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

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2. MBARI/CenCOOS, CA;
3. Woods Hole Oceanographic Institution (WHOI), Woods Hole, MA;
4. NOAA Office of National Marine Sanctuaries (ONMS), Washington, DC;
5. Texas A&M University (TAMU/GCOOS), College Station, TX;
6. NOAA Florida Keys National Marine Sanctuary (FKNMS), Key West, FL;
7. NOAA Monterey Bay National Marine Sanct. (MBNMS), Monterey, CA;
8. NOAA SW Fisheries Science Center (SWFSC), La Jolla, CA,
9. Center for Ocean Solutions, Stanford University, Pacific Grove, CA;
10. NOAA Fish and Wildlife Research Institute (FWRI), St Petersburg, FL;
11. NOAA Office of Response and Restoration (ORR), Seattle, WA;
12. NOAA SE Fisheries Science Center (SEFSC), Miami, FL;
13. NOAA Atlantic Oceanographic and Meteorol. Lab. (AOML), Miami, FL;
14. Roffer's Ocean Fishing Forecasting Service (ROFFS™), Melbourne, FL.

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

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We mourn the tragic loss of
Dr. Howard on Feb 8, 2018

Research Scientist
Physical Oceanography: Data Management Systems for Oceanography.

MBON GCOOS Partner and co-PI
A great friend and wonderful individual, Matt demonstrated that serving biological data by IOOS ERDDAP and enrolling into Darwin Core/OBIS is easy.
Develop a community of practice...

...to understand marine biodiversity and how it changes over time

...for fundamental ecology studies and ensure sustainable development
Sanctuary sites engaged with California Current IEA, MBON demonstration projects and Gulf of Mexico IEA

**Addressing Sanctuary Needs: data & tools**
Smithsonian MarineGEO Partnership

Our infrastructure is people

- **Vital signs:**
  - coastal seabed focus
  - diversity time series

- **Diagnostic tests:**
  - Coordinated exp’ts

- **Capacity building**
Main activities

• Field data collection
• Identify, obtain other biological data
• New approaches:
  – Seascapes (biogeographic areas from satellite obs.)
  – Environmental DNA (eDNA)
• Adopting and improving data schema for NOAA IOOS operational applications
  – Darwin Core / OBIS
• Development of a global MBON
The Sanctuaries MBON pilot concept

Observations

Seascapes

Data Integration

eDNA

Informs

Ocean literacy

14 LIFE BELOW WATER
People are at the core of our effort

Over 30 expeditions in each FL Keys & MB 2015-2018
eDNA genetic markers give snapshots of biodiversity across various groups that are difficult to capture through other methods. Each marker is most sensitive towards detecting different groups of organisms.

16S rDNA

18S rDNA

COI

Measuring shifts in the base of the web gives insights into higher trophic level variability.

12S rDNA

Sanctuaries MBON eDNA Team: FWRI, MBARI, Stanford, & USF
eDNA summary statistics

Monterey Bay (2013-2018)
• 42 cruises
• Samples collected: 1448

Florida Keys (2015-2018)
• 15 eDNA cruises, 12 small boat
• Samples collected: 1285

Sequenced for 12S: 297
16S: 454
18S: 639
COI: 417

AUV (2015-2018)
• 26 missions
• Autonomous eDNA samples collected: 366
  • Sequenced for 18S: 5
  • Sequenced for COI: 19

Sanctuaries MBON eDNA Team: FWRI, MBARI, Stanford, & USF
Zooplankton Methods Comparison (Florida)

Net tows

- Metridia
- Miracia
- Pareucalanus
- Scaphocalanus
- Zausodes

- Acrocalanus
- Centropages
- Euchaeta
- Euphausia
- Pontella
- Subeucalanus
- Temora

eDNA

- Acartia
- Candacia
- Calanidae
- Clausocalanus
- Corycaeus
- Delibus
- Nannocalanus
- Oithona
- Oncaea
- Paracalanus
- Sapphirinidae
- Undinula

Traditional microscopy

- Copilia
- Farranula
- Labidocera
- Microsetella
- Temorapia

Sanctuaries MBON eDNA Team: FWRI, MBARI, Stanford, & USF

Djurhuus et al., 2018
Combine information from all four markers to determine community changes over time.

Monterey Bay National Marine Sanctuary:

- Monthly cruises to stations within Monterey Bay
- Build on long-standing time series

eDNA Monitoring
When did we sample?
Samples captured different ocean conditions

Upper water temperature changes in Monterey Bay
Higher Phytoplankton & Vertebrate diversity seen by eDNA with warmer conditions in FL and MB

Sanctuaries MBON eDNA Team: FWRI, MBARI, Stanford, & USF

Closek & Djurhuus et al., in preparation
Peer-Reviewed Publications


Public Submissions

1. SDG14 MBON Tool: Infographics & eDNA Viewer


3. Closek & Djurhuus, et al. (2018) Environmental DNA (eDNA) extraction using Qiagen DNeasy blood and tissue kit. dx.doi.org/10.17504/protocols.io.mvzc676

   16S: dx.doi.org/10.17504/protocols.io.m3ec8je
   18S: dx.doi.org/10.17504/protocols.io.mv2c68e
   COI: dx.doi.org/10.17504/protocols.io.mwnc7de
   12S: dx.doi.org/10.17504/protocols.io.m3bc8in
**Satellite data**

**NASA MODIS (2000-present)**
Daily, monthly, annual, climatology, anomalies:
- Sea Surface Temperature
- Ocean color

**NOAA VIIRS (2011-present)**
Daily, monthly, annual, climatology, anomalies:
- Sea Surface Temperature
- Ocean color

**Landsat, Commercial (WorldView 2, 3)**
Individual images, mosaics

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**Seascapes**
- Regional (Gulf of Mexico, US West coast, Arctic Ocean)
- Global

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**Sanctuaries MBON Seascapes Team: OSU, USF, NOAA NESDIS**
Satellite-derived Seascapes

Kavanaugh (OSU), and all

Ongoing efforts

- Global
- EMU intercalibration
- Case Studies:
  - Arctic
  - Temperate
  - Subtropical
- Habitat – species relationships
- Operational
  - NOAA NESDIS
  - NASA COVERAGE

Global classification

Regional downscaling

Static+3D

Dynamic+2D

Ecological Marine Units

Arctic MBON; Distributed Biological Observatory

Dynamic Seascapes

Dynamic habitat maps

Arctic MBON
**Seascape validation: south Florida**

March 11-18, 2016  
May 05-12, 2016  
September 12-19, 2016

Seasonal shifts of phytoplankton assemblages

Also validating: eDNA, zooplankton

*In prep*: Dynamic satellite seascapes as predictors of seasonal shifts of phytoplankton assemblages in south Florida waters. Enrique Montes, Anni Djurhuus, Christopher R. Kelble, Daniel Otis, Frank E. Muller-Karger, and Maria T. Kavanaugh
Addressing Sanctuary and Other User Needs

• Data tools:
  – development of interactive data tools using ecosystem conceptual models (e.g., Integrated Ecosystem Assessment)
  – Curated views of the MBON Portal for Sanctuaries:
    • Taxa aggregations – fishes
    • Areas of interest:
      – Sanctuary Preservation Areas, Ecological Reserves, benthic layers, others.
  – Early warning systems for detection of anomalous conditions in the Sanctuaries

• Satellite products:
  – High-res imagery for disaster response (i.e. Irma impacts in the FKNMS)
  – Time series data for detection of anomalous conditions (FK, FGB, MB).

• Local to global scaling
IOOS Data management: MBON Portal

- Beta version is live

https://mbon.ioos.us/
Data Integration

**MBON Portal: Interactive Tools**
for data storytelling

[Image of various logos and a map divided into global and local sections, with arrows indicating 'Supports'

Explorer (global)  Infographic (local)

https://mbon.ioos.us/
Dynamically updating sanctuary status and trends

Infographics
Audience: Public, managers, educators

Curated Data Views
Audience: Advisory groups, researchers, teams

Data portals
Audience: Scientists, technical experts
Addressing Sanctuary Needs: data tools

Processes and products being shared across programs and regions

Collaboration between sanctuaries, IEA, MBON expanding to Gulf of Mexico

Collaboration of IEA with

Marine Biodiversity Observation Network (MBON)

U.S. MBON PORTAL
Ocean climate and biodiversity of pelagic fish (forage species)

MEPS Vol 580: 205-220, DOI: 10.10.3354/meps12278

• 1995-97 and 2015 heat waves (ENSO) show high diversity.

• Affects fisheries and coastal water quality.
Ecospace scenarios:
Fish biomass variation with Marine Protected Area (MPA) size, fishing effort, and movement

Fishing effort: larger effect on biomass than MPA size
Early warning and alert system for Sanctuaries

- Detection of anomalies in CHL, SST, Turbidity
- FGBNMS, FKNMS, others
- Dashboard and email alerts in real time

Stetson Bank
Early warning alerts for Sanctuaries

User dashboard for FGBNMS is live.
Florida Youth Outreach

• St. Pete Science Fest Oct. 20-21, 2017
  • 175+ 4th & 5th graders and 800+ “kids of all ages”
  • Activities teach about reef biodiversity, led by Simonello, supported by GCOOS, SECOORA and IMARS

• Stewart Middle Magnet School, Tampa, FL Nov-Dec activities
  • 60 students “lunch and learn” with FMK on remote sensing and biodiversity
  • USF CMS Campus Visit -- 50 students learn about MBON, conduct research with Keys Infographic, interact with AUVs, tour the R/V Weatherbird.
  • Featured on USF Facebook, Twitter and Hillsborough County School District website

• USF CMS awareness FMK interview
Successes of the Sanctuaries
MBON

Successes:

• Well-defined conceptual framework for a collaborative MBON, national, international

• eDNA: collection and extraction methods tested and validated (i.e. zooplankton)

• Satellite-based, dynamic seascape products automated pipeline co-developed with CoastWatch

• Biodiversity field monitoring program fully implemented in both Sanctuaries

• Expanding links: NOAA ocean acidification program, NOAA Omics, State and Federal fisheries & environmental monitoring, NSF LTER (Everglades), IOOS and other observation programs

• MBON continues to support GEO BON’s WG and TF
Challenges of the Sanctuaries MBON

Challenges:

• Development and maintenance of data system / visualization tool:
  – The amount of work is staggering – many details
  – How to transition to a sustainable model?

• 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?

• Operationalization of eDNA to monitor biodiversity
• Communications flow on news and outreach
• Integrating the MBON observations into Condition Reports
• Coordination of myriad moving parts with partners and X-MBON projects
• Building critical international partners and linkages for Pole-to-Pole
• Operational MBON
  – Developing path to sustainability
2018-2019 Plans

- Microbes-to-Whales (M2W) eDNA
- Biodiversity indicators for SDG14
- Operational Seascapes data via NOAA NESDIS / CoastWatch
- Early Warning System
- MBON Portal: Infographics/Explorer
- Global MBON (GEO BON MBON, Pole-to-Pole, Marine GEO-TMON/Smithsonian)
- X-MBON
Working with and supporting other US and international MBON projects
The First U.S. IOOS Biological Data Training Workshop

February 8-9, 2018
Seattle, WA.

Partnership

MBON / OBIS Portals

Enrolling data

Web services: Darwin Core / WoRMS, rOBIS and ERDDAP

MBON

Marine Biodiversity Observation Network

IOOS

Integrated Ocean Observing System

OBIS

OCEAN BIOGEOGRAPHIC INFORMATION SYSTEM
INTERNATIONAL LINKAGES

Global Ocean Observing System

GOOS: ESSENTIAL OCEAN VARIABLES
Focus on EOVs driven by societal needs
- Global implementation -

ESSENTIAL BIODIVERSITY VARIABLES
Focus on EBVs driven by science questions and other user needs (policy, societal)
- National and regional implementation -

Biodiversity Observation Network (BON)

MARBINE OBSERVATION NETWORK
National — Regional — Global — Thematic
National Governments — Non Government Organizations — Agencies — Institutions — Citizen Science

Data integration and dissemination
+ other national, international data systems

OTHER DATA PROVIDERS AND USERS
✓ National Governments and Organizations
✓ International Organizations
✓ Non Government Organizations
✓ Research Institutions
✓ Citizen Scientists

INTERNATIONAL LAUNCHES

OBSERVING LIFE IN THE OCEANS FOR SOCIETAL BENEFIT
(- INFORMATION FLOW -)
MBON beyond the US: GEO, GOOS, CBD, UN SDG

- Pole-to-Pole MBON pilot
  - the Americas
- BON in a Box
- UN Sustainable Development Goal 14

Outreach and planning
• MBON presentation at the GEO Plenary (Washington, DC, 2017)
• Monthly Webinars
• Pole-to-Pole in the Americas Workshop (Brazil, Aug 9-15, 2018)
Linking Essential Biodiversity Variables (EBVs) and Essential Ocean Variables (EOVs)

Based on the Framework for Ocean Observing (OceanObs ‘09):

EOVs are central to GOOS strategic planning and implementation
EBVs are central to GEO BON strategic planning and implementation

Marine EBV are complementary to EOV
EBV and EOV are Complementary
MBON beyond the US: – In Progress

• GOOS Bio-Eco Panel and RNC
• OBIS and IOOS – IOOS adopts DarwinCore + training efforts
• MBON Portal development (X-MBON, IOOS)
• Indicator development for SDG14 in progress
• Global ‘omics observatories
• WCMB in Montreal on May 17 (prototype to demo to CBD officials)
• GOOS Regional Alliances Meeting, June 12, Santa Marta, Colombia
• SBSTTA in Montreal on July 27 (promote the polished prototype)
• CBD in Egypt November 2018 (unveiling the tool/portal international)
• OceanObs 19
• SCOR P-OBS Working Group: Integration of Plankton-Observing Sensor Systems to Existing Global Sampling
• CMAR corridor: MBON is working with Ecuador, Panama, Colombia and Costa Rica to help define research needs in this EBSA.
• NOAA Ocean Exploration Research
Smithsonian MarineGEO Partnership
Our infrastructure is people

• Vital signs: coastal seabed focus diversity time series

• Diagnostic tests: Coordinated exp’ts

• Capacity building
X-Seascapes

MBON
Marine Biodiversity Observation Network
Satellite-derived Seascapes

Kavanaugh (OSU), and all

Ongoing efforts

• Global classification of dynamic seascapes
• EMU intercalibration
• Case Studies:
  • Arctic
  • Temperate
  • Subtropical
• Habitat –species relationships
• Operational, multiscale products
• Collaboration:
  • NOAA NESDIS
  • NASA COVERAGE

Global classification

Regional downscaling

Dynamic+2D

Static+3D

Ecological Marine Units

Arctic MBON; Distributed Biological Observatory

Dynamic Seascapes

Dynamic habitat maps

Arctic MBON
Comparing Visual Surveys and eDNA Detections in Temperate Rocky Reef Communities

Do environmental DNA (eDNA) detections match classic visual census records?

Data analysis performed by both UCSB Postdocs: Thomas Lamy & Kathleen Pitz
**Visual SCUBA survey**
- 11 80 m² transects (11 rocky reefs)
- Classic Underwater Visual Census
- Water collection and filtering

**eDNA pipeline**
- Miseq runs for 3 markers: 12S (fish), 18S (phytoplankton, algae) and COI (zooplankton, inverts)
- MBARI eDNA analysis pipeline

**Sampling Locations**
- Santa Barbara
- Channel Islands National Park

**Visual SCUBA survey**
- 131 taxonomic units
  - genus (N=16)
  - species (N=91)
  - coarse grouping (N=17)

**eDNA pipeline**
- 1710 unique taxonomies
  - Classes (N=80)
  - Orders (N=324)
  - Families (N=686)
  - Genera (N=963)
  - Species (N=1123)
A case study with bony fishes:

28 species detected in visual survey

- Absent in eDNA (N=11)
- Present in eDNA (N=17)
- No Reference Sequence (N=4)
- 12S Reference Available (N=7)
- Genus/Family Detected (N=8)
- Species-specific ID Detected (N=9)

Comparing Bony Fish Families detected by both methods

Visual Survey

- N=3
- N=11
- N=44

eDNA
A case study with bony fishes:

Species Detected by both Visual and eDNA methods

Visual Biomass

Biomass (g.m⁻²) / Number of rarefied reads

Gibbonsia spp.
Blacksmith
Pile perch
Black surfperch
Garibaldi
Rock wrasse
Señorita
Painted greenling
Cabezon
Sheephead

Sites

eDNA Relative Abundance

Gibbonsia spp.
Blacksmith
Pile perch
Black surfperch
Garibaldi
Rock wrasse
Señorita
Painted greenling
Cabezon
Sheephead
MBON
Marine Biodiversity Observation Network