Continuous Multidisciplinary Observations in the Southern California Current Elucidate Events in Climate, the Ecosystem, and Fisheries

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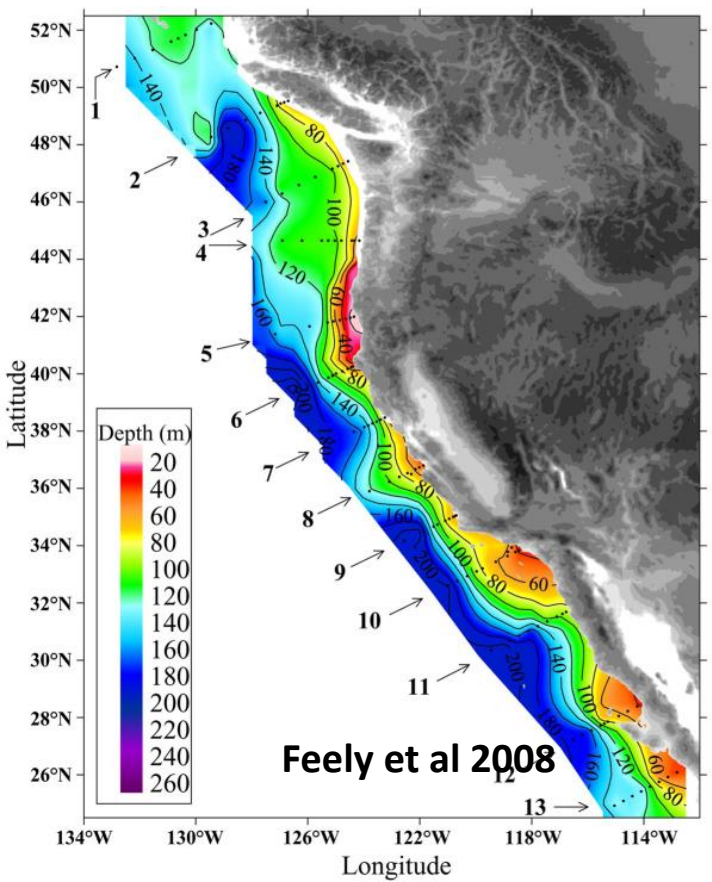
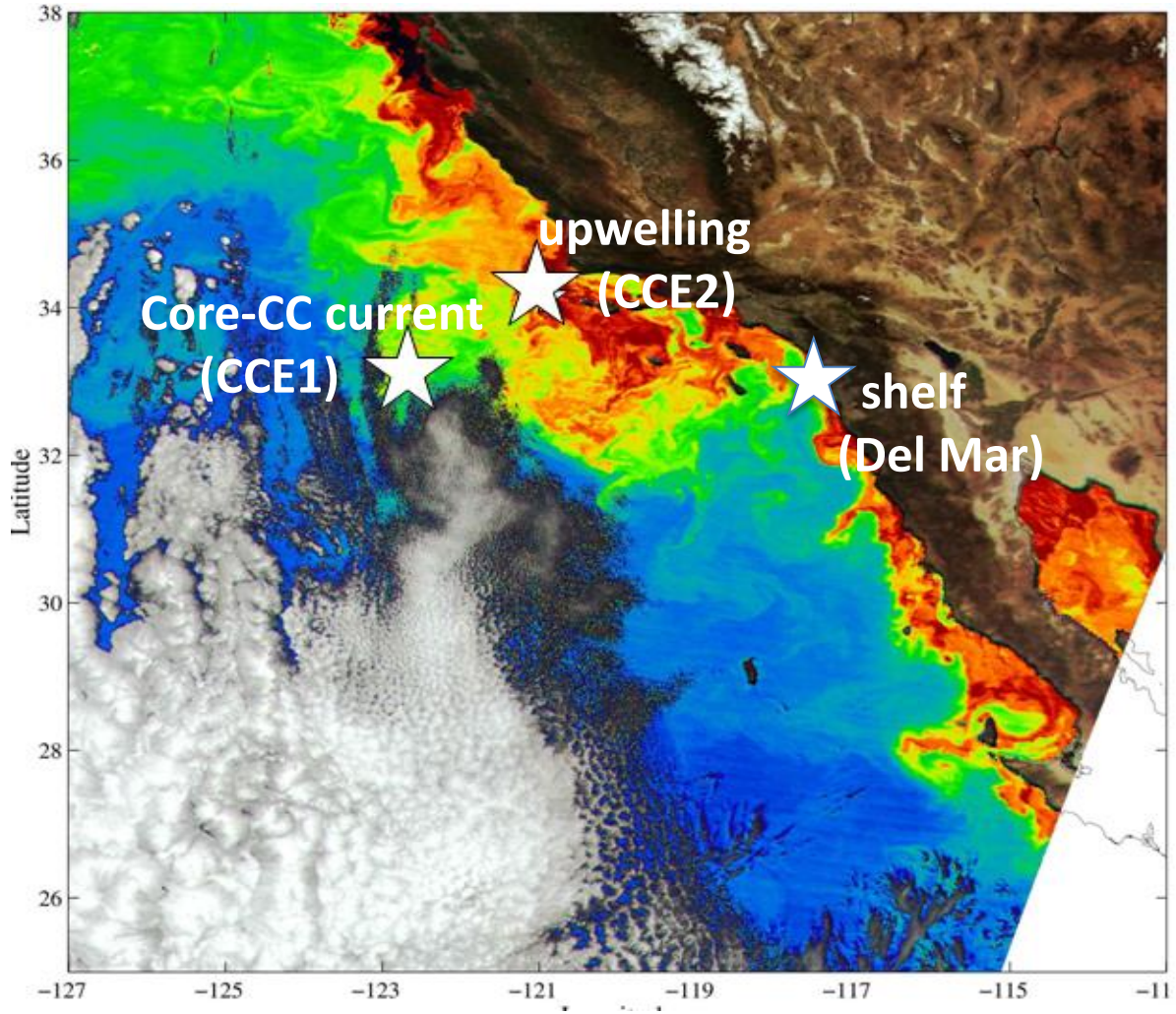
SCRIPPS INSTITUTION OF OCEANOGRAPHY
UC San Diego

NOAA

Continuous multi-discplinary observations covering 3 regimes

Shared and co-funded by
- NOAA COD
- NOAA OA program
- NOAA NMFS





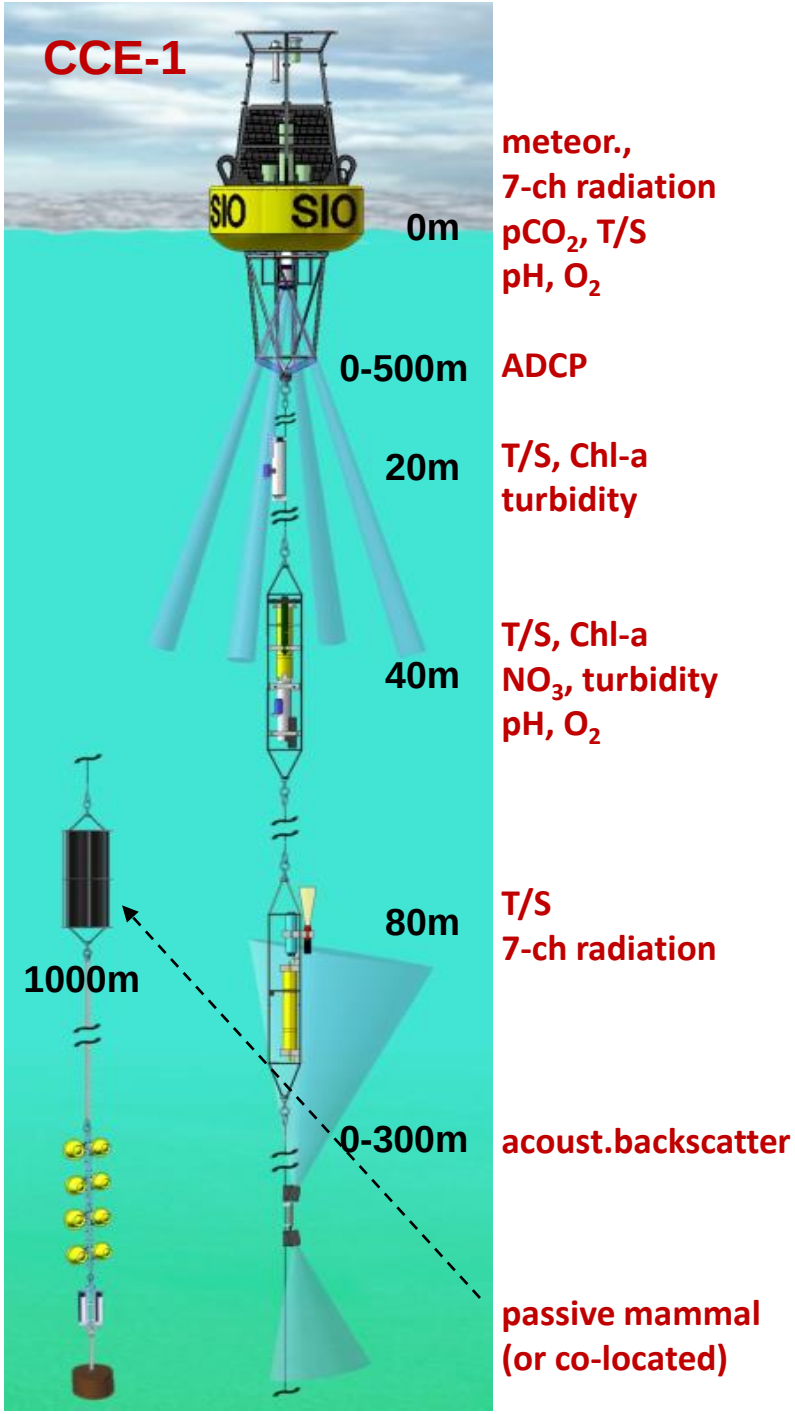
- **success story for partnering of multiple NOAA lines offices, NOAA labs, and academia**

- **unique leveraging and complementarity of many observing components**

- **state-of-the art technology, continually evolving, all real-time**

- **highly modular, easy to expand, acts as a RAD**

(data views on http://mooring.ucsd.edu/CCE)



Physical/climate forcing of events and budget estimates

relevant for

- **Ocean acidification**
- **Nutrient supply**
- **Ecosystem state**
- **Fishery stock, recruitment, migration**

Timescales

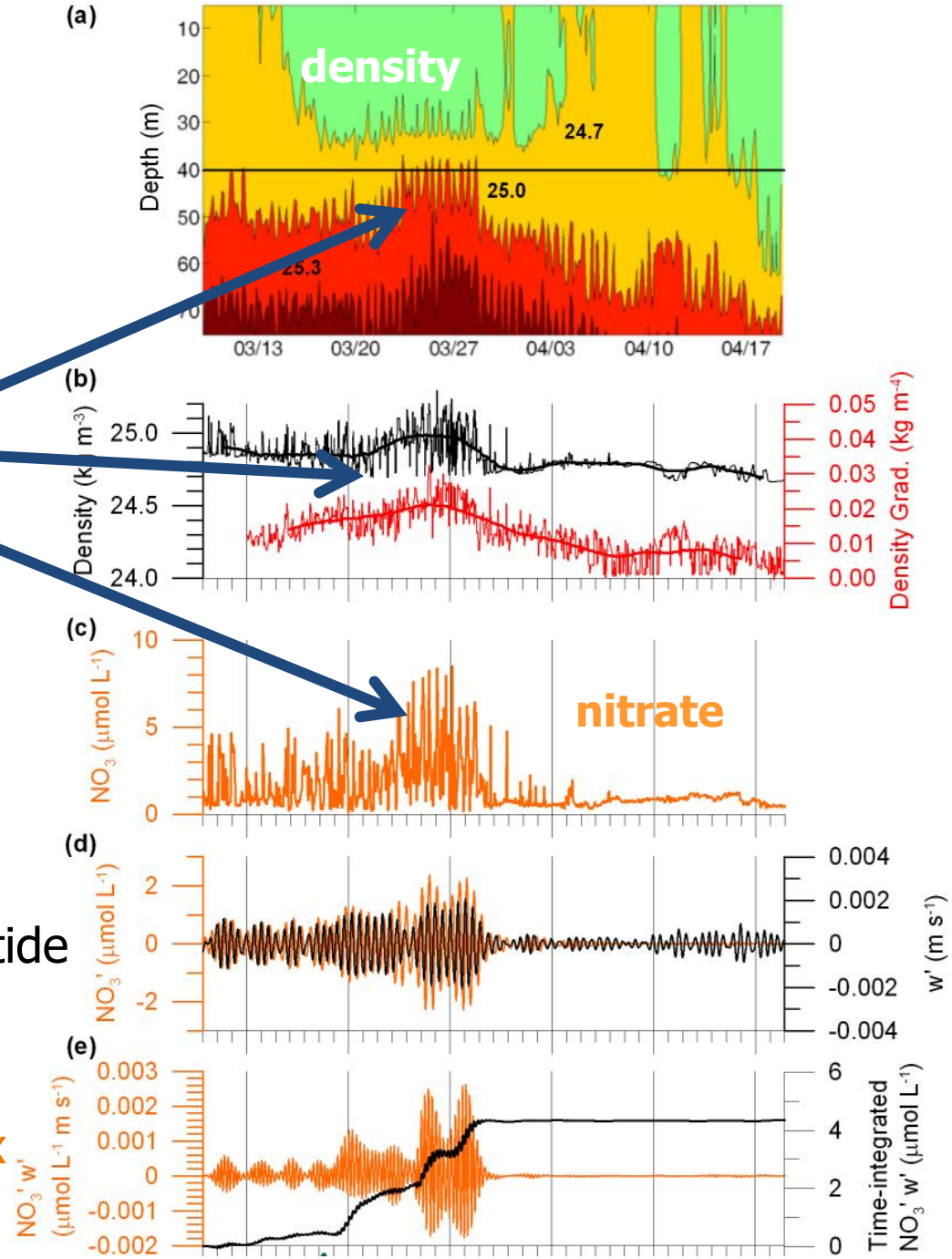
- **Diurnal and (internal) tidal (1 day)**
- **Upwelling and mixing events (1 week)**
- **Changes in source water masses (months to a year)**
- **Climate variability, e.g. ENSO (tracking time evolution and how the low-frequency changes affect high-frequency events) (multi-year)**

Internal tidal pumping of nutrients (CCE1)

internal tide events

bandpass isolating tide

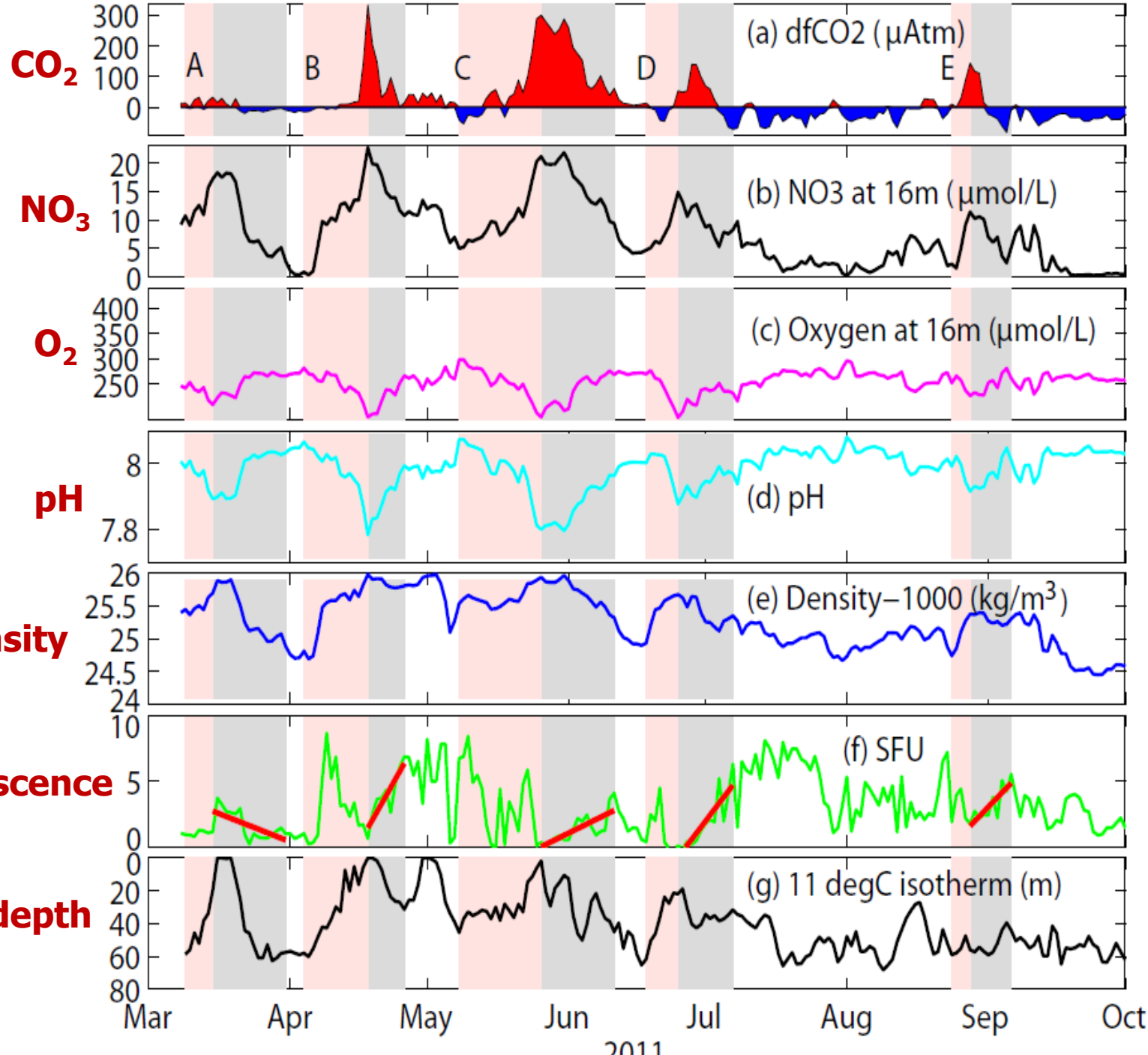
estimated upward nutrient flux



Upwelling events and plankton blooms

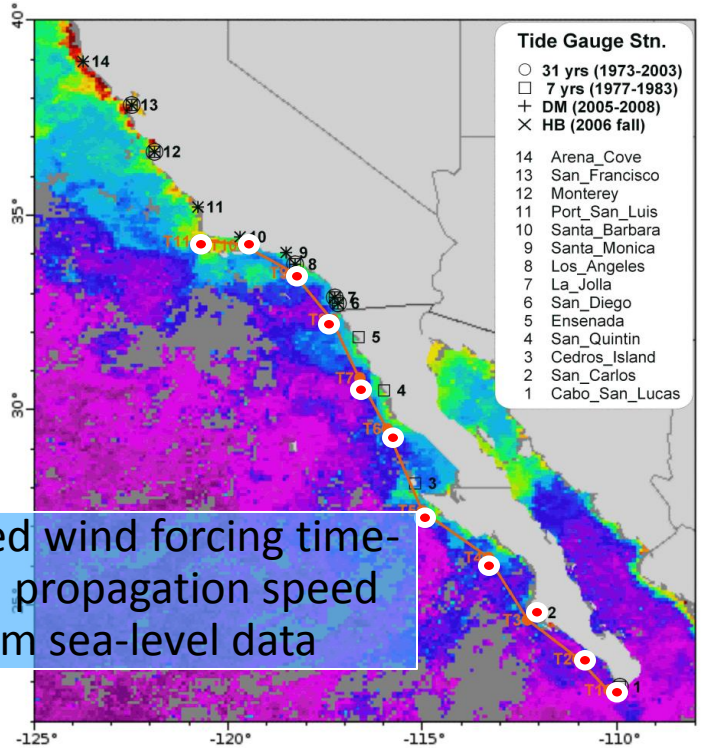
2011

at CCE2



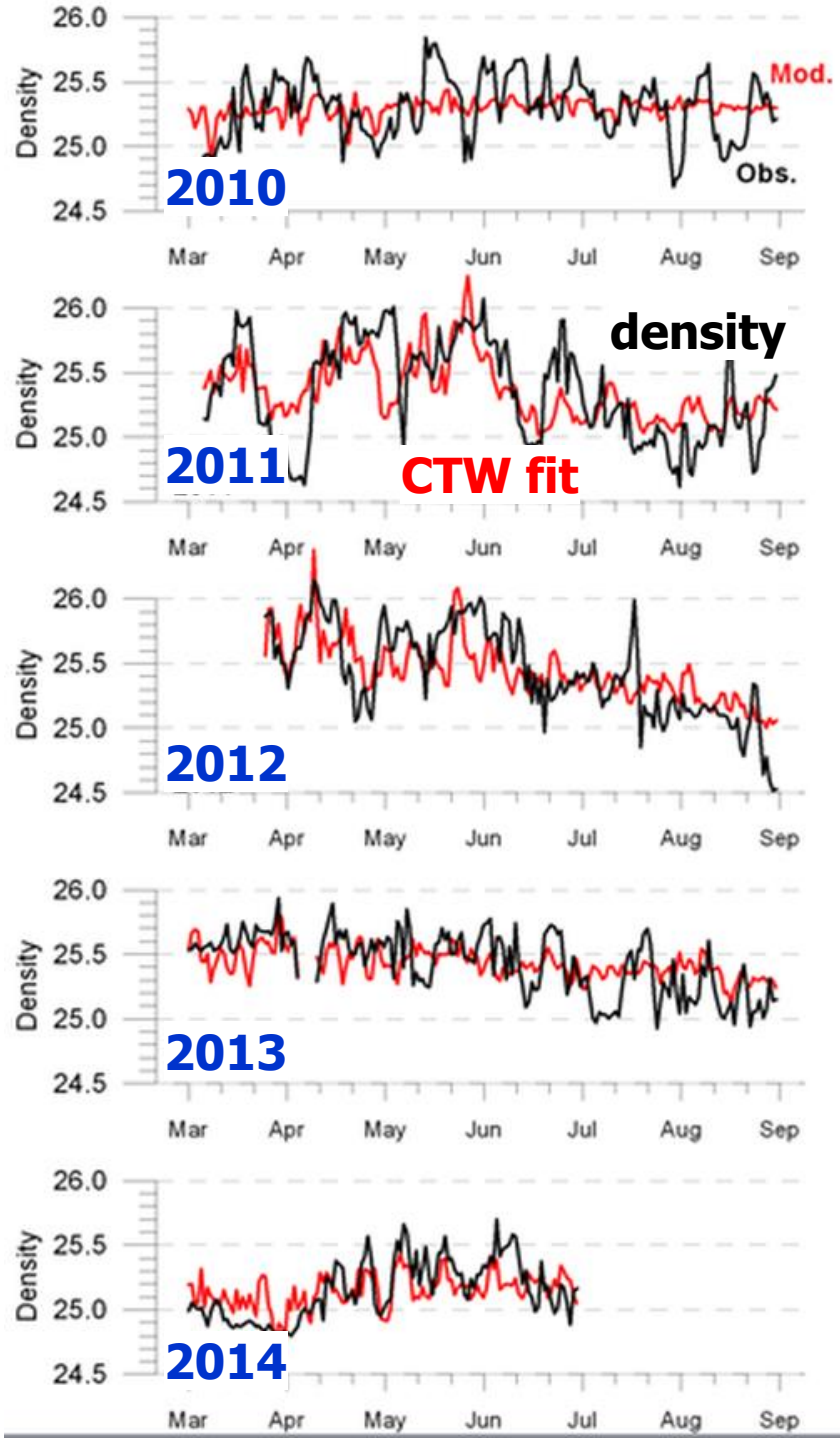
Upwelling is forced largely by remote winds:

pseudo-coastally trapped wave fit

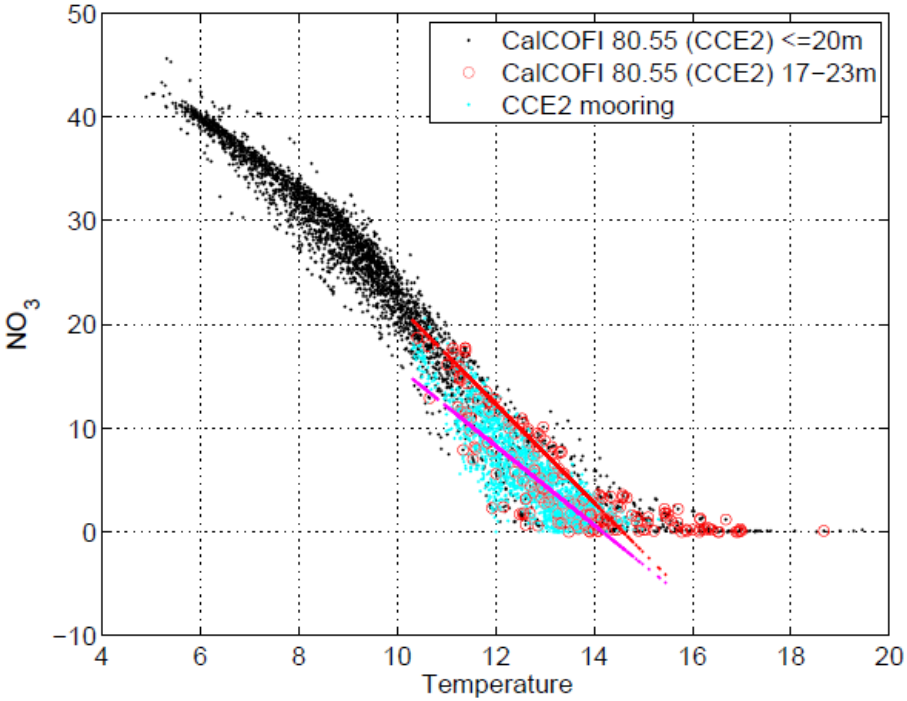


Accumulated wind forcing time-lagged with propagation speed inferred from sea-level data

Correlation for 2011	15m density	15m NO3
Bakun index	0.24	0.26
CTW fit	0.66	0.69



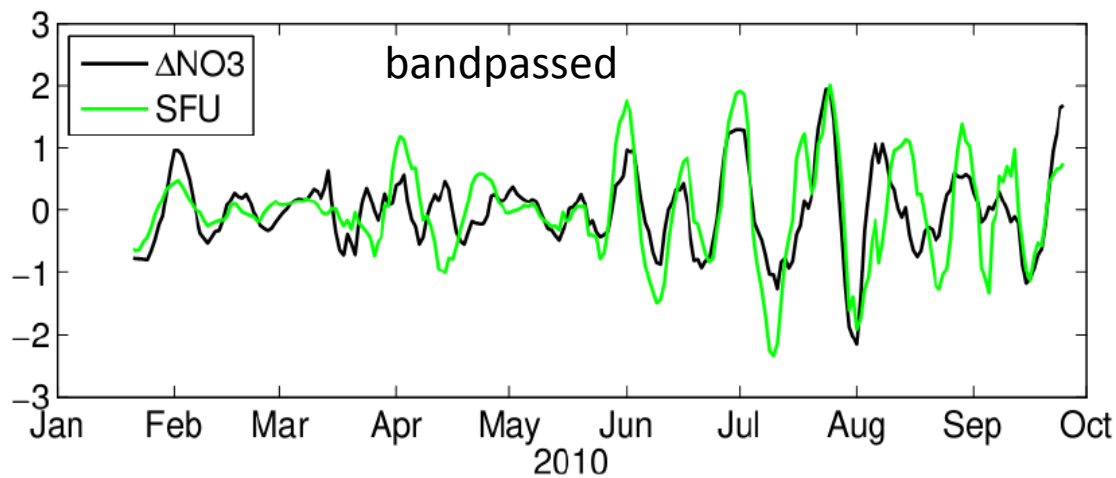
Nutrient/chlorophyll budgets in upwelling events



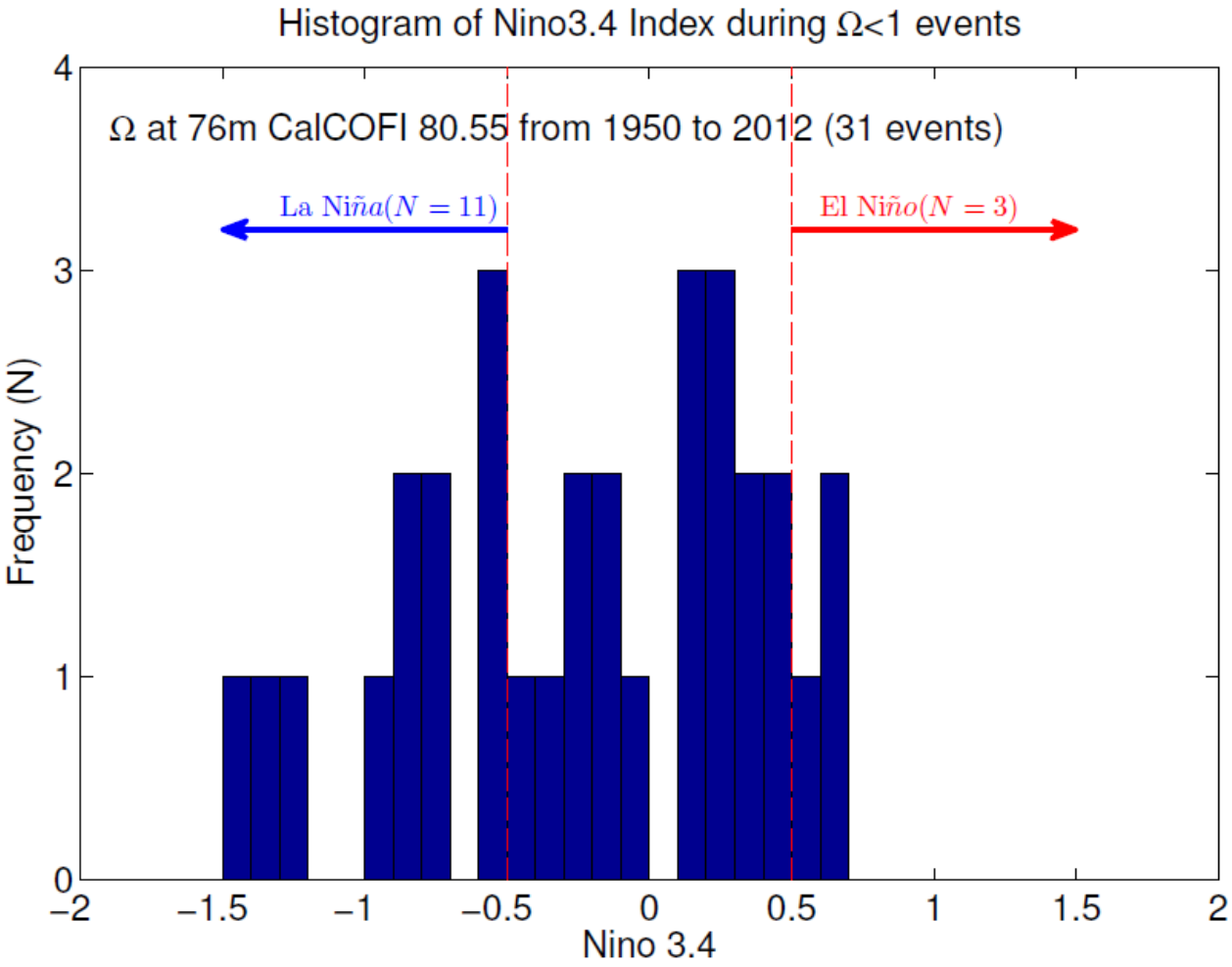
Infer NO_3 of freshly upwelled water from temperature (not changing fast)

By the time water arrives at CCE2 mooring NO_3 has been used→ deficit/usage

quantitative relation between "used" nutrients and created phytoplankton

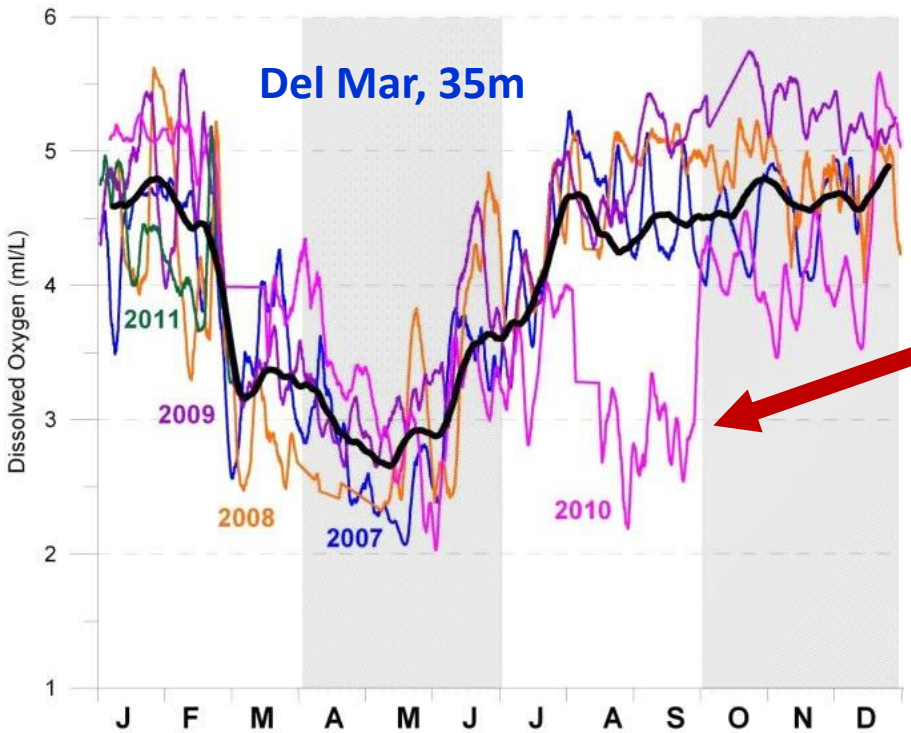


Low-frequency climate variability changes the events



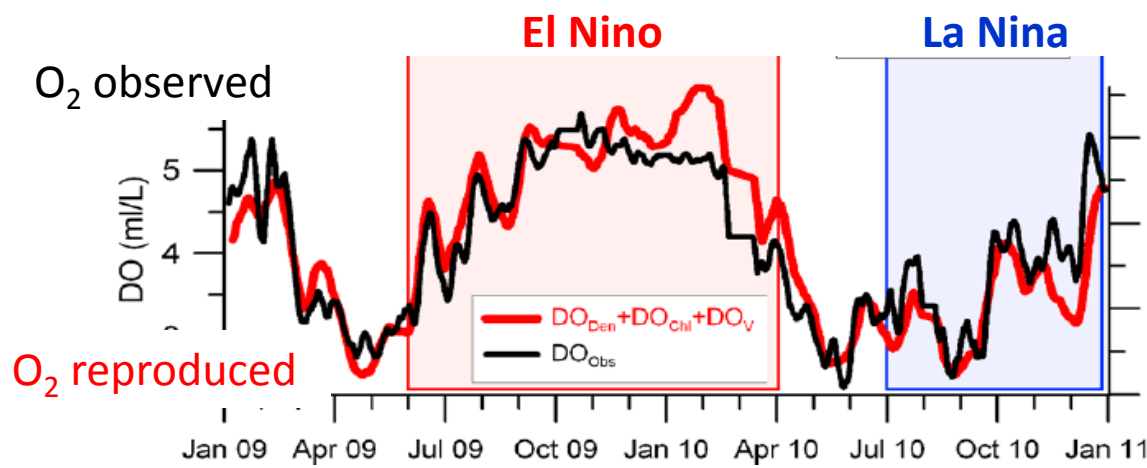
ENSO affects the statistics of corrosive water (Ω<1) events

Multi-disciplinary time series reveal how ENSO changes the system



La Niña impact on pH and oxygen (Del Mar)

Isopycnal uplifting plus alongshore advection and chlorophyll influence can explain oxygen variability.
(Nam et al, 2011)



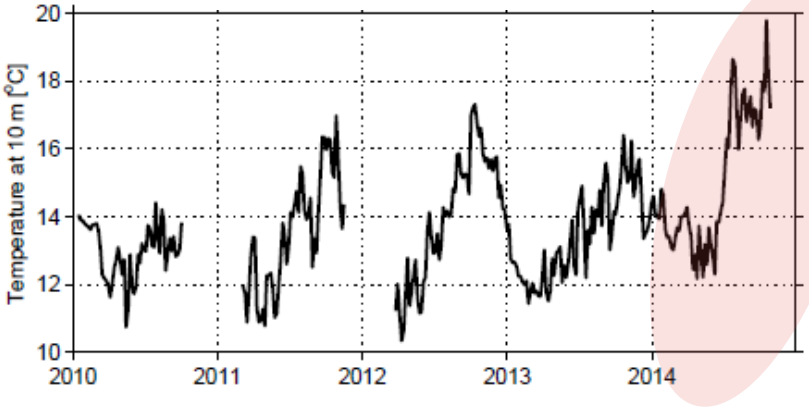
Statistics of upwelling events (3 years) at CCE2, 15m

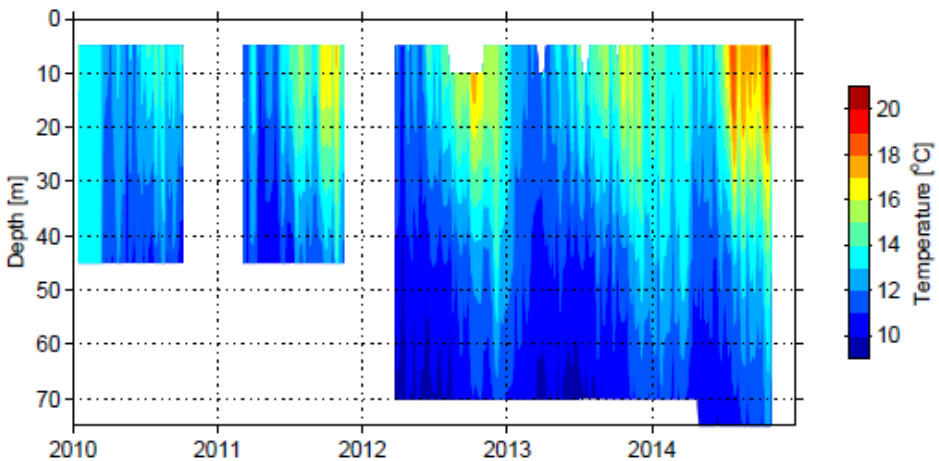
2011-2013 (Mar-Aug)	Total Observational Duration (days)		561
	Total Event Durations (days)		144
	Time Mean & Std. Dev. of Event Duration (days)		10.3 ± 4.4
	DO (μM/L)	Time Mean & Std. Dev.	274.6 ± 41.9
		Min. & Max.	145.5 & 376.7
		Time Mean & Std. Dev. of Event Intensity	86.0 ± 33.0
	pH	Time Mean & Std. Dev.	8.03 ± 0.09
		Min. & Max.	7.78 & 8.26
		Time Mean & Std. Dev. of Event Intensity	0.18 ± 0.06
	Ω_{arag}	Time Mean & Std. Dev.	2.04 ± 0.37
		Min. & Max.	1.21 & 3.14
		Time Mean & Std. Dev. of Event Intensity	0.67 ± 0.20

Extremely unusual conditions this summer

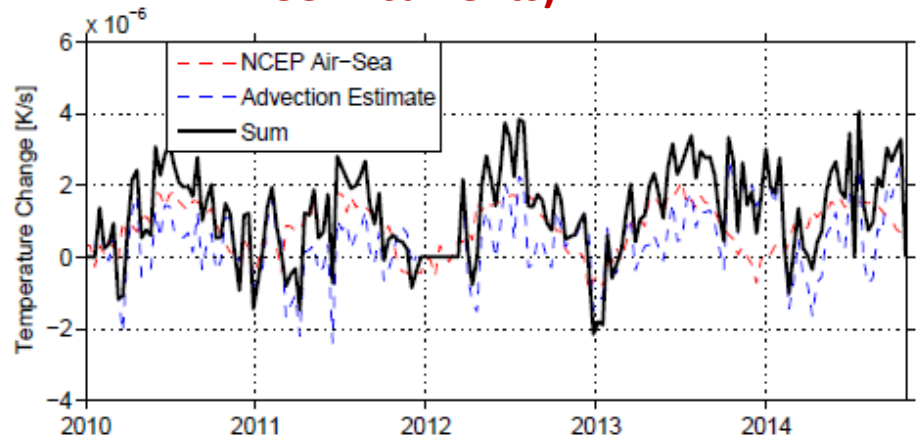
CCE2 10m temperature

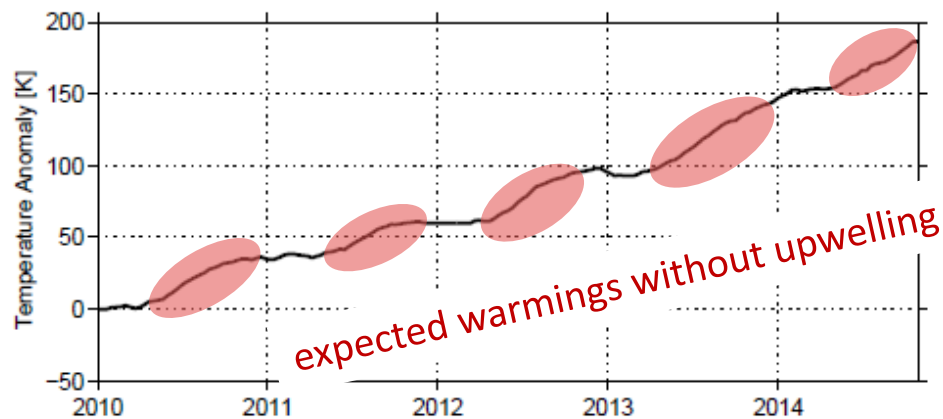
3°C warmer this year





Rough T budget (NCEP surface heat flux and advection using CCE2 currents)





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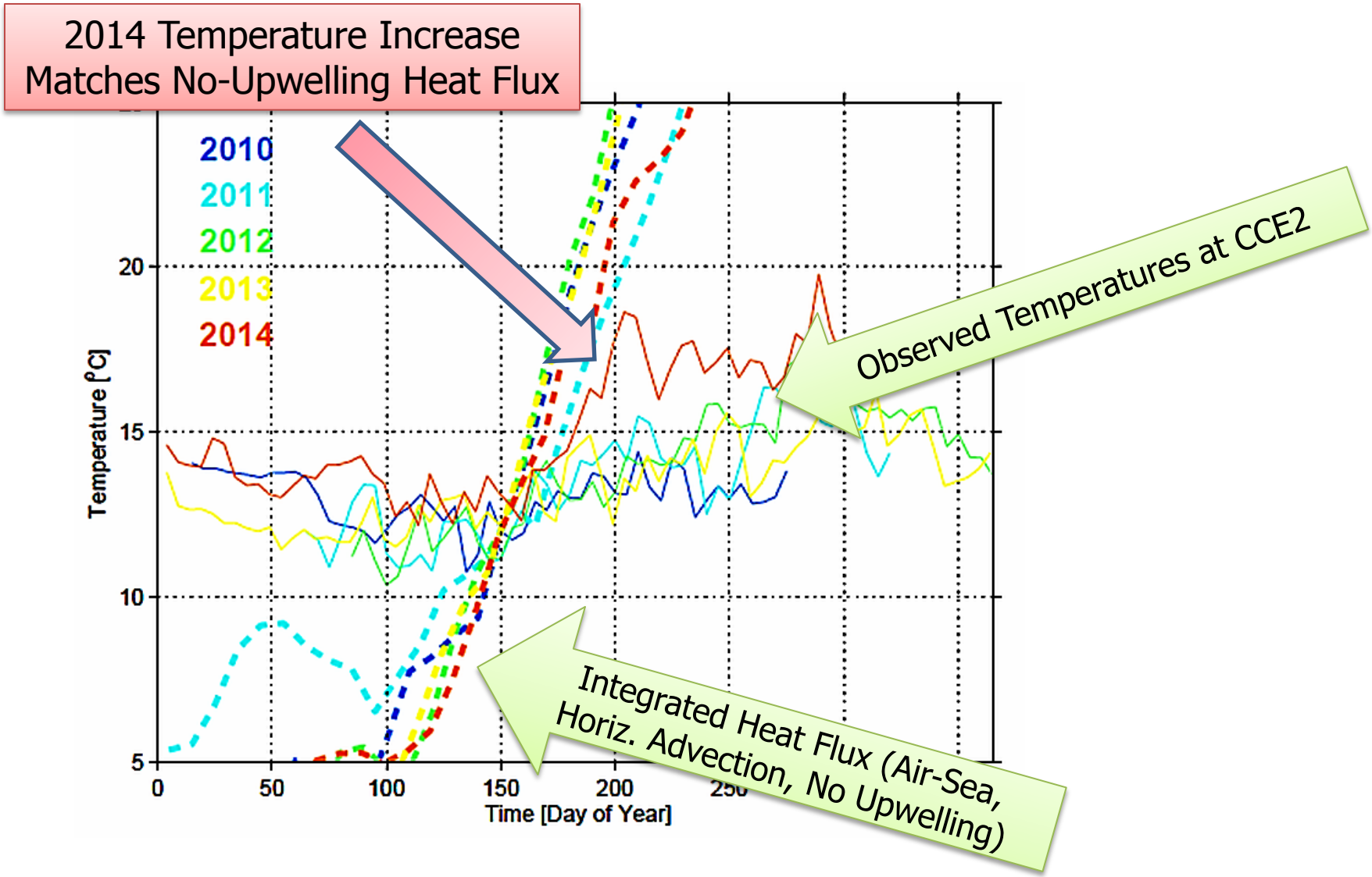
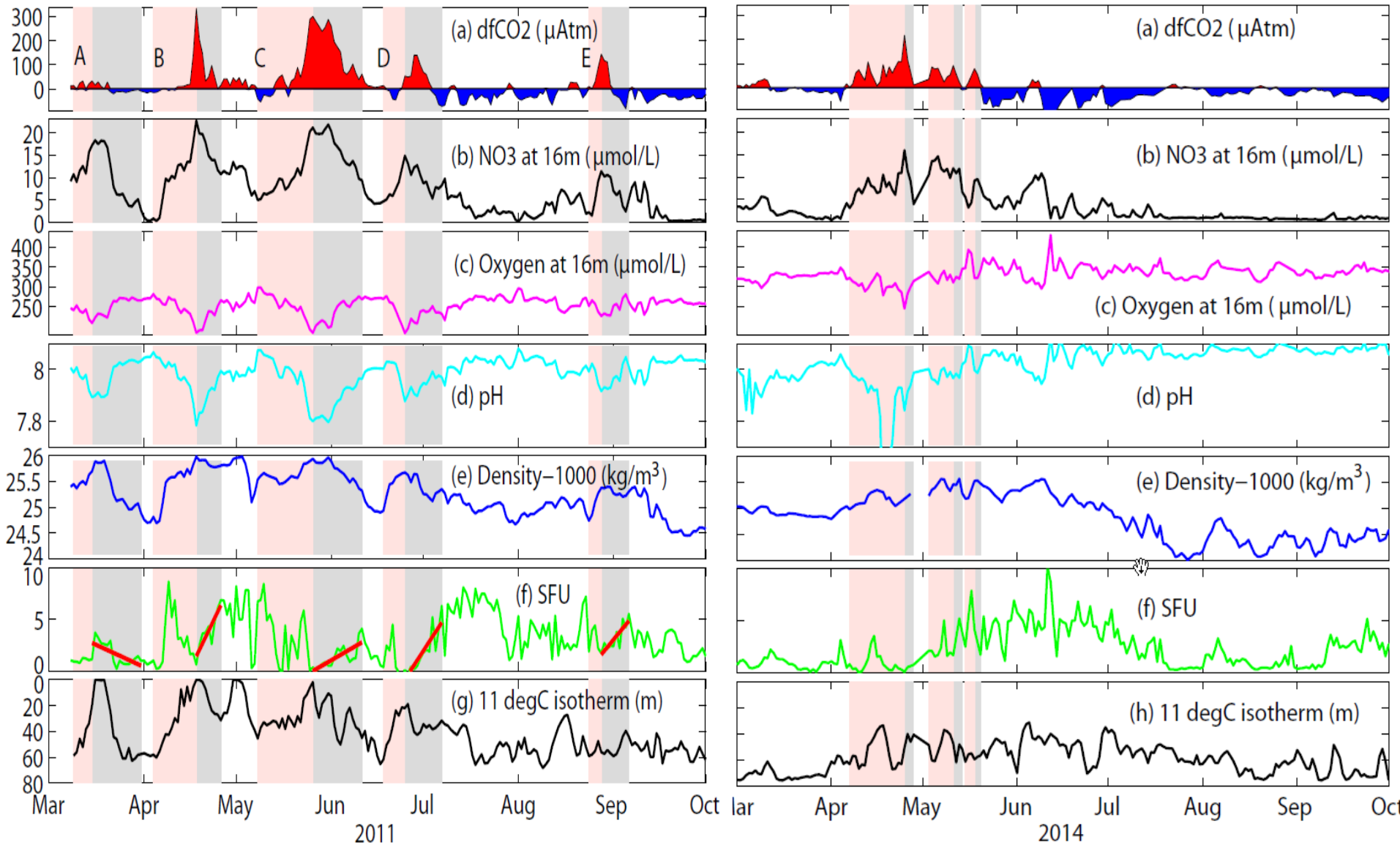


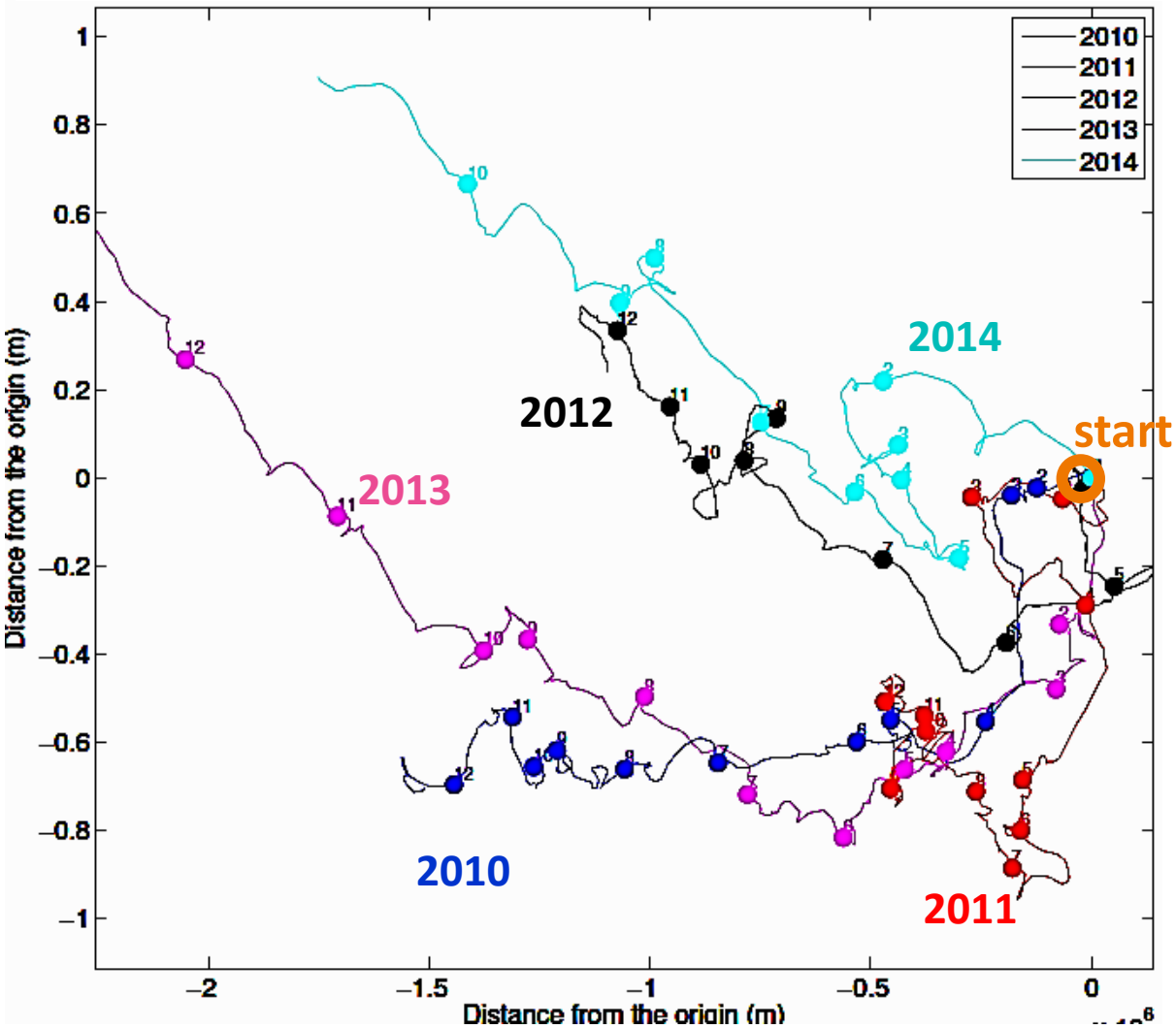
But: winds during summer are not anomalous (along entire coast)

Low density, depressed isotherms, etc, already at beginning of season…



Hypothesis: unusual northward flow already at beginning of year…

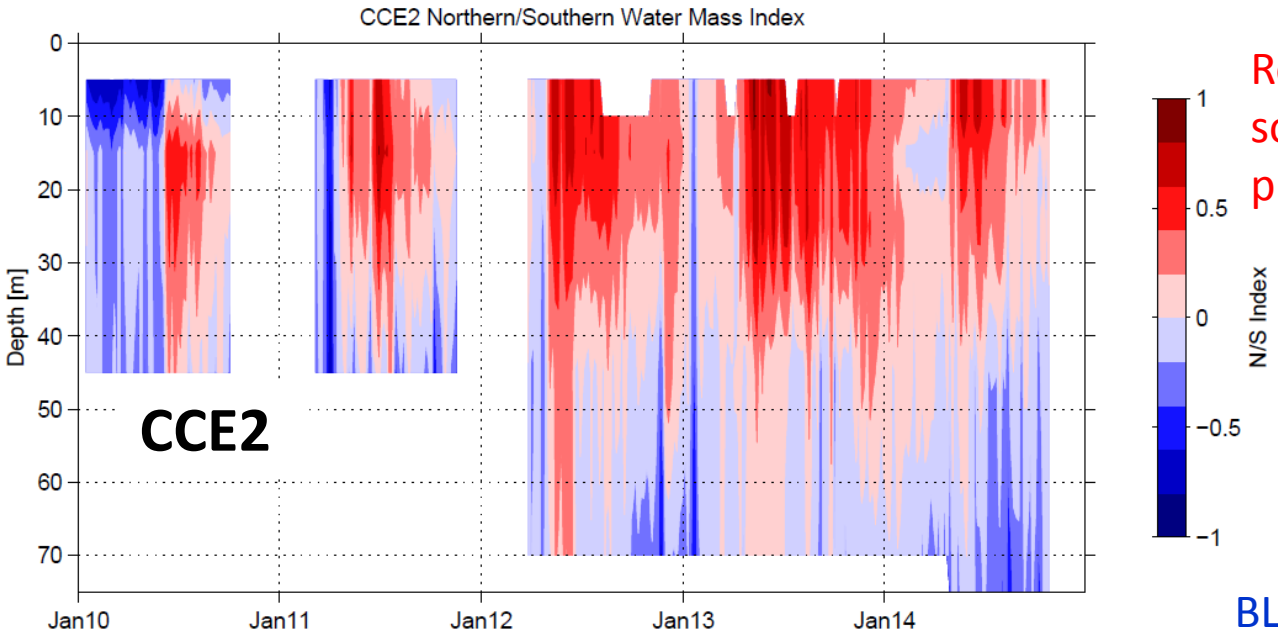
Progressive vector diagrams of CCE2 currents (artificial displacement)



…. brought warm, stratified water into the region

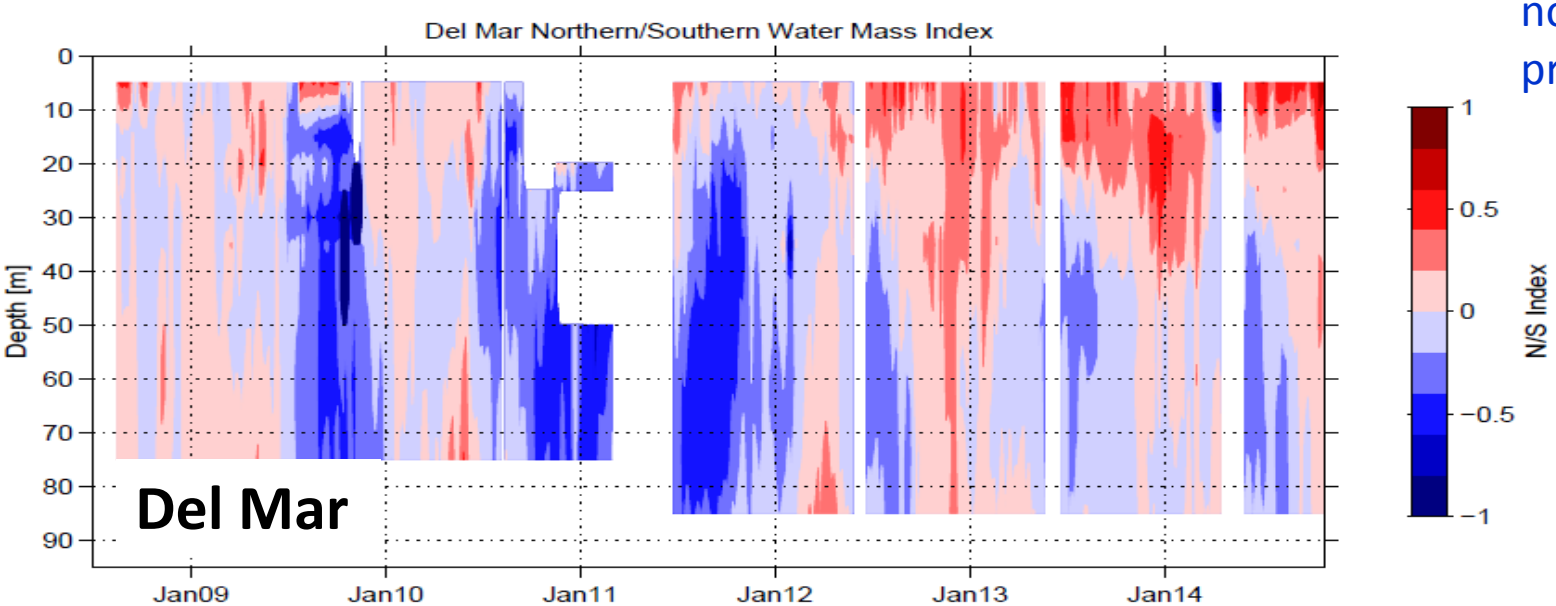
→ different preconditioning of water column for upwelling

Analysis of water mass changes (and their causes/impacts)



Red = southern water properties

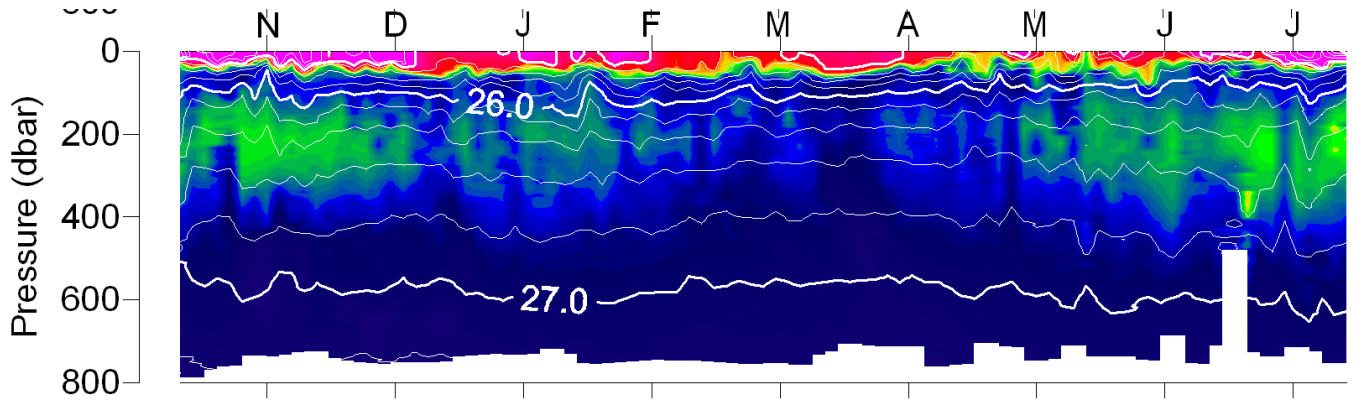
BLUE = northern water properties

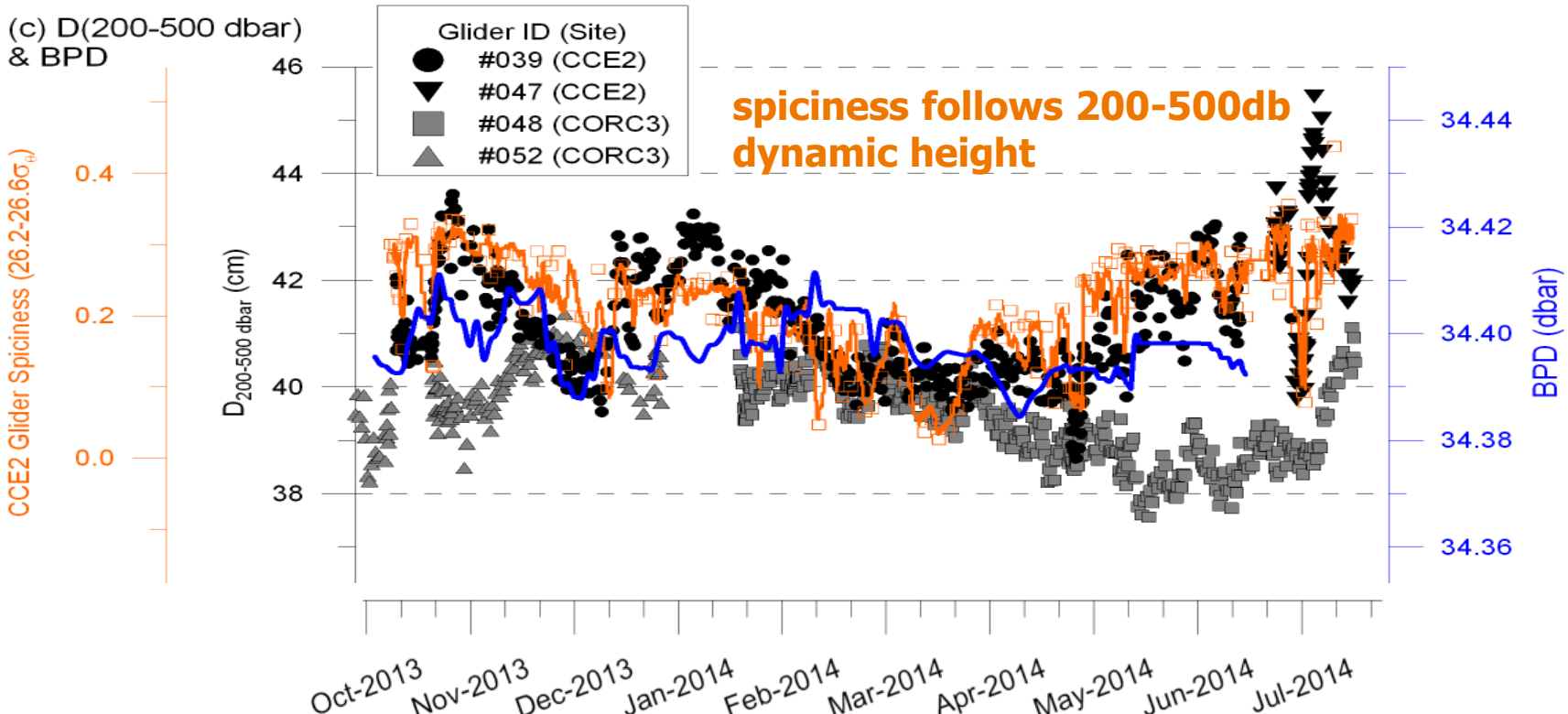


Changes in the California Undercurrent (source for upwelling)

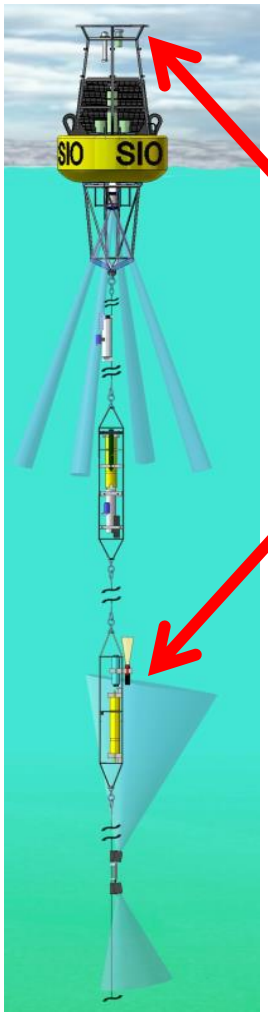
spiciness as indicator for water from the south

CCE2

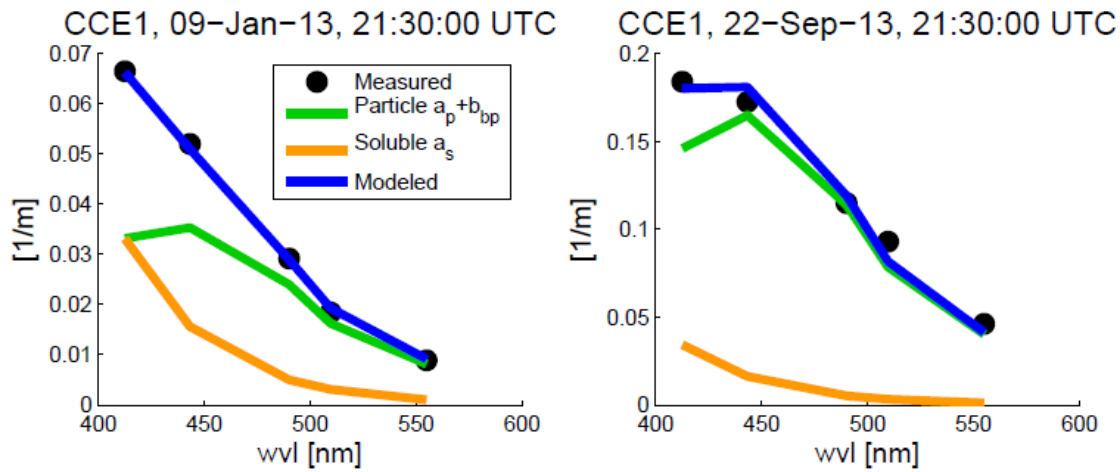


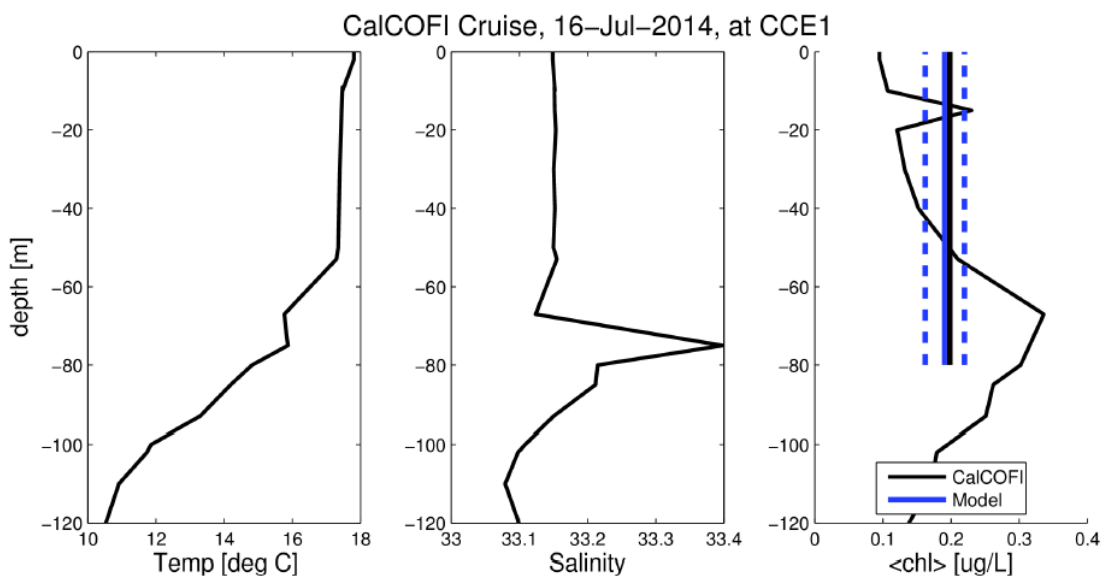


New method for total column chlorophyll (after F. Chavez)



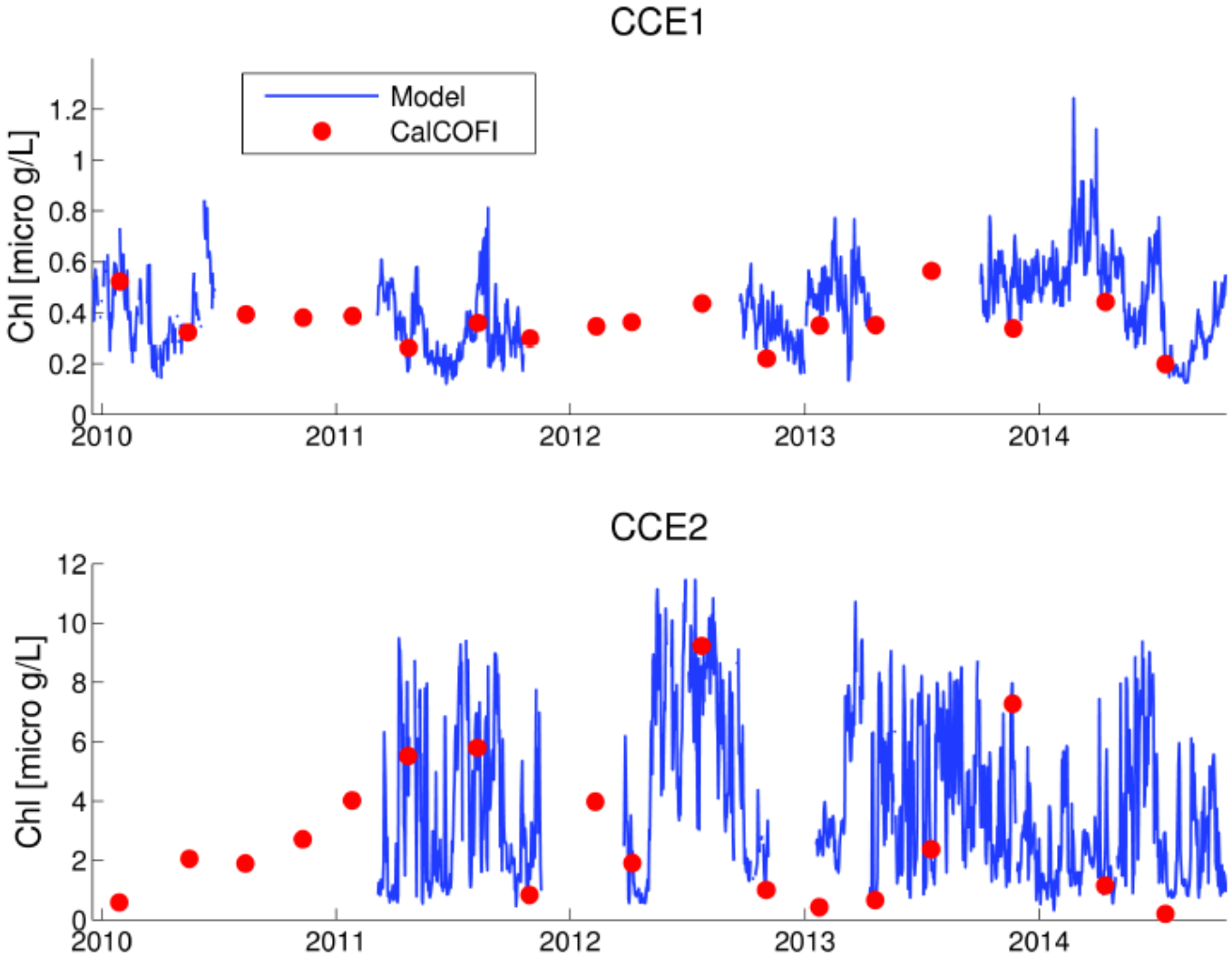
irradiance sensors (7 wavelengths)





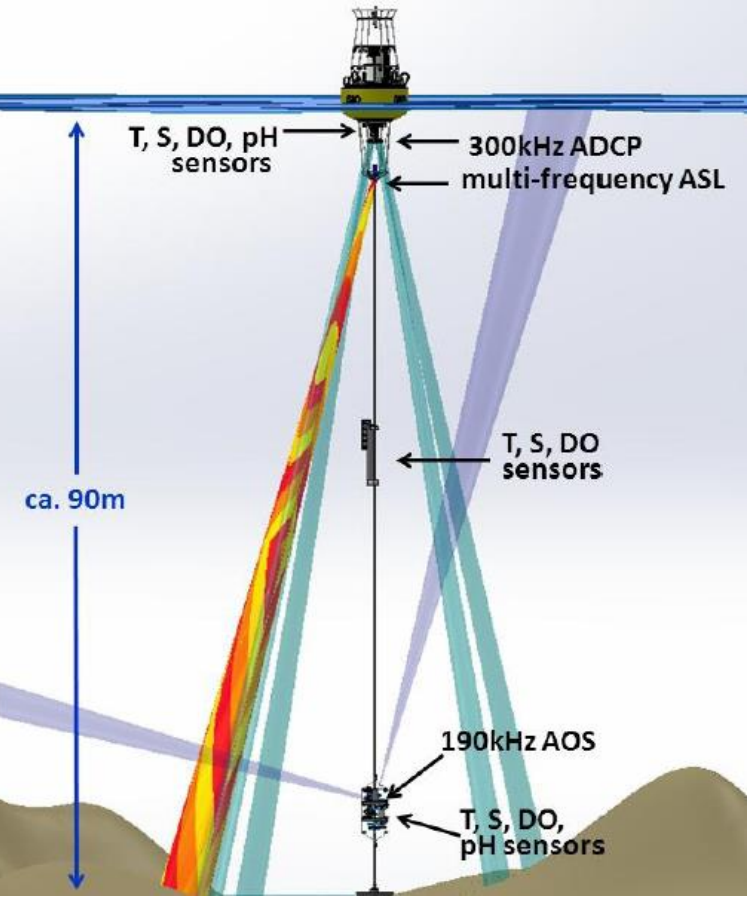
developed by Sam Wilson →

Working well now - more robust and complete measurement of chlorophyll abundance (important for habitat definitions)

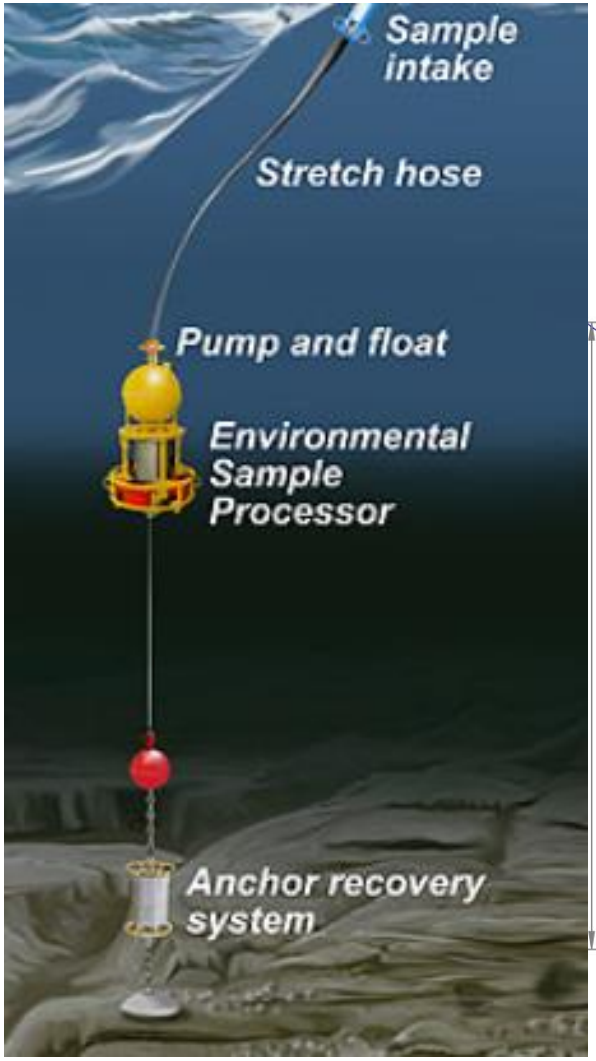


Potential technology enhancements for the moorings:

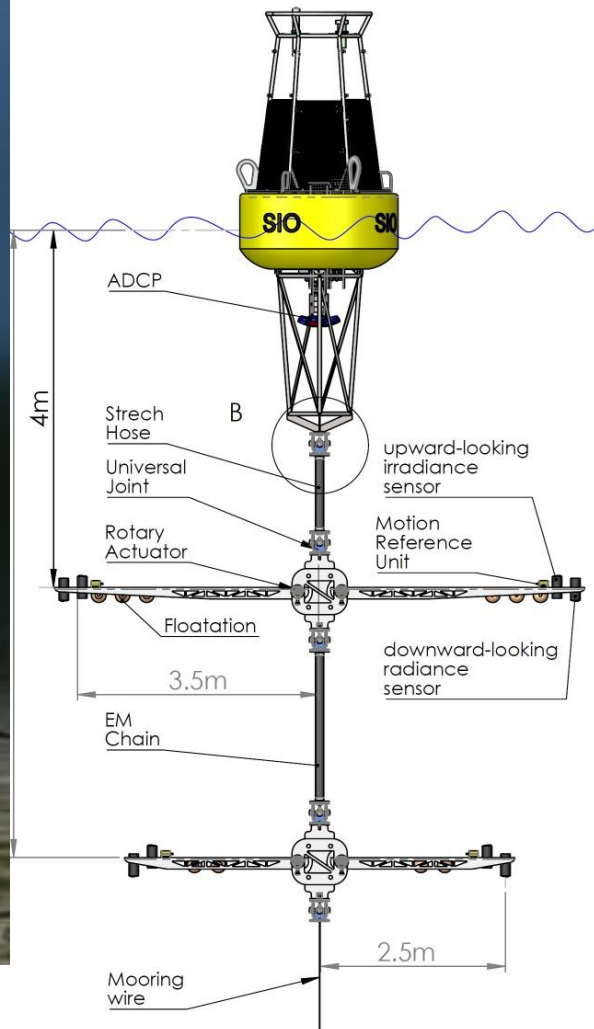
Multi-frequency backscatter for species differentiation/tollgates



ESP addition to Del Mar underway, later CCE1/2 ?



Modifications proposed for NASA ocean color calibration…



Summary:

Continuous multi-frequency (fixed-point) timeseries are crucial to

- **understand <u>physical/climate</u> forcing of OA and ecosystem on many timescales**
- **allow to relate events and processes <u>across</u> the regimes**
- **follow time evolution and origin of changes**
- **construct budgets over diurnal to seasonal timescales**

The mooring can be used to carry additional sensors from the community or agencies….