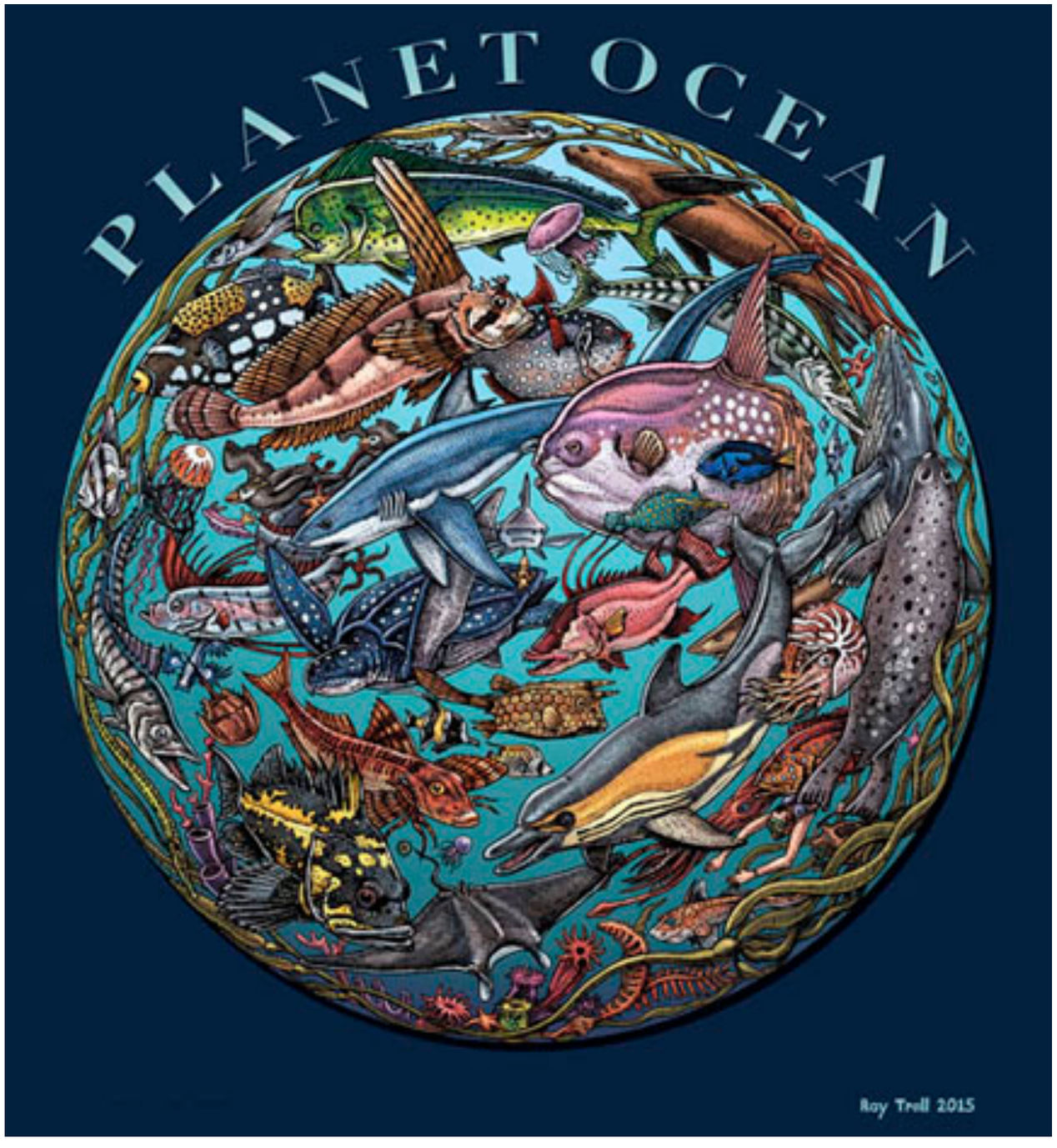
Santa Barbara Channel
Marine Biodiversity Observation Network



BOEM
Bureau of Ocean Energy Management

T.G.I. TROLL GLOBAL INDUSTRIES
SCIENCE ART & MYSTERY

Marine Science Institute
University of California Santa Barbara

GEOBON

Articles

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:

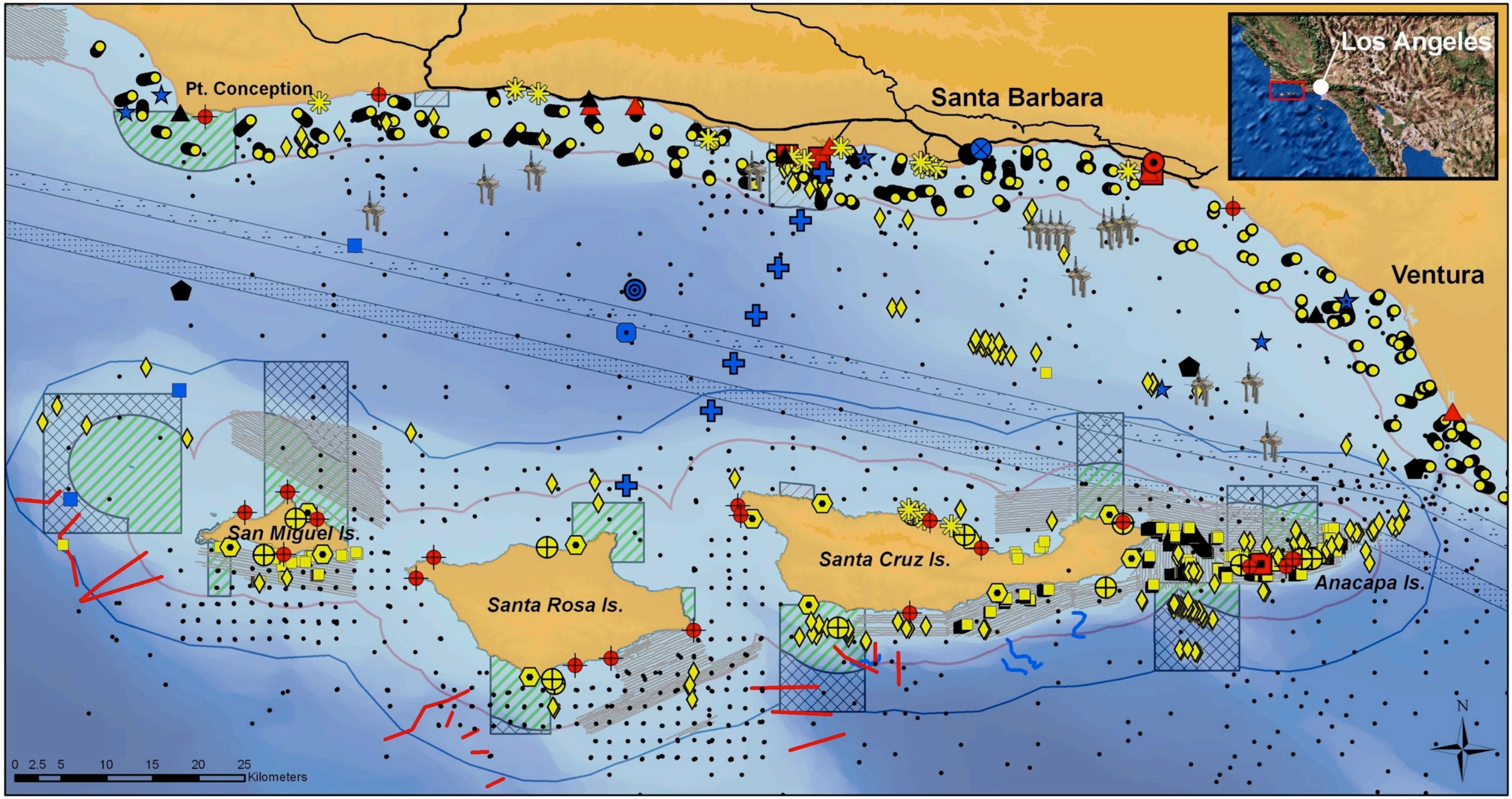
1. Integrate biodiversity data to enable inferences about regional biodiversity

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

Existing Monitoring Partners

Santa Barbara Channel, California



Legend

- CalCOFI
- CalCOFI / SCCOOS
- NOAA NMFS Midwater Trawls
- Mark VI Sediment Trap
- SIO Whale Acoustics
- SCCOOS HAB Monitoring
- Plumes and Blooms
- SCCOOS CDIP Buoy
- SCCOOS HF Radar
- SCCOOS Manual Shore Station
- SCCOOS Automated Shore Station
- LiMPETS Rocky Intertidal
- LiMPETS Beach
- SONGS Estuary Monitoring
- CINP/MARINe Rocky Intertidal
- Love Submersible Survey
- SBC LTER
- CNIP Kelp Forest
- CINMS OB Moorings
- USGS ROV Video
- USGS Scuba-ROV Surveys
- Love Oil Platform Survey
- USGS Sediment Samples
- USGS Survey Tracks
- CINMS Deep Sea Coral Transects
- CINMS OE Transects
- CA State Water
- Federal MPA
- CINMS Boundary
- Shipping North
- Shipping South
- SMCA
- SMCA (No-Take)
- SMP
- SMR
- SMRMA
- Special Closure

Bathymetry
Depth (m)
0
-1939

Projection: NAD 1983

Blue = Pelagic, Black = Oceanography, Red = Intertidal, Yellow = Benthic/Subtidal

CalCOFI - California Cooperative Oceanic Fisheries Investigations
SCCOOS - Southern California Coastal Ocean Observing System
NOAA - National Oceanic & Atmospheric Administration
NMFS - National Marine Fisheries Service
SIO - Scripps Institute of Oceanography
HAB - Harmful Algal Blooms
CDIP - Coastal Data Information Program
HF - High Frequency
LiMPETS - Long-term Monitoring Program & Experimental Training for Students
SONGS - San Onofre Nuclear Generating Station
SBC LTER - Santa Barbara Coastal Long-term Ecological Research
CNIP - Channel Islands National Park
MARINe - Multi-Agency Rocky Intertidal Network
CINMS - Channel Islands National Marine Sanctuary
ROV - Remotely Operated Vehicle
USGS - United States Geologic Survey
MPA - Marine Protected Area
SMCA - State Marine Conservation Area
SMP - State Marine Park
SMR - State Marine Reserve
SMRMA - State Marine Recreational Management Area

1. Integrate biodiversity data to enable inferences about regional biodiversity

Approach:

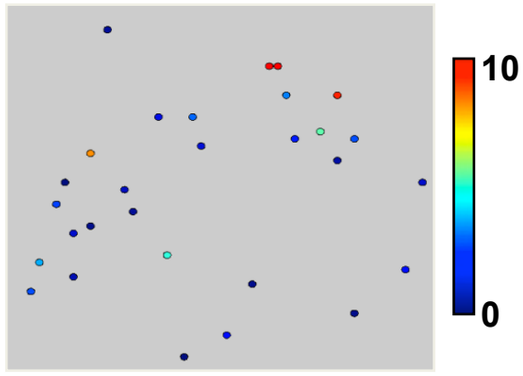
A) Focus on *taxocenes* and *communities* - comparable sets of organisms e.g. microbes, benthic megafauna

1. Integrate biodiversity data to enable inferences about regional biodiversity

Approach:

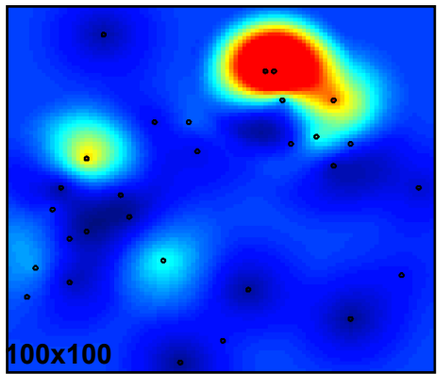
B) Use geospatial statistics and predictive modeling to extrapolate these measurements to larger scales

direct measurements



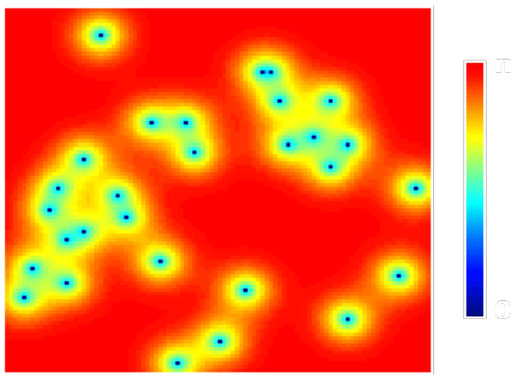
sparse

optimal estimates



Using direct data only

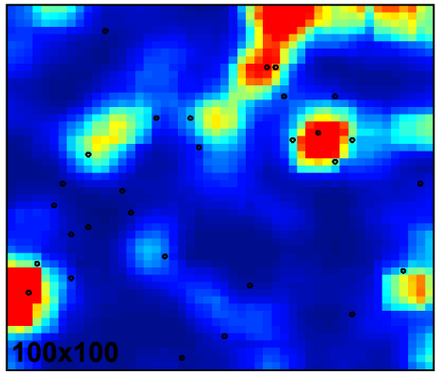
uncertainty



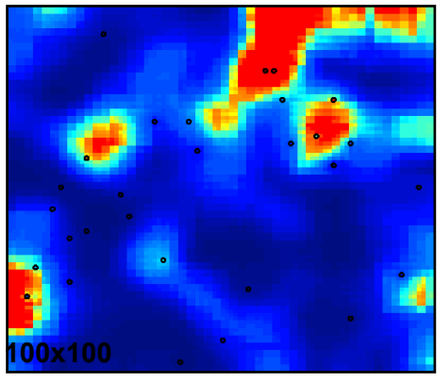
integration & expansion

Scaling accounting for data resolution data accuracy

indirect measurements

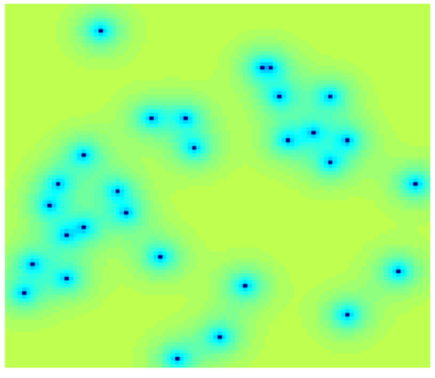


abundant



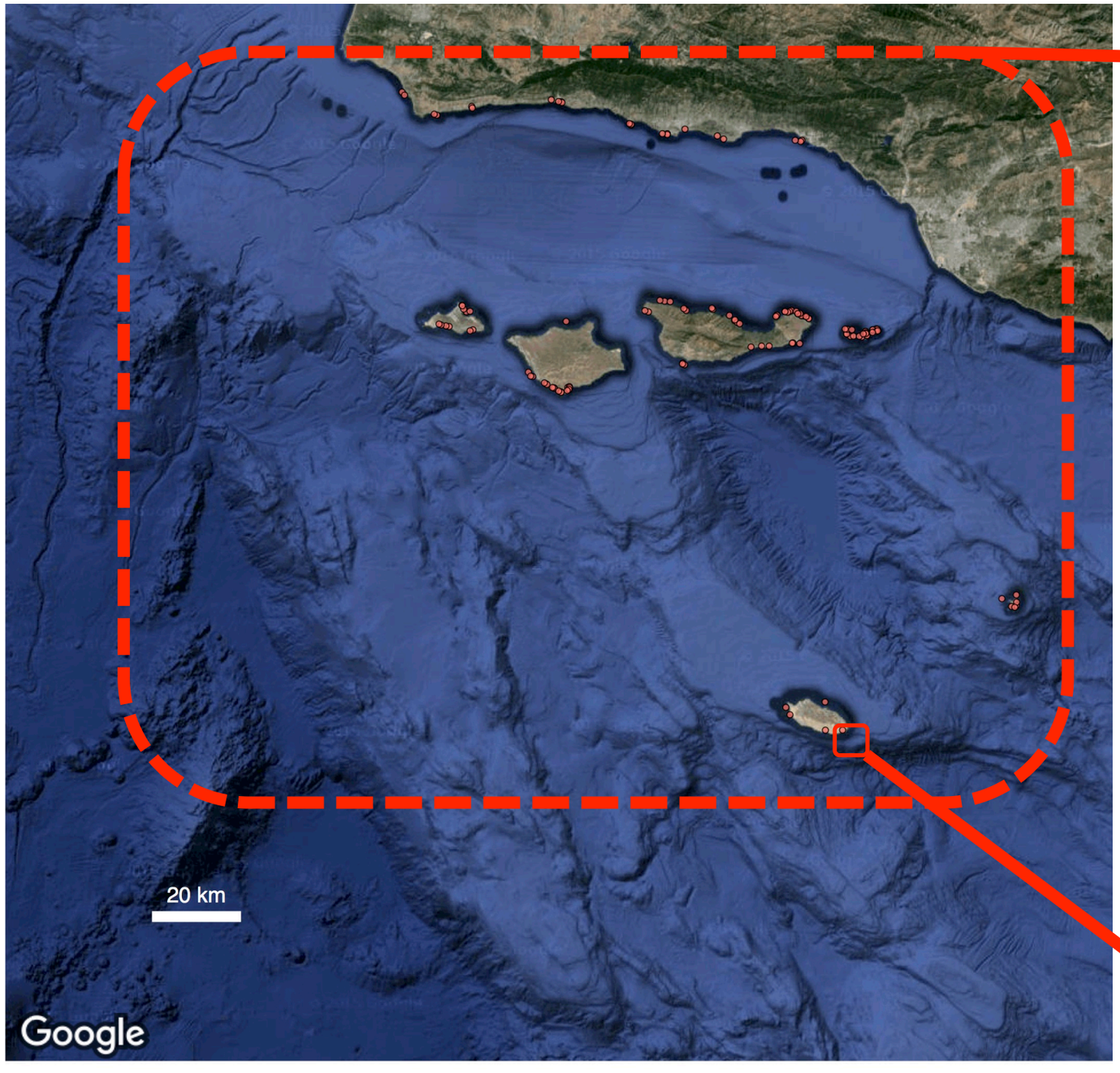
Using direct + indirect data

uncertainty

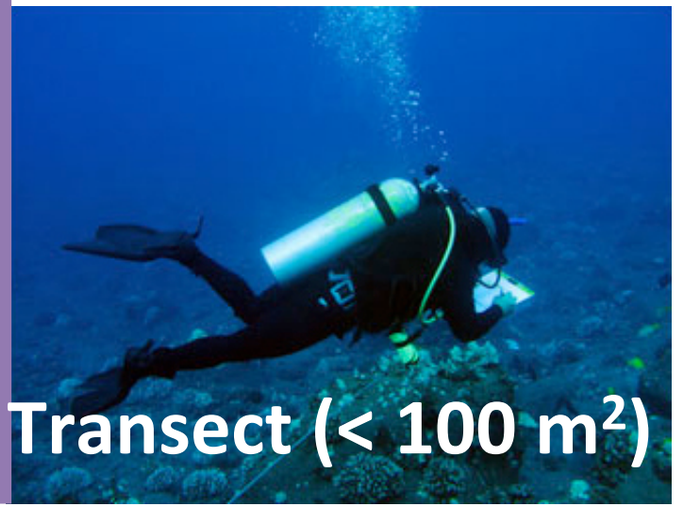


Complex and multiscale patterns of community structure

Communities are spatially structured at **multiple scales**. The spatial variation in community composition is **beta diversity**



Scaling with space



variation in community composition

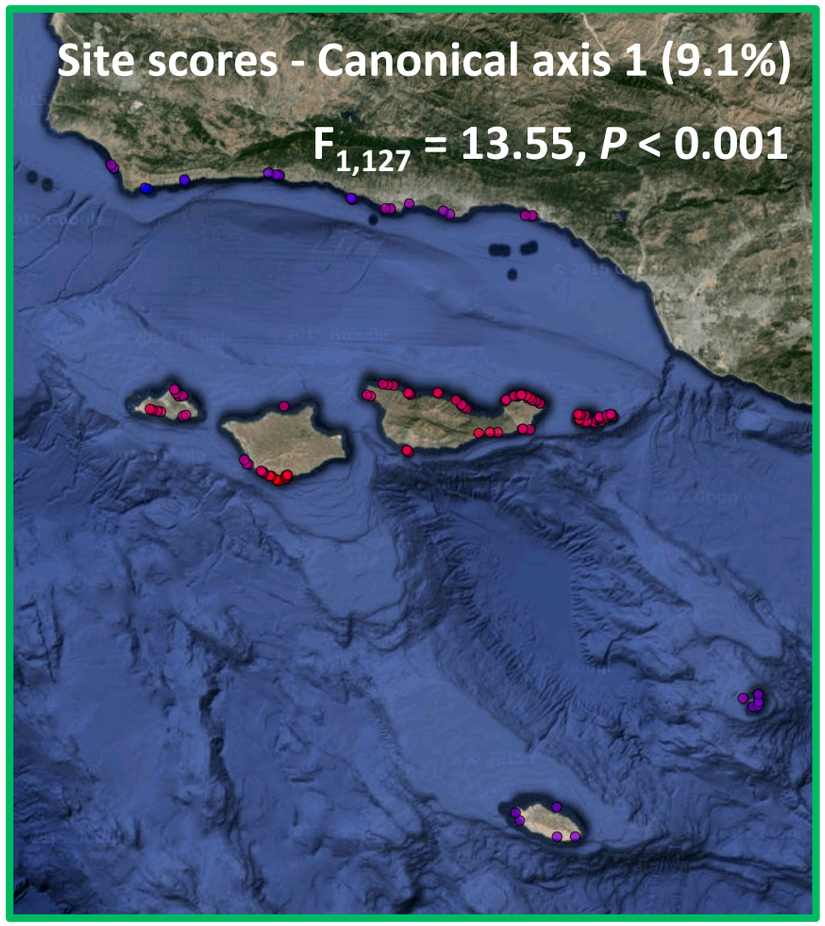
38% — Biogeographic trend

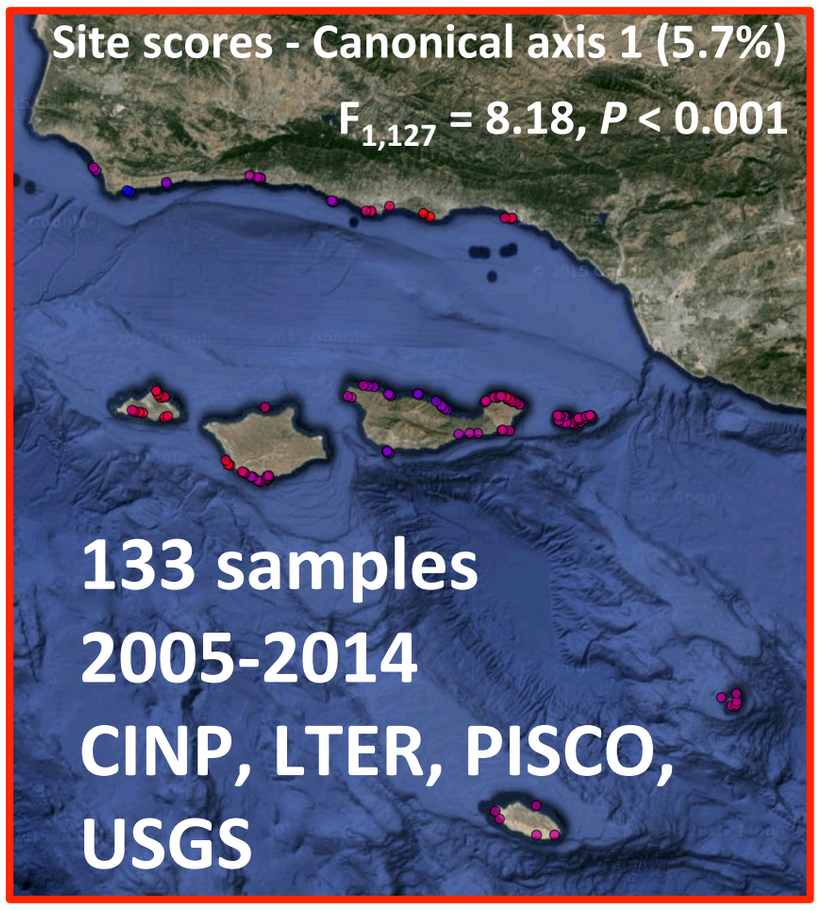
11% — Positive spatial structures

7% — Negative spatial structures

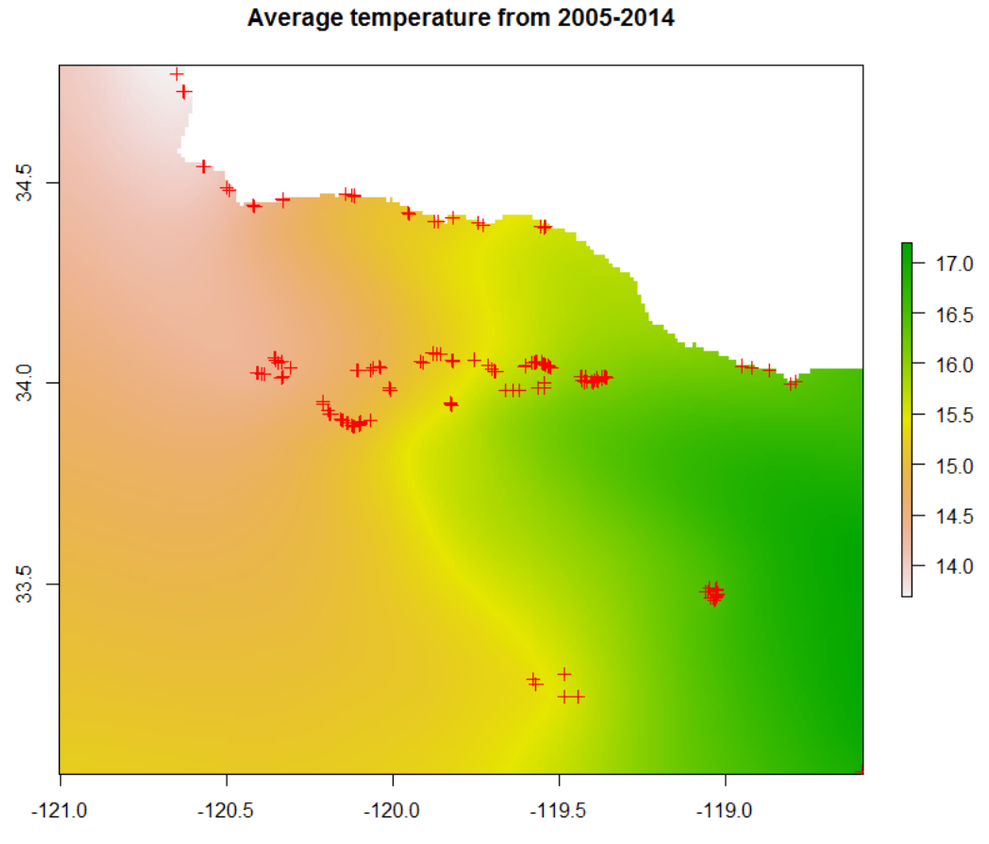
44% — Random noise (error)

Lamy et al., in prep





What are the ecological processes and environmental drivers underlying each of these scales?



Identifying environmental drivers

- 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

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

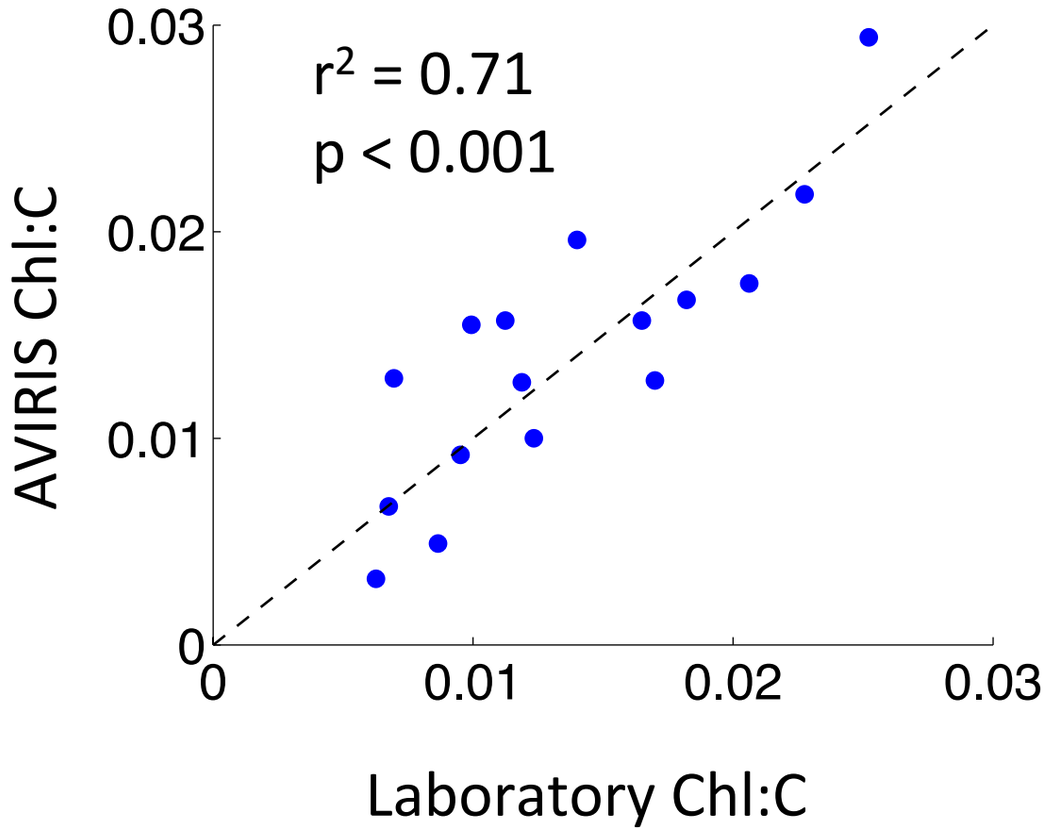
- 30 m resolution multispectral imagery
- Kelp reflectance calibrated to biomass measured by divers in SBC LTER long-term plots
- SBC time series includes ~ 6-8 usable images per year since 1984 from central CA to Baja CA

Canopy biomass of *Macrocystis pyrifera* (top) can be quantified from Landsat 5 imagery (bottom).

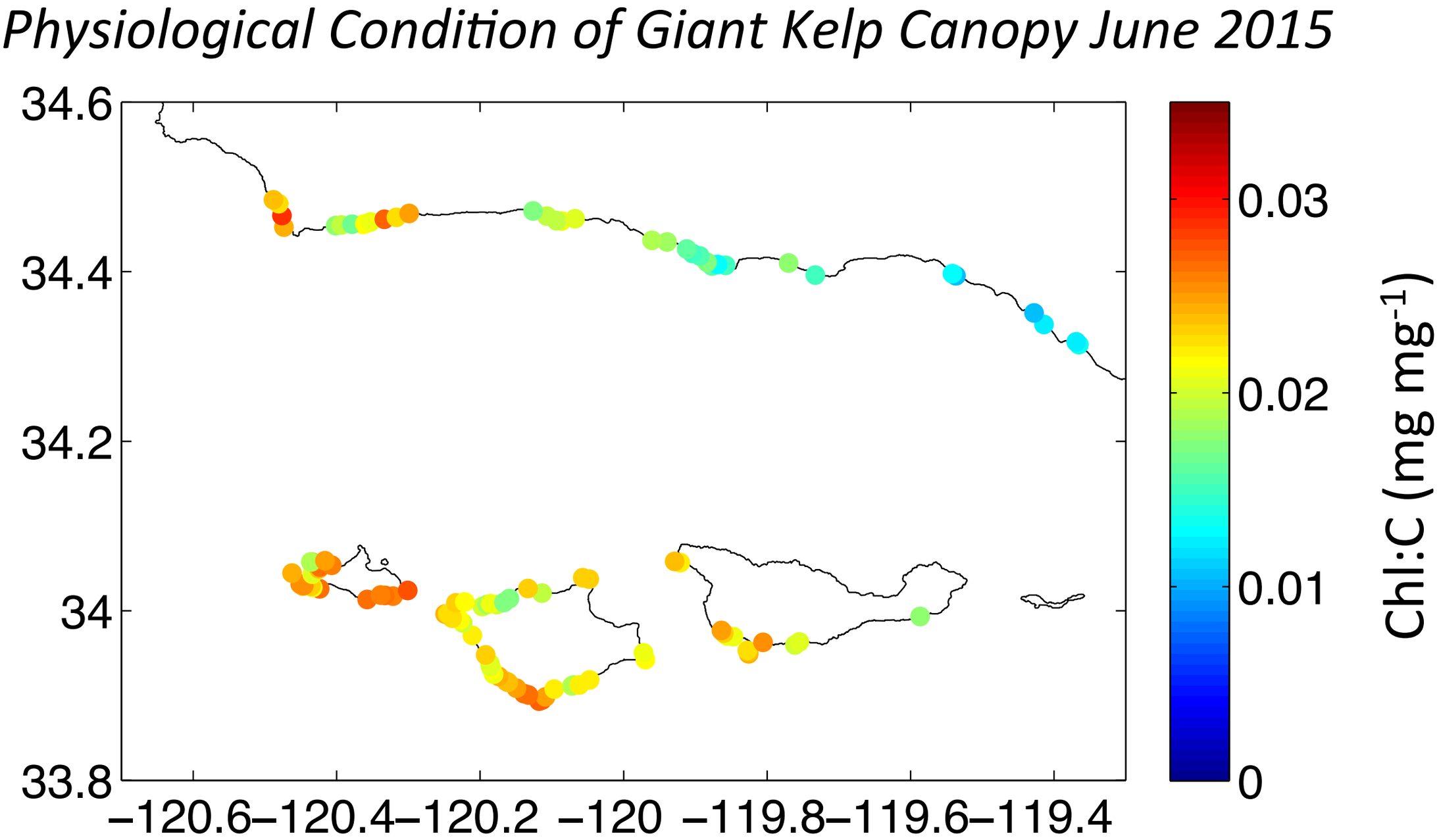
Hyperspectral aerial flights conducted 3x year^{-1} in 2013 – 2015 using the AVIRIS sensor in HysplRI preparatory campaign

Thomas Bell, David Siegel

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

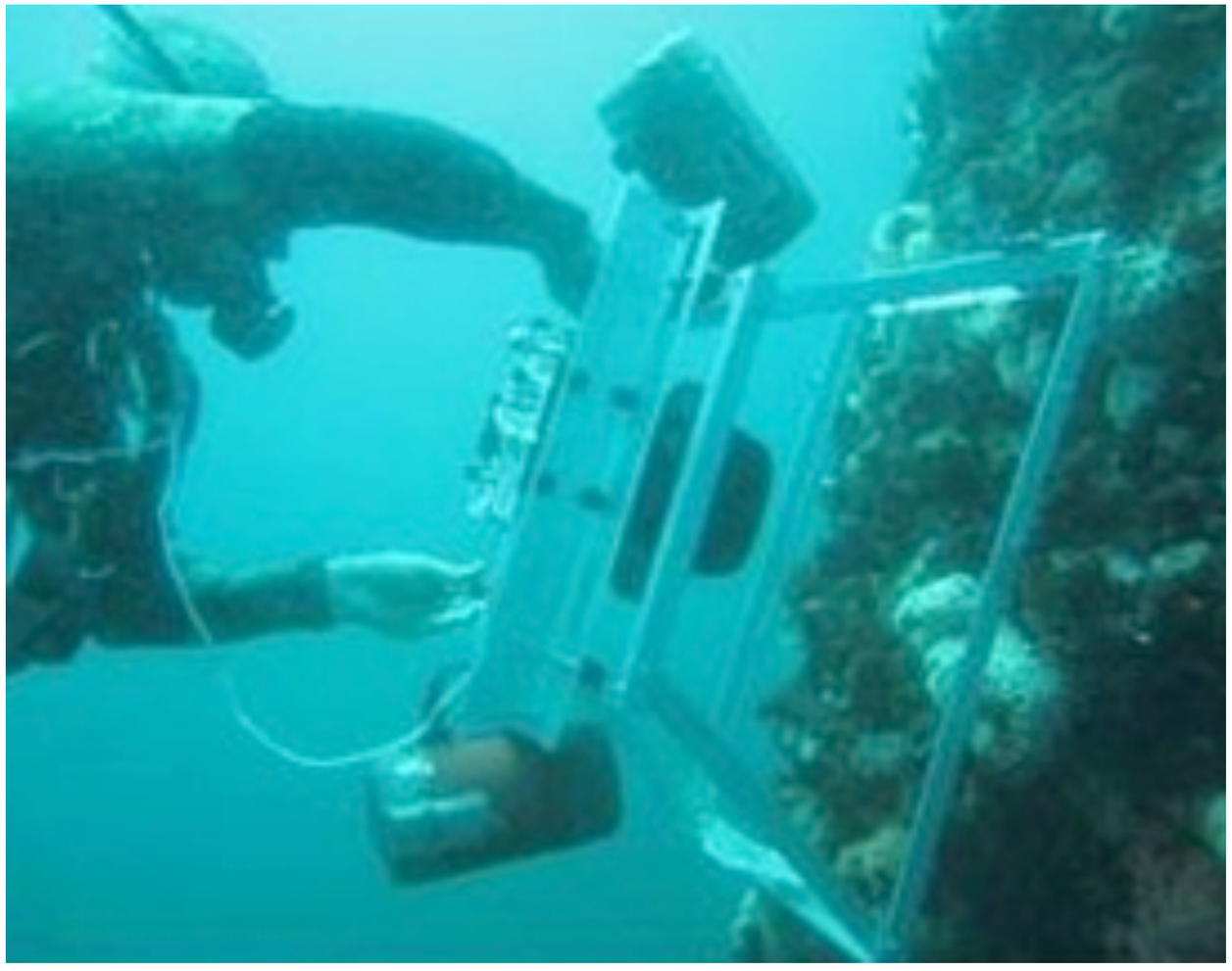


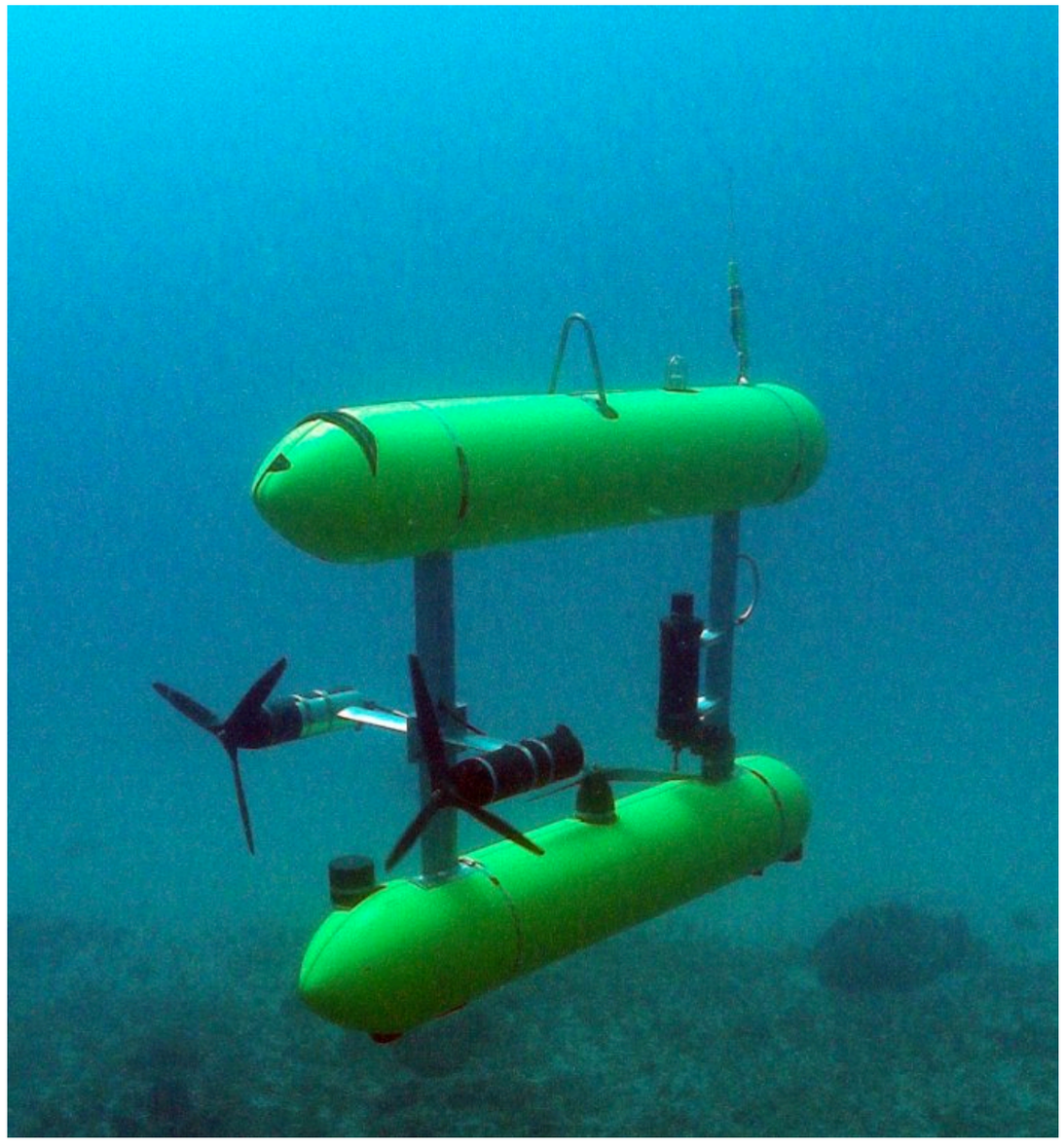
Regional patterns of kelp Chlorophyll mirror the east-west gradient of temperature and nutrients in the Santa Barbara Channel



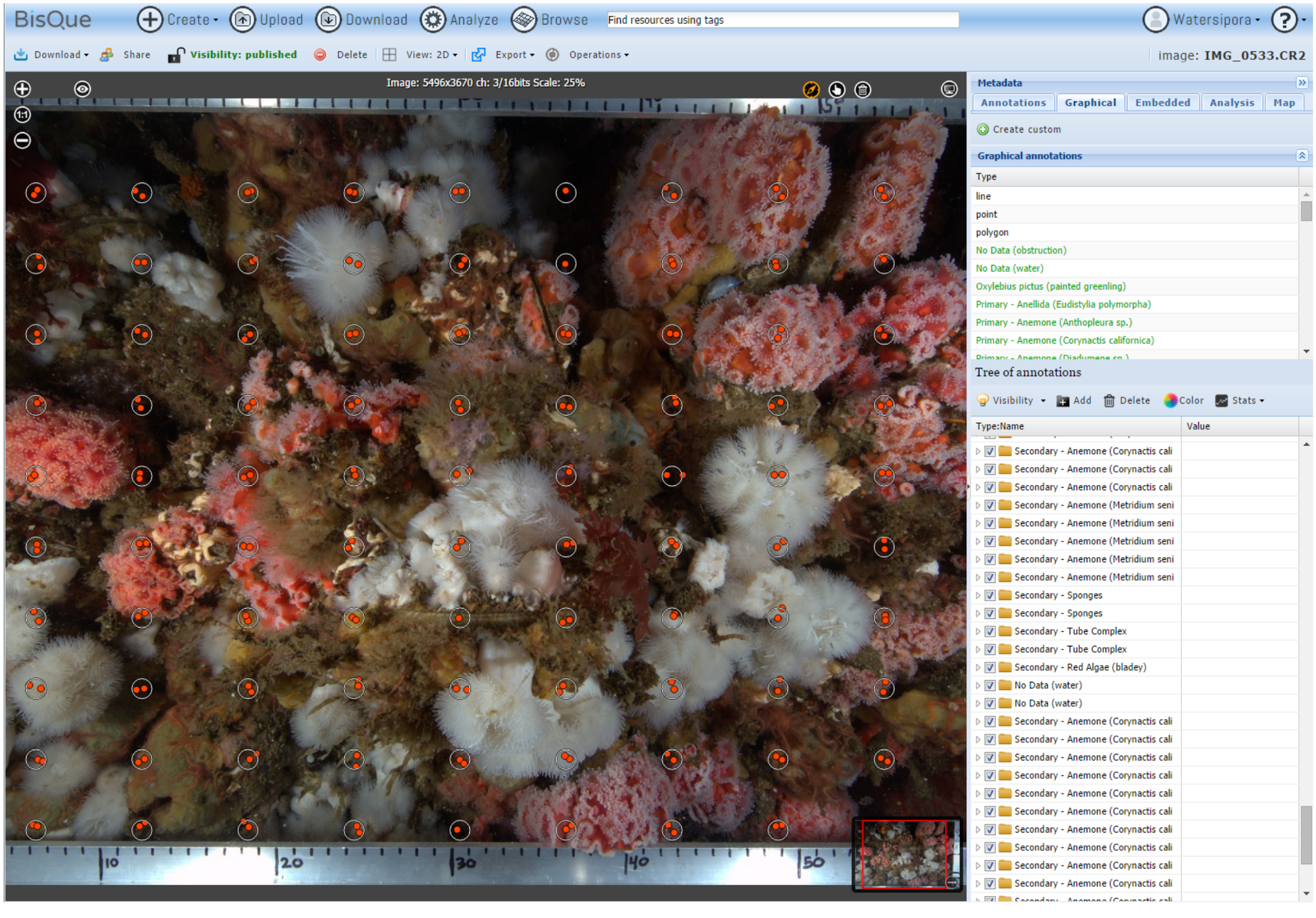
Goal 2. Develop advanced methods in optical and acoustic imaging and genomics for monitoring biodiversity

Optical Imaging





UCSB Center for BIO-IMAGE INFORMATICS



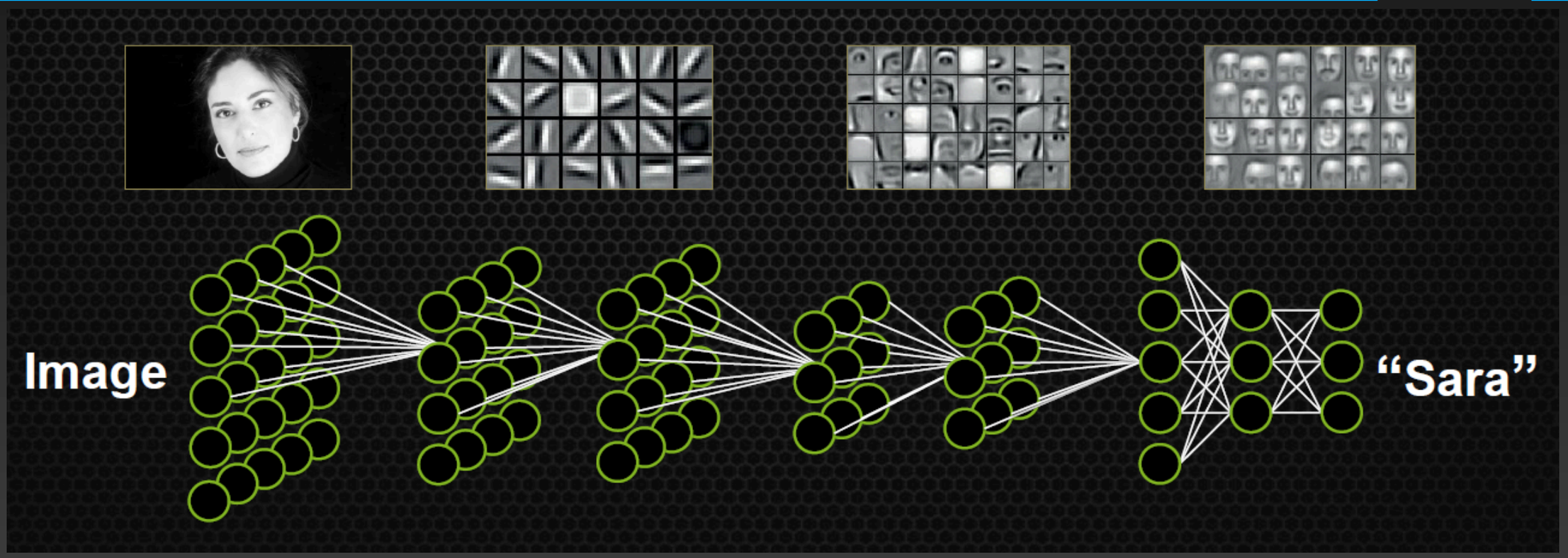
Deep learning for image analysis

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)

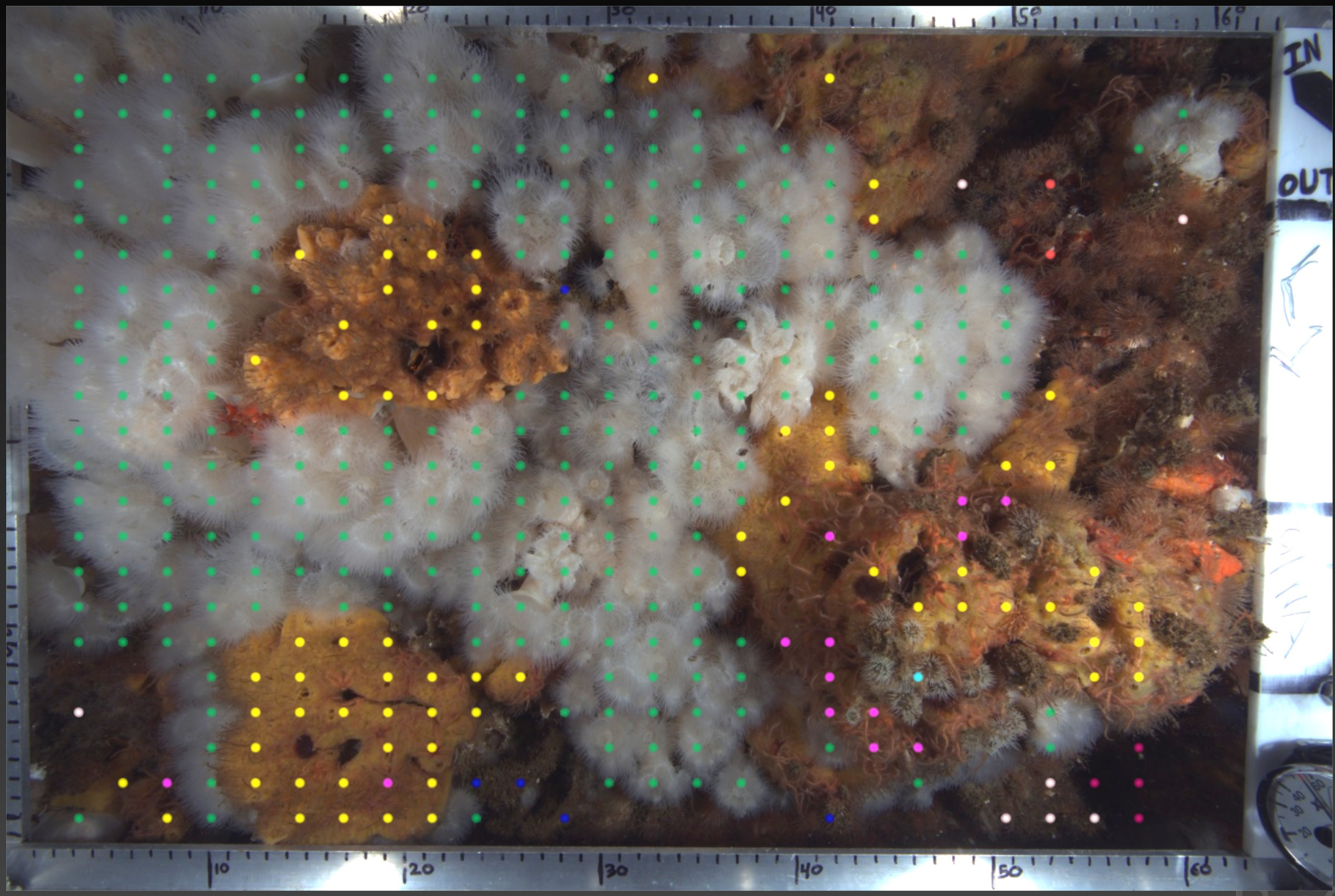


Convolutional levels: Feature extraction typically required an engineer to select or develop a feature descriptor with CNNs it is learned from data.

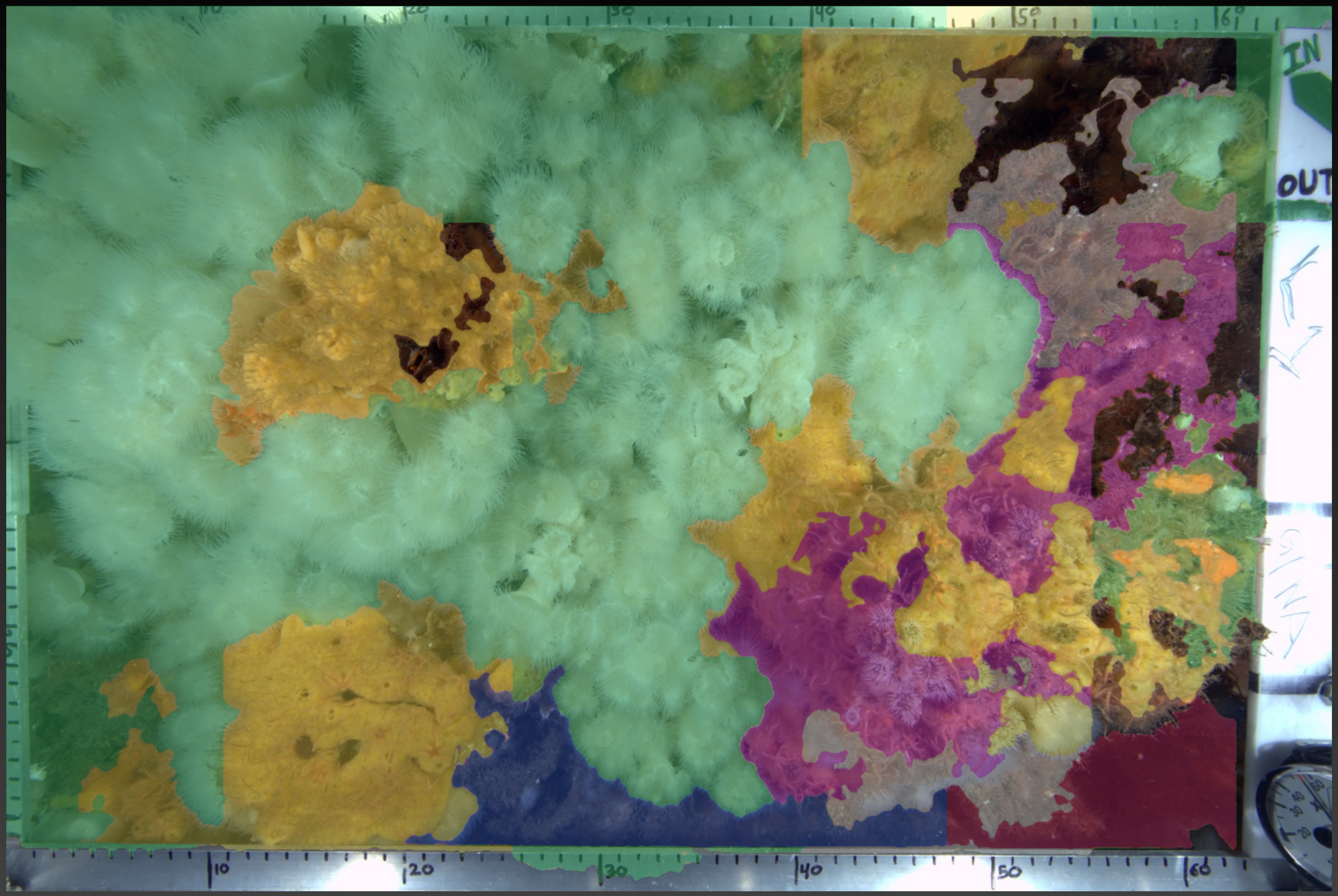
Classifier: fully connected layers

BisQue

Percent cover at 95% goodness



Segmentation at 95% goodness

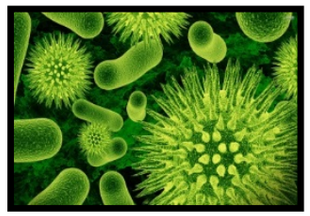


Goal 2. Develop advanced methods in optical and acoustic imaging and genomics for monitoring biodiversity

Ecosystem

Total DNA collected on filters

Amplification of barcode genes for particular groups (prokaryotes to vertebrates)

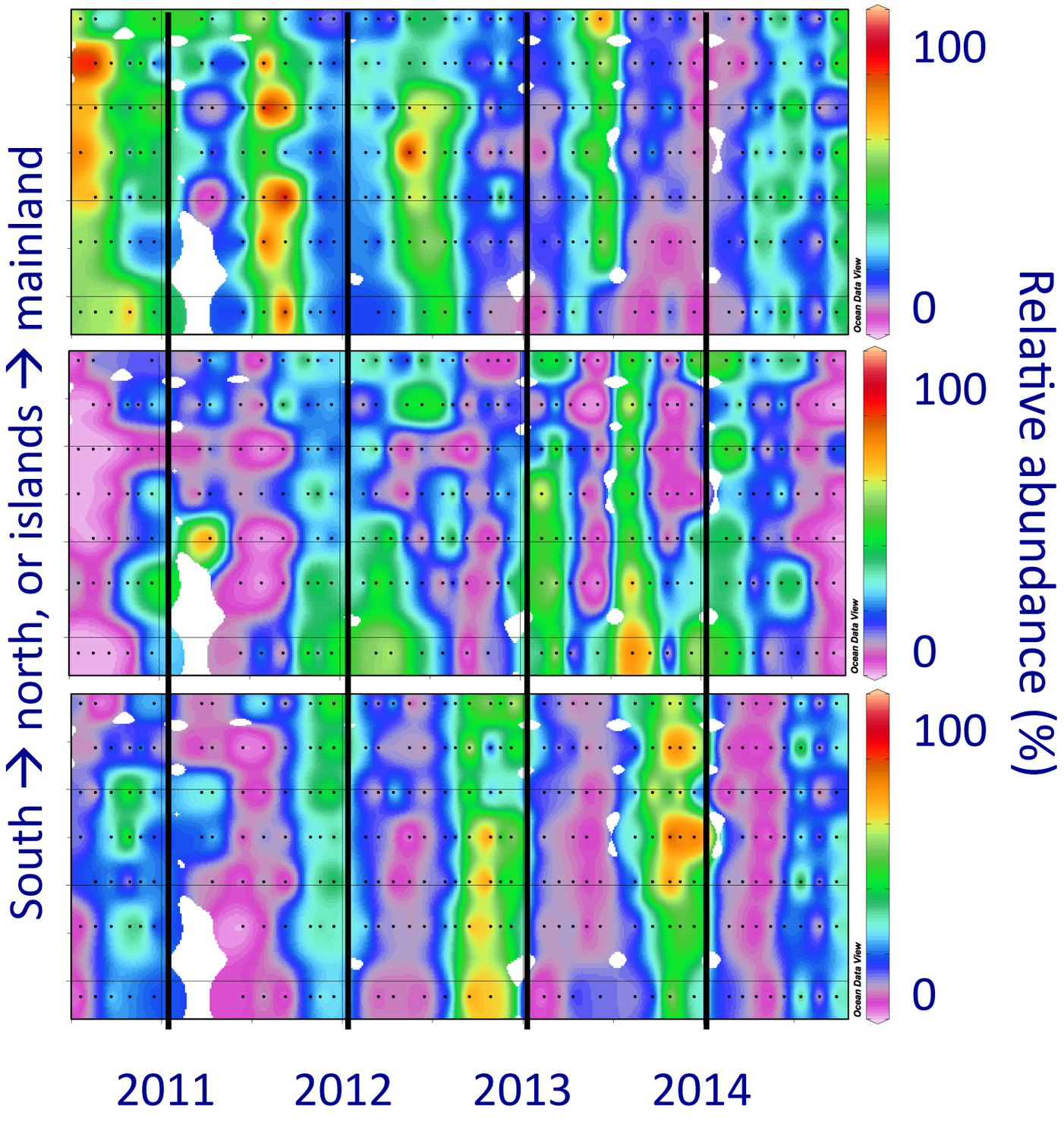


A Genomic View of Biodiversity Across Multiple Trophic Levels

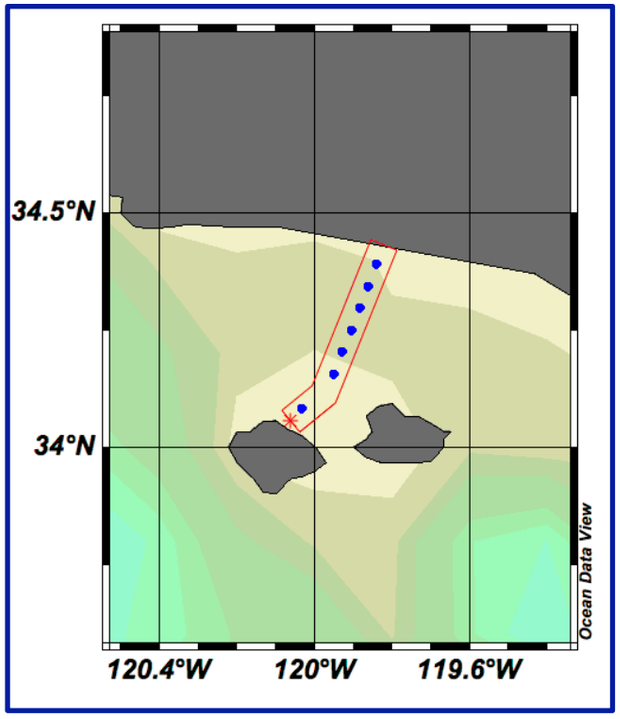
Targets:

- Microbes
- Microplankton
- Ichthyoplankton
- eDNA

Time-series shows repeatable, seasonal surface bacterioplankton communities



- Time-series on Plumes & Blooms cruise line
- 44 cruises, 2010-14
- Profile to 300m at center station
- new Earth Microbiome Project 16S rDNA primers

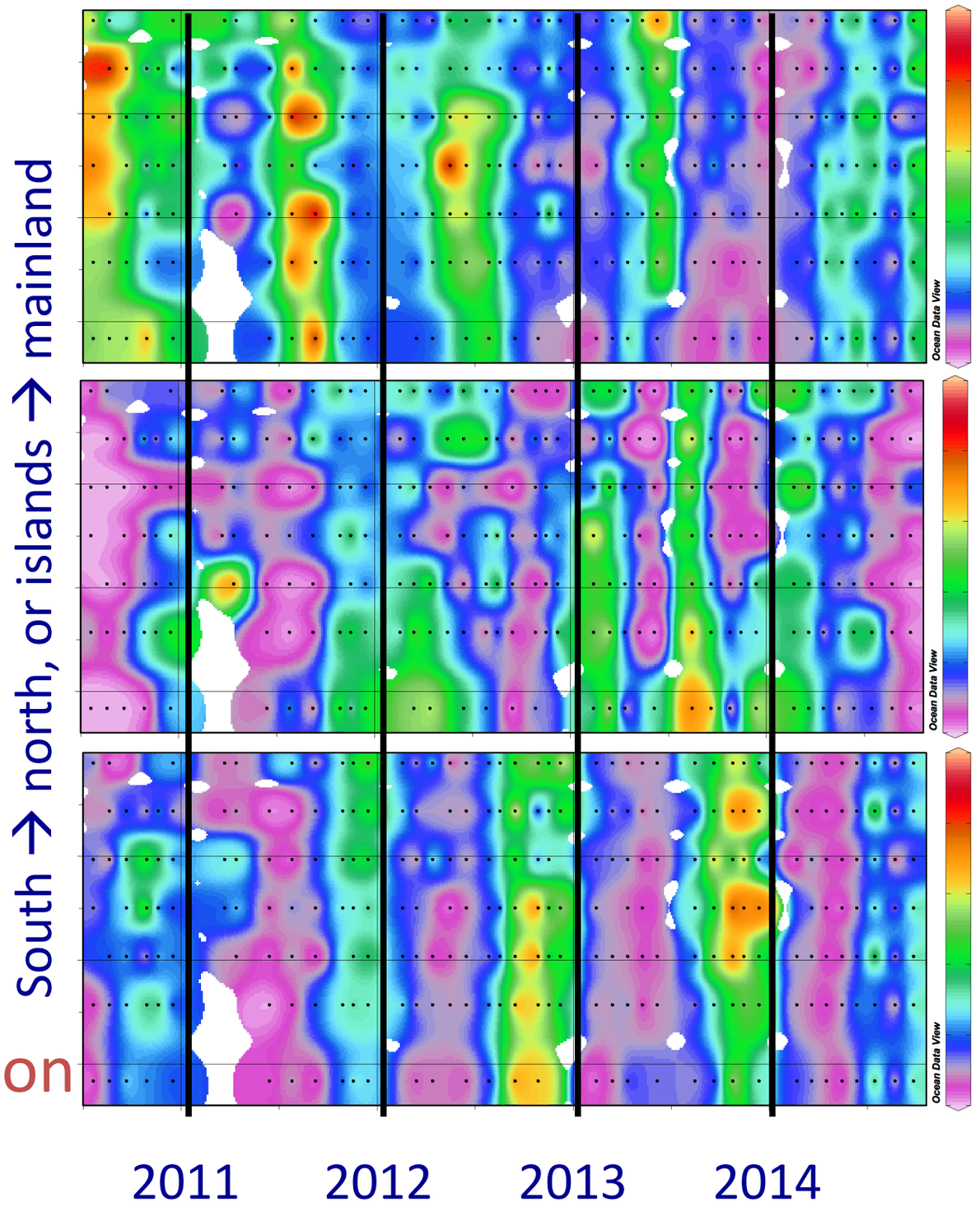


These dominant OTUs have clear, distinct correlations to bottom-up controls

SAR86
Blooms

SAR11
Surface 1
Mixing & upwelling

SAR11
Surface 2
Stratification



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

Negative:
- Inorganic nutrients

Positive:
- Inorganic nutrients

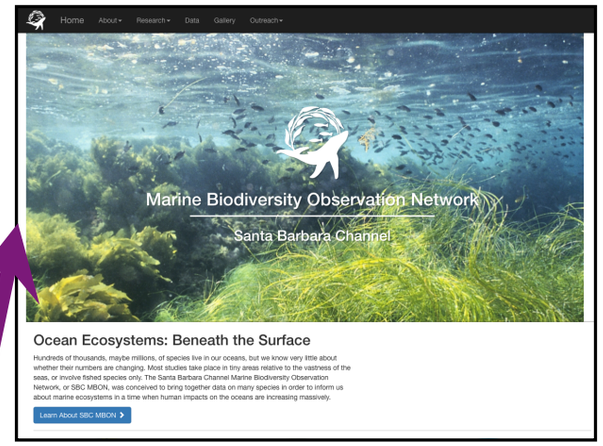
Negative:
- [DOC]
- Temperature

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**

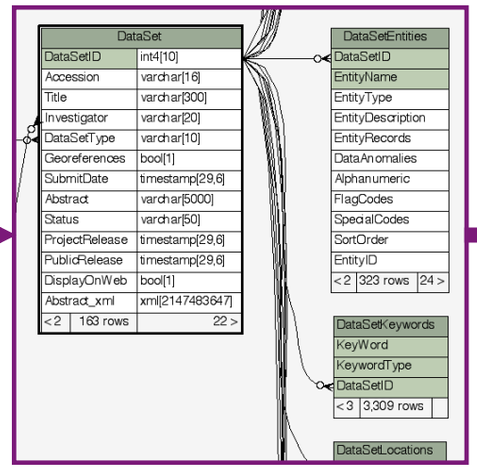


DataONE Member Node?

Servers

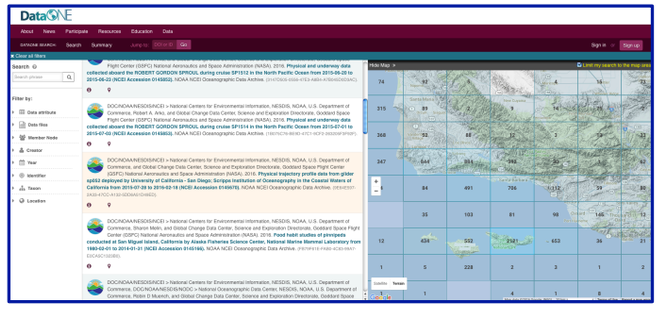
Integrate ingested & de novo data

Data Package Design



EML Metadata Export

Data Package Checking



IOOS, Marine Cadastre, NCEI