Redefining "Operational" for Satellite Ocean Color data

Cara Wilson

NOAA/NMFS/SWFSC
Environmental Research Division (ERD)
Pacific Grove, CA, USA
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….
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.
**NOAA Overview**

- Consists of different line offices:
  - NWS National Weather Service
  - OAR Oceanic and Atmospheric Research
  - NOS National Ocean Service
  - NMFS National Marine Fisheries Service
  - NESDIS National Environmental Satellite, Data and Information Services (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_
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

<table>
<thead>
<tr>
<th></th>
<th># Papers</th>
<th>Oceanography</th>
<th>Fisheries</th>
</tr>
</thead>
<tbody>
<tr>
<td>CZCS</td>
<td>428</td>
<td>208</td>
<td>7</td>
</tr>
<tr>
<td>GLI</td>
<td>34</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>SeaWiFS</td>
<td>1175</td>
<td>478</td>
<td>24</td>
</tr>
<tr>
<td>MERIS</td>
<td>140</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>MODIS</td>
<td>361</td>
<td>74</td>
<td>4</td>
</tr>
<tr>
<td>OCM</td>
<td>65</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>OCTS</td>
<td>64</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2267</strong></td>
<td><strong>821</strong></td>
<td><strong>35</strong></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th># Papers</th>
<th>Oceanography</th>
<th>&quot;Fish&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>CZCS</td>
<td>428</td>
<td>208</td>
<td>8</td>
</tr>
<tr>
<td>GLI</td>
<td>34</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>SeaWiFS</td>
<td>1175</td>
<td>478</td>
<td>32</td>
</tr>
<tr>
<td>MERIS</td>
<td>140</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>MODIS</td>
<td>361</td>
<td>74</td>
<td>3</td>
</tr>
<tr>
<td>OCM</td>
<td>65</td>
<td>19</td>
<td>8</td>
</tr>
<tr>
<td>OCTS</td>
<td>64</td>
<td>17</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>2267</td>
<td>821</td>
<td>54</td>
</tr>
</tbody>
</table>

From Wilson, ICES JMS (2011)  Source: ISI Web of Science. Analysis done 5/19/10
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.
How does NOAA currently use ocean color data?
Harmful Algal Bloom (HAB) detection

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.

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.

Breder, Stutz

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 conditions from Egmont Key, FL

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


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

[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


MODIS data courtesy of NASA/GSFC and NOAA/PFEL
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.

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

Monitoring oceanic hydrothermal activity

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
South Sarigan seamount erupted May 29, 2010.

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.
VIIRS data now accessible via ERDDAP and with EDC for ArcGIS

Cara Wilson¹, Bob Simons¹, Dave Foley¹,² and Roy Mendelssohn¹

cara.wilson@noaa.gov

¹NOAA/NMFS/SWFSC/Environmental Research Division (ERD), Pacific Grove, CA, USA
²Institute of Marine Sciences, University of California Santa Cruz, Santa Cruz, CA, USA

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 dataset and data sources. In addition to the VIIRS chl 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, ESRcsv, JSON, ODVtext, 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 graphic on the left is produced by the URL below:

http://coastwatch.pfeg.noaa.gov/erddap/griddap/erdVHChlamday.png?chlal[(2012-08-15T00:00:00Z)][(70:35)][(-15:45)]&.draw=surface&.vars=longitude,latitude,chlal&.colorBar=|Log|0.01|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 grang 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
The rocky road from research to operations for satellite ocean-colour data in fishery management

Cara Wilson*

*Corresponding Author: tel: +1 831 648 5337; fax: +1 831 648 8440; e-mail: cara.wilson@noaa.gov.


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.