Santa Barbara Channel
Marine Biodiversity Observation Network

Marine Science Institute
University of California Santa Barbara
Envisioning a Marine Biodiversity Observation Network

BioScience • May 2013 / Vol. 63 No. 5

J. EMMETT DUFFY, LINDA A. AMARAL-ZETTLER, DAPHNE G. FAUTIN, GUSTAV PAULAY, TATIANA A. RYNEARSON, HEIDI M. SOSIK, AND JOHN J. STACHOWICZ
Who we are
Principal/Associate Investigators

Marine Science Institute
Robert Miller, Andrew Rassweiler, Daniel Reed, Milton Love

Ecology Evolution and Marine Biology
Craig Carlson, Deborah Iglesias-Rodriguez, Doug McCauley

Geography
David Siegel, Phaedon Kyriakidis

Electrical and Computer Engineering
BS Manjunath

USGS
Kevin Lafferty

UCSD - SIO
John Hildebrand

NOAA – NMFS SWFSC
Andrew Thompson
Partners

Channel Islands National Marine Sanctuary
Channel Islands National Park
Santa Barbara Coastal Long Term Ecological Research Program
Plumes and Blooms
Southern California Coastal Water Research Project
Southern California Coastal Ocean Observing System (SCCOOS)
Gray Whales Count
San Onofre Nuclear Generating Station Mitigation Monitoring
CalCOFI
**SANTA BARBARA CHANNEL (SBC) BON**

Goals:

1. Integrate biodiversity data to enable inferences about regional biodiversity

2. Develop advanced methods in optical and acoustic imaging and genomics for monitoring biodiversity in partnership with ongoing monitoring and research programs

3. Implement a tradeoff framework that optimizes allocation of sampling effort
1. Integrate biodiversity data to enable inferences about regional biodiversity

Approach:

A) Focus on *taxocenes* and *communities* - comparable sets of organisms e.g. microbes, benthic megafauna
1. Integrate biodiversity data to enable inferences about regional biodiversity

Approach:

B) Use geospatial statistics and predictive modeling to extrapolate these measurements to larger scales
Communities are spatially structured at **multiple scales**. The spatial variation in community composition is **beta diversity**.
variation in community composition

38% — Biogeographic trend
11% — Positive spatial structures
7% — Negative spatial structures
44% — Random noise (error)

Lamy et al., in prep

Site scores - Canonical axis 1 (9.1%)
\[ F_{1,127} = 13.55, P < 0.001 \]

Site scores - Canonical axis 1 (5.7%)
\[ F_{1,127} = 8.18, P < 0.001 \]

133 samples
2005-2014
CINP, LTER, PISCO, USGS
What are the ecological processes and environmental drivers underlying each of these scales?

- Physical environment (SST, Bathymetry, substrate, slope)
- Pelagic primary production (Chl a)
- Benthic primary production (Kelp biomass)
- Disturbance regime (wave height, ENSO)
- Connectivity - source and destination strength

Identifying environmental drivers
Giant Kelp: A Foundation Species

- Provides tremendous structural complexity
- Major food source for many grazers
- Detritus fuels local and regional food webs
Landsat Kelp Forest Biomass

• 30 m resolution multispectral imagery
• Kelp reflectance calibrated to biomass measured by divers in SBC LTER long-term plots
• SBC time series includes ~ 6-8 usable images per year since 1984 from central CA to Baja CA

Canopy biomass of *Macrocystis pyrifera* (top) can be quantified from Landsat 5 imagery (bottom).
Hyperspectral aerial flights conducted 3x year\(^{-1}\) in 2013 – 2015 using the AVIRIS sensor in HyspIRI preparatory campaign

*Thomas Bell, David Siegel*

Chl:C estimated from hyperspectral images closely resembles Chl:C measured in the laboratory

\[ r^2 = 0.71 \]

\[ p < 0.001 \]
Regional patterns of kelp Chlorophyll mirror the east-west gradient of temperature and nutrients in the Santa Barbara Channel.
Goal 2. Develop advanced methods in optical and acoustic imaging and genomics for monitoring biodiversity

Optical Imaging
Deep learning for image analysis

UCSB Center for Bio-image Informatics

Benefits
- Fully automated - no feature selection
- Fast classification on GPUs
- High accuracy
- Generalizes to any data

Convolutional Neural Network (CNN)

Convolutional levels: Feature extraction typically required an engineer to select or develop a feature descriptor with CNNs it is learned from data.

Classifier: fully connected layers
Percent cover at 95% goodness
Segmentation at 95% goodness
Goal 2. Develop advanced methods in optical and acoustic imaging and genomics for monitoring biodiversity

Targets:
- microbes
- microplankton
- ichthyoplankton
- eDNA

A Genomic View of Biodiversity Across Multiple Trophic Levels
Time-series shows repeatable, seasonal surface bacterioplankton communities

- SAR86
- SAR11
- SAR11

Relative abundance (%)

2011 2012 2013 2014

- South → north, or islands → mainland
- South
- Surface 1
- Surface 2

• Time-series on Plumes & Blooms cruise line
• 44 cruises, 2010-14
• Profile to 300m at center station
• new Earth Microbiome Project

16S rDNA primers
These dominant OTUs have clear, distinct correlations to bottom-up controls

**Positive Spearman’s rho:**
- Bacterial production
- Phyto biomass
- Diatom indicators

**Negative:**
- Inorganic nutrients

**Positive:**
- Inorganic nutrients

**Negative:**
- [DOC]
- Temperature

**Positive:**
- Temperature

**Negative:**
- Bacterial production
- Inorganic nutrients
- Phyto biomass
Santa Barbara Channel  MBON IMS

- Adopted community protocols and standards
- Per LTER
  - Relational Database Management System -> XML
  - Structural quality control
  - Local catalog
- Federation mechanism – DMAC group

Servers

Integrate ingested & de novo data

Data Package Design

EML Metadata Export

Data Package Checking

IOOS, Marine Cadastre, NCEI