Observing Life in the Sea

MBON All-Hands Meeting
Silver Spring, MD
May 03, 2016

Monterey Bay, Florida Keys, and Flower Garden Banks National Marine Sanctuaries

Principal Investigators:
Frank Muller-Karger (USF)
Francisco Chávez (MBARI)
The Sanctuaries MBON pilot

Outline

- Data management
- Outreach
- International dimensions
- Next steps
- Project successes and challenges

- Working “X-MBON”
The Sanctuaries MBON pilot: primary goals

- Develop a practical and sustainable pilot MBON with the National Marine Sanctuaries Program
- Integrate with, augment, and synthesize information from ongoing programs
- Develop technologies for biodiversity assessments:
  - environmental DNA (eDNA)
  - Remote sensing time-series: Seascapes
- Integrate biological data into national/international databases
- Plan to transition to an operational system
The importance of biodiversity

Ecological diversity is intimately tied to habitat diversity and to the capacity of organisms to adapt and survive as a species.

Understanding habitat and biological diversity and function is fundamental to define conservation strategies.

Diversity defines the function and health of ecosystems

- Taxonomic and Phenotypic diversity:
  - An expression of the diversity in habitats and niches

- Genetic diversity - variability in DNA that gives species the capacity for adaptation, speciation and resilience in the face of stress
MBON Components

Environmental Conditions
- pH, T, Sal, O₂, CO₂, etc.

Data Analysis And Modeling

Ecosystem Function
- Trophic Structure, Productivity, Element cycling, etc.

Biodiversity
- Species & Abundance

PRODUCTS
- Biodiversity Indicators, Indices, and relationships

Information Systems
- Data archiving, standardization

Stakeholders, Communication & Management

Biodiversity

Sustainable Communities

Data Analysis and Modeling

Ecosystem Function

Information Systems

Stakeholders, Communication & Management

Biodiversity
The Sanctuaries MBON pilot concept

- Monterey Bay
- Florida Keys
- Channel Islands
- Flower Garden Banks

Data Integration:
- IOOS/GOOS
- I-OBIS
- GEO BON

Multivariate seascape analysis

eDNA

Web-based information system

- Sanctuary Condition Reports
- Resource managers and policy makers
- Scientists and educators

Supports
IOOS Data management

- Data enrollment strategies being applied
  - Enrolling historical and new data:
    - Reef Visual Census data (RVC)
    - Coral reef cover Florida Keys (CREMP)
    - Rockfish data for Monterey Bay NMS / California
    - Daily River Discharge for US GOM Rivers – first record to current day in NetCDF*.
    - Water Quality Parameters for 5 Gulf States – all known records to 2014 in NetCDF*.
    - FWRI/FWC Provided 32 Data Layers and 7 table relevant to FKNMS MBON
    - Similar numbers of data for MB
    - Etc.
  - Ancillary bio-optical data being submitted to NASA SeaBASS
  - 2005-2008 Monthly SeaScapes produced by Maria Kavanaugh (WHOI) on hand in NetCDF
  - Satellite Data Archives Identified (USF - IMaRS)
  - Development of a pilot biodiversity mapping tool
  - Data Management Plan in Development
  - New HPC ERDDAP/TDS Servers on 10GB line being deployed*
Example: NOAA’s SEFSC Reef Visual Census: Average fish length (cm) distribution. Figure shows time-varying fish length within selected polygon.
DMAC: Development of MBON Visualization

Select biodiversity indices

Select individual species, plot over time

Select biodiversity indices, plot over time
Field programs

Complement Multiple Data Collection Efforts in Each Sanctuary

South Florida Program run by AOML partners:
- Chris Kelble—bio oc./prim prod
- Lindsey Visser
- Libby Johns – phys oc. analyses
**Florida Keys field program**

FKNMS and AOML partners have enabled field and lab operations in the Keys since August 2015.

Sample collection and processing in FKNMS Key West facility (conducted by NOAA staff):
- Lonny Anderson
- Rosemary Abbitt
- Beth Dieveney
- Sean Morton
NOAA facility in Key West supports sampling at W. Sambo and Looe Key

- NOAA facility available for MBON at Key West.
- Sample processing takes ~ 3 hours
- Lead: Lonny Anderson

- 30 ft. boat
- Three FKNMS personnel
- ~ 1 hour to Looe Key
- ~ ½ hour to Western Sambo
- Sampling takes < 30 min.

Sample storage in -80 °C freezer
High salinity event during July 27-31, 2015, in Florida Bay and FKNMS
Discrete Chl-a during July 27-31, 2015, in Florida Bay and FKNMS
Chl-a fluorescence during July 27-31, 2015, in Florida Bay and FKNMS
Mississippi River plume intrusion during July cruise
MODIS Aqua 1km Chl-a composite (7/23/15-7/27/15)
Sampling Stations grouped by “Eco-regions”:
Monterey Bay
Oceanic Shelf
All (combined)
Time series are calculated for total species and major guilds
130 total taxa

Santora et al. In prep.
Sanctuaries MBON eDNA: vertebrates, zooplankton, and microbes

- Testing of eDNA extraction methods completed – manuscript in prep.
- Primers: selection completed for some organisms
- eDNA validation in progress (i.e. zooplankton and whales)

Microscopy: Taxonomy & counts
Biomass
eDNA
MBON Genomics Team

- Stanford – Vertebrates (12S)
- MBARI – Phyto, Zooplankton (18S, 28S, CO1)
- USF – Microbes/Viruses/Zooplankton (16S)
- FWRI – Phytoplankton (18S)
- SBCBON – Microbes (16S), fish, etc.
- AMBON – Microbes, phyto (16S, 18S)

Collaborations

- X-MBON: Santa Barbara, Alaska MBON
- NOAA Omics Research: (K. Goodwin, J. Hendee)
  - Atlantic Oceanographic & Meteorological Lab
  - Southwest Fisheries Science Center (SWFSC)
3rd Generation ESP & Long Range AUV
MBON Sequencing Work and Data Flow

(Field, laboratory and NGS)

- Water Samples
- Water Sample Metadata identifier
- Sample Filtration
- DNA extraction
- PCR (12S, 16S, 18S, 28S, CO1)
- Illumina Library Prep
- Paired End Illumina Sequencing
- Paired End Sequence Reads

(QC and processing)

- Environmental Sample Metadata
- Sample Processing Metadata (extraction method, primers, etc)
- Paired End Sequence Reads
- Merge Paired End Reads (PEAR)
- Quality Filter (USEARCH)
- Demultiplex (Unix - awk)
- OTU Clustering (USEARCH)
- Taxonomy Assignment (BLAST + MEGAN - LCA)
- Annotated Sequences + Metadata (.biom)
- Data Management and Comms

MBON Server

- MBON Genomics Teams
  - Stanford – Vertebrates (12S)
  - MBARI – Phyto, Zooplankton (18S, 28S, CO1)
  - USF – Microbes/Viruses/Zooplankton (16S)
  - FWRI – Phytoplankton (18S)
  - SBCBON – Microbes (16S), fish, etc.
  - AMBON – Microbes, phyto (16S, 18S)

- Data Repository (SRA, Dryad)
- Reference Database (GenBank, Silva, etc)
- Data Repository (SRA, Dryad, BioProjects)
Remote Sensing of Seascapes
MODIS-Aqua 1-km seasonal climatologies (2002 - 2015) for seascape analyses - FKNMS

**Chl-a (mg/m³)**
- Winter
- Spring
- Summer
- Fall

**SST (°C)**
- Winter
- Spring
- Summer
- Fall

**nFLH (mW cm⁻² um⁻¹ sr⁻¹)**
- Winter
- Spring
- Summer
- Fall

**PAR (Einsteins m⁻² day⁻¹)**
- Winter
- Spring
- Summer
- Fall
MODIS-Aqua 1-km seasonal climatologies (2002 -2015) for seascape analyses - MBNMS

Chl-a

mg/m$^3$

SST

°C

nFLH

mW cm$^{-2}$ um$^{-1}$ sr$^{-1}$

PAR

Einsteins m$^{-2}$ day$^{-1}$
Satellite-derived seascapes by Maria Kavanaugh (WHOI)

Now available:
- Fully automated processing of L1B MODIS satellite data for all MBON areas
- High frequency dynamic maps

Monterey Bay

Florida Keys
Seascapes of the MBNMS and Adjacent Areas

Habitat metrics in the MBNMS: Midwater trawl data 2003-2010

### Presence

<table>
<thead>
<tr>
<th>Seascape ID</th>
<th>Anchovy</th>
<th>Krill</th>
<th>Rockfish</th>
<th>Sanddab</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>0.2</td>
<td>1.0</td>
<td>1.0</td>
<td>0.8</td>
</tr>
<tr>
<td>11</td>
<td>0.0</td>
<td>1.0</td>
<td>1.3</td>
<td>1.1</td>
</tr>
<tr>
<td>12</td>
<td>1.3</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

### Biomass

<table>
<thead>
<tr>
<th>Seascape ID</th>
<th>Anchovy</th>
<th>Krill</th>
<th>Rockfish</th>
<th>Sanddab</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>0.4</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>11</td>
<td>0.0</td>
<td>1.0</td>
<td>1.2</td>
<td>1.1</td>
</tr>
<tr>
<td>12</td>
<td>1.2</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Analysis of variance of abundances across seascapes. Letters denote results of multiple comparisons tests, where unique letters have statistically significant different means.
Seascapes of the FKNMS and Adjacent Areas

Seascapes guides habitat metrics validation: South Florida Program cruise March 14-18, 2016

Stations sampled (28)
- Parameters:
  - eDNA
  - Zooplankton
  - Phytoplankton
  - Prim. Production
  - Chl-a
  - HPLC
  - CDOM
  - $R_{RS}$
  - Hydrography

Six seascape types sampled

Next cruise: May 9-13, 2016

Seascape weekly composite at 4 km pixel resolution (March 4-11, 2016).
Global Seascapes

In progress/Next steps:

- In situ validation

- Automate data flow between NASA, USF, WHOI, IOOS DMAC / Axiom

- Improving algorithms: Harmful Algal Blooms (HAB), carbonate system

- Expand high-resolution coverage:
  - Flower Garden Banks, AK-BON, Santa Barbara, other NMS

- Evaluate user metrics

- GEOBON and broader links:
  - Work with Roger Sayre (USGS) to link remote sensing Seascapes and Ecological Marine Units/EMU (USGS/esri)
    - Pole to Pole Biodiversity and Biogeography
  - Other partners/internationally
Remote Sensing of Seascapes

Manuscript Accepted:

Communications & Outreach

CJ Reynolds, Jennifer Brown

- Newsletter (distributed via all_mbon@marine.usf.edu)

Will have roughly quarterly distribution
Next steps: Putting it all together

- Build the decision-support tool to answer Sanctuary Condition Report questions
Successes and challenges within the Sanctuaries MBON

Successes:

- Conceptual framework for collaborative MBON:
  - Academic entities
  - NOAA programs, State government, international (GEO BON, IOC/GOOS, SBSTTA/CBD)
  - In conversation with several NGOs: MedPAN (Assoc. of Mediterranean Marine Protected Areas managers), Mexican Fund for the Conservation of Nature, etc.

- eDNA: collection and extraction methods tested

- Satellite-based, dynamic seascape products: automated pipeline for input data in place for several MBON regions of interest

- Biodiversity field monitoring program implemented in both Sanctuaries

- MBON data used to update 2015 Monterey Bay NMS Condition Report

- Making links: NOAA ocean acidification program, NOAA Omics, State and Federal fisheries & environmental monitoring, NSF LTER (Everglades), IOOS and other observation programs
  - IOOS GCOOS has funded a Doctoral fellowship at USF to work MBON-LTER-SFP
Challenges:

- Development and maintenance of data system / visualization tool:
  - The amount of work is staggering – many details
  - How to transition to a sustainable model?
- eDNA validation at different trophic levels
  - For ex. vertebrates in different regions
- Curation and permanent archive of biological datasets from various sources:
  - Identifying and understanding datasets is an ongoing effort
  - How do these data transition into a permanent archive? How do we maintain access needed for operational & research utility?
  - How do we engage monitoring programs to enroll data?
- Communications flow on news and outreach
- Integrating the MBON observations into the FKNMS Condition Report-2017(?)
- Coordination of myriad moving parts with partners and X-MBON projects
- Building critical international partners and linkages for Pole-to-Pole
- Operational MBON
  - path to sustainability not clear
**X-MBON team:**
- NOAA IOOS / NASA
- Sanctuaries MBON
- Santa Barbara MBON
- AK MBON
- MarineGEO (Tennenbaum/SI)
- Conversations with
  - USGS/esri
  - International groups: GEO / GEO BON / AmeriGEOSS / USGS-EMU

**Focus of discussions:**
- DMAC (range of topics)
- eDNA (methods)
- EBV’s/EOV’s / Biodiversity indicators
- Seascapes (coverage, interpretation, validation, improvement)
- Communications/Outreach
- Applications
DMAC: Development of MBON Visualization

Overlay layers (SST, others)

Biological diversity indices are being incorporated across various regions and for different datasets.
Communications & Outreach

- Sanctuaries MBON Website (http://www.marinebon.org/)
MBON beyond the US: GEO, GOOS, CBD

GOALS:
- Pole-to-Pole MBON pilot
  - the Americas
- BON in a Box

Outreach and planning
- MBON presentations at GEO Plenary, Mexico (2015)
- MBON presentation at the Convention of Biological Diversity (Montreal, Apr 24, 2016)
- GEO BON Open Science Meeting (Leipzig, Jul 4-6, 2016)
- GEO MBON All-Hands Workshop (Leipzig, Jul 6-7, 2016)
- Pole-to-Pole in the Americas Workshop (Puerto Morelos, Mexico, Sep 26-30, 2016)
- MBON presentation at the GEO-XIII Plenary (St Petersburg, Russia, Nov 9-10, 2016)
Successes:

- Frequent and dynamic communications
- Active discussions on:
  - eDNA
  - Seascapes
  - DMAC: enrollment, visualization, and analysis
  - EBV’s/EOV’s / Biodiversity indicators
  - Applications
- Collaboration with international groups:
  - GEO / GEO BON / AmeriGEOSS / USGS-EMU
  - Pole to pole MBON idea has traction
Successes and challenges

Challenges:
- AMBON is not fully funded
- DMAC underfunded
- Definition of biodiversity monitoring priorities for contrasting ecosystems (from tropics to Arctic)
- Entraining additional areas/regions/programs:
  - In the US
  - Internationally
- Sustaining operations
- Time is ticking...