HOW SATELLITE OCEAN COLOR CAN AID OUR UNDERSTANDING OF OCEAN ACIDIFICATION

National Oceanic & Atmospheric Association (NOAA)

Ocean Acidification Program Office

Dwight Gledhill, NOAA OAP Deputy Director

http://www.oceanacidification.noaa.gov/
Ocean Acidification


120 GT1
≈ 1/2 of fossil-fuel & cement-manufacturing emissions
Ocean Acidification

\[ \text{CO}_2_{\text{gas}} + \text{H}_2\text{O} \rightarrow H^+ + \text{HCO}_3^- \]

\[ H^+ + \text{CO}_3^{2-} \rightarrow \text{HCO}_3^- \]

![Graph showing pH and Carbon Dioxide concentration over time](image)

Hawaii Ocean Time-series (HOT)
How significant are these changes?

Idealized diversity trajectories of selected calcareous and organic fossil lineages.

- Organic-walled dinocysts
- Calcareous nanofossils
- Planktic foraminifers
- Benthic foraminifers
- Shallow reef builders

**Time (My):**
- Deglaciation
- PETM
- Cretaceous asteroid impact
- Toarcian OAE
- End-Triassic mass extinction
- End-Permian mass extinction

Source: Honisch et al., 2012

Current fossil fuel emission rates
8.3 PgC/year

2.4 PgC/year

Clarkson et al., 2015
The NOAA Ocean Acidification Program (OAP) was established under SEC. 12406. of the Federal Ocean Acidification and Monitoring Act (FOARAM) to oversee and coordinate research, monitoring, and other activities consistent with the strategic research and implementation plan developed by the interagency working group on ocean acidification.

The program is to foster and direct …the establishment of a **long-term monitoring program of ocean acidification** utilizing existing global and national ocean observing assets, and adding instrumentation and sampling stations as appropriate to the aims of the research program…
Species Response to Ocean Acidification

- *Thalassiosira rotula*
- *Thalassiosira weissflogii*
- *Chlorella autotrophica*
- *Thalassiosira pseudonana*
- *Dunaliella salina*
- *winter flounder*

- *black sea bass*
- *walleye pollock*
- *Thalassiosira oceanica*
- *Atlantic surf clams*
- *bay scallop*
- *hard clam*

- *pteropod*
- *krill*
- *copepods*
- *Red king crab*
- *Tanner crab*
- *Blue king crab*

- *Dungeness crab*
- *rock sole*
- *summer flounder*
- *herring*
- *ling cod*
- *surf smelt*

- *sea scallop*
- *geoduck*
- *olympia oysters*
- *Golden crab*
- *snow crab*
- *pygmy rock crab*

- *American lobster*
- *Pacific cod*
- *Atlantic tomcod*
- *Atlantic silverside*
- *Mummichog*
Ocean Acidification v2.0

Coastal Carbon Dynamics
What role do coasts play in controlling ocean carbon?
Corrosive plume off Casco Bay, Maine:
Salisbury et al., UHN
NOAA Ocean Acidification Monitoring
Remotely Sensing Ocean Acidification

CDIAC CO2 System Program

Remotely Sensing Ocean Acidification

\[ A_T = a + b(SSS - 35) + c(SSS - 35)^2 + d(SST - 20) + e(SST - 20)^2 \]


\[ pCO_{2,sw} = y_0 + A e^{(-K_0/B)} + pCO_{2,air} \]


http://www.coral.noaa.gov/accrete/oaps.html

Ruben van Hooidonk (AOML)
Remotely Sensing Ocean Acidification

pCO₂ based on Signorini et al., 2013

Sea Surface Temperature Application to OA

Application: temperature, solubility of carbon dioxide, mineral solubility

Salinity Sensors Application to OA

Application: salinity, total alkalinity, solubility of carbon dioxide, mineral solubility, mixing

Atmospheric CO₂ Application to OA

Application: air-sea gas disequilibrium, secular changes in OA


<table>
<thead>
<tr>
<th>Satellite</th>
<th>Agency Name</th>
<th>Sensor</th>
<th>Wavelength</th>
<th>Geophysical Measurement</th>
<th>Effective Repeat Interval</th>
<th>Product Spatial Resolution (km)</th>
<th>Orbit</th>
<th>Launch Date</th>
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<tbody>
<tr>
<td>Orbiting Carbon Observatory-2 (OCO-2)</td>
<td>NASA</td>
<td>Triple spectrometers</td>
<td>NIR</td>
<td>Absorption ()</td>
<td>15 days</td>
<td>1,000</td>
<td>Polar</td>
<td>2014</td>
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</tbody>
</table>
Application: air-sea gas exchange

Satellite Ocean Color Application to OA

Application: chlorophyll, particulate & dissolved colored carbon, particulate inorganic carbon, primary & net community productivity, classification

Coastal Mapping Application to OA

Application: coral reef area, coral reef health, shallow water resuspension, near coastal processes

Soil Moisture/Water Budgets Application to OA

Application: water cycle studies, freshwater flux to the ocean

Altimetry Application to OA

Application: ocean currents, mixing

User Community and Stakeholders of OA Data

An Oysters Tale...

The J-SCOPE forecast system for Washington and Oregon coastal waters
User Community and Stakeholders of OA Data

## User Community and Stakeholders of OA Data

<table>
<thead>
<tr>
<th>Applications, Tools, Products</th>
<th>Name</th>
<th>Frequency</th>
<th>Users</th>
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<tbody>
<tr>
<td></td>
<td>LME 20xx Ecosystem Report Card</td>
<td>Annual</td>
<td>Alaska Fishery Management &amp; Industries</td>
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<td>Long-term bio-economic forecast</td>
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<td>Regional Vulnerability Assessment</td>
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<td>On-demand</td>
<td>New England and Mid-Atlantic Marine Fisheries Commission</td>
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<td>Large Marine Ecosystem IEA</td>
<td>ND</td>
<td>Greater Atlantic Regional Fisheries Office</td>
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<td>National Coral Reef Status &amp; Trends Report Card</td>
<td>TBD</td>
<td>Regional Fishery Management Councils</td>
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<tr>
<td></td>
<td>Etc.</td>
<td></td>
<td>Coral Reef Management Community</td>
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Concluding Thoughts

• The vulnerability of society to the impacts of ocean acidification differs regionally due to local chemistry, biology, and economic dependence. This heterogeneity creates an opportunity for information product needs.

• Most of the user needs for OA data products emerge from the marine resource management and industry community in the form of synthesis assessments. Not necessarily nRT.

• Satellite Ocean Color products are particularly of aid in improving synoptic mapping of OA with the coastal domain where biological forcing imparts a first-order effect to carbonate system dynamics.

• Applications range from classification of water types for improved empirical relations to direct determination of relevant processes (e.g. NPP).

• Opportunities exist to further improve coastal/shelf algorithms by furthering joint OAR-NESDIS geochemical surveys (i.e. ECOA)
Thank you

http://oceanacidification.noaa.gov/

Questions?

The Global Ocean Acidification Network (GOA-ON)

The Global Ocean Acidification Network (GOA-ON) is building upon repeat hydrographic surveys, time-series...

NOAA OCEAN ACIDIFICATION PROGRAM

Ocean acidification is occurring because the world’s oceans are absorbing increasing amounts of atmospheric carbon dioxide, leading to lower pH and greater acidity. This is literally causing a sea change and threatening the fundamental chemical balance of ocean and coastal waters from pole to pole.

Ocean acidification refers to a reduction in the pH of the ocean over an extended period, typically decades or longer, which is caused primarily by uptake of carbon...