Response of Kane`ohe Bay, Hawai`i to Storm Runoff Input

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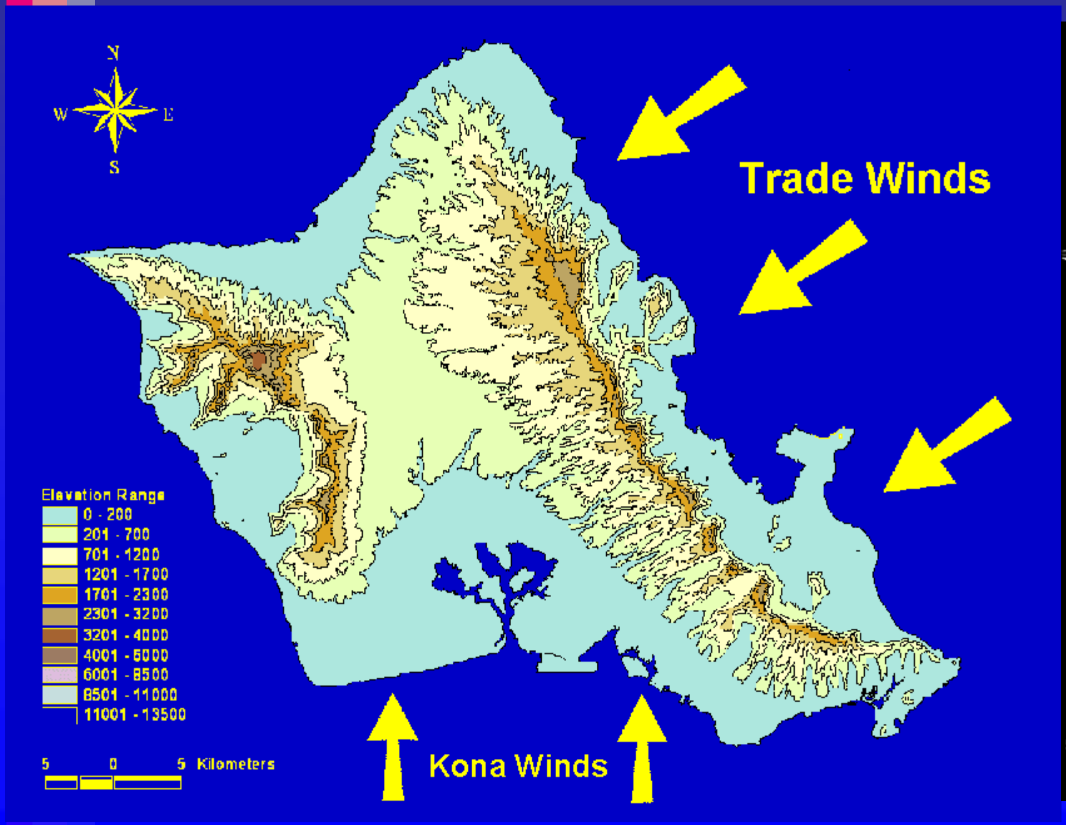
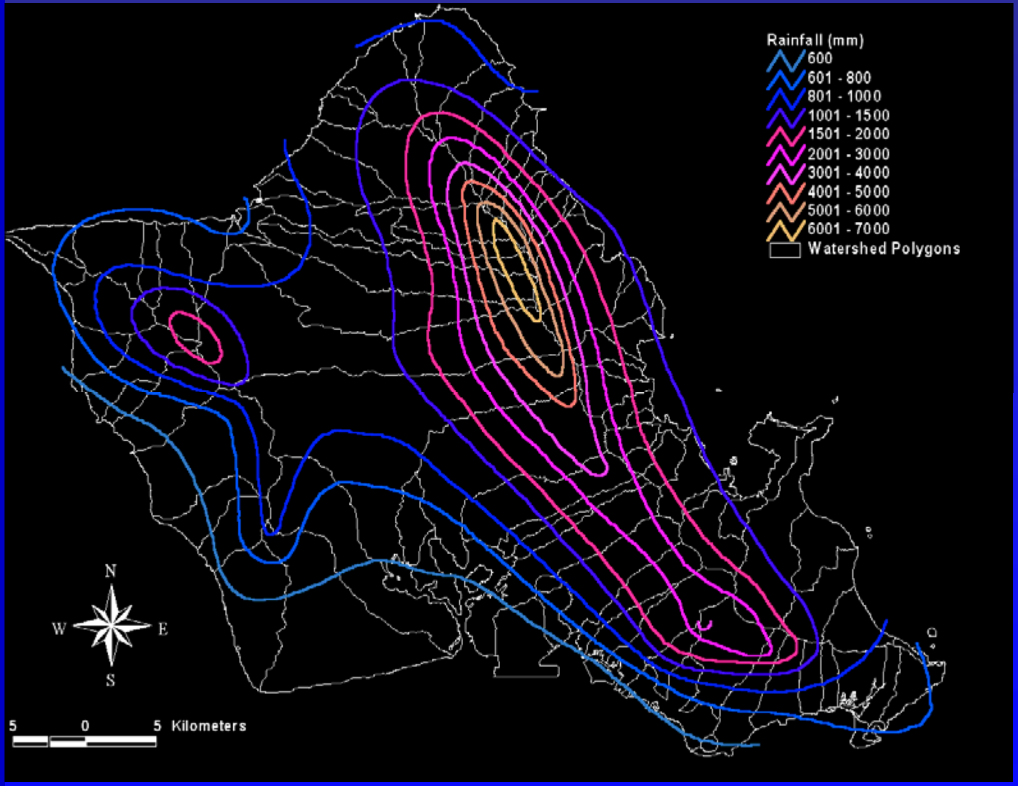
1. Hawai`i is host to intense short duration rains on steep watersheds
2. High runoff & erosion lead to extensive material transfer to the sea
3. Our study is motivated by interest in response of coastal ocean to land inputs and concern about sensitive near-shore resources ($$)



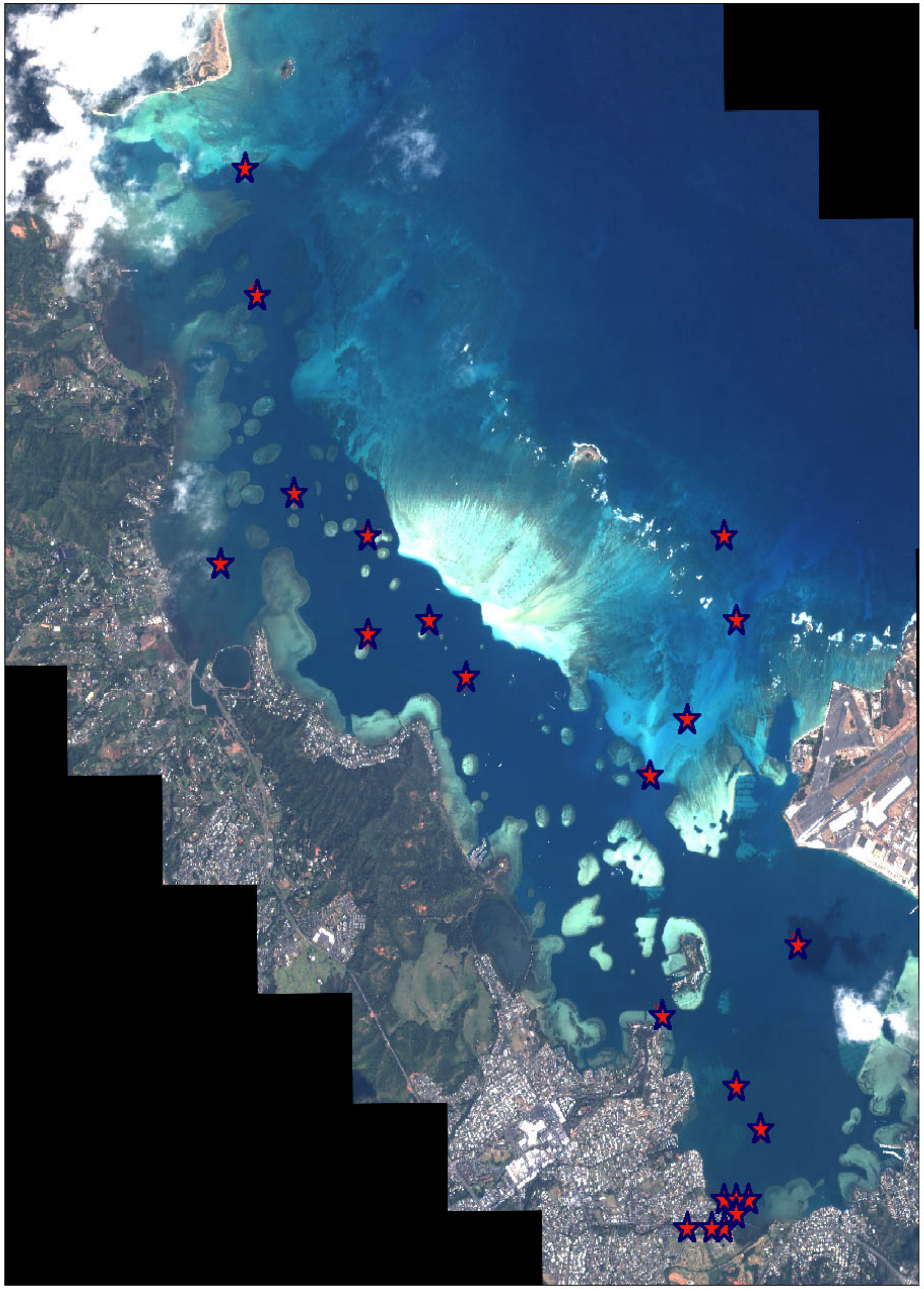


Kane`ohe Bay

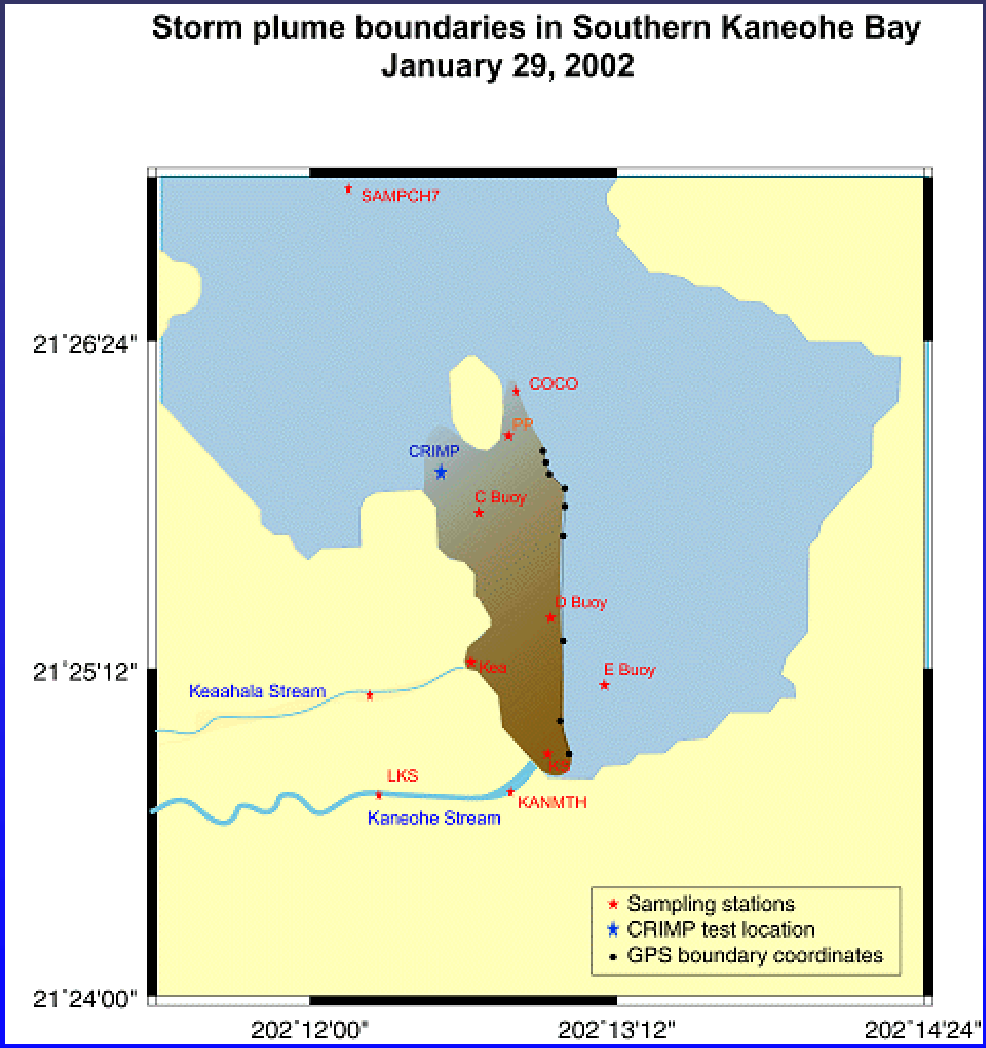
- Located on East or ‘Windward’ side of O`ahu, Hawai`i
- Largest Bay in Hawai`i (~13 km x 4 km)
- Large barrier reef, numerous patch reefs, multiple (small) riverine inputs
- South portion of bay has long water residence time
- Abundant previous work makes Kane`ohe an ideal study site
  - **Coral biology**
  - **Long-term synoptic nutrient time-series data**
  - **Nutrient input and dispersion**

Objectives

- Monitor receiving waters in "real time"
- Temporally characterize physical and biogeochemical processes in bay
- Quantify impact of storm inputs on bay productivity
- Test hypothesis that dissolved and particulate nutrients from storm pulses control nutrient budget of bay
- Evaluate impact of storm pulses on exchange of CO_2 between bay and atmosphere

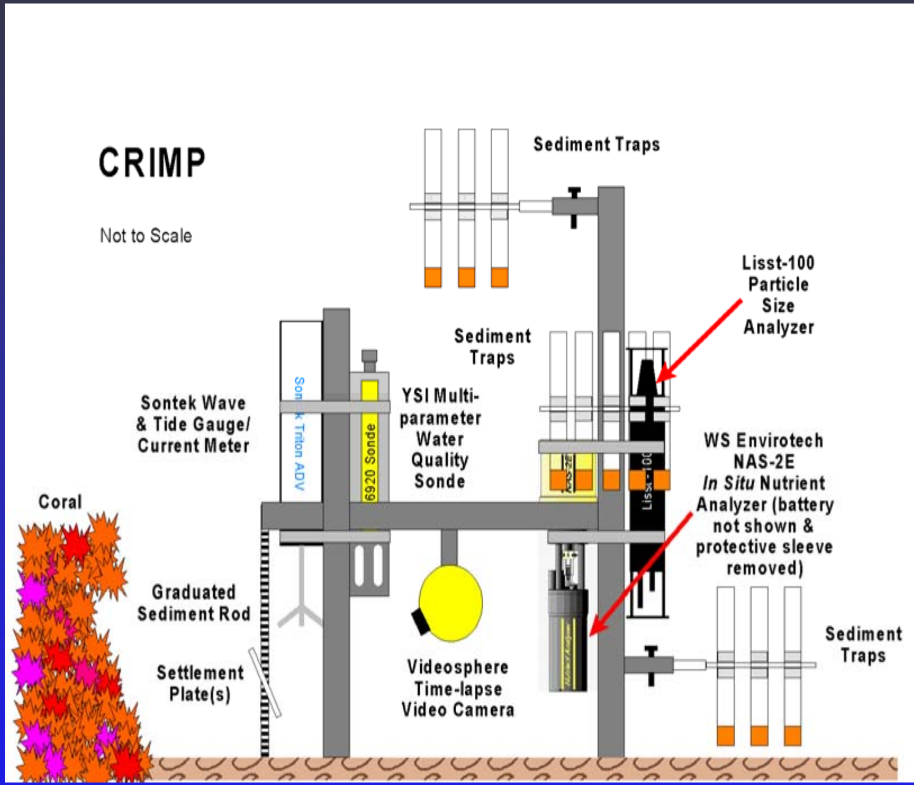


Station Distribution



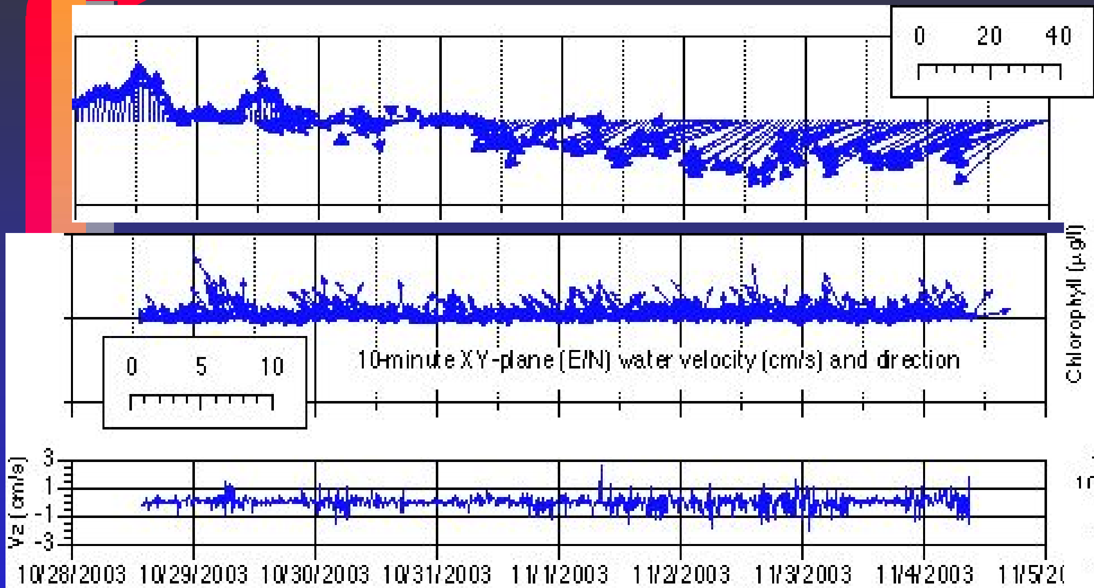
Measurements

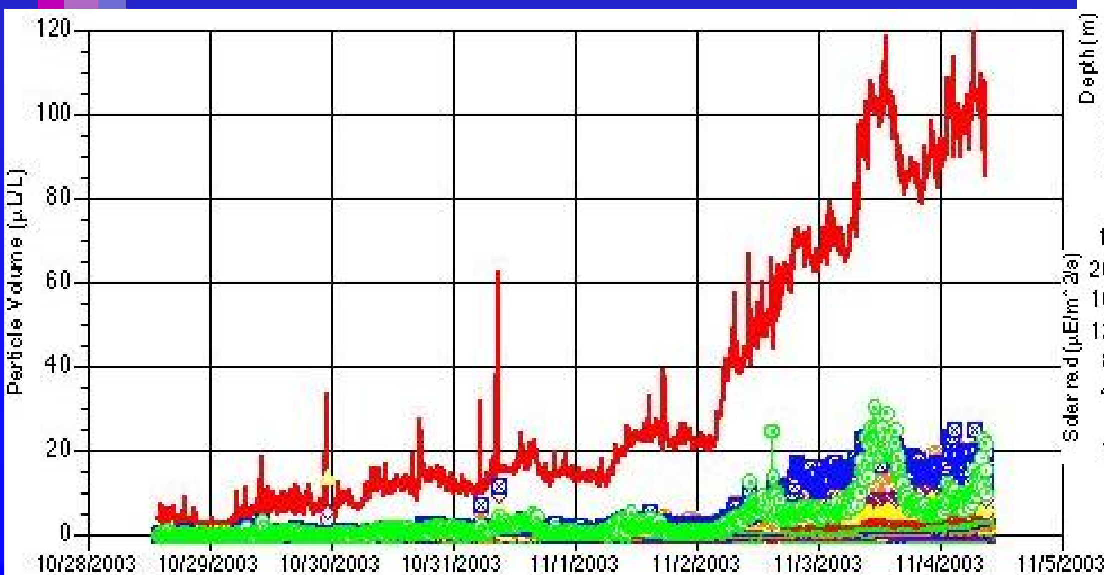
- Chl-a, conductivity/salinity, DO, pH, T, turbidity
- Nutrients: (NO_3^- + NO_2^- and PO_4^{3-})
- Particle size distribution (32 size classes)
- Sediment fluxes (multiple traps)
- Waves, tides, currents

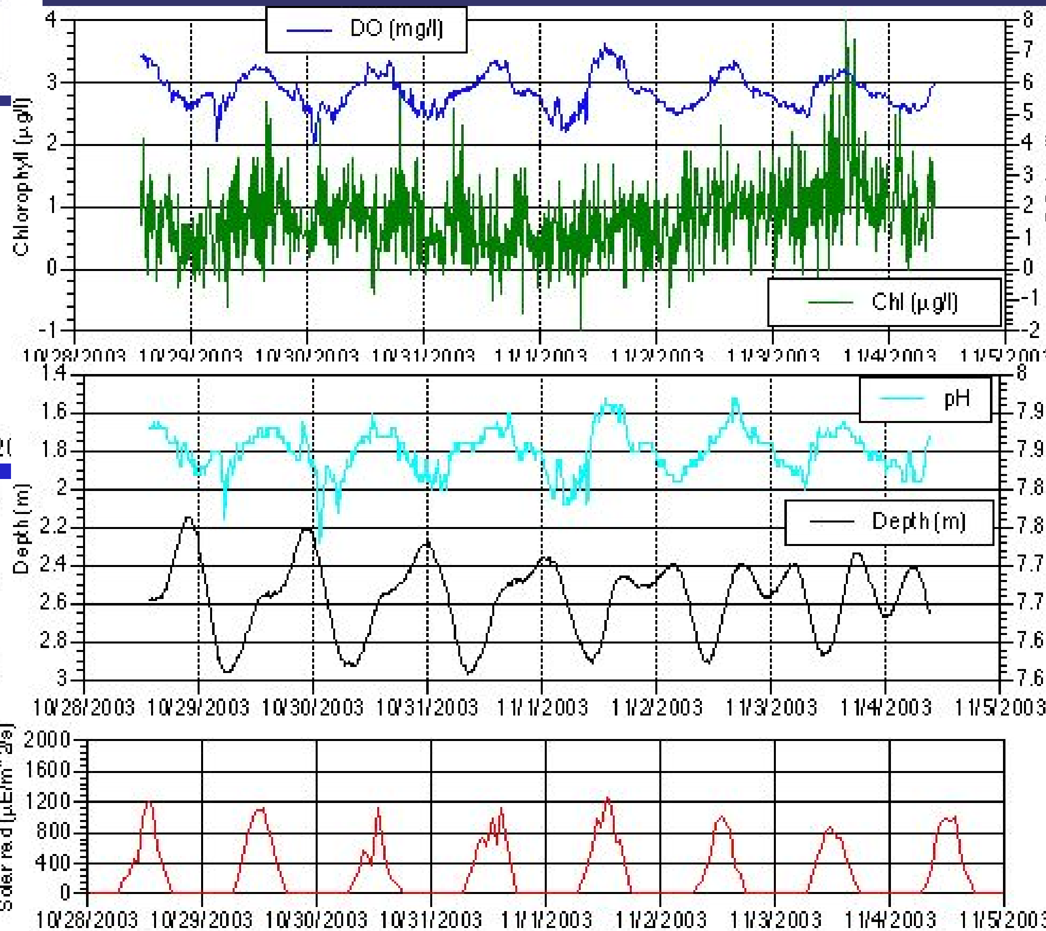


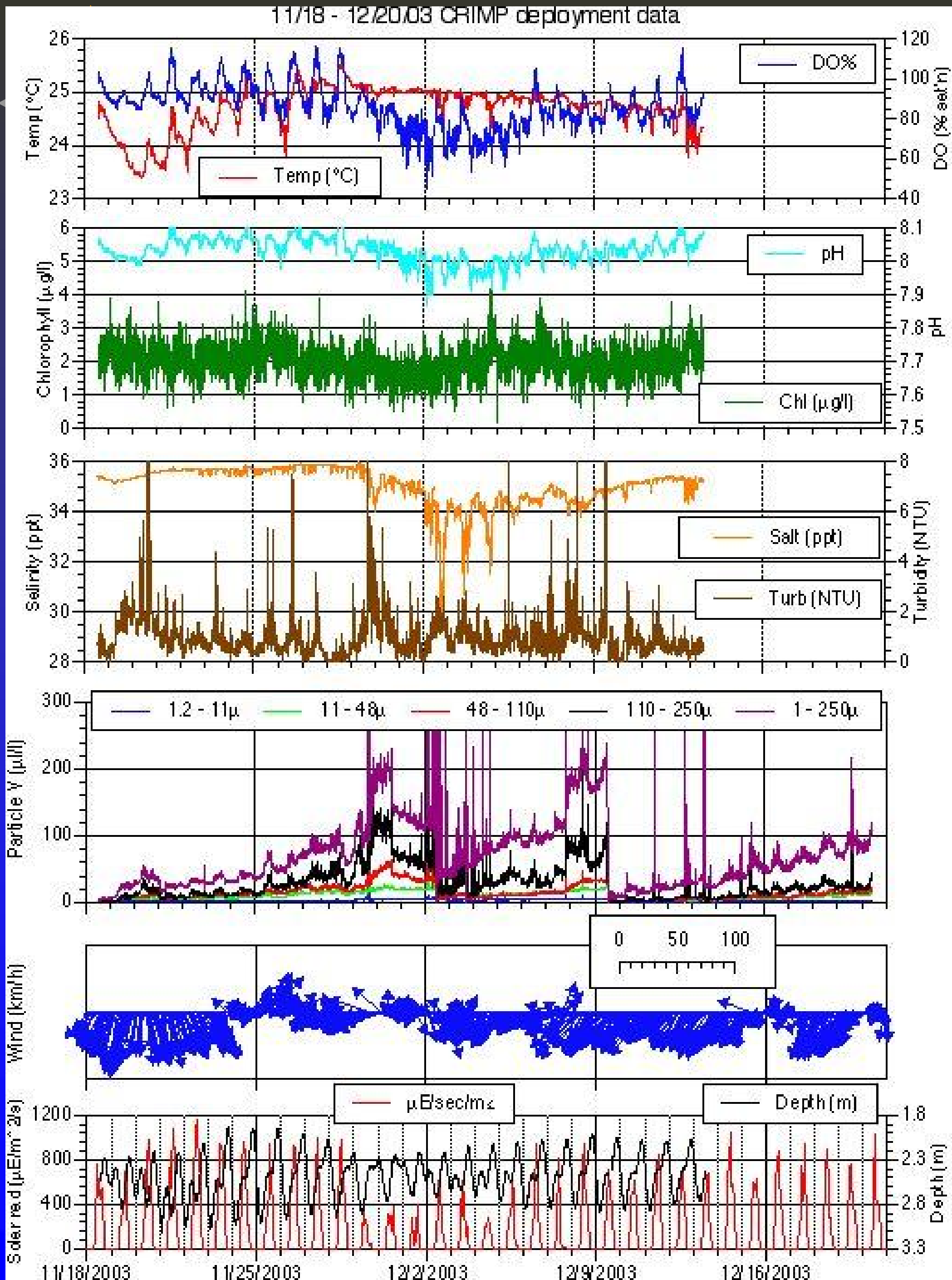
- Depth profiles of water quality parameters
- Collection of water samples for high sensitivity nutrient analysis (NO_3^-, NO_2^-, NH_4^+, PO_4^{3-} and $Si(OH)_4$)
- Collection of water samples for high precision measurement of carbonate system parameters

Variations in “Background”

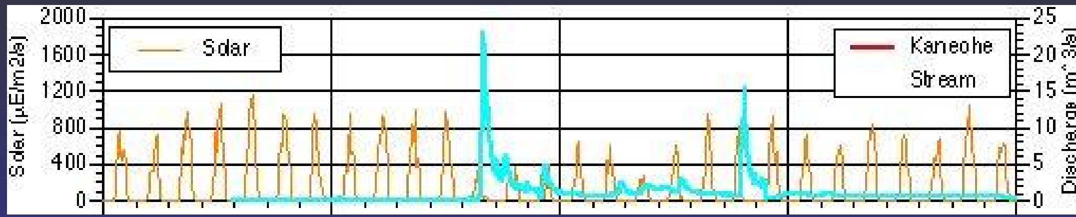






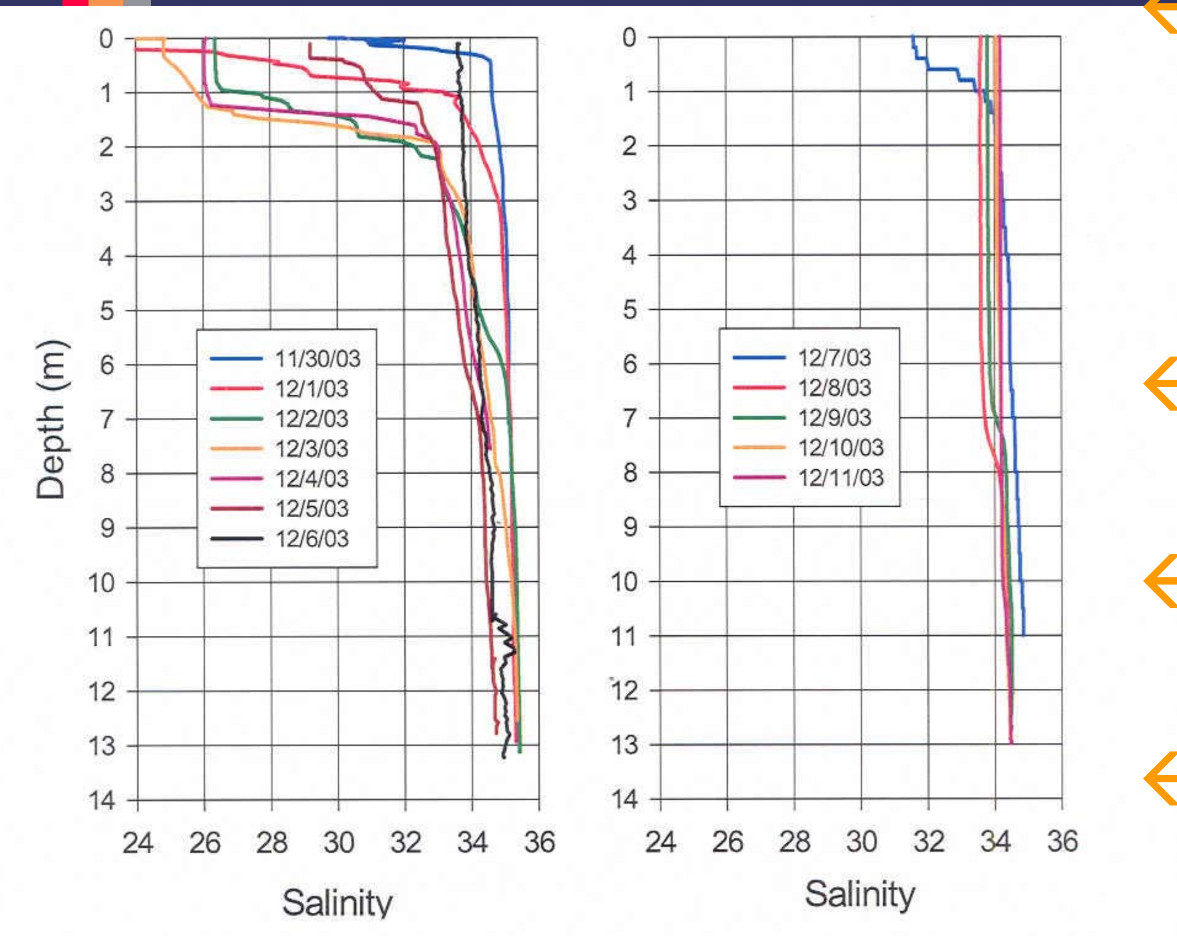


11/29/2003 Storm



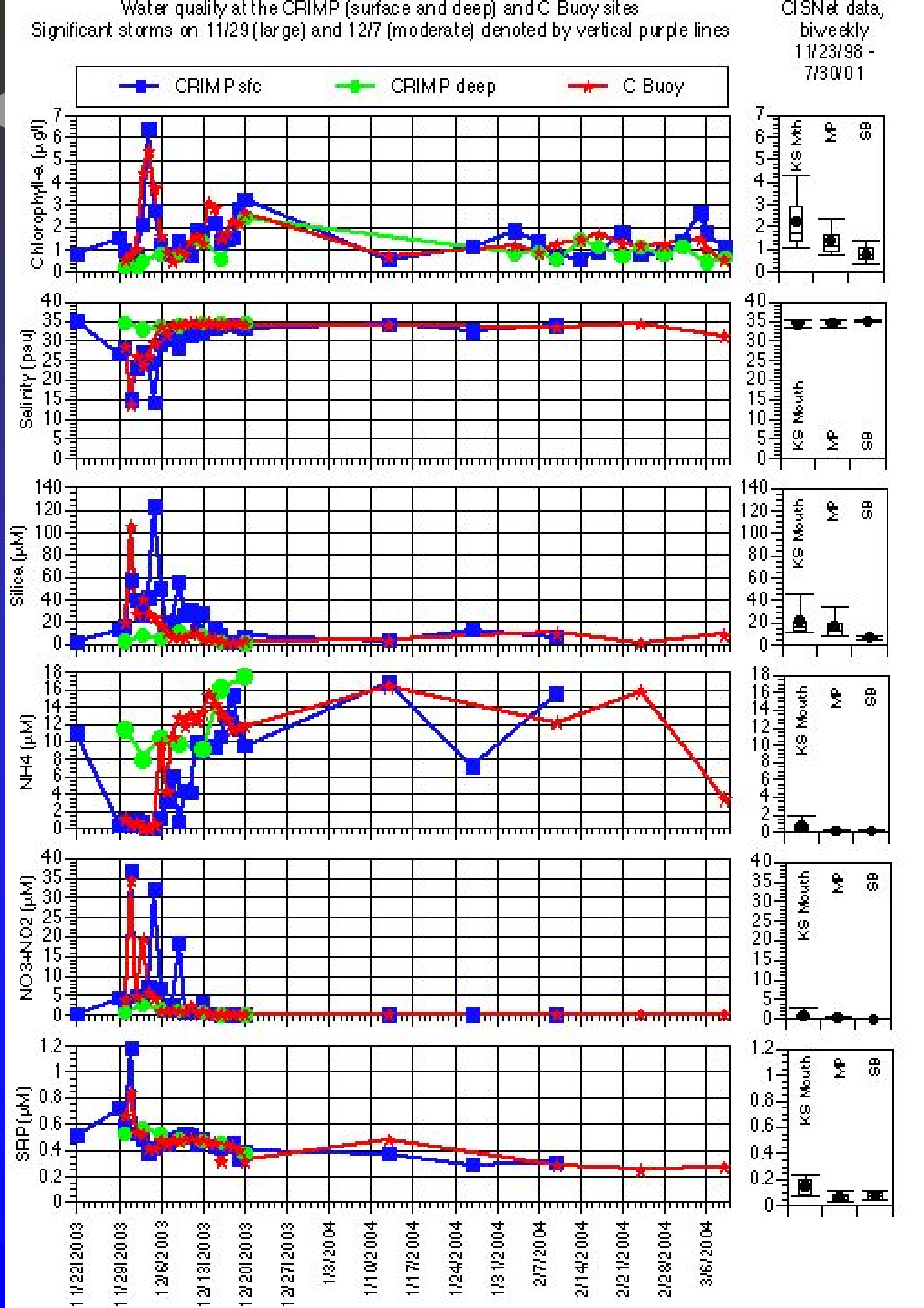
- First significant rain after very dry summer
- Two rain events in 8 days
- "Kona" storm evolution for 1st event
- Large input(s) of fresh water and suspended solids to Kane`ohe Bay
- Strong changes in solar radiation

Salinity Profiles in South Central Bay



- Low sal layer develops at surface due to northward propagation of freshwater plume on 11/30/03
- Lowest salinity surface layer noted on 12/1/03
- Gradual dissipation of low sal layer over next 5 days
- Water column fully mixed by 12/6/03
- 12/07/03 storm has minor effect on surface water salinity

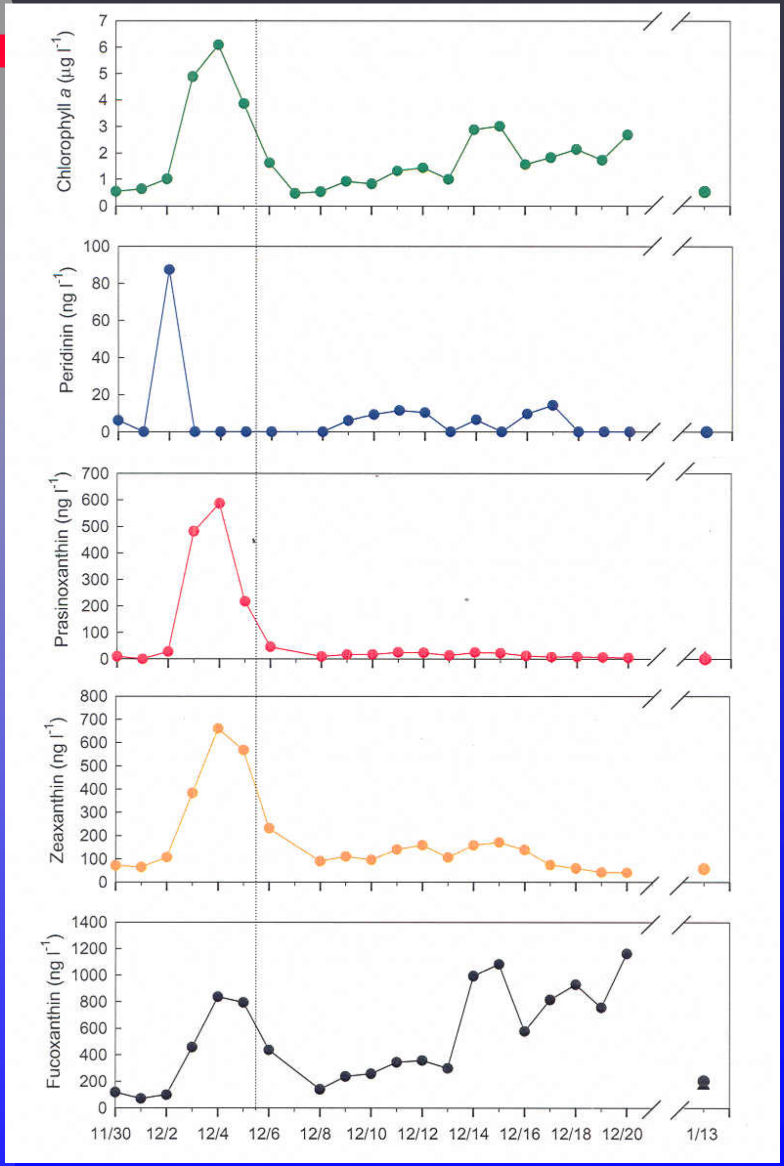
- Stream discharge on 11/29 was 411,000 m^3
- Clearly delineated plume extended throughout a large portion of southern Kaneohe Bay
- Strongly stratified water column remained about one week… mixed completely by 12/6/2003
- Second smaller (295,000 m^3) runoff event only slightly freshened bay surface waters
- Initial plume was maintained by light-variable winds during and after the storm.
- Trade winds subsequent to second storm resulted in rapid mixing of the plume/water column.

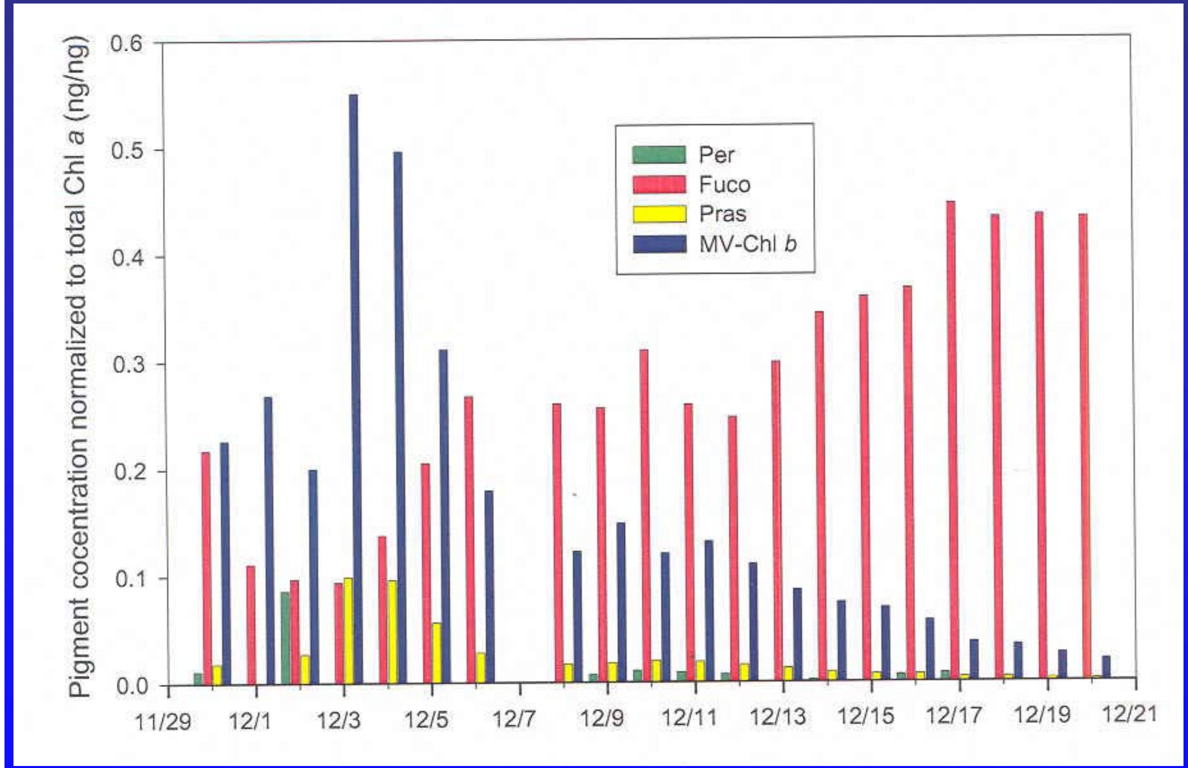


11/29/2003 Storm (discrete sample data)

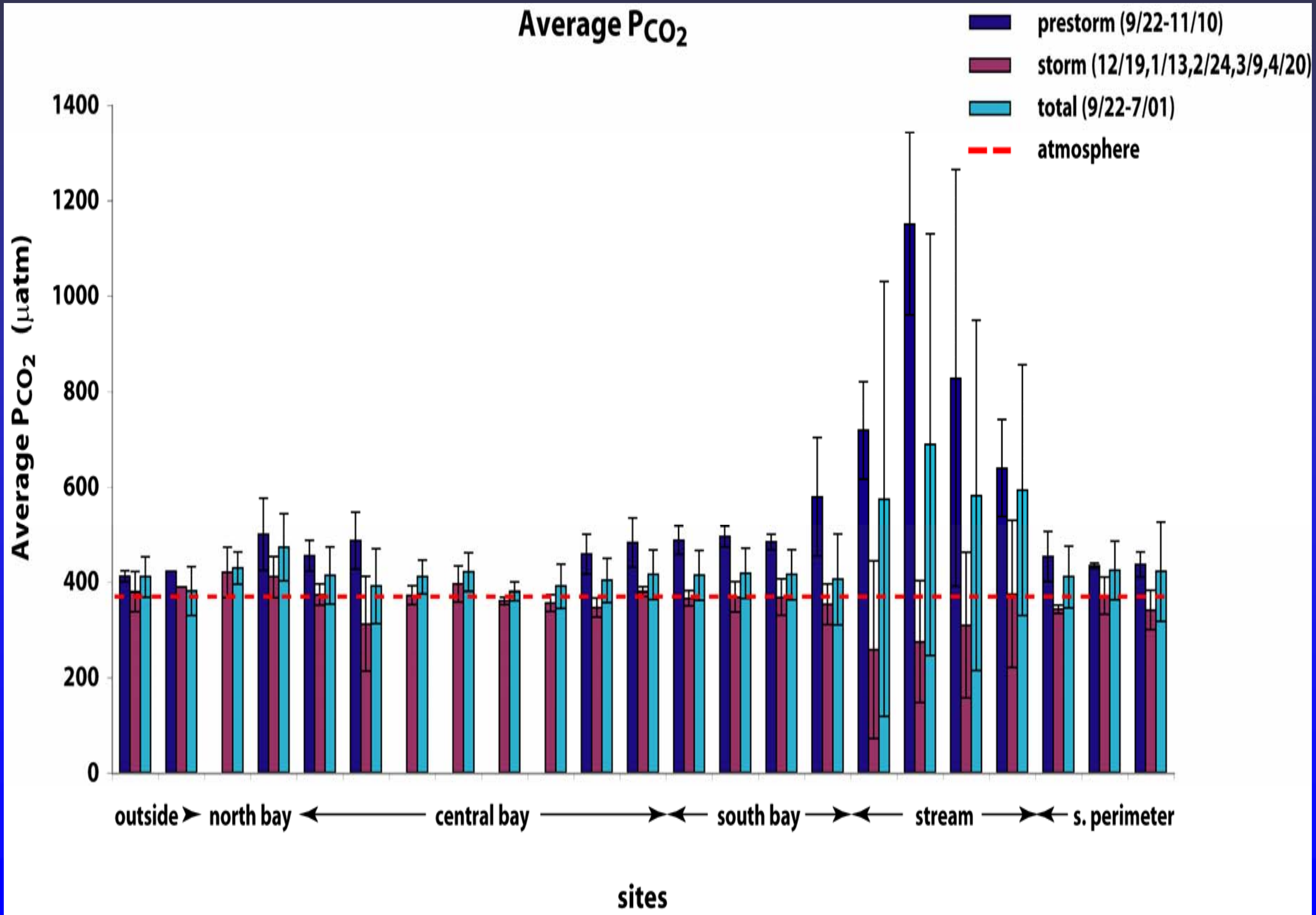
- ← Strong pulse of nutrients
- ← Rapid phytoplankton response (chl-a)
- ← Rapid drawdown of (most) nutrients
- ← Sustained large increase in NH_4^+ after storm…
- ➔ Remineralization of OM delivered by storm?

Pigment Analysis, Phytoplankton Diversity

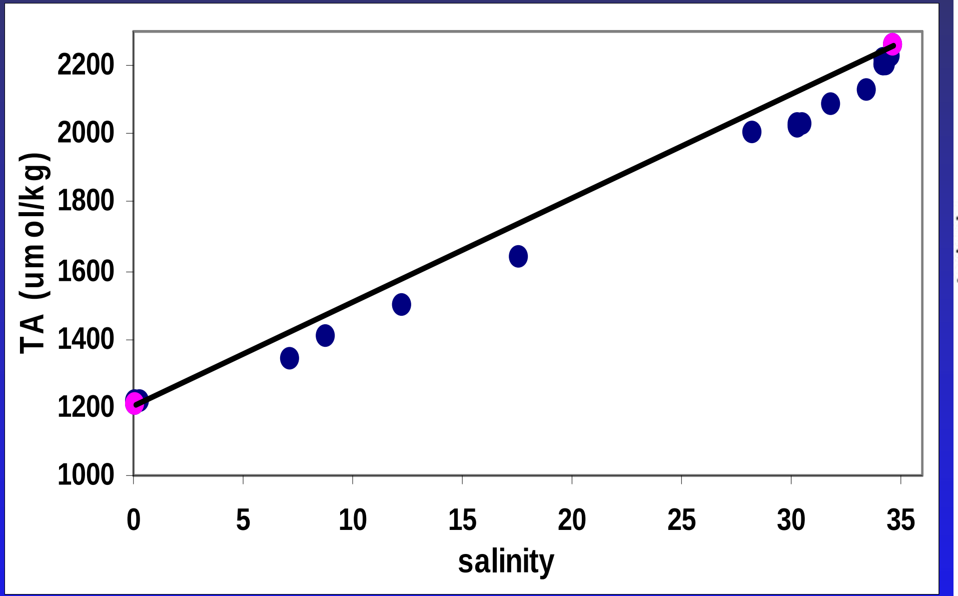


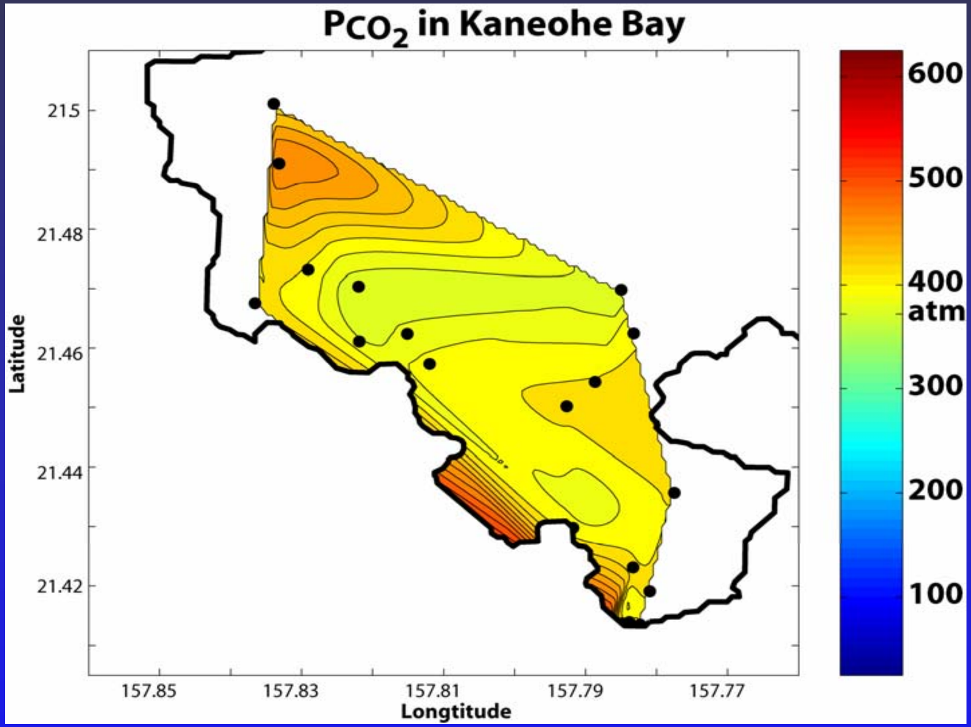


Changes in P_{CO_2}



Calcification in Kane`ohe





1. **Calcification drives high P_{CO2}**
2. **Storm induced phytoplankton blooms draw down CO_2**
3. **Yet the bay remains an overall NET SOURCE**

Conclusions

1. Kane`ohe Bay is N limited (DIN:DIP normally ~2 to 4)
2. DN initially added mostly as NO_3^-
3. DIN:DIP (25) in storm runoff radically alters proportion of nutrients available for biological uptake
4. Post-bloom increases in nutrients in bay water not from increased stream base-flow or recycling of bloom POM
5. During other events “limiting” nutrient switched from N to P but not after 11/29/2003 storm when P > 0.3 µM
6. The rise and persistence of high NH_3 for several months after the storm may sustain longer-term productivity
7. Bloom led to drawdown of CO_2 in bay, **temporarily** changing it from a net source of CO_2 to a net sink

More…

1. Increases in Chl-a and changes in community reflect evolving biological response stimulated by storm inputs
2. Strong phytoplankton response did not reduce nutrients to limiting levels → increased zooplankton grazing?
3. Response of predators to increased grazer abundances prevented grazers from cropping phytoplankton to “background”
4. System stabilized quickly after initial bloom, with most of the new production grazed
5. Small amount that escaped grazing pressure, however, led to slow/steady increase in the phytoplankton standing stock for several weeks

Acknowledgments

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