

# ***Ocean Colour: Early Successes and Future Needs***

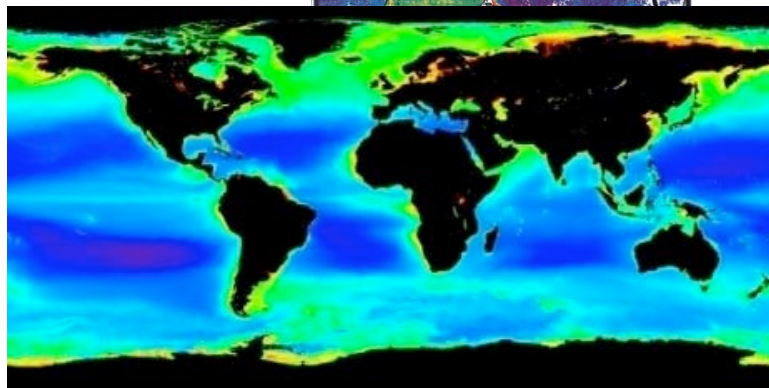
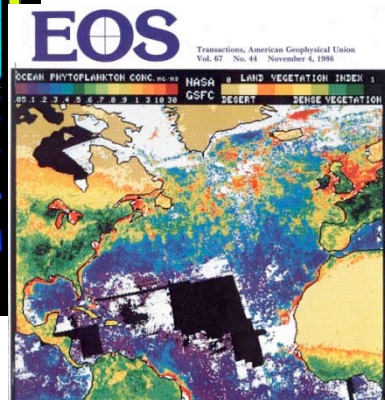
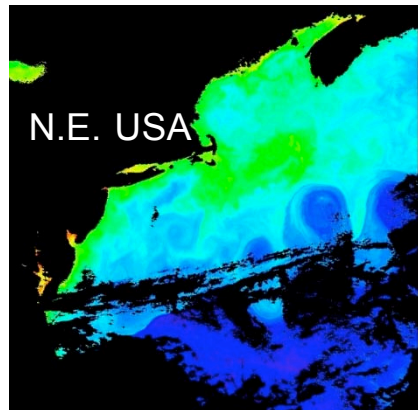
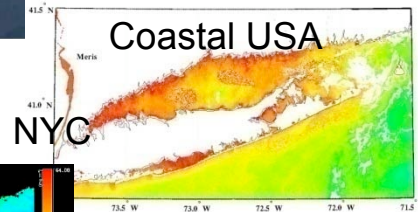
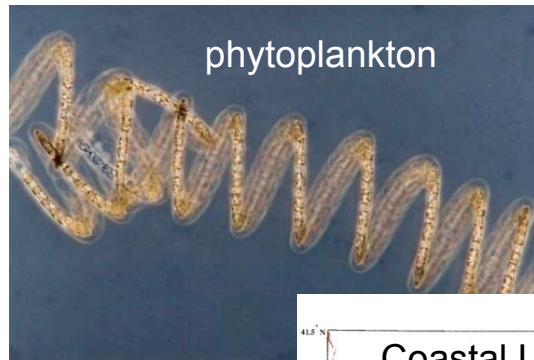
J.A. Yoder, WHOI

What is the key science driver for using Ocean Colour Radiometry (OCR) for research and applications? What is OCR, and what does it provide?

Examples of early successes from research and applications.

4-D observations related to ocean biogeochemistry and marine ecosystems will be possible using floating platforms (gliders or *ARGO* floats) and satellite OCR.

Sustaining OCR capabilities into the future requires high level of cooperation between international space agencies.



## Science Driver for Research and Applications:

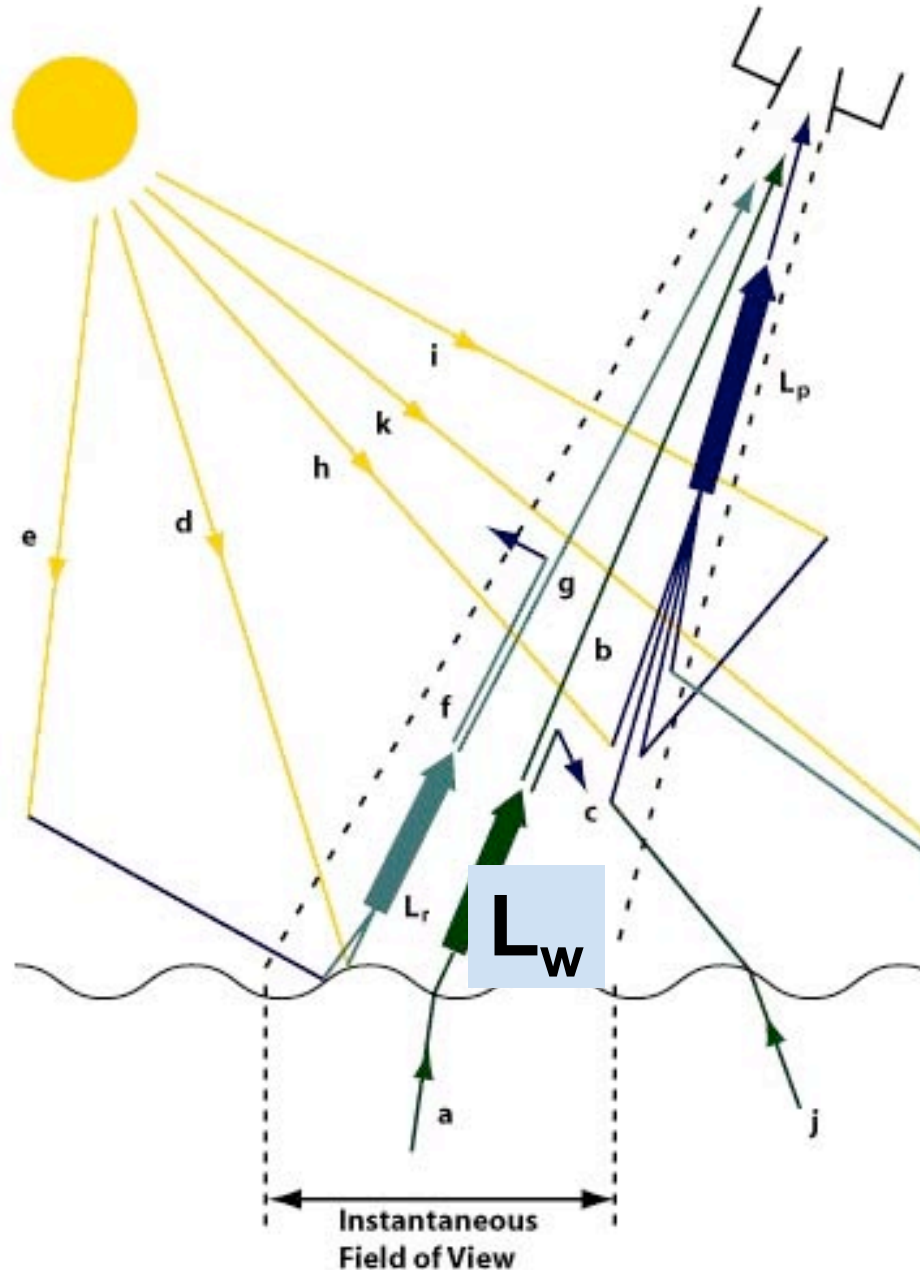
What is the variability of key biogeochemical and ecological indices related to ocean productivity at meso- to basin-scales and at time scales ranging from days to interannual?



Marine Phytoplankton  
(Diatoms)  
Ca. 200X mag.

Photos by Dr. Jan  
Rines, GSO/URI





## Pathlengths to a Satellite Sensor for Sunlight Shining on the Sea

$L_w$  = water leaving radiance which contains the information on in-water constituents such as phytoplankton concentration.

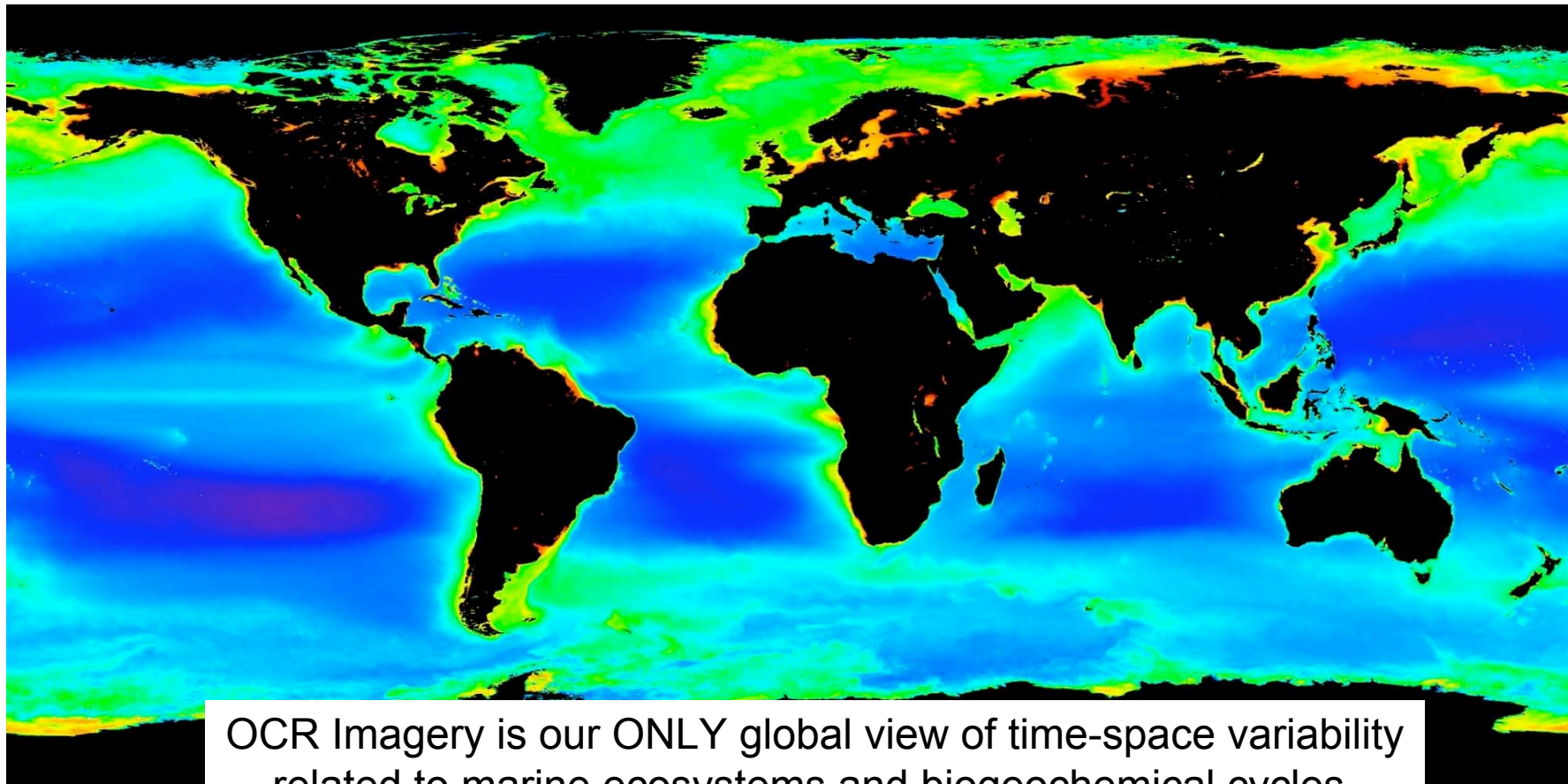
However, most of the signal reaching the sensor has been affected by scattering and absorption in the atmosphere. S/N = about 0.1 on average for key wavelengths.

Sensor Wavelengths for *SeaWiFS* – which is in polar orbit, crossing equator at local noon, 1 km pixel resolution, 1500-2800 km swath width

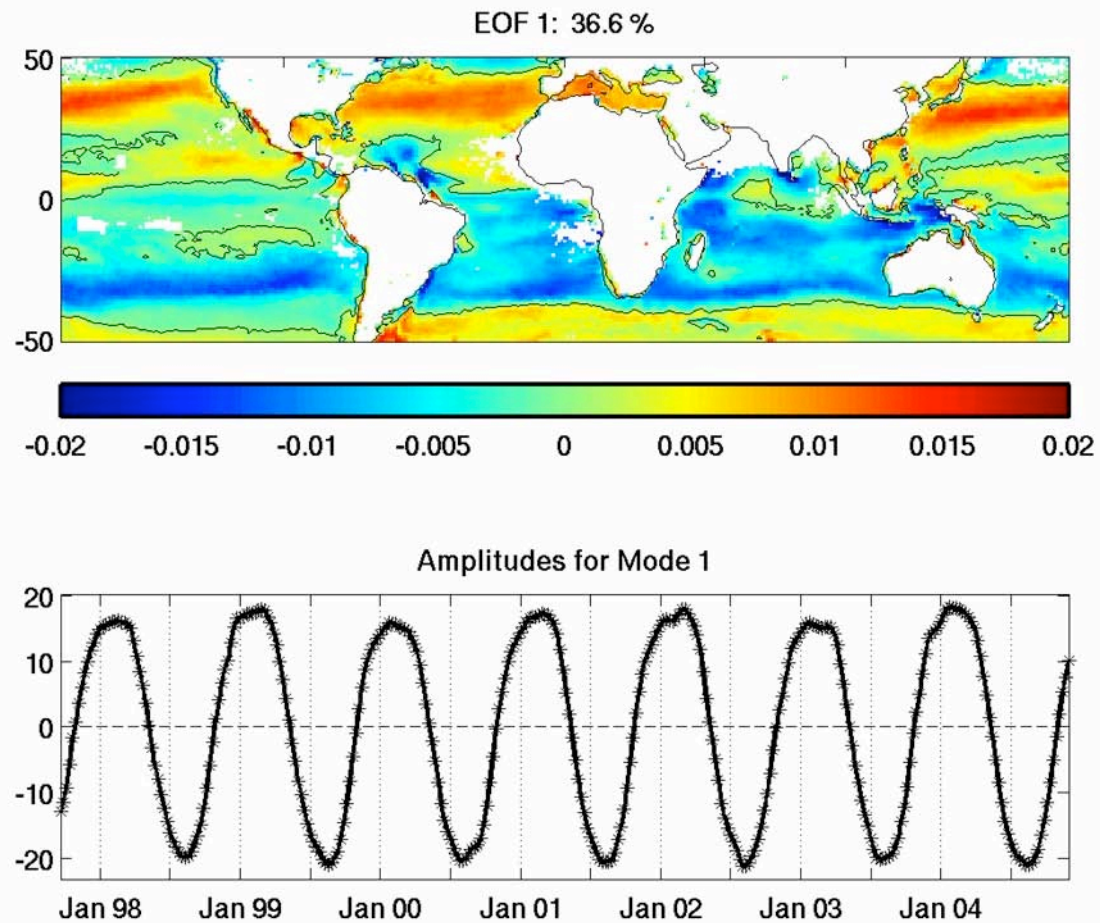
Band Number	Wavelength (nm)	Purpose
1	402-422	Colored Dissolved Organic Matter
2	433-443	Phytoplankton Pigments (eg Chl a)
3	480-490	Phytoplankton Pigments (eg Chl a)
4	500-520	Phytoplankton Pigments (eg Chl a)
5	545-565	Back Scatter - Particulate Carbon
6	660-680	CZCS Heritage and Back Scatter
7	745-785	Atmospheric Correction
8	845-885	Atmospheric Correction

Note: Additional spectral bands, e.g. on *MERIS*, yield improved algorithms and new products.

# Composite *SeaWiFS* Chlorophyll Image: 1997-2009 (G. Feldman, NASA-GSFC)



# Seasonal OCR Chlorophyll Variability In the Global Ocean



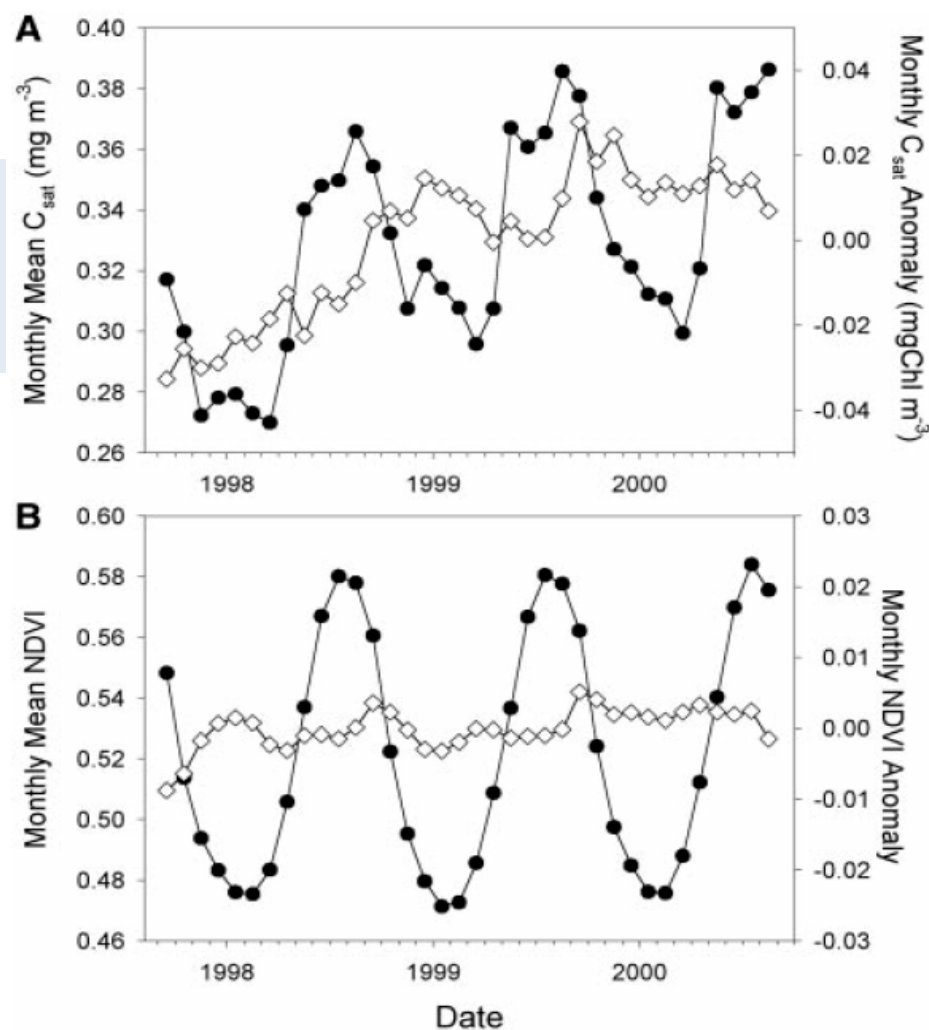
From Yoder and Kennelly 2006

# Interannual Variability: Productivity Change During ENSO Transition:

Global monthly means (●) and anomalies (◇)

**Ocean:**  
SeaWiFS  
chlorophyll

**Land:**  
SeaWiFS land  
vegetation  
index

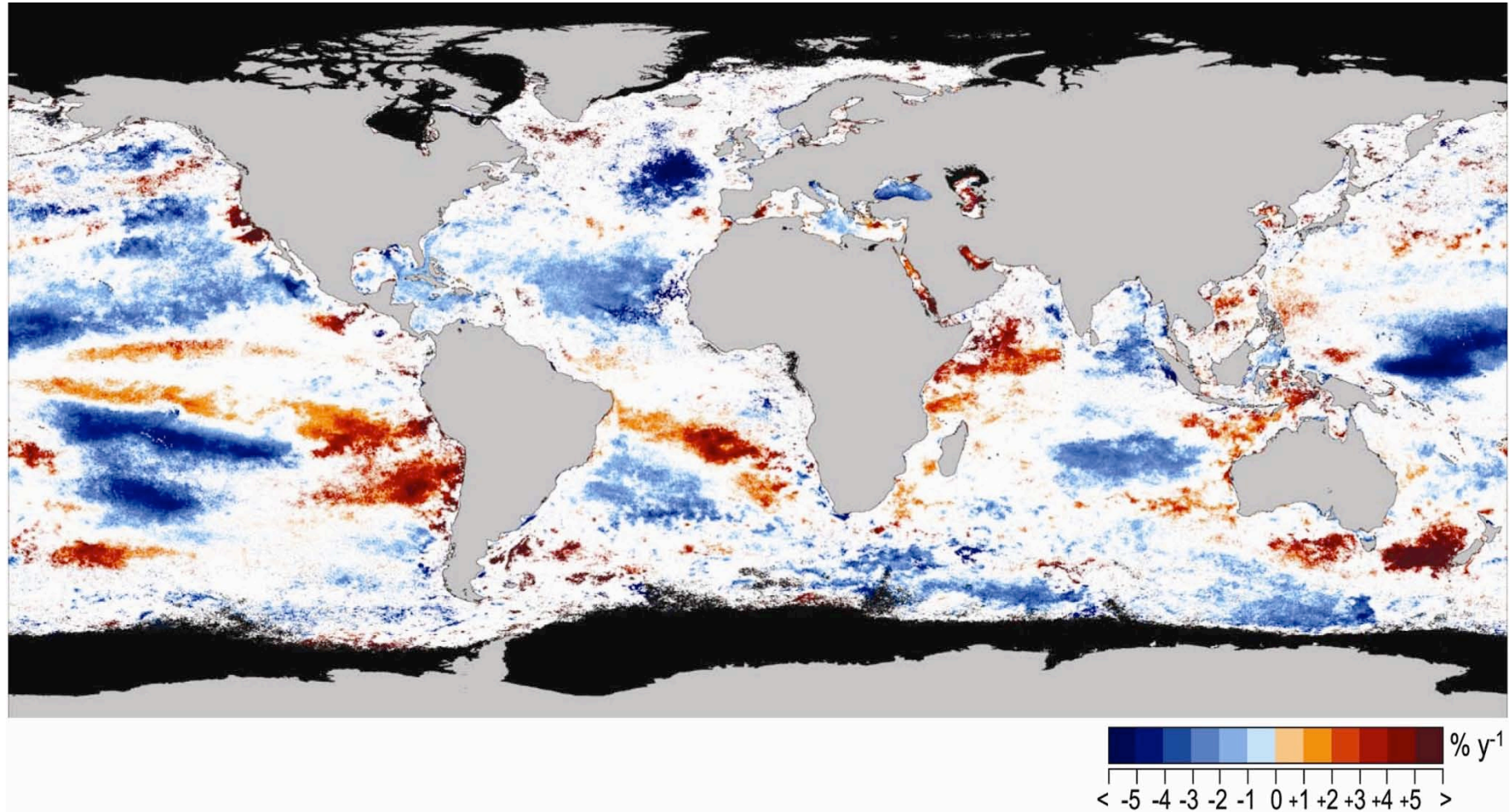


Changes in ocean and land vegetation led to global productivity increase of **6 Pg/year** during transition from 1997 *El Nino* to 1999 *La Nina*, with most response in the ocean.

Behrenfeld et al. 2001, *Science*.

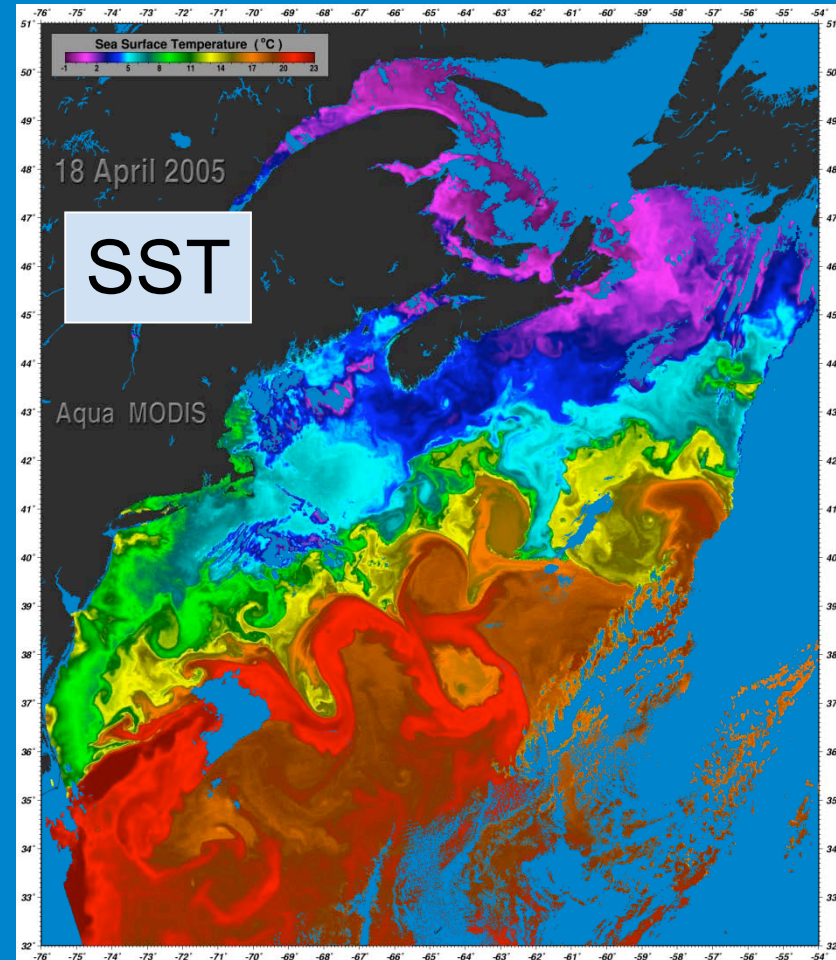
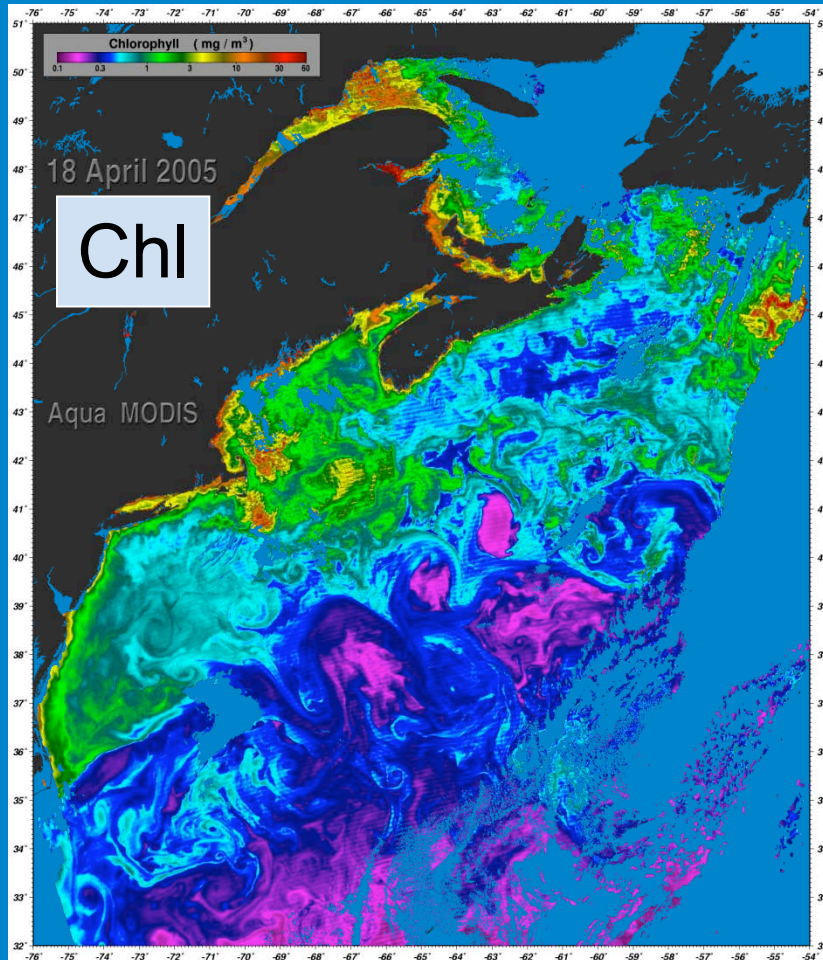


# Long Term Trends Related to Changes to Ocean Stratification?



*Slope of the linear regression for Chl-a (expressed in % year<sup>-1</sup>) over 10 years of SeaWiFS data (November 1997–October 2007) from Vantrepotte and Mélin (2009).*

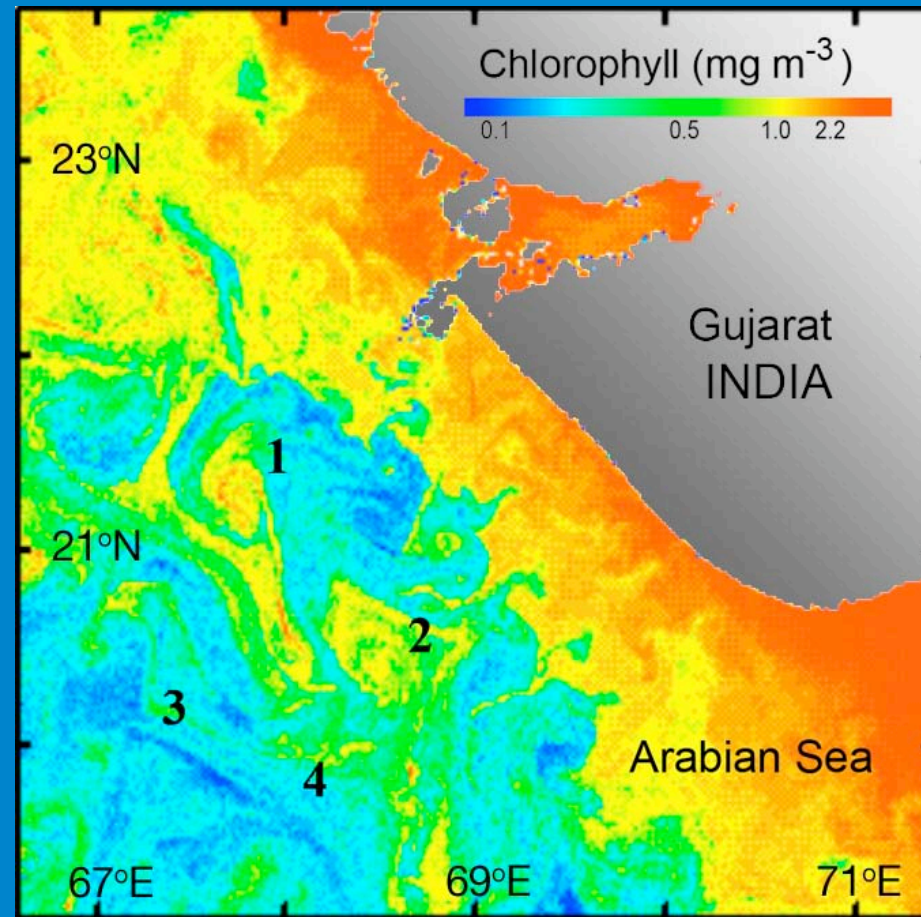
# OCR Revealed Importance of Meso-scale Variability and the Close Link to Physical Features such as Eddies, Plumes and Planetary Waves.



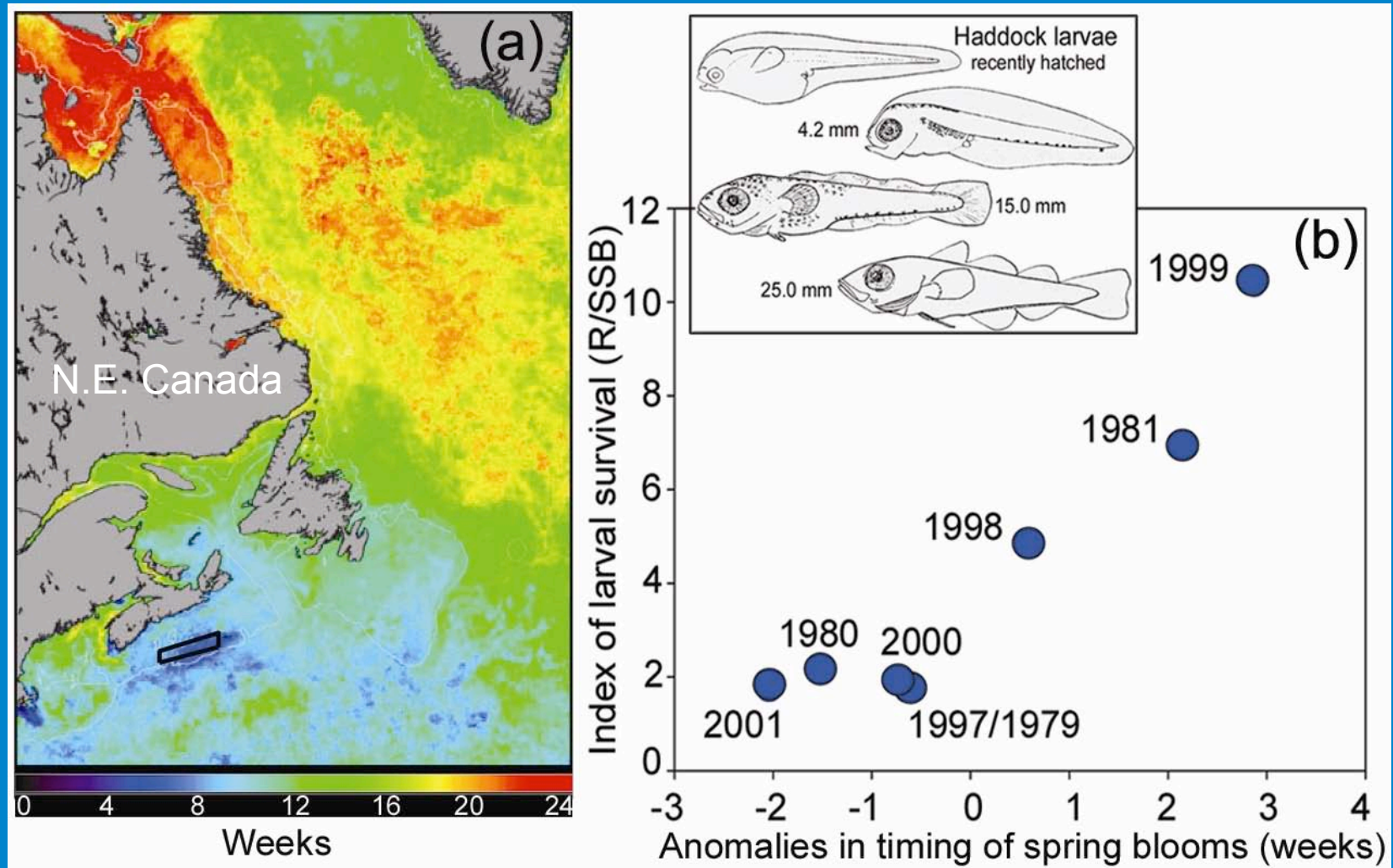


## SAFARI Initiative – Fisheries Application

### Indian Potential Fishing Zones (PFZs)

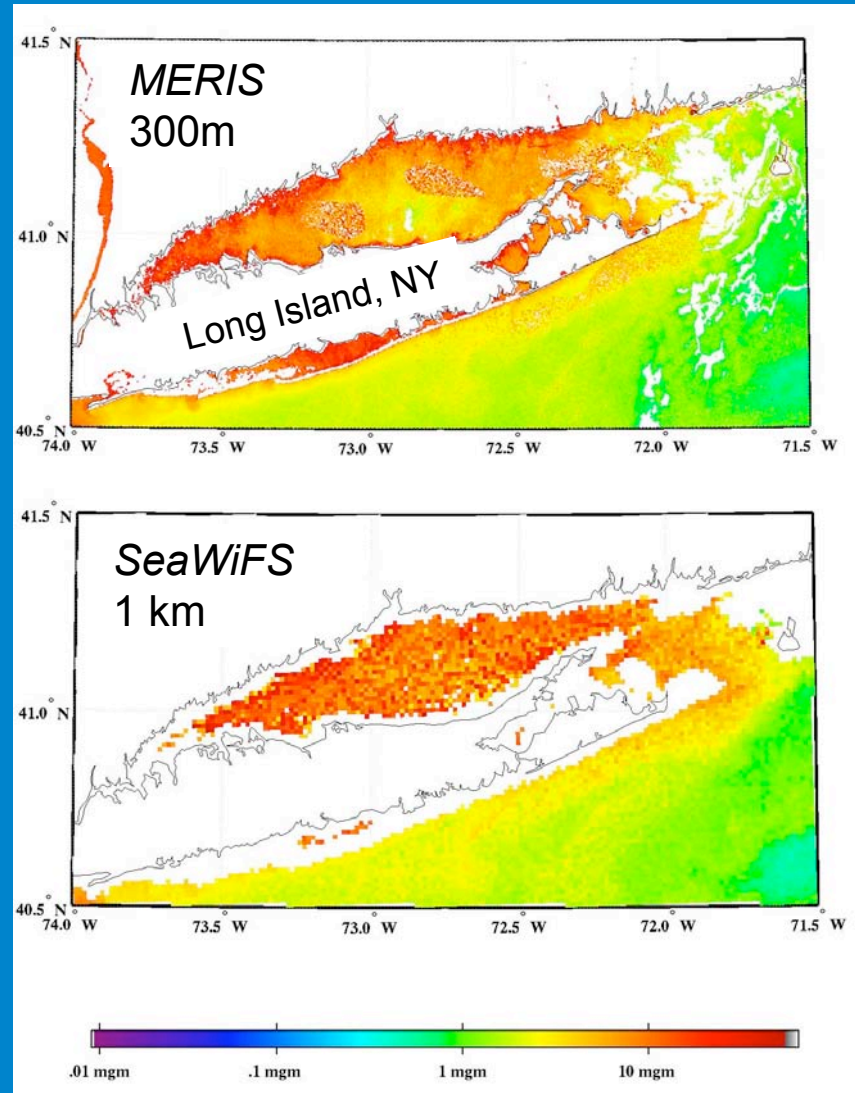


# SAFARI Initiative Showing Fisheries Management Application






Most GEO applications for OCR imagery are for coastal waters.  
Imaging coastal waters requires imagery with pixel resolution  $> 1$  km.

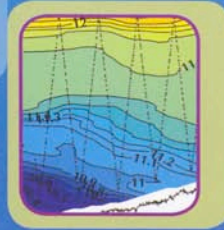


Note the plumes and other structures in the *MERIS* 300-m image not resolved in the 1-km *SeaWiFS* image.

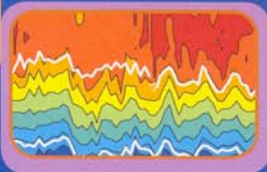
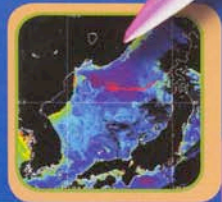


# ALPS

Autonomous and Lagrangian  
Platforms and Sensors



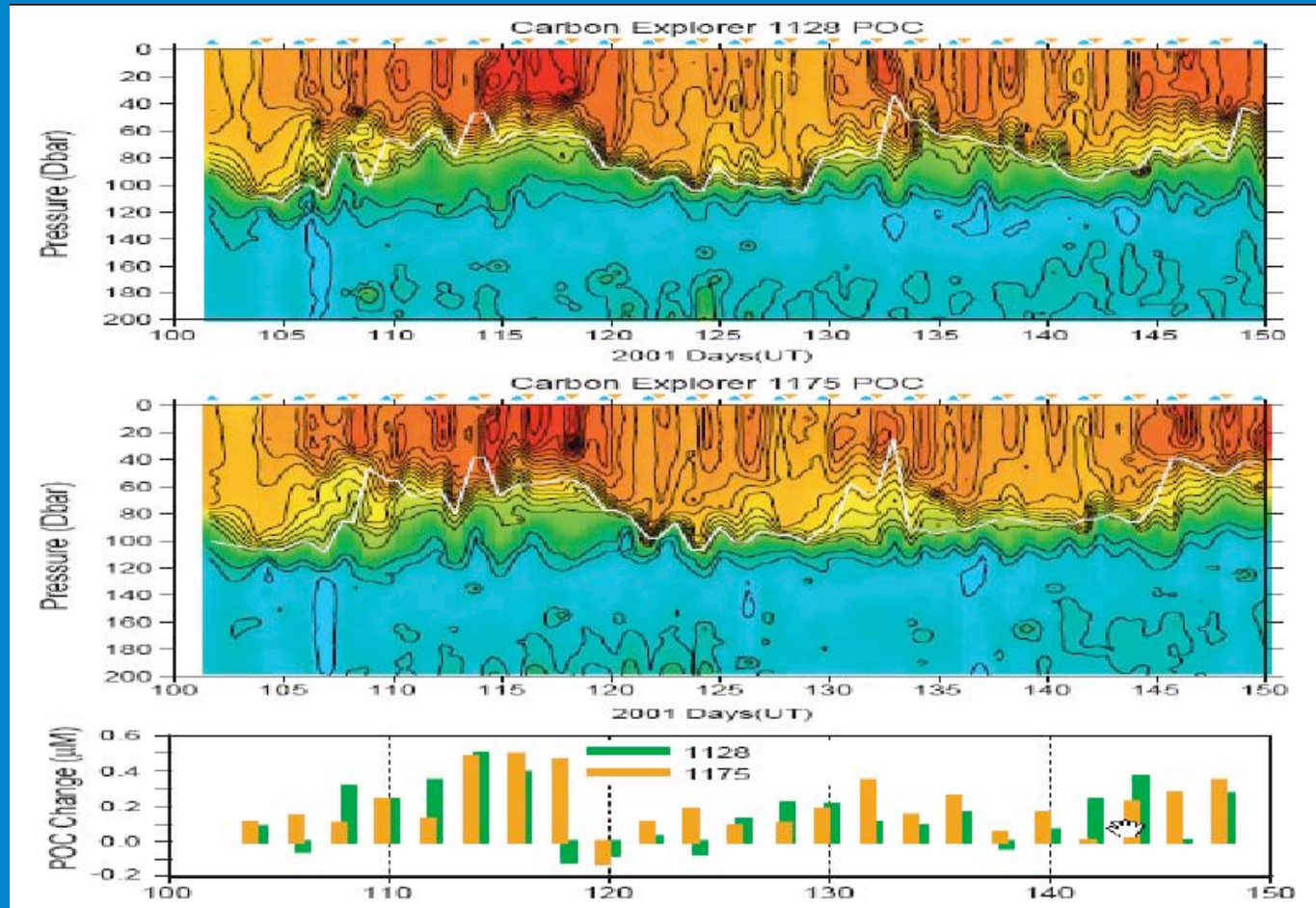
A Report of the Workshop  
Held March 31 - April 2, 2003  
in La Jolla, California



4-D observations  
related to ocean  
biogeochemistry  
and marine  
ecosystems will be  
possible using  
floating platforms  
(gliders or *ARGO*  
bio-floats)  
combined with  
satellite OCR.

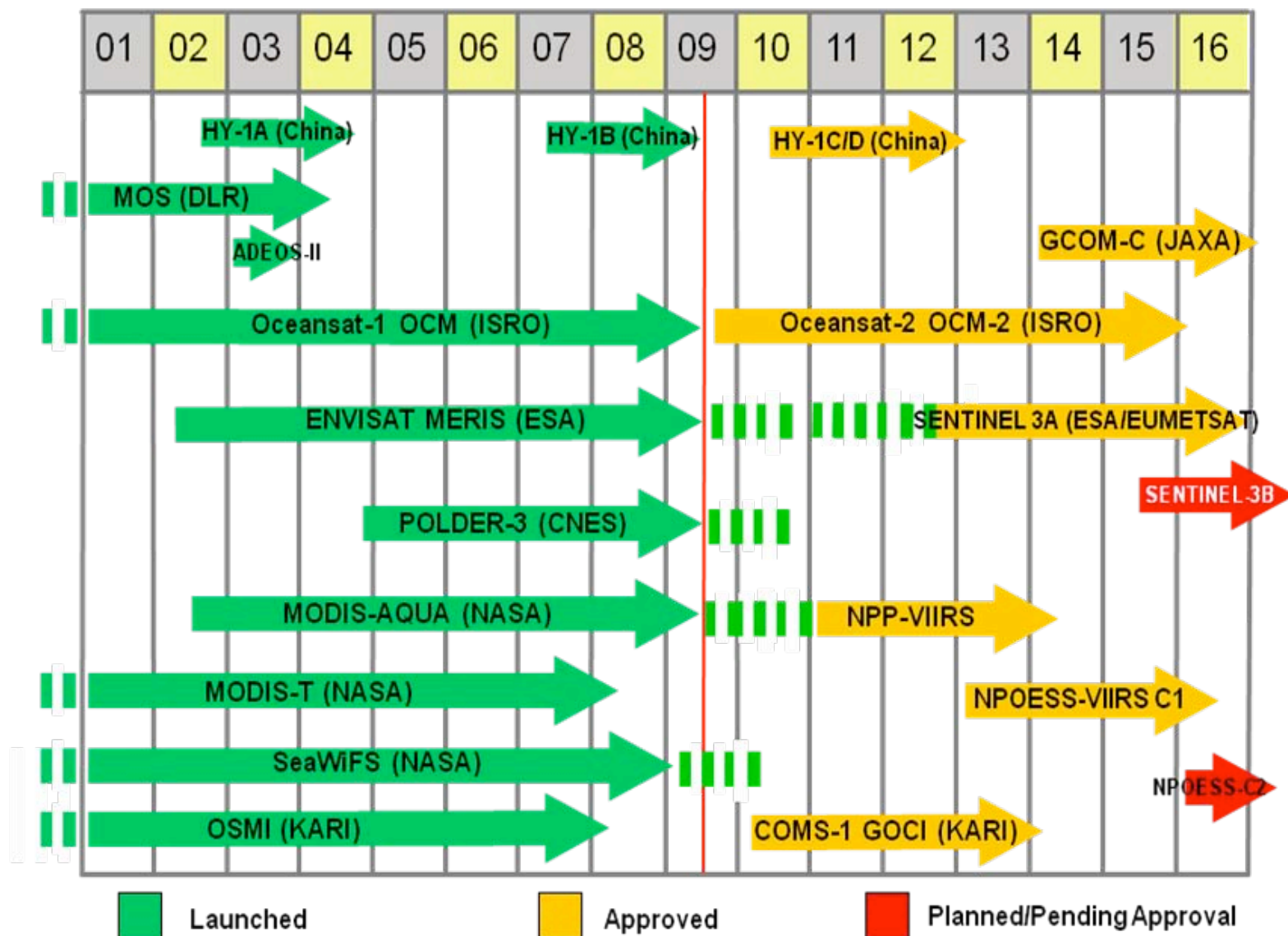
# Particulate Carbon Time Series from ARGO Floats

From Bishop et al. 2002





## Ocean Colour Radiometry Missions





# Conclusions

The decadal+ time series of calibrated, global ocean color radiances from multiple sensors is one of the important developments of our time for the study of ocean ecosystems and biogeochemical cycles.