International Ocean Colour Science Meeting 2013

Advancing Global Ocean Colour Observations

Redefining "Operational" for Satellite Ocean Color data

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Pacific Grove, CA, USA

NASA ➔ NOAA

Research Agency

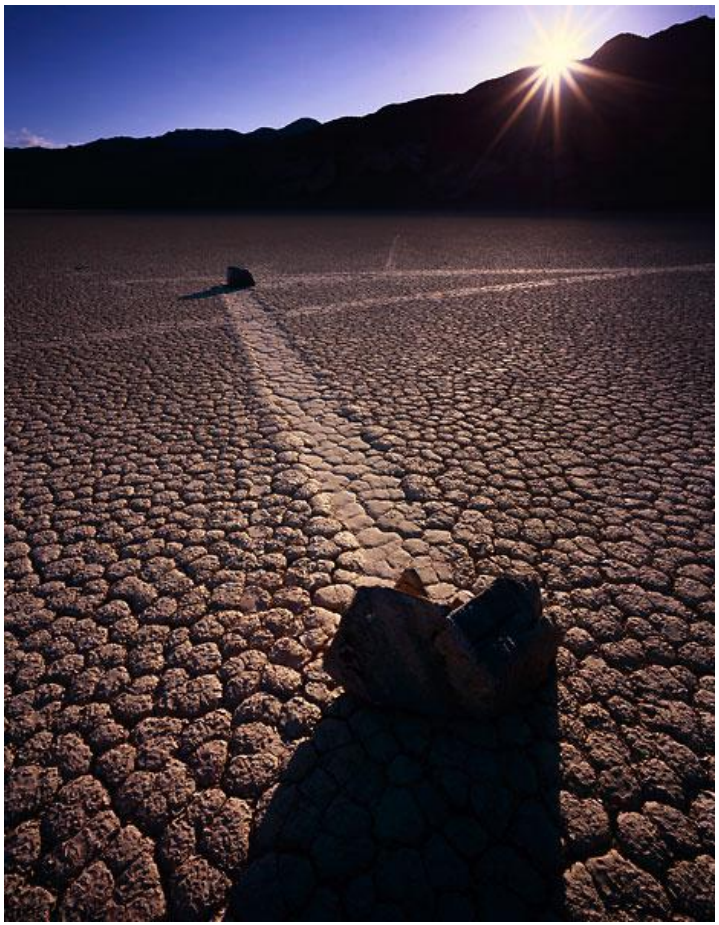
Operational Agency

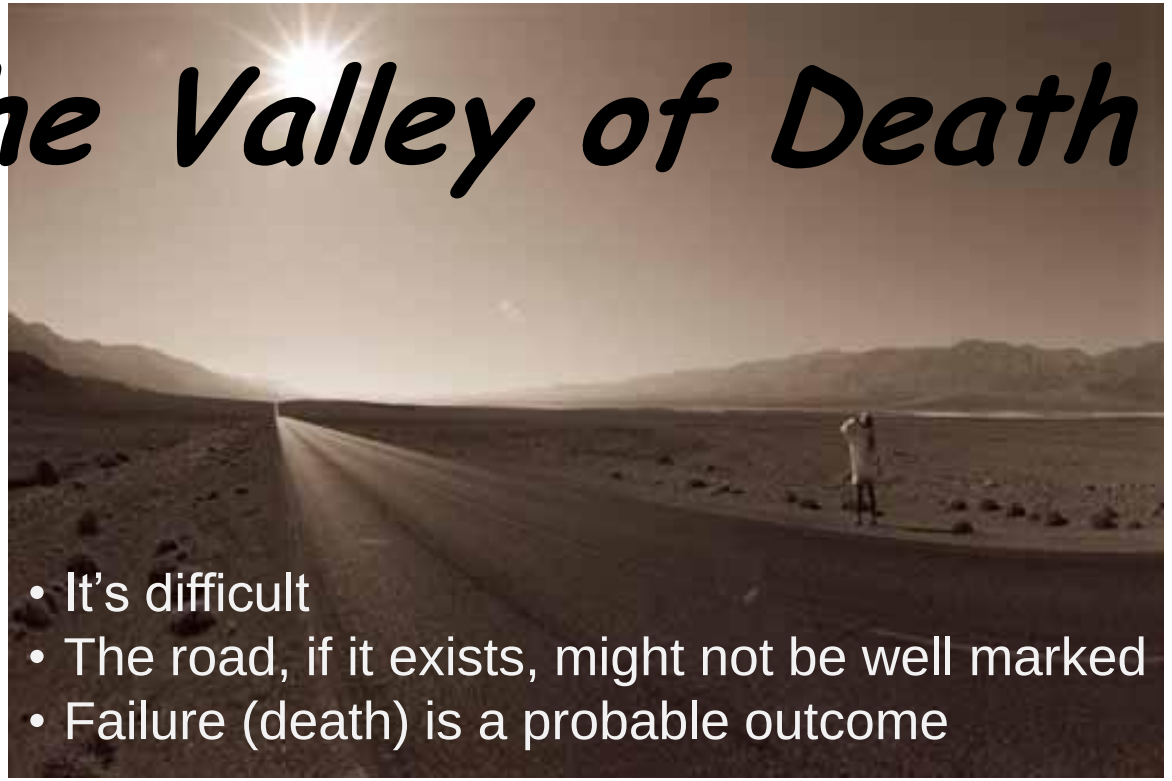
Ocean color
Sea surface height
Surface winds

- NOAA will be taking over the operational acquisition of major satellite measurements such as SSH, **ocean color** and surface winds.
- In support of this, NOAA needs to demonstrate the ***operational use of these data*** within the agency.

Research to Operations (R2O)

Crossing the Valley of Death





- It's difficult
- The road, if it exists, might not be well marked
- Failure (death) is a probable outcome

Bring lots of water!

“Operational”

What does it mean?

1. *relating to, or based on operations*
2. *ready for, or in a condition to undertake, a destined function*

- Merriam-Webster’s Dictionary

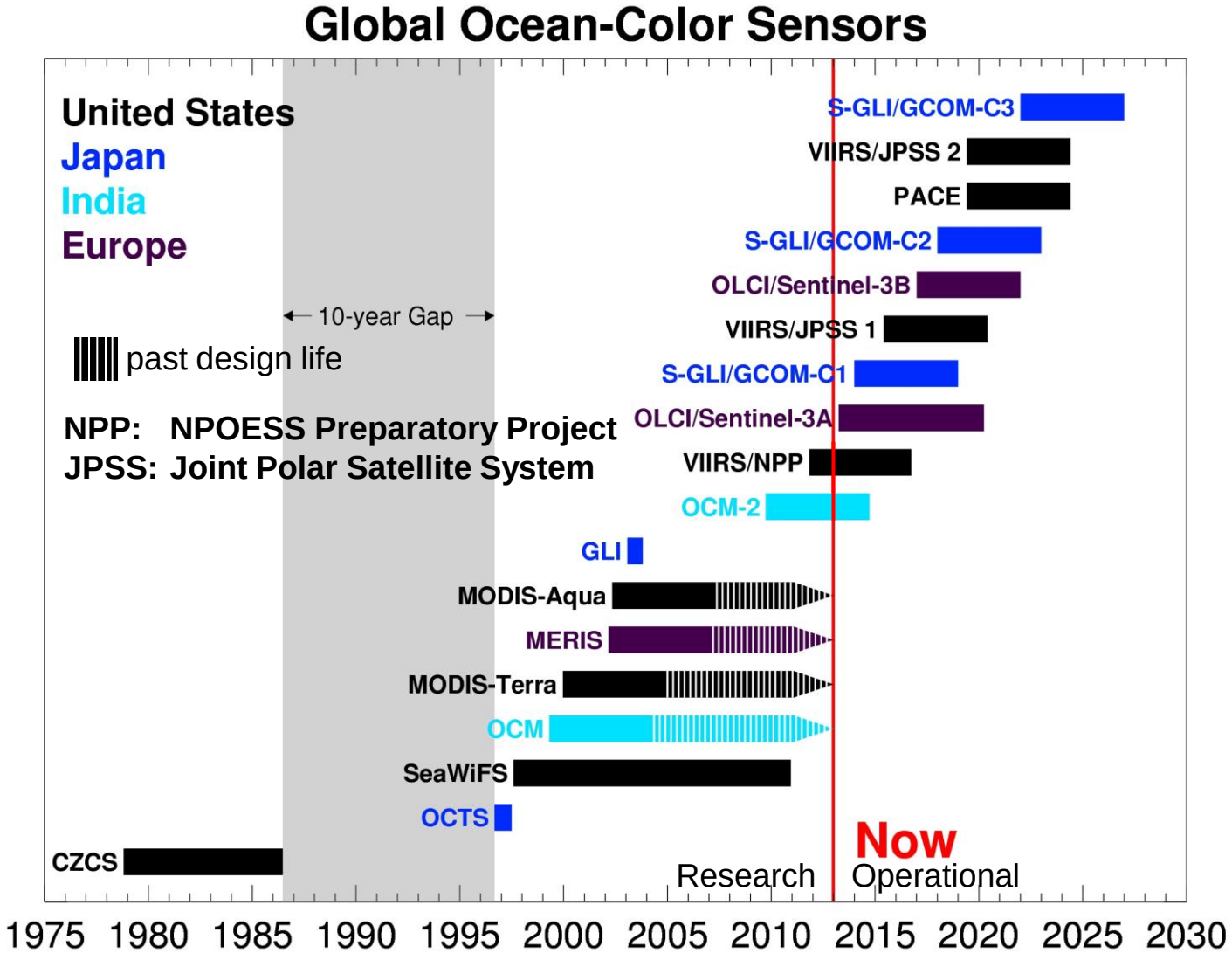
Strict definition is vague at best…

- In the R2O context “operational” is often interpreted as “anything not research”.

Also rather ambiguous…

- In the world of (meteorological) satellite data, “operational” is often assumed to mean a near-real time (NRT) 24/7 application.
- For fisheries and marine resource managers, interannual and decadal timescales are often more relevant than NRT 24/7.
- It is likewise often assumed that “operational” means any quality of data will suffice – this is definitely not the case for ocean color data….

Ocean Color Timeline



Research to Operations (R2O)

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NOAA Overview

- Consists of different line offices:

  NWS **N**ational **W**eather **S**ervice
  OAR **O**ceanic and **A**tmospheric **R**esearch
  NOS **N**ational **O**cean **S**ervice
  NMFS **N**ational **M**arine **F**isheries **S**ervice
  NESDIS **N**ational **E**nvironmental **S**atellite, **D**ata and **I**nformation **S**ervices (within NOAA NESDIS is considered a provider not a user)

- NMFS's mandate:

  NOAA is dedicated to protecting and preserving the nation's living marine resources through scientific research, fisheries management, enforcement and habitat conservation.

NOAA does not help fisherman harvest fish

Operational Fisheries

What does it mean?

One definition:

to utilize oceanographic information to more efficiently harvest fisheries resources

- Kendall & Jackson, Fish. Oceanogr., 1998

But this only takes into consideration one of the three principal aspects of fisheries:

1. Harvesting
2. Assessment
3. Management/Conservation

NOAA only deals with Assessment & Management aspects

Research to Operations (R2O)

How is it playing out for ocean color?

- While the research community is aware of the value of satellite ocean color data and the need for continuity in these measurements, advocacy from the operational community, fisheries management, in particular, has been lacking.
- Satellite ocean color data is currently underutilized in stock assessment & fisheries management.
- With the launch of VIIRS on NPP in Oct 2011, a gap in in the continuity of US ocean color was narrowly avoided. The absence of an easily identifiable operational need for ocean color data was largely responsible for the “almost” gap.

Species composition of CA landings

Environmental Influences?

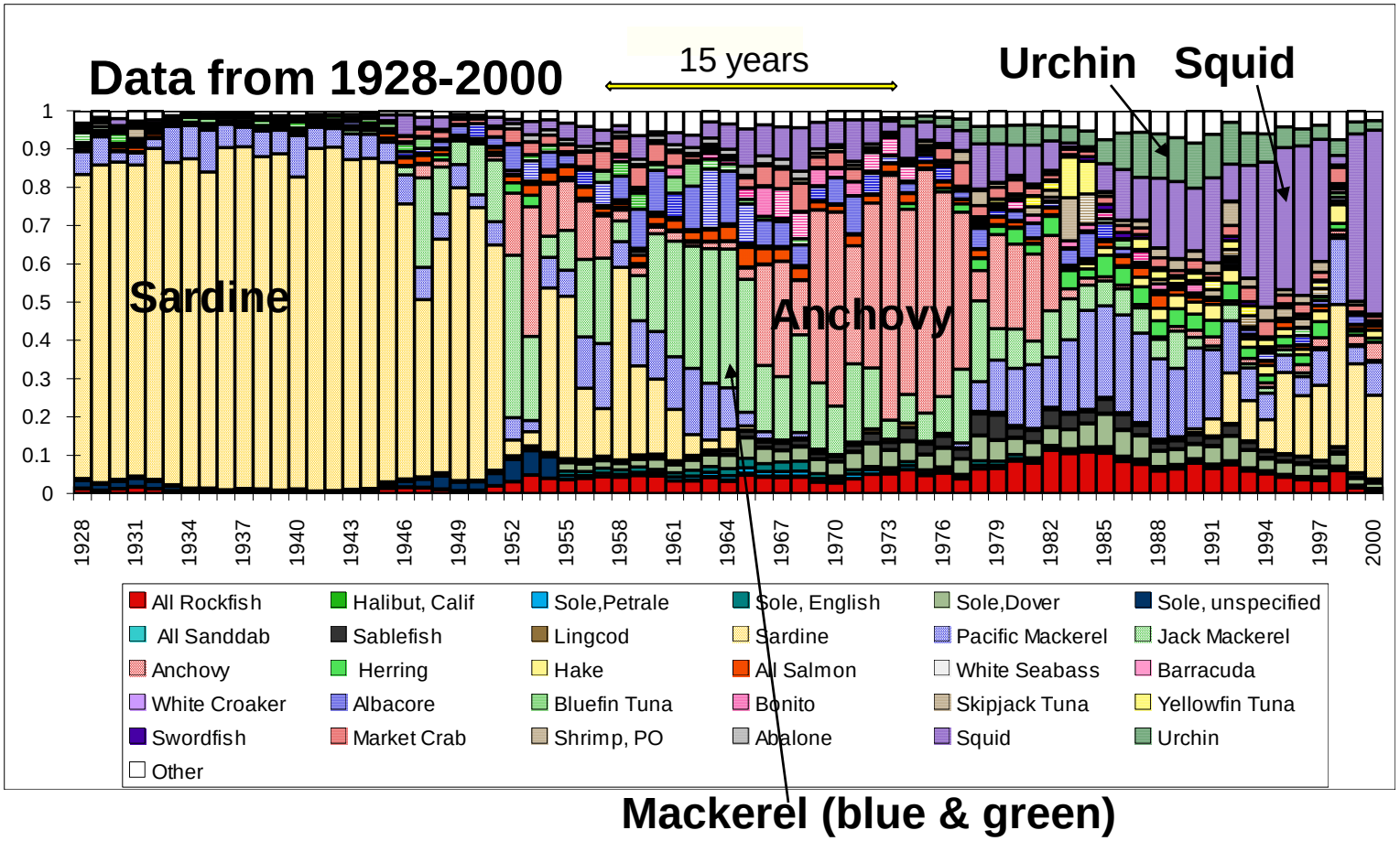

Figure courtesy of Jan Mason, NOAA/NMFS/SWFSC/ERD

Ocean Color Publications

	# Papers	Oceanography		Fisheries	
CZCS	428	208	49%	7	2%
GLI	34	11	32%	0	0%
SeaWiFS	1175	478	41%	24	2%
MERIS	140	14	10%	0	0%
MODIS	361	74	20%	4	1%
OCM	65	19	29%	0	0%
OCTS	64	17	27%	0	0%
Total	**2267**	**821**	**36%**	**35**	**2%**

From Wilson, ICES JMS (2011) Source: ISI Web of Science.
Analysis done 5/19/10

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From Wilson, ICES JMS (2011) Source: ISI Web of Science.
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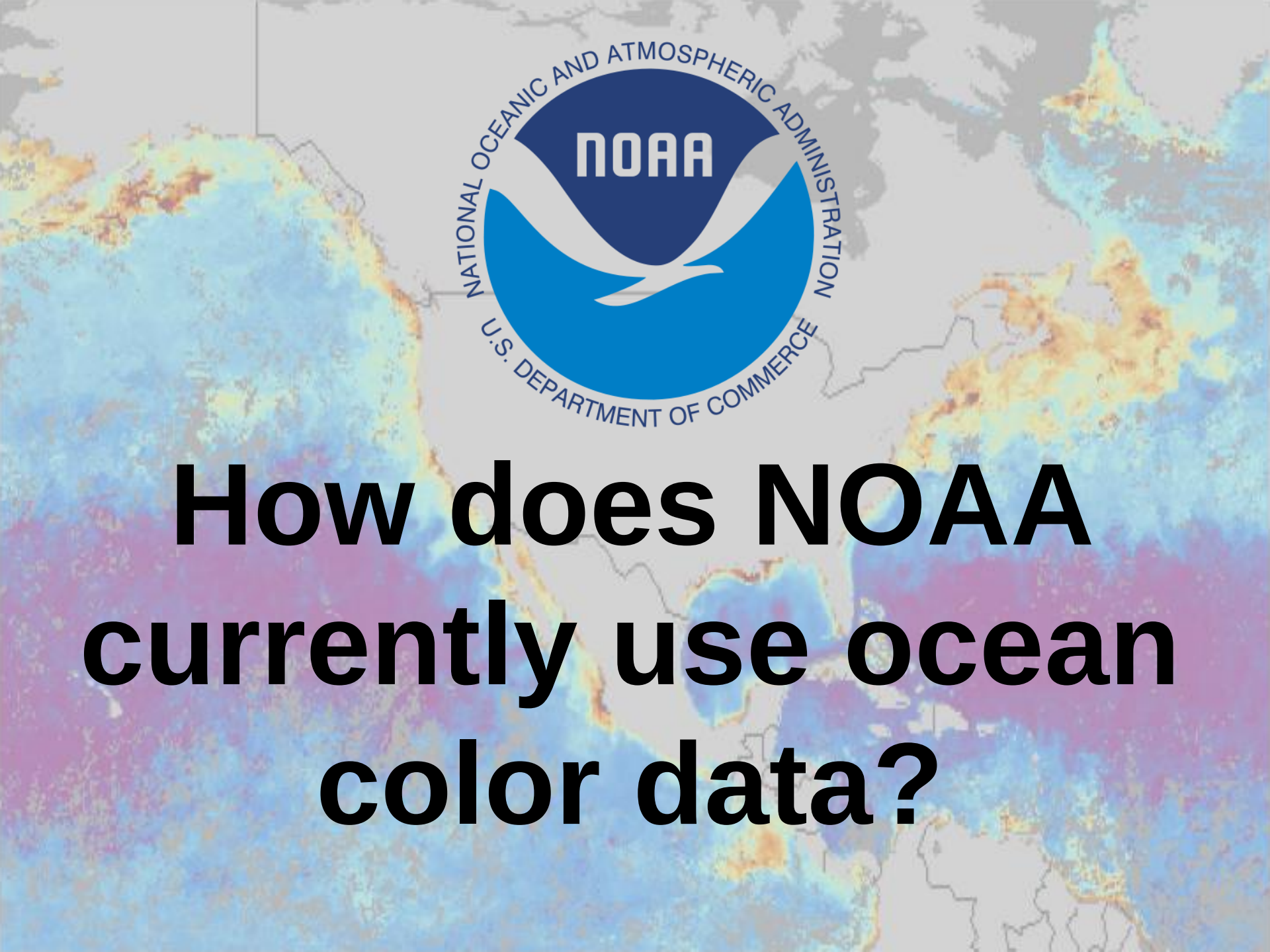


How does NOAA currently use ocean color data?

Harmful Algal Bloom (HAB) detection

NOS

Distributed to Local/State/Federal Government

Page 1

Gulf of Mexico Harmful Algal Bloom Bulletin
21 September 2004
National Ocean Service/NCCOS and CSC
NESDIS/CoastWatch and NDBC
Last bulletin: September 17, 2004

Analysis
HAB Forecast:

No harmful algal blooms have been found along Florida's coast. Recent tropical storms have caused sediment resuspension and non-harmful blooms, which may cause discolored water.

Analysis:

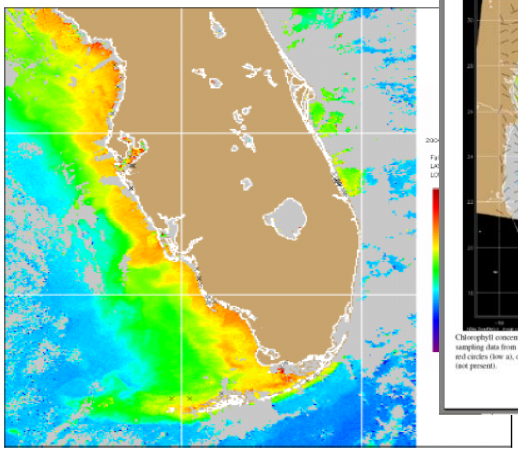
Samples taken last week from southwest Florida near Sarasota, Fort Meyers, and Naples showed no Karenia brevis. Imagery shows elevated chlorophyll along much of Florida's west coast: concentrations over 4 micrograms per liter off Cape San Blas and Cedar Key; over 5 micrograms per liter near Clearwater, Sarasota, Naples; and over 7 micrograms per liter Everglades City.

Winds have favored upwelling in southwest Florida for several days and are forecasted to continue for the rest of the week and through the weekend. These conditions are conducive to HAB formation, so this area should be monitored. Sampling here is recommended. Conditions in the panhandle don't favor HAB formation.

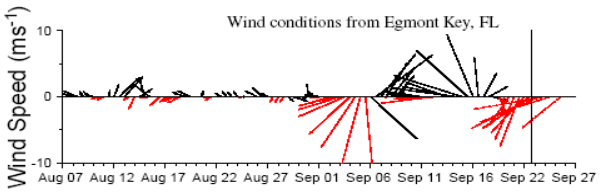
Bronder, Stolz

Please note the following restrictions on all SeaWiFS imagery derived from CoastWatch.

1. These data are restricted to civil marine applications only; i.e. federal, state, and local government use/distribution is permitted .
2. Distribution for military, or commercial purposes is NOT permitted.
3. There are restrictions on Internet/Web/public posting of these data.
4. Image products may be published in newspapers. Any other publishing arrangements must receive OrbImage approval via the CoastWatch Program.



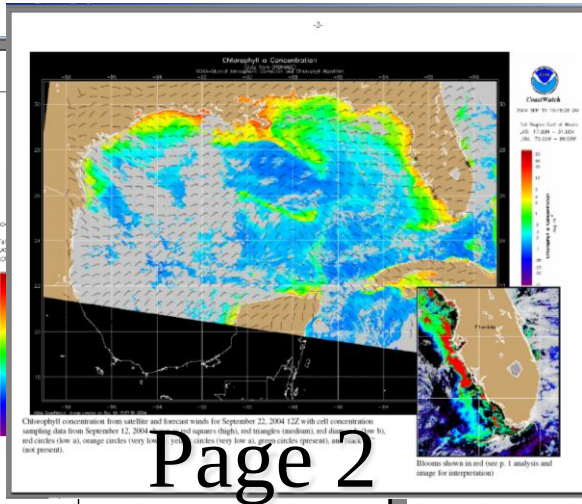
Chlorophyll concentration from satellite with possible HAB areas shown by red polygon(s). Cell concentration sampling data from September 12, 2004 shown as red squares (high), red triangles (medium), red diamonds (low b), red circles (low a), orange circles (very low b), yellow circles (very low a), green circles (present), and black "X" (not present).



Wind speed and direction are averaged over 12 hours from measurements made on buoys. Length of line indicates speed; angle indicates direction. Red indicates that the wind direction favors upwelling near the coast. Values to the left of the dotted vertical line are measured values; values to the right are forecasts.

Southwest Florida: Winds have been northeasterly for the past few days, and are forecasted to shift to easterly then northeasterly over the next couple of days. The NWS Marine Forecast calls for easterly winds until Thursday, then northeasterly winds over the weekend. Florida Panhandle: Winds have been northeasterly for the past few days, and are forecasted to become easterly for the next couple of days.

Page 2



Courtesy of Rick Stumpf, NOS

Tagging Studies

NMFS

Electronic tagging is a key methodology used by NOAA Fisheries to gather information on stock productivity and recruitment, fish behavior, feeding ecology and habitat selection – information needed for accurate and responsible fisheries management[1]

Satellite data, such as ocean color, SST, SSH and SVW, are necessary to place the telemetric data from tags in an environmental context as part of the transition to an ecosystem approach to management.

[1]Report of the NMFS Workshop on advancing electronic tag technologies and their use in stock assessment. NOAA Tech. Memo. NMFS-F/SPO-82, 82 pp, 2007.

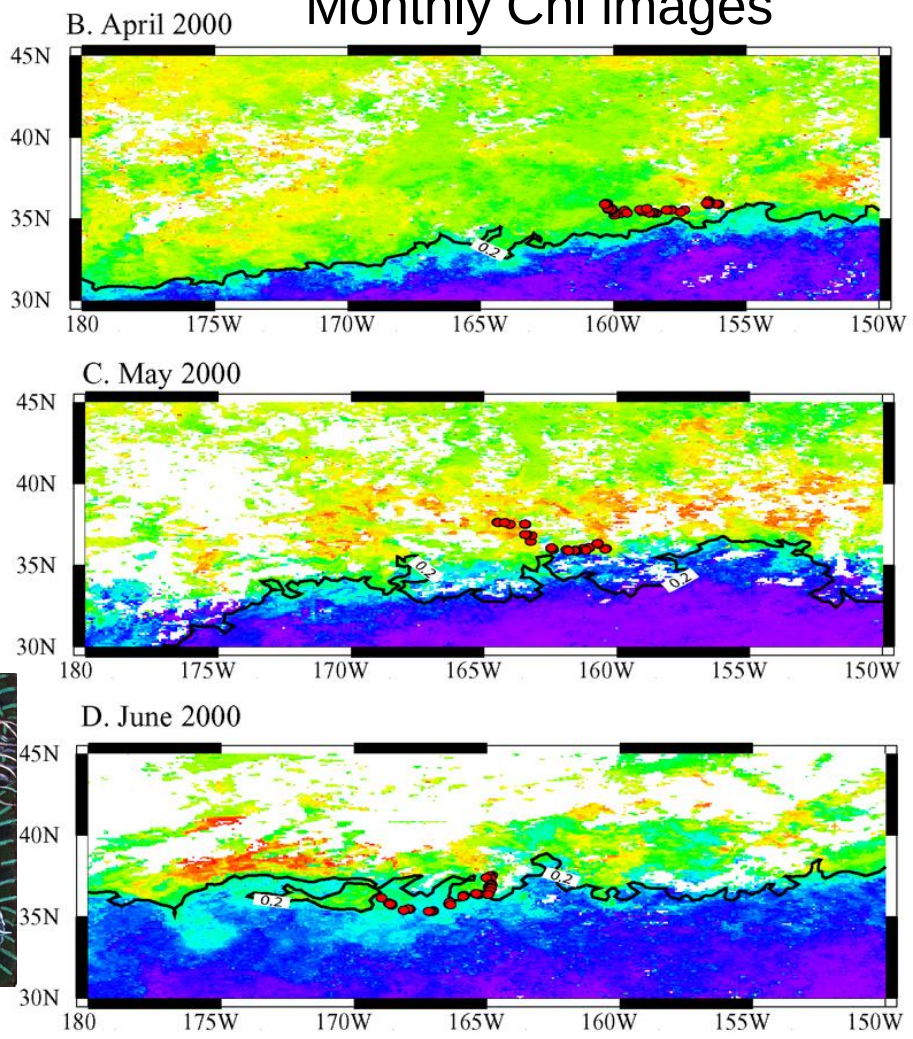
http://spo.nmfs.noaa.gov/tm

Habitat - TZCF

NMFS/PIFSC

The Transitional Zone Chlorophyll Front (TZCF) provides important habitat to sea turtles. Monitoring its seasonal and interannual variability is crucial to better understand the environmental influences on these endangered species. [Polovina et al, 2001; Baker et al., 2007]

Monthly Chl images



artwork © Ray Troll

Turtle locations

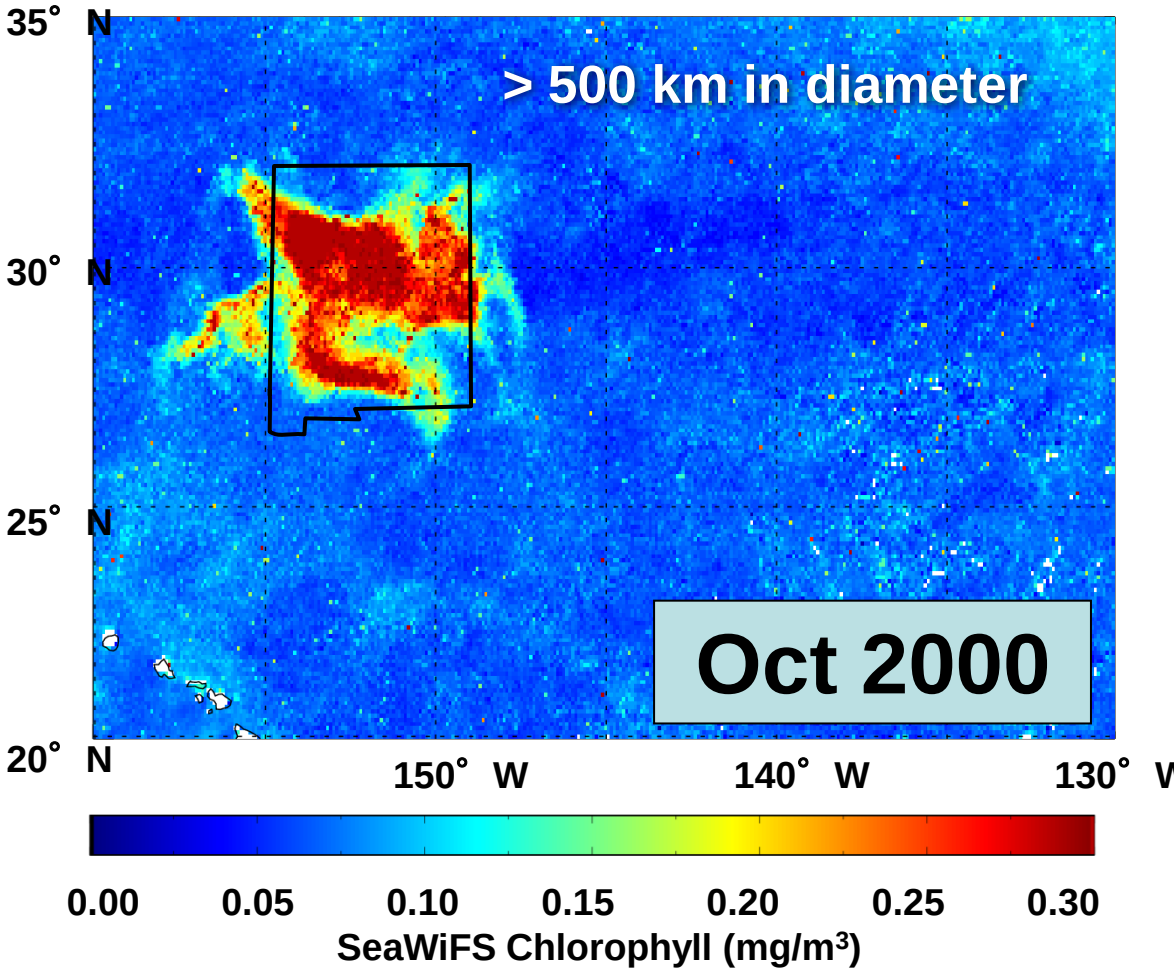
Discovering Habitat

NMFS/SWFSC

Large recurrent chlorophyll blooms discovered with satellite data in the middle of the oligotrophic Pacific gyre.

The blooms occur within the target area of several fisheries, including albacore and swordfish, but their impact on higher trophic levels is not known.

artwork © Ray Troll

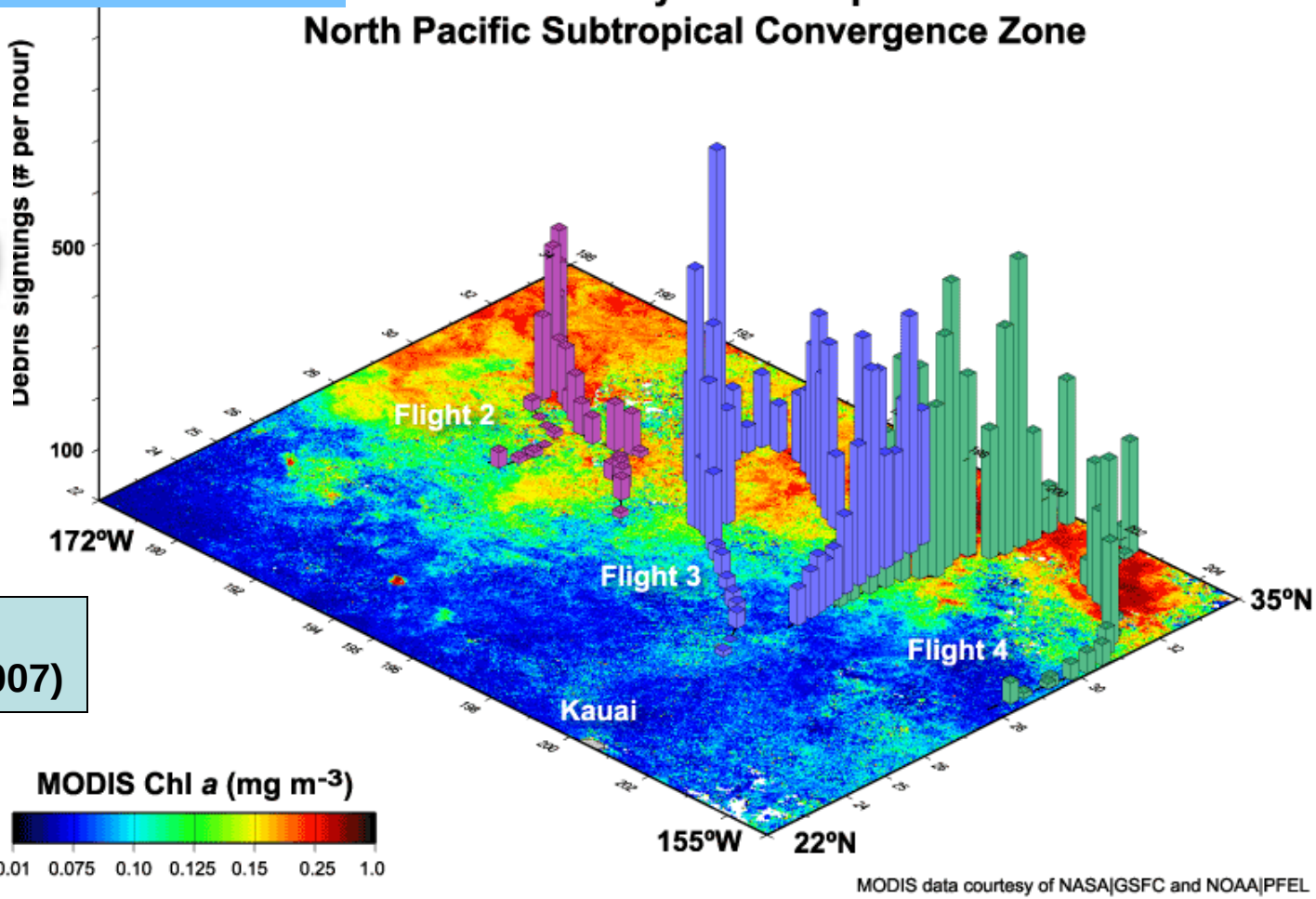


[Wilson, GRL, 2003; Wilson et al., JMS, 2008; Wilson, GRL, 2011]

Ghostnet Results

OAR & NMFS/SWFSC

Ghostnet Surveys March/April 2005
North Pacific Subtropical Convergence Zone



Pichel et al.,
Mar. Pollut. Bull. (2007)

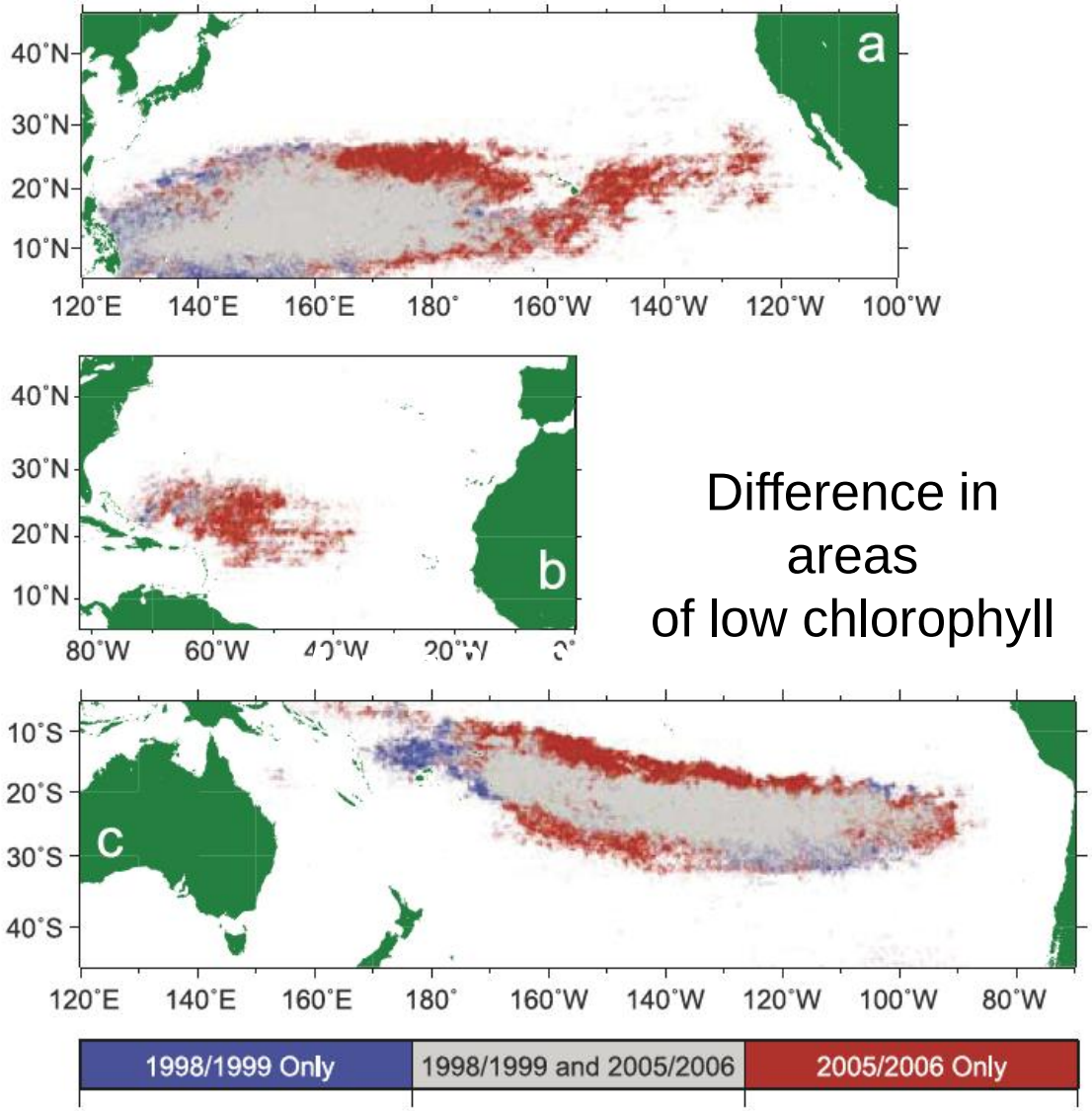
MODIS data courtesy of NASA|GSFC and NOAA|PFEL

Monitoring long-term ocean variability

NMFS/PIFSC

Analysis of 9 years of SeaWiFS data shows regions of lowest chlorophyll in all oceans is expanding (the red areas). This expansion is consistent with global warming scenarios based on increased vertical stratification in the mid-latitudes, but the rates of expansion observed exceed recent model predictions.

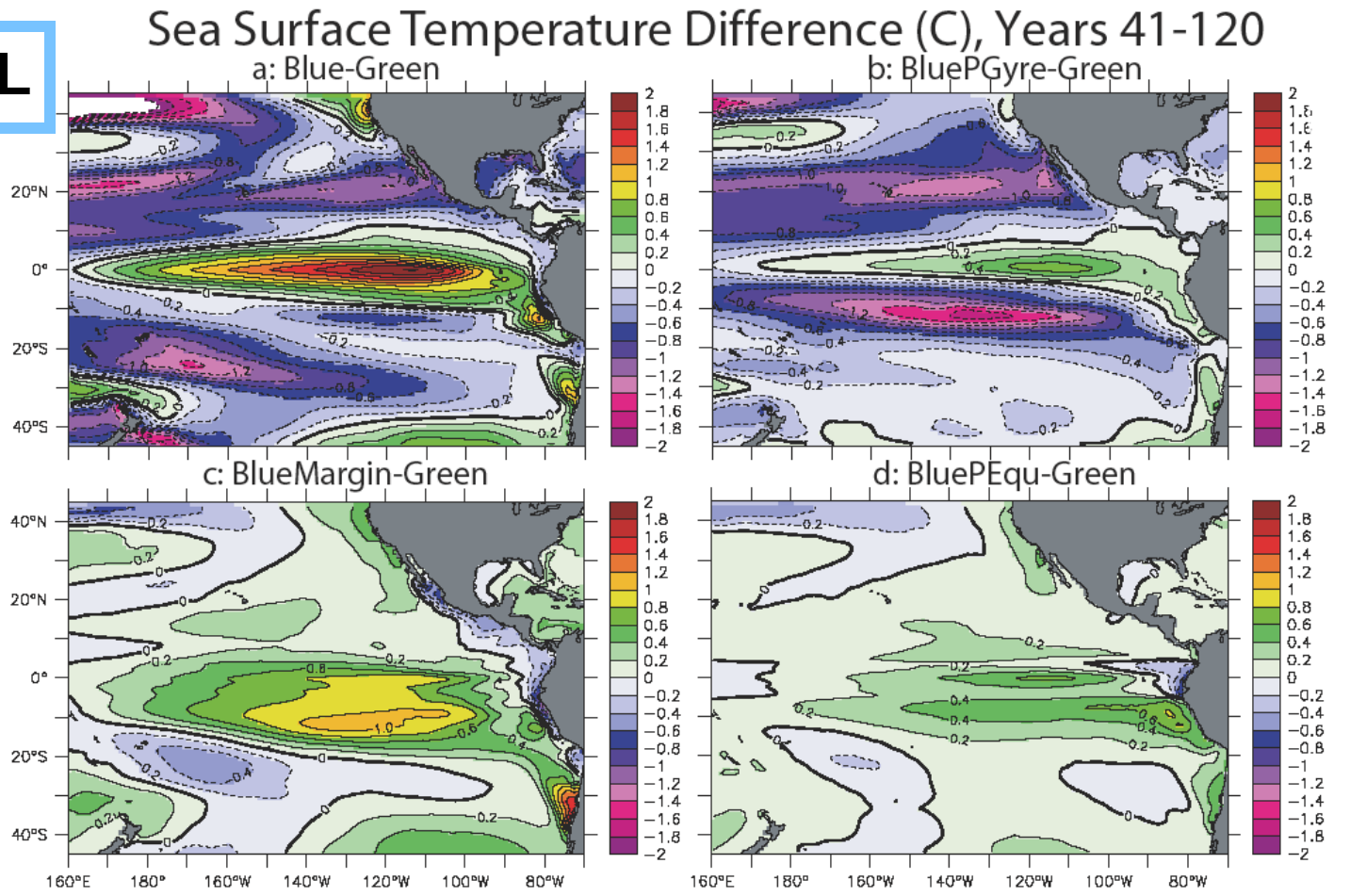
Polovina et al., *GRL*., 35, 2008.



Difference in areas of low chlorophyll

Understanding climate

OAR/GFDL



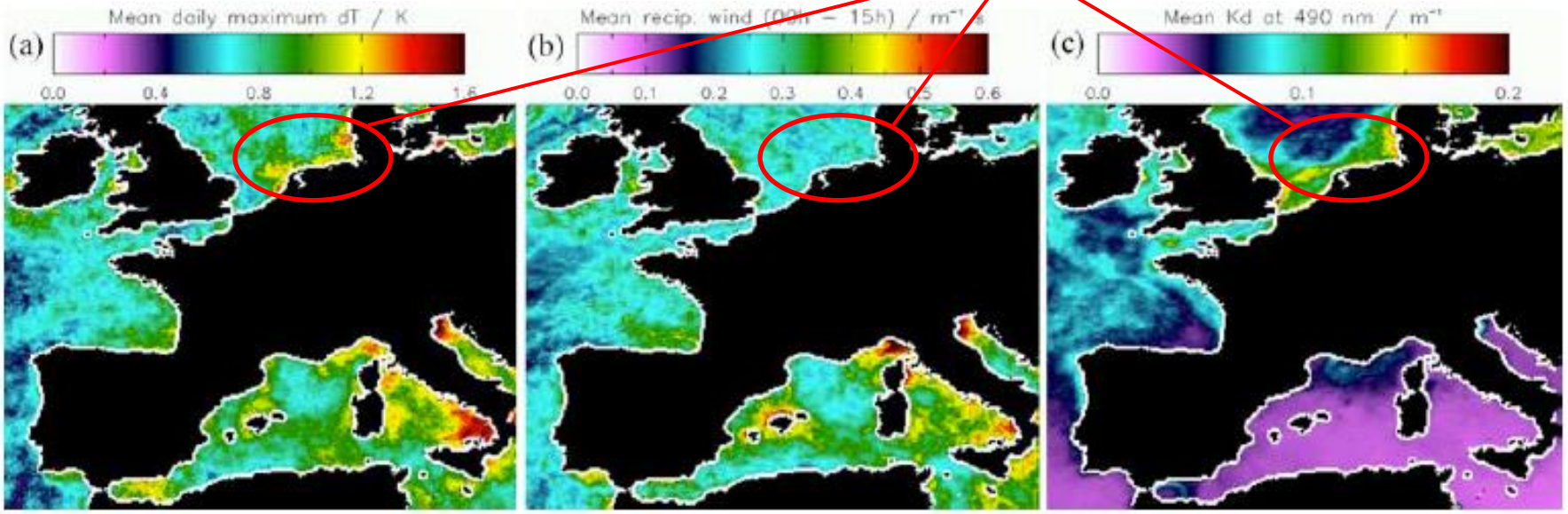
Anderson et al., *Ocean Science*, 5, 313–327, 2009.

Shown are OGCM-simulated long-term SST changes resulting from permanently clarifying the seawater (a) globally, (b) only in low-chlorophyll regions, (c) only in high-chlorophyll regions, and (d) only near the equator.

Influences on Diurnal SST Variability

- NOAA developing improved diurnal warming models for application to multi-sensor SST products
- Large warming events in some regions significantly correlated with ocean color variations

Diurnal variations better explained by variations in diffuse attenuation coefficient than wind speed



Merchant et al., *GRL*, 35, 2008.

Monitoring oceanic hydrothermal activity

OAR/PMEL

South Sarigan seamount erupted May 29, 2010

minimum depth ~184 m

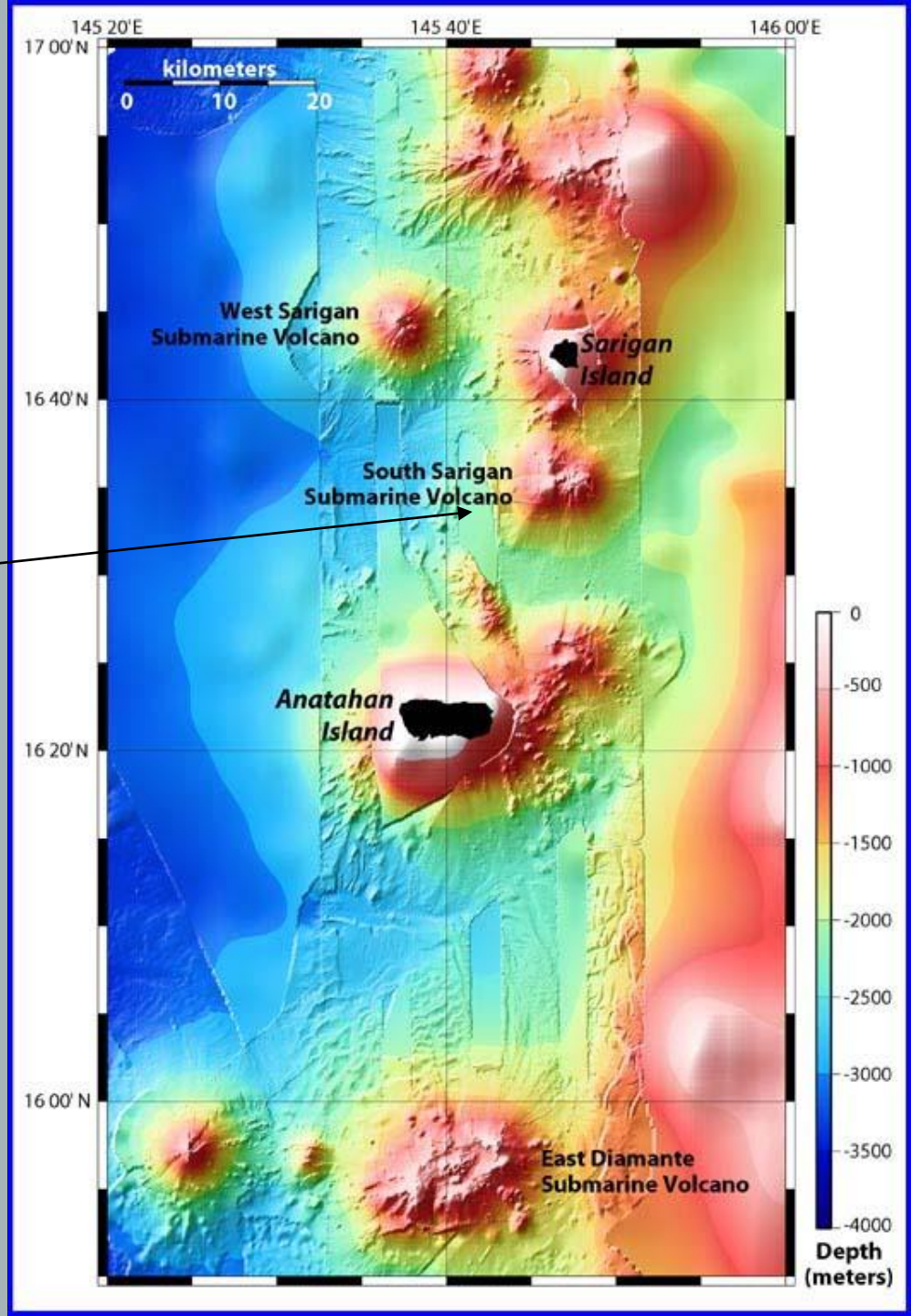


Figure courtesy of NOAA Ocean Explorer Submarine Ring of Fire 2003, Mariana Arc expedition

http://oceanexplorer.noaa.gov/explorations/03fire

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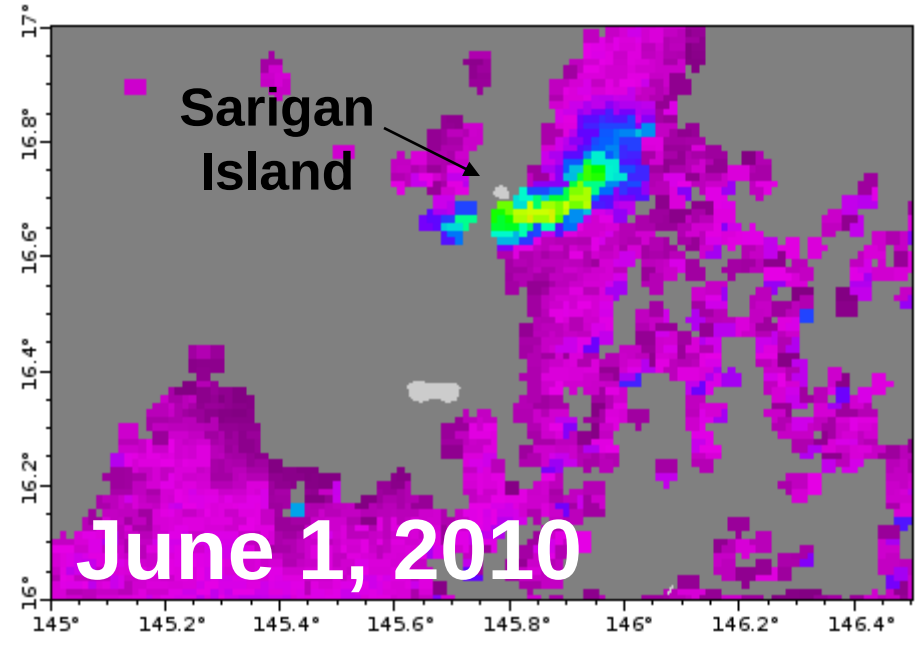
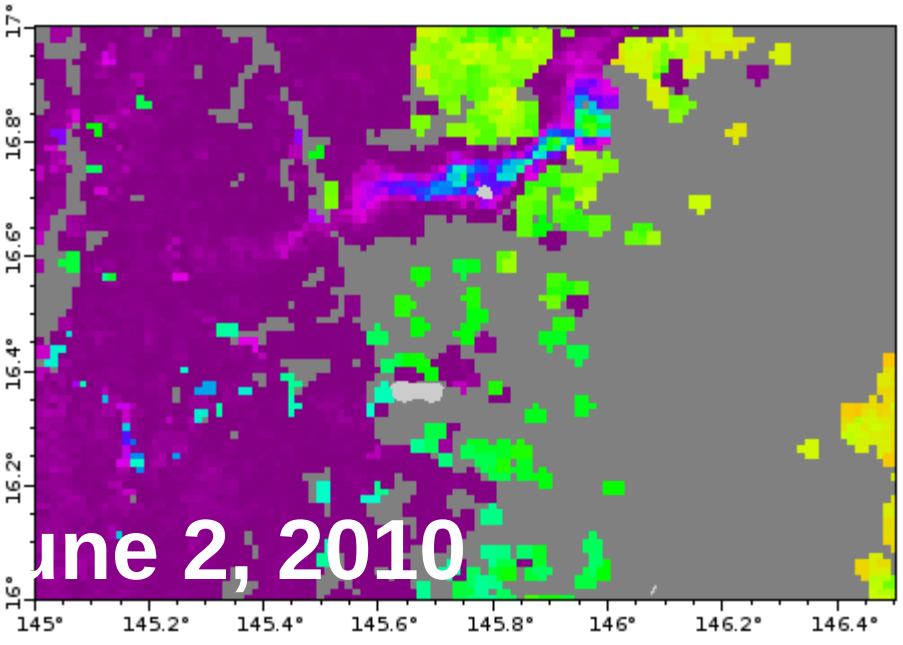
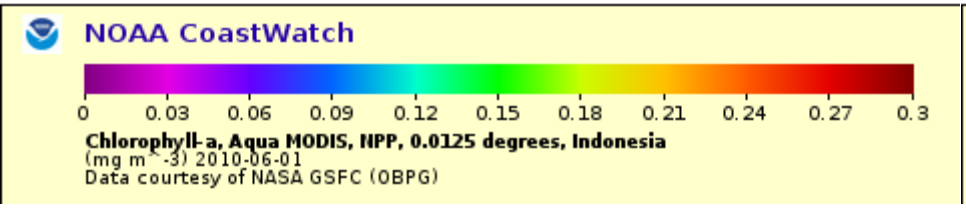
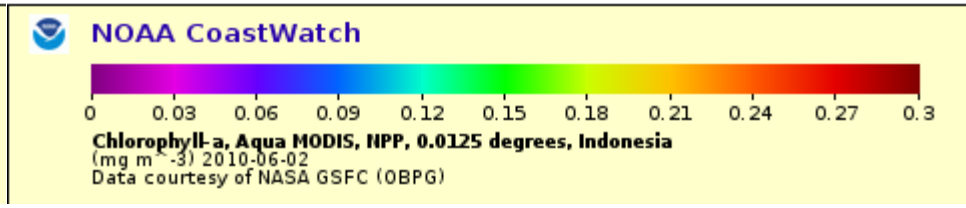


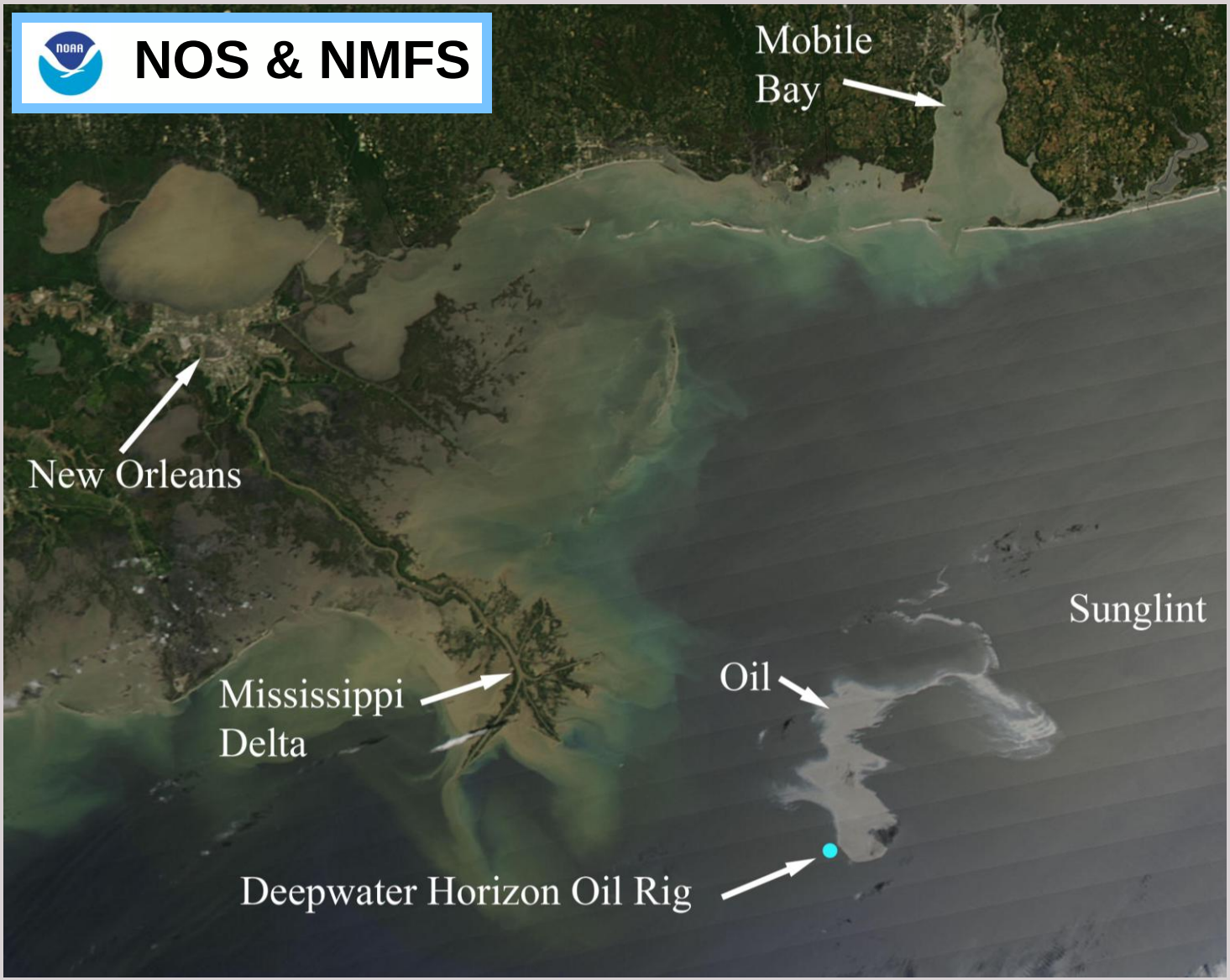






Haxel and Merle, OAR/PMEL, data from NOAA CoastWatch WCRN

Event Monitoring - Deep Water Horizon Oil Spill: True color imagery from MODIS et al. was invaluable



MODIS 250 m image of spill 04/25/10

VIIRS Data now accessible via ERDDAP and with EDC for ArcGIS

Cara Wilson[1], Bob Simons[1], Dave Foley[1,2] and Roy Mendelssohn[1]

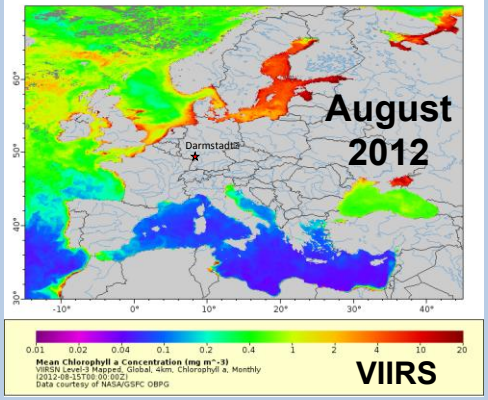
cara.wilson@noaa.gov

[1]NOAA/NMFS/SWFSC/Environmental Research Division (ERD), Pacific Grove, CA, USA

[2]Institute of Marine Sciences, University of California Santa Cruz, Santa Cruz, CA, USA

VIIRS

VIIRS (Visible Infrared Imaging Radiometer Suite) is the latest US ocean color satellite. It was launched October 28, 2011 on the Suomi NPP (National Polar-orbiting Partnership) satellite, a joint NASA-NOAA mission.



ERDDAP: Easier Access to Scientific Data

Environmental Research Division's Data Access Program

http://coastwatch.pfeg.noaa.gov/erddap/

(or google "ERDDAP ERD")

- Allows a consistent way to get data from a variety of different datasets and data sources. In addition to the VIIRS chla data, ERD's ERDDAP serves other satellite datasets such as SeaWiFS, MODIS chl, multiple SST datasets, QuikScat & ASCAT wind vectors, Aquarius salinity data, as well as non-satellite datasets (ie ARGO floats, NDBC buoys)
- Multiple data formats are available (ncdf, grib, csv, ESRIcsv, JSON, DDVtext, mat, text and more)
- Multiple image files formats are available (png, transparent png, pdf, kml)
- Allows temporal and spatial subsetting
- ERDDAP is "RESTful", meaning the URL completely defines the data you want, in the format you want. For example, the the graphic on the left is produced by the URL below:

dataset name | format | date | longitude | latitude

http://coastwatch.pfeg.noaa.gov/erddap/griddap/erdVHchlamday.png?chla[(2012-08-15T00:00:00Z)][(70):(30)][(-15):(45)]&.draw=surface&.vars=longitude|latitude|chla&.colorBar=||Log|.01|20|

Changing .png in the above URL to .mat will download the data in a malab formatted file

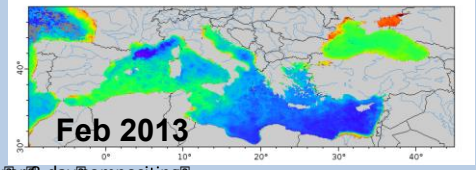
Changing .png in the above URL to .ncdf will download the data in a netCDF file

Changing .png in the above URL to .graph will generate a webpage where the image can be modified

Changing .png in the above URL to .html will generate a webpage where a chunk of the data can be downloaded

Changing 2012-08-15T00:00:00Z in the above URL to (last) will generate the image with the most recent data

Changing erdVHchlamday in the above URL to erdVHchla1day or erdVHchla8day will generate the image with 1-day or 8-day compositing



MAKING DATA ACCESS EASIER...

Poster Session - Applications, Users Services & Products

Summary

NOAA's usage of Ocean Color data

- HAB detection and monitoring (NOS)
- characterizing habitat of living marine resources (NMFS)
- oil spill detection & monitoring (NOS, NMFS)
- marine debris detection (NMFS, OAR)
- ecosystem-based fisheries management (NMFS)
- detecting surface expression of hydrothermal activity (OAR)
- quantifying temporal variability (NMFS, OAR)

Take Home Points

- **For many ocean color operational applications, interannual and decadal timescales are more relevant than NRT 24/7.**
  Meaning it is imperative that climate quality records (CDRs) of ocean color data be generated and maintained, which requires:
  - calibration/validation
  - on-orbit maneuvers
  - reprocessing
- **Operational uses of ocean color data may seem like "research"**
  But they are not!
- **Easy and efficient data distribution & access are critical**

Reprints Available

ICES Journal of Marine Science (2011), 68(4), 677–686. doi:10.1093/icesjms/fsq168

The rocky road from research to operations for satellite ocean-colour data in fishery management

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Wilson, C. 2011. The rocky road from research to operations for satellite ocean-colour data in fishery management. – ICES Journal of Marine Science, 68: 677–686.

Received 11 February 2010; accepted 4 September 2010; advance access publication 17 November 2010.

The aim of the SAFARI project is to accelerate the assimilation of earth-observation data into fisheries research and management by facilitating the application of rapidly evolving satellite technology. This assumes that these data will be available in future. However, for ocean-colour data, that assumption may not hold because of possible gaps in data continuity. Of the many types of satellite data, ocean colour is the most important to fisheries, because it is the only biological measurement. However, current ocean-colour sensors are all operating beyond their planned design life, and there are potential problems with future launches. Although the research community is aware of the value of satellite ocean-colour data, advocacy from the operational community, fishery management in particular, has been lacking. In the United States, the absence of an easily identifiable operational need for ocean-colour data is largely responsible for the likely gap in data continuity. A range of current and potential operational uses of ocean-colour data, some reasons why these data have been underutilized in fishery management, and what can be done to mitigate them are discussed and outlined.