Informing Priorities for Biological and Ecosystem Observations, supporting evolution of the U.S. Integrated Ocean Observing System

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Regional Associations Across the United States

The Global Ocean Observing System (GOOS)
The Task Team

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Sarah Miller – U.S. Army Corps of Engineers
James Price - Bureau of Ocean Energy Management
Samantha Simmons (Chair) - Marine Mammal Commission
Michael Weise - Office of Naval Research
Hassan Moustahfid - Integrated Ocean Observing System
Rebecca Shuford - National Oceanic & Atmospheric Administration
Kandace Binkley - National Science Foundation
Mark Fornwall - US Geological Survey
Raphe Kudela – Regional Associations (CeNCOOS)
Jay Pearlman, Eileen Hofmann - RCN
Support: Nick Rome, Hannah Dean – Consortium for Ocean Leadership
Why Biology and Why Now?

- 26 core IOOS variables
- Phytoplankton species
- Zooplankton species
- Zooplankton abundance
- Fish species
- Fish abundance

• 2012 IOOS Summit
  [http://www.iooc.us/summit/](http://www.iooc.us/summit/)

<table>
<thead>
<tr>
<th>Variable</th>
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<tbody>
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<td>Acidity</td>
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<td>Bathymetry</td>
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<td>Contaminants</td>
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<td>Optical Properties</td>
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<td>Partial Pressure of CO2</td>
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<td>Pathogens</td>
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<td>Surface Waves</td>
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<td>Temperature</td>
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<td>Total Suspended Matter</td>
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Task Team Goals

A. Improve the availability of existing IOOS core biological variables
   • phytoplankton species (and abundance)
   • zooplankton species
   • zooplankton abundance
   • fish species
   • fish abundance

B. Identify, and prioritize additional cross-cutting biological and ecosystem observation needs
The Framework for Ocean Observing

Ocean Obs ’09

Characterize observing systems across disciplines & technologies

Establish priorities for observing

Identify readiness levels

http://www.oceanobs09.net/foo/
Framework for Ocean Observing

A simple system

Input (Requirements)

Process (Observations)

Output (Data & Products)
We cannot measure everything, nor do we need to

Driven by requirements, negotiated with feasibility

Essential Ocean Variables / Core Variables

- Driven by requirements
- Rooted in reality
- Measurement must be feasible

Impact

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<th>Low</th>
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Feasibility

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<tr>
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B. Identify, and prioritize additional cross-cutting biological and ecosystem observation needs

- Survey of needs for biological and ecosystem observations
  REQUIREMENTS
- Expert workshop (Community input)
  IMPACT and FEASIBILITY analysis

Outputs – reports and recommendations

Survey results
Climate

Primary Producers (Phytoplankton, HABs)

Habitat-formers (Corals, SAV, wetlands)

Pelagic invertebrates (Zooplankton, Squid)

Microbes*

Mammals, Turtles (Protected spp)

Fishes (Harvested and others)

Benthic Inverts (Indicator spp)

Habitat-formers (Corals, SAV, wetlands)

PELAGIC

BENTHIC

Humans

Ocean Physics and Chemistry
List of Variables

- fish species/abundance
- coral species/abundance
- submerged aquatic vegetation
- species/abundance
- marine mammal species/abundance
- phytoplankton species/abundance
- zooplankton species/abundance
- benthic invertebrate species/abundance
- sea bird species/abundance
- microbial species/abundance
- sea turtle species/abundance
- pelagic invertebrate nekton
- species/abundance
- primary productivity
- fish fecundity
- ambient/passive acoustic measurements
- coral recruitment
- marine mammal fecundity
- sea bird fecundity
- zooplankton fecundity
- benthic invertebrate fecundity
- sea turtle fecundity
- microzooplankton grazing
- fish diet
- sea bird diet
- seal diet
- sea turtle diet
Impact: Feasibility Analysis

• First, prioritize each of the variables based on IMPACT (Low, Medium, High, Essential)
• Second, prioritize each variable based on FEASIBILITY (Concept, Pilot, Mature)
Each variable scored based on 5 Themes (GOOS Biology Panel meeting Townsville 2012):

- Productivity
- Biodiversity
- Ecosystem Services
- Human Activities & Pressures
- Scientific Benefit
FEASIBILITY Rating

- For each variable scored based on readiness level for requirements, observations, data & information
Impact vs. Feasibility

- Fish abundance
- Marine mammal abundance
- Coral abundance
- Fish fecundity
- Zooplankton abundance
- Submerged aquatic vegetation abundance
- Sound
- Marine mammal fecundity
- Sea bird diet
- Benthic invertebrate abundance
- Microbial abundance
- Benthic invertebrate fecundity
- Primary productivity
- Marine mammal species
- Phytoplankton species
- Submerged aquatic vegetation species
- Seabird species
- Sea turtle abundance
- Sea turtle species
- Seal diet
- Pelagic invertebrate nekton species
- Sea turtle fecundity
- Zooplankton fecundity
- Microzooplankton grazing
- Fish species
- Phytoplankton abundance
- Coral species
- Sea bird abundance
- Zooplankton species
- Fish diet
- Sea bird fecundity
- Sea bird fecundity
- Benthic invertebrate species
- Coral recruitment
- Microbial abundance
- Sea turtle diet
We must consider interactions, both spatial and temporal, among climate, physics, chemistry, and biology.

- Highest priority should be to include species and abundance of other core functional groups (pelagic and benthic) that are not in the current core variables list.

- Following species and abundance, biological vital rates (BVRs) are the next priority of biological information to be included as IOOS core variables. BVRs include, production, recruitment, mortality, fecundity, growth, and feeding rates.

- Also, information on nekton diet should be included as an IOOS core variable.

- Finally sound should be included as an IOOS core variable.
Questions?

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Biological variables list

Zooplankton species/abundance
Fish species/abundance
Phytoplankton species/ABUNDANCE
MICROBIAL SPECIES/ABUNDANCE/ACTIVITY
INVERTEBRATE SPECIES/ABUNDANCE
SUBMERGED AQUATIC VEGETATION SPECIES/ABUNDANCE
CORAL SPECIES/ABUNDANCE
SEA TURTLES SPECIES/ABUNDANCE
SEA BIRDS SPECIES/ABUNDANCE
MARINE MAMMAL SPECIES/ABUNDANCE
BIOLOGICAL VITAL RATES
NEKTON DIET
SOUND
<table>
<thead>
<tr>
<th>Core variables</th>
<th>Biological core variables (Including pelagic and benthic organisms)</th>
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<tbody>
<tr>
<td>Acidity</td>
<td>Zooplankton species/abundance</td>
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<tr>
<td>Bathymetry</td>
<td>Fish species/abundance</td>
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<td>Bottom Character</td>
<td>Phytoplankton species/ABUNDANCE1</td>
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<td>Colored Dissolved Organic Matter</td>
<td>MICROBIAL2 SPECIES/ABUNDANCE/ACTIVITY3</td>
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<tr>
<td>Contaminants</td>
<td>INVERTEBRATE SPECIES/ABUNDANCE4</td>
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<tr>
<td>Dissolved Nutrients</td>
<td>SUBMERGED AQUATIC VEGETATION SPECIES/ABUNDANCE</td>
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<td>Dissolved Oxygen</td>
<td>CORAL SPECIES/ABUNDANCE</td>
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<td>Heat Flux</td>
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<tr>
<td>Ice Distribution</td>
<td>SEA BIRDS SPECIES/ABUNDANCE</td>
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<td>Ocean Color</td>
<td>MARINE MAMMAL SPECIES/ABUNDANCE</td>
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<td>Optical Properties</td>
<td>BIOLOGICAL VITAL RATES5</td>
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<td>Partial Pressure of CO2</td>
<td>NEKTON DIET6</td>
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<tr>
<td>Pathogens</td>
<td>SOUND</td>
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</tbody>
</table>

1 Phytoplankton species (but not abundance) is already an identified core variable
2 Here, “microbial” refers to heterotrophic bacteria and archaea. Although, in general terms, microbes encompass microbial eukaryotes, which include the phytoplankton and smaller zooplankton species, we retain the distinction between microbes vs. phyto- and zooplankton for simplicity and historical continuity
3 Microbial activity is included here rather than within biological vital rates, since it is more relevant for characterizing rates and quantities associated with the biogeochemical cycling of elements, which in turn influence primary and secondary production.
4 Includes pelagic invertebrate nekton (as distinct from zooplankton) as well as benthic invertebrates
5 Includes, production, recruitment, mortality, fecundity, growth, and feeding rates
6 Includes the diets of fish, sea birds, sea turtles, and marine mammals
Primary Producers

Habitat Forming* - Phytoplankton including microbes

Primary Consumers** - (herbivores, detritivores, bacteria)

Consumers (carnivores) **

Benthic - Ectotherms

Pelagic - Endotherms

*Macroalgae, seagrasses, corals, crusto-coralline algae

**Considerable zonation in both
Developing a global ocean observing system that prioritises ecosystem variables from a political and societal point of view

Patricia Miloslavich, Nic Bax, Samantha Simmons, Ward Appeltans, Melissa Andersen

http://ioc-goos.org/biology
Defining Biological EOVs: The DPSIR model

Identifies the information needed to understand and manage human impacts on the environment.
<table>
<thead>
<tr>
<th>Physics</th>
<th>Biogeochemistry</th>
<th>Biology and Ecosystems</th>
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<tr>
<td>Sea State</td>
<td>Oxygen</td>
<td>Phytoplankton biomass and productivity</td>
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<td>Ocean surface vector</td>
<td>Inorganic macro nutrients</td>
<td>HAB incidence</td>
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<td>Sea Ice</td>
<td>Carbonate system</td>
<td>Zooplankton diversity</td>
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<td>Sea level</td>
<td>Transient tracers</td>
<td>Fish abundance and distribution</td>
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<td>SST</td>
<td>Suspended particulates</td>
<td>Apex predator abundance and distribution</td>
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<td>Subsurface temperature</td>
<td>Nitrous oxide</td>
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<td>Surface currents</td>
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<td>Subsurface currents</td>
<td>Dissolved organic carbon</td>
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<td>SSS</td>
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<td>Microalgal canopy cover</td>
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<td>Subsurface salinity</td>
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### Proposed Biological EOVs: functional groups

<table>
<thead>
<tr>
<th>Phenomenon of interest</th>
<th>EOV</th>
<th>Subvariables /Supporting/</th>
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<tbody>
<tr>
<td>Status of phytoplankton</td>
<td>Phytoplankton biomass and</td>
<td>Biomass/abundance (chlorophyll-a, HPLC pigments, cell count); primary productivity;</td>
</tr>
<tr>
<td></td>
<td>productivity</td>
<td>carbon/chlorophyll, succession</td>
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<tr>
<td>Harmful Algal Blooms (HABs)</td>
<td>HAB incidence</td>
<td>Toxicity</td>
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<tr>
<td>Status of zooplankton</td>
<td>Zooplankton diversity</td>
<td>Diversity, Biomass, Abundance, grazing, phenology</td>
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<tr>
<td>Fish status</td>
<td>Fish abundance and distribution</td>
<td>Diversity, Abundance, biomass, catch, functional traits</td>
</tr>
<tr>
<td>Status of apex predators</td>
<td>AP abundance and distribution</td>
<td>Diversity, Vital rates, diet, behaviour</td>
</tr>
</tbody>
</table>

(*) Microbes recognized: biodiversity, pathogens
### Proposed Biological EOVs: ecosystems

<table>
<thead>
<tr>
<th>Phenomenon of interest</th>
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<th>Subvariables / Supporting variables</th>
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</thead>
<tbody>
<tr>
<td>Coral reef health</td>
<td>Live coral cover</td>
<td>Herbivorous fish abundance, coral disease, % bleached, coral form abundance (massives, plate, branching etc), light penetration</td>
</tr>
<tr>
<td>Seagrass health</td>
<td>Seagrass cover</td>
<td>Seagrass shoot density, seagrass shoot length, algal abundance, seagrass disease, grazer abundance</td>
</tr>
<tr>
<td>Mangrove health</td>
<td>Mangrove cover</td>
<td>Species, stem density, DBH, canopy height, leaf production rate</td>
</tr>
<tr>
<td>Macroalgal forest health</td>
<td>Canopy cover</td>
<td>Productivity, recruitment and mortality, cover of turf-forming and encrusting coralline algae, grazer abundance</td>
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</tbody>
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