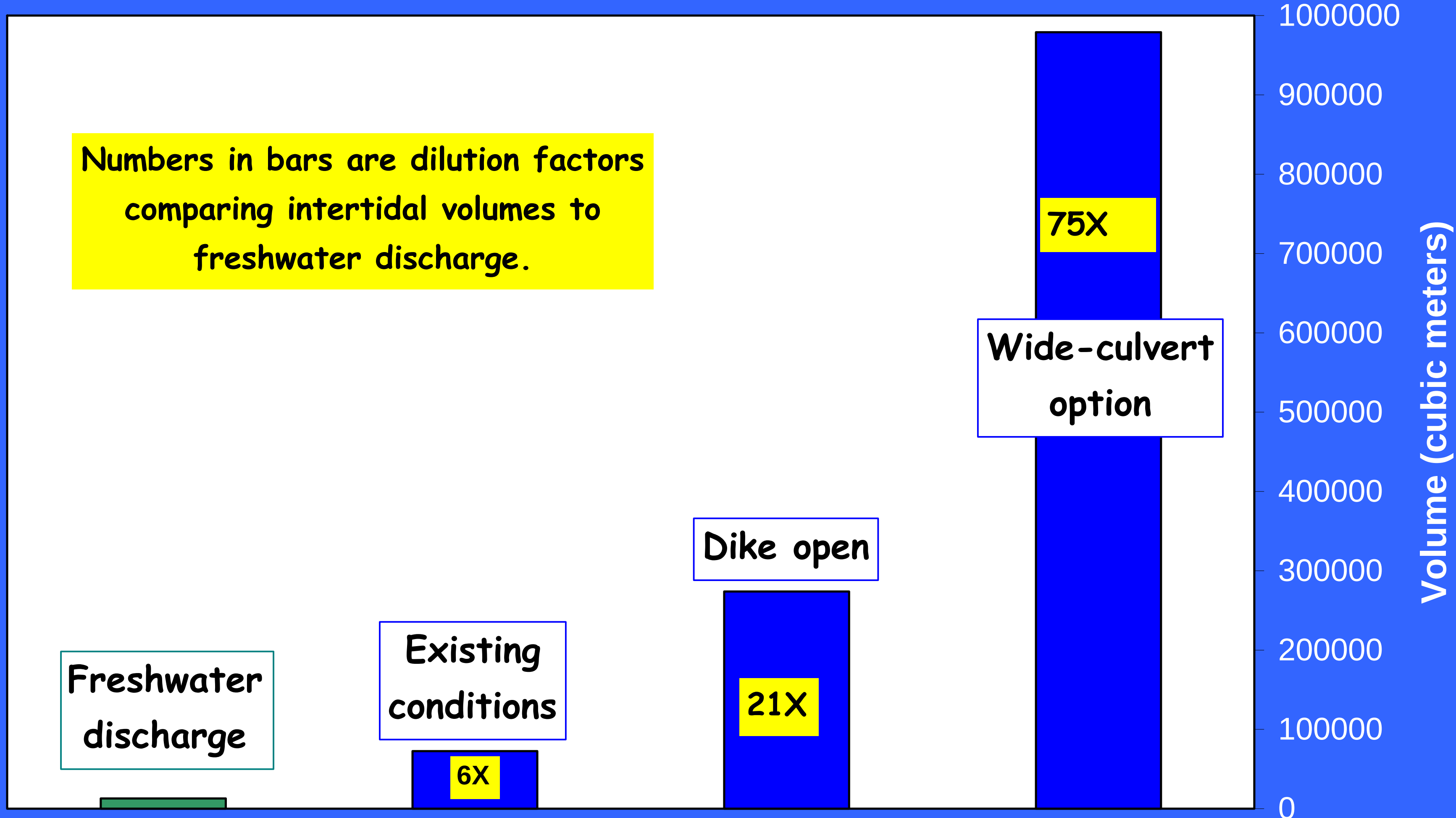
Intertidal volume = the volume of water in the diked river that flows in during each flood tide.
Under current tide-restricted conditions, river high-tide height is very low and low-tide height is relatively high compared to the unrestricted harbor, resulting in a small tidal range and intertidal volume, and low flushing rate.

Restoration of tidal exchange could increase intertidal volume 13.5 times:



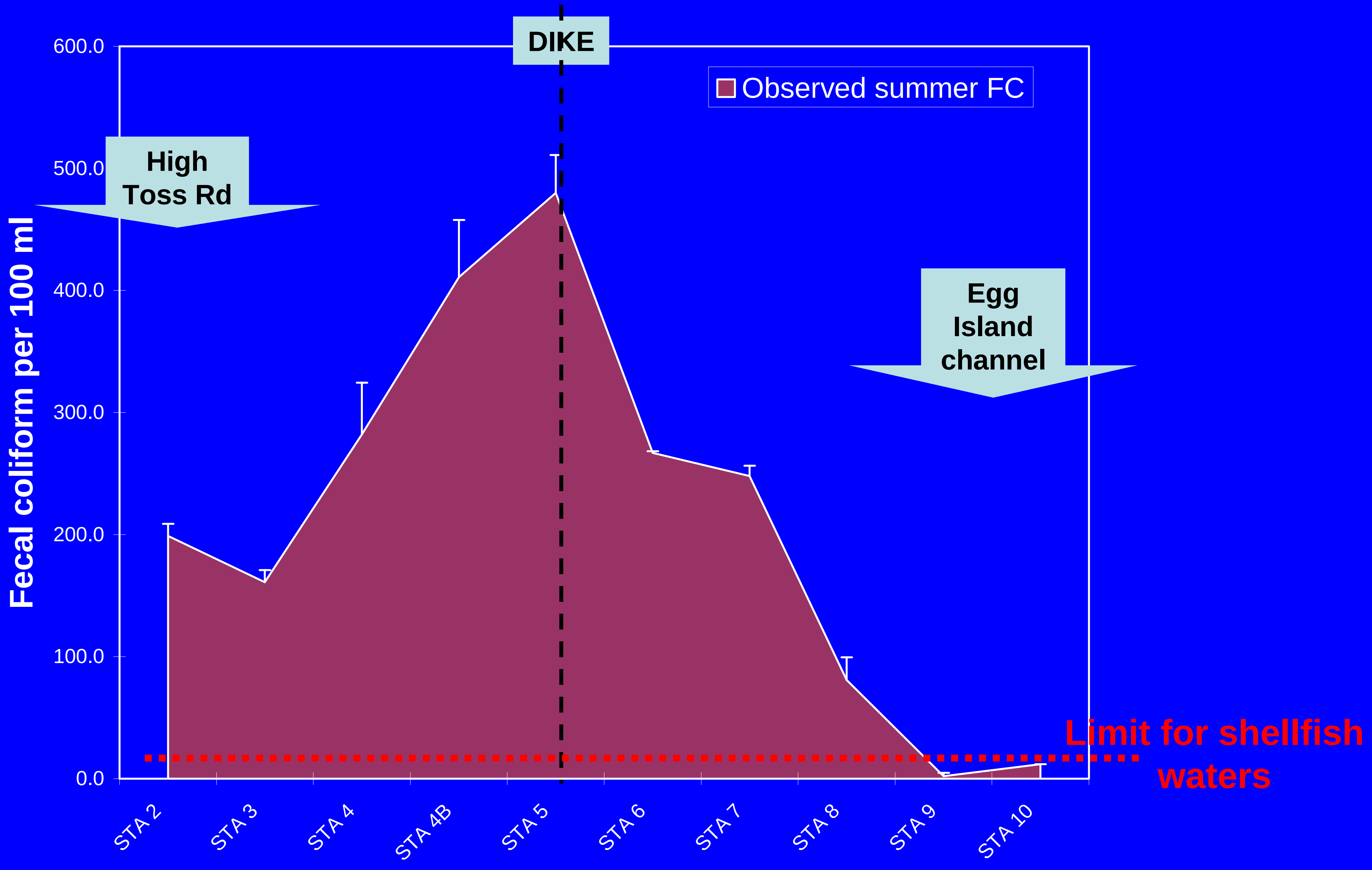
Given predicted tide heights plus measured flood-plain bathymetry, we can predict increases in intertidal volume and flushing with tide restoration.

Herring River freshwater discharge vs intertidal volumes for existing conditions and restoration alternatives

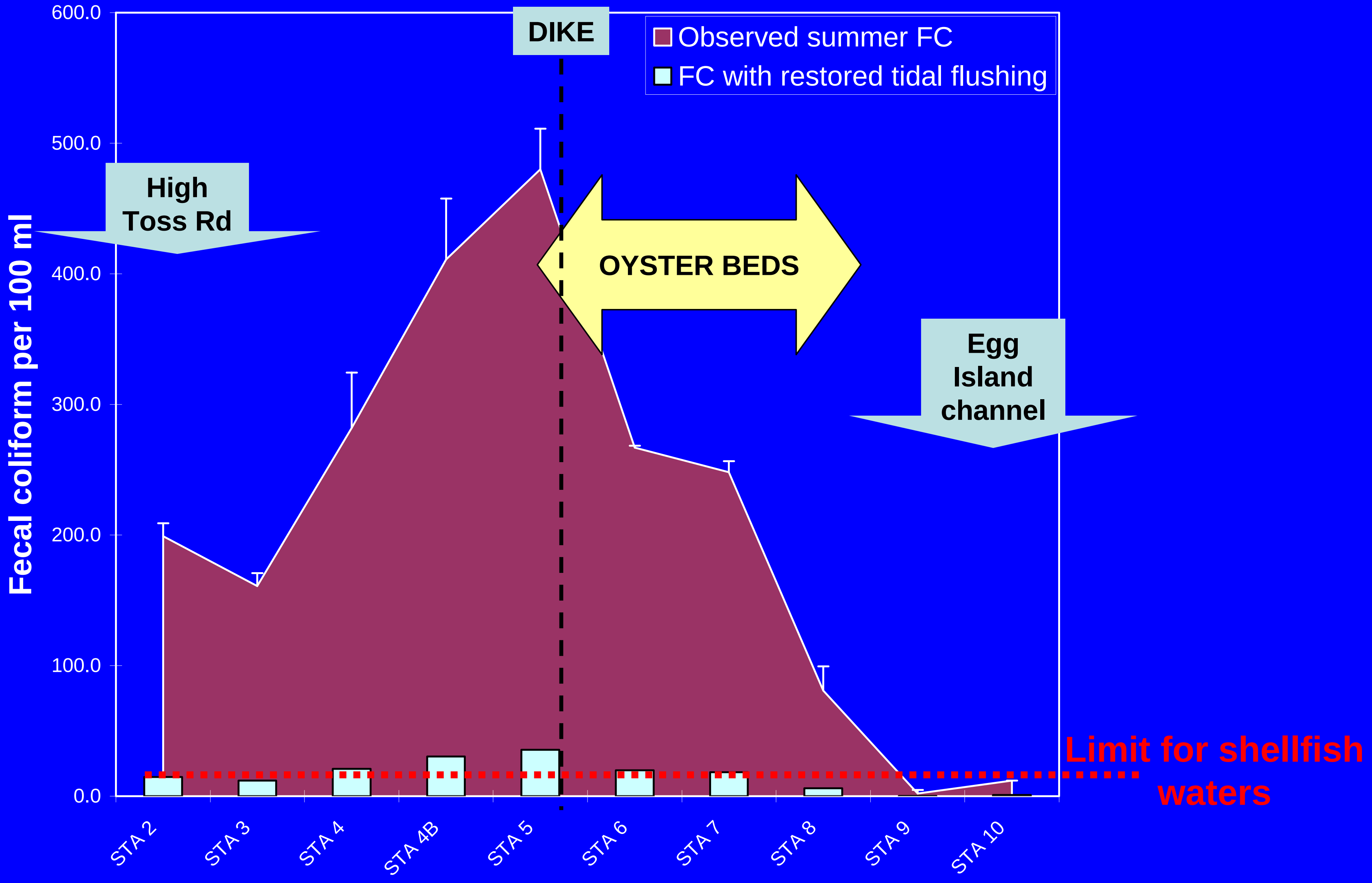


High-FC river discharge is currently diluted 6:1 by salty bay waters.
With the present dike fully open, dilution increases to 21:1.
And with a wide culvert that removes most tide restriction, dilution increases to 75:1, with about 13 times the current (2005) intertidal volume.

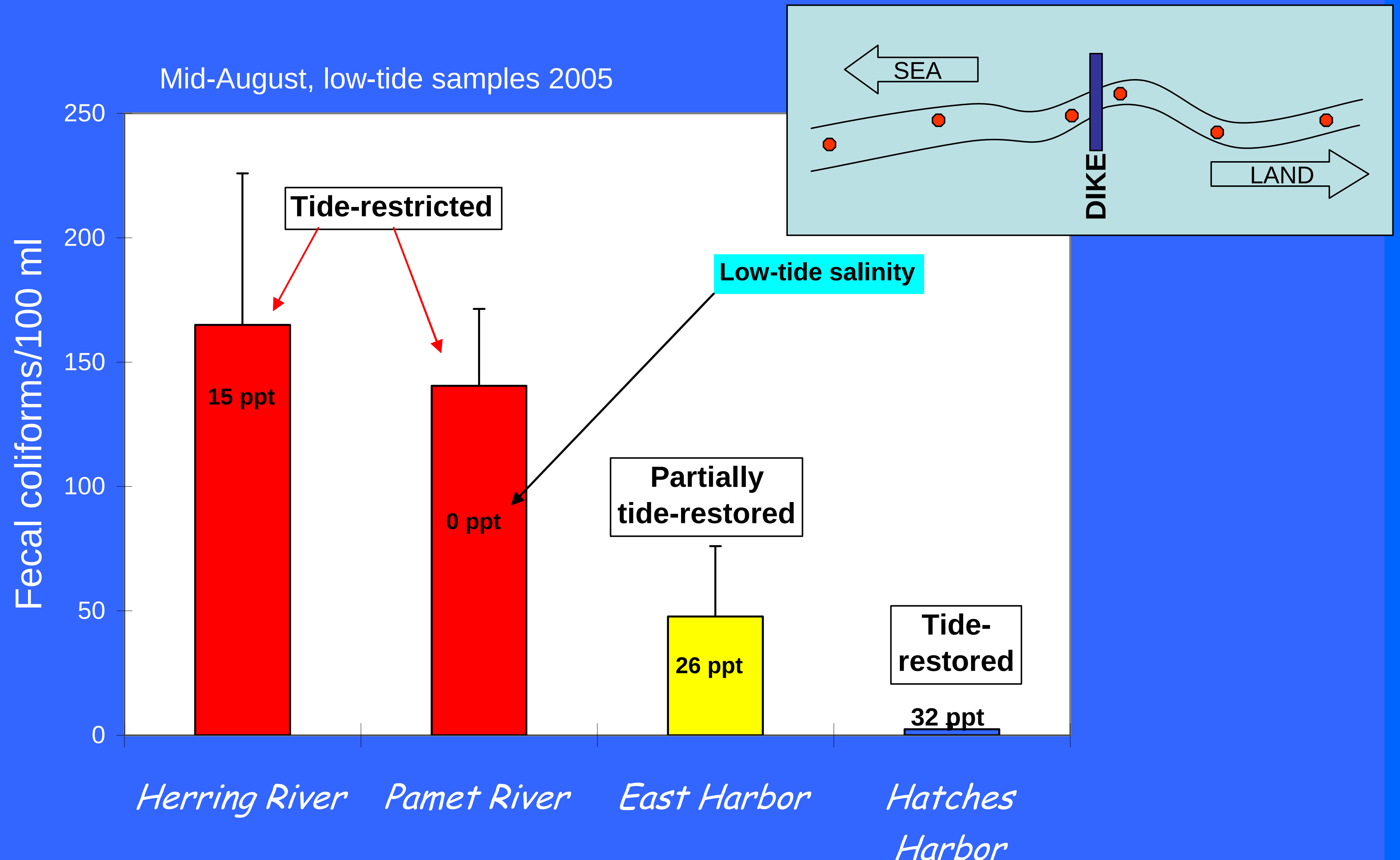
Typical summer fecal coliform distribution in the lower Herring River under current tide-restricted conditions,



Effects of restoring tidal exchange on River fecal coliform. An expected 13.5 times increase in intertidal volume would reduce current FC concentrations (red area) to levels (blue bars) that would technically allow the re-opening of shellfish beds, which have been closed for decades.



Fecal coliform and outer Cape tide restrictions



Surveys of other outer Cape diked marshes show that high FC contamination appears related to the degree of tidal restriction, reduced flushing and decreased salinity. This is consistent with observations at Herring River and supports the idea that tidal restoration would suppress bacterial contamination.

Conclusions re fecal coliform (FC) in Herring River:

- FC is highest 3000 feet on either side of the dike’s tide restriction at low tide.
- FC is unrelated to turbidity, e.g. through sediment resuspension.
- Egg Island aquaculture is currently protected (just) from FC by high-salinity Cape Cod Bay water.
- **Restored river tidal exchange should decrease FC by:**

  1) dilution and

  2) lower survival with increased salinity, dissolved oxygen and pH.
- **Dilution alone would reduce observed FC to levels that should:**

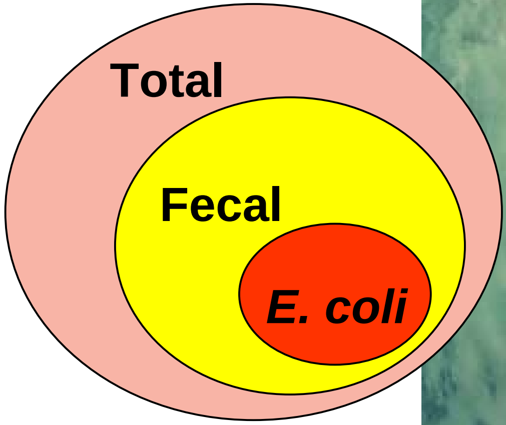
  1) allow the re-opening of presently closed shellfish beds and

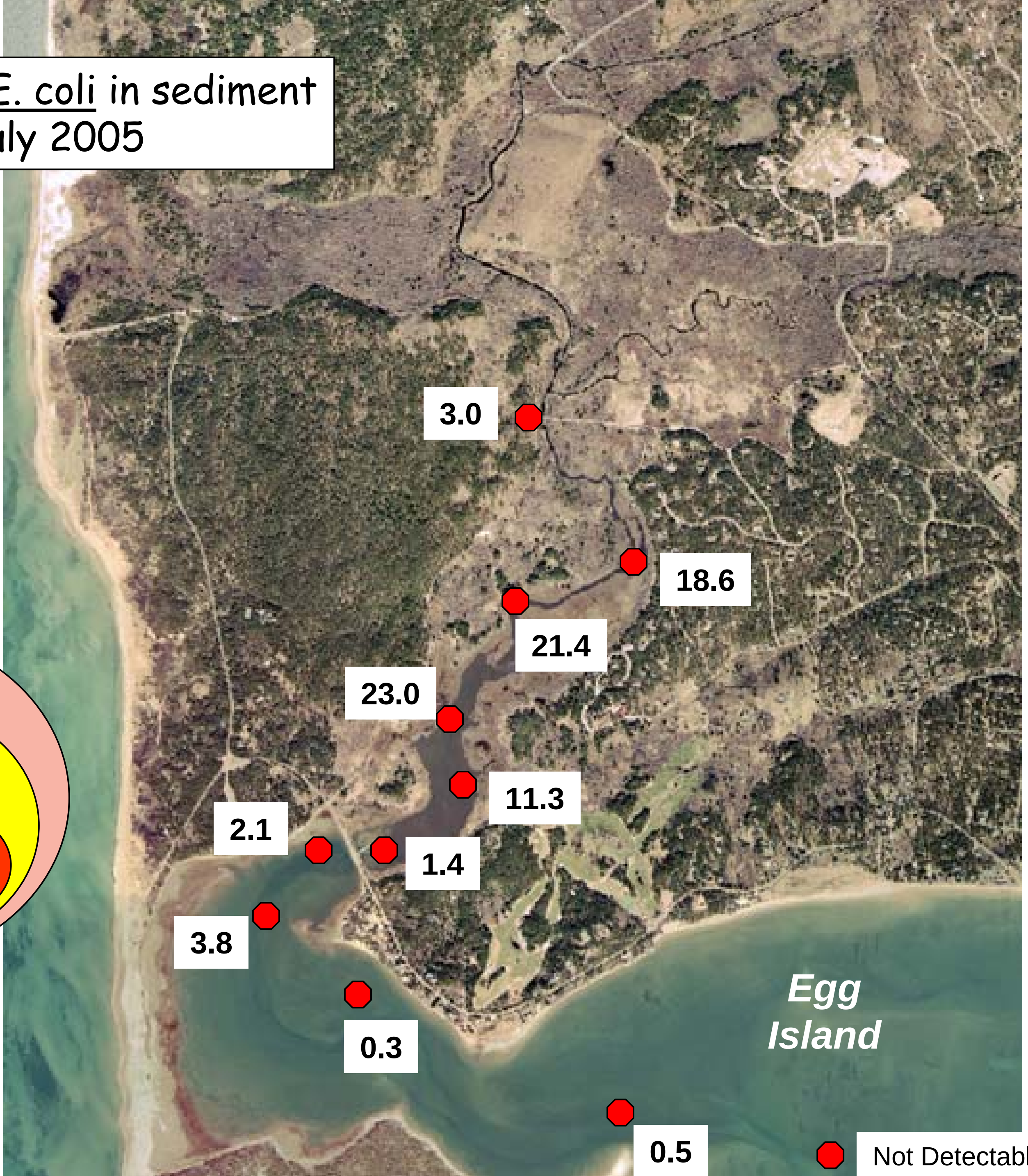
  2) improve low-tide water quality at Egg Island.

Restored River tidal flushing is likely to:

- reduce or eliminate bacteria contamination in the river mouth,
- allow extensive oyster beds to be re-opened,
- and improve low-tide water quality at Egg Island.

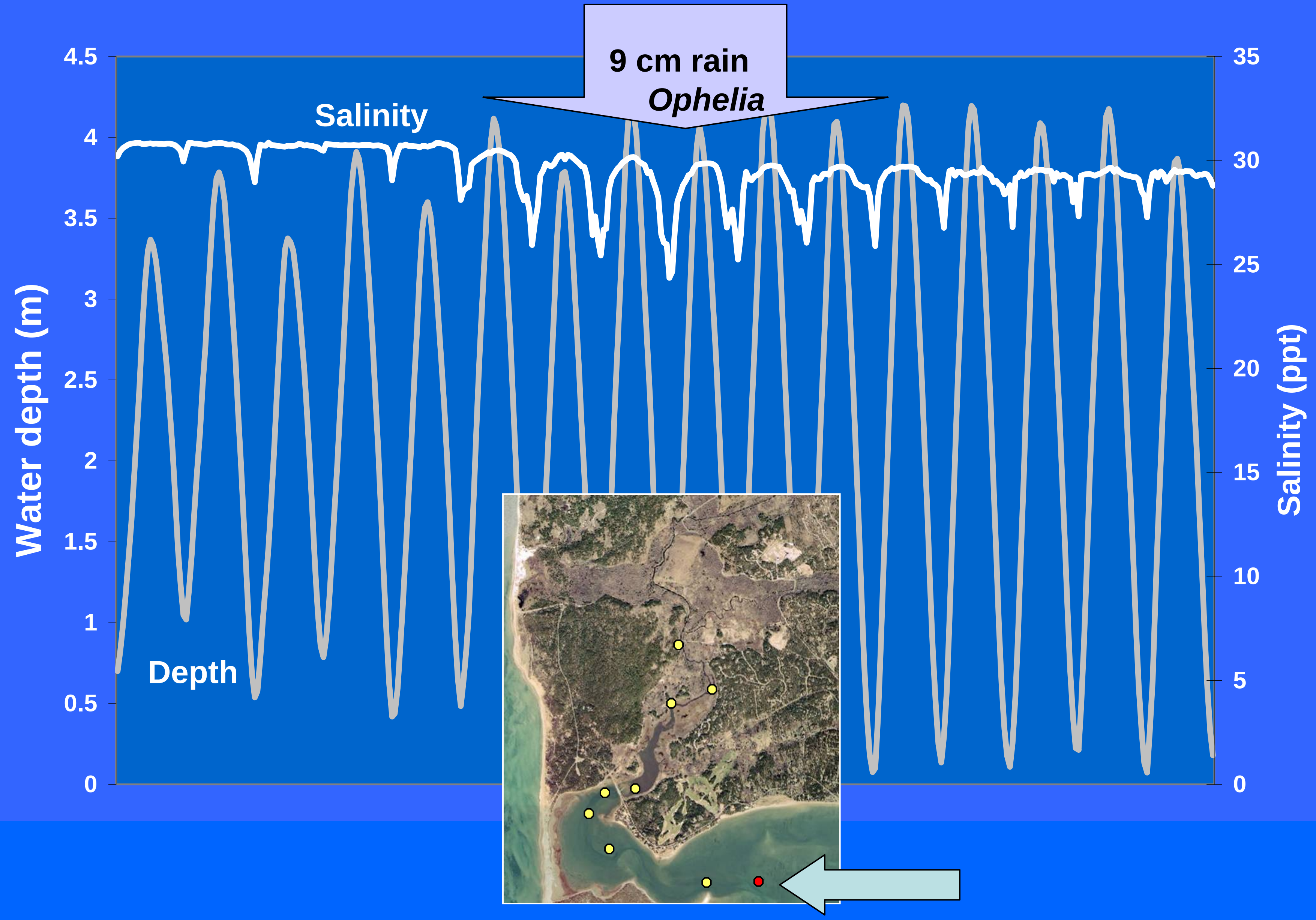
Herring River <u>*E. coli*</u> in sediment
20 July 2005





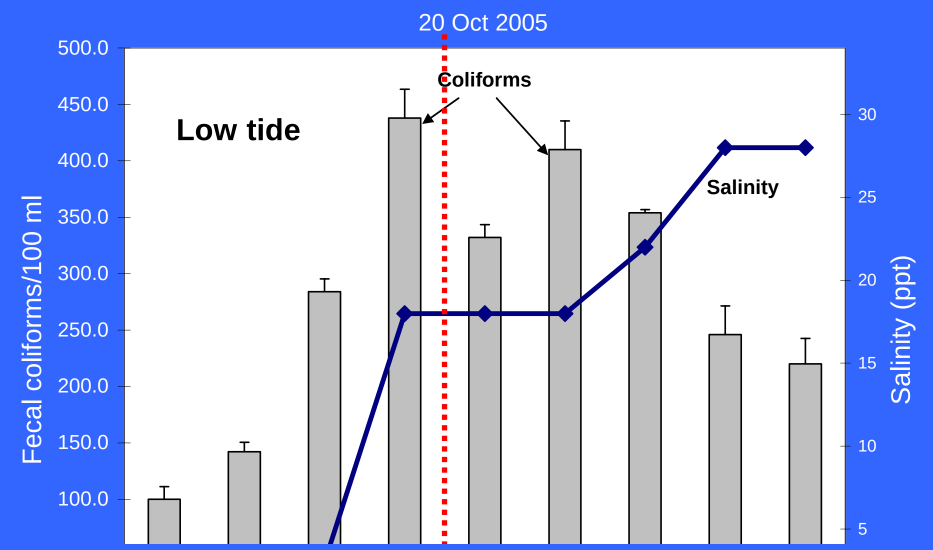
Not Detectable

Station 10; Old Saw channel
13 - 21 Sep 2005



FC in Fall,
20 October 2005

LOW TIDE



HIGH TIDE