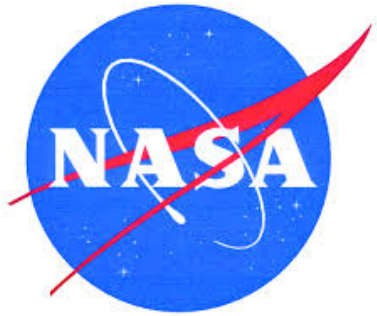


BOEM
Bureau of Ocean Energy Management

MARINE BIODIVERSITY OBSERVATION NETWORK

SANTA BARBARA CHANNEL

Marine Science Institute
University of California Santa Barbara

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

Who we are

Partners

Plumes and Blooms

Channel Islands National Marine Sanctuary

Southern California Coastal Water Research Project

Santa Barbara Coastal Long Term Ecological Research Program

Southern California Coastal Ocean Observing System (SCCOOS)

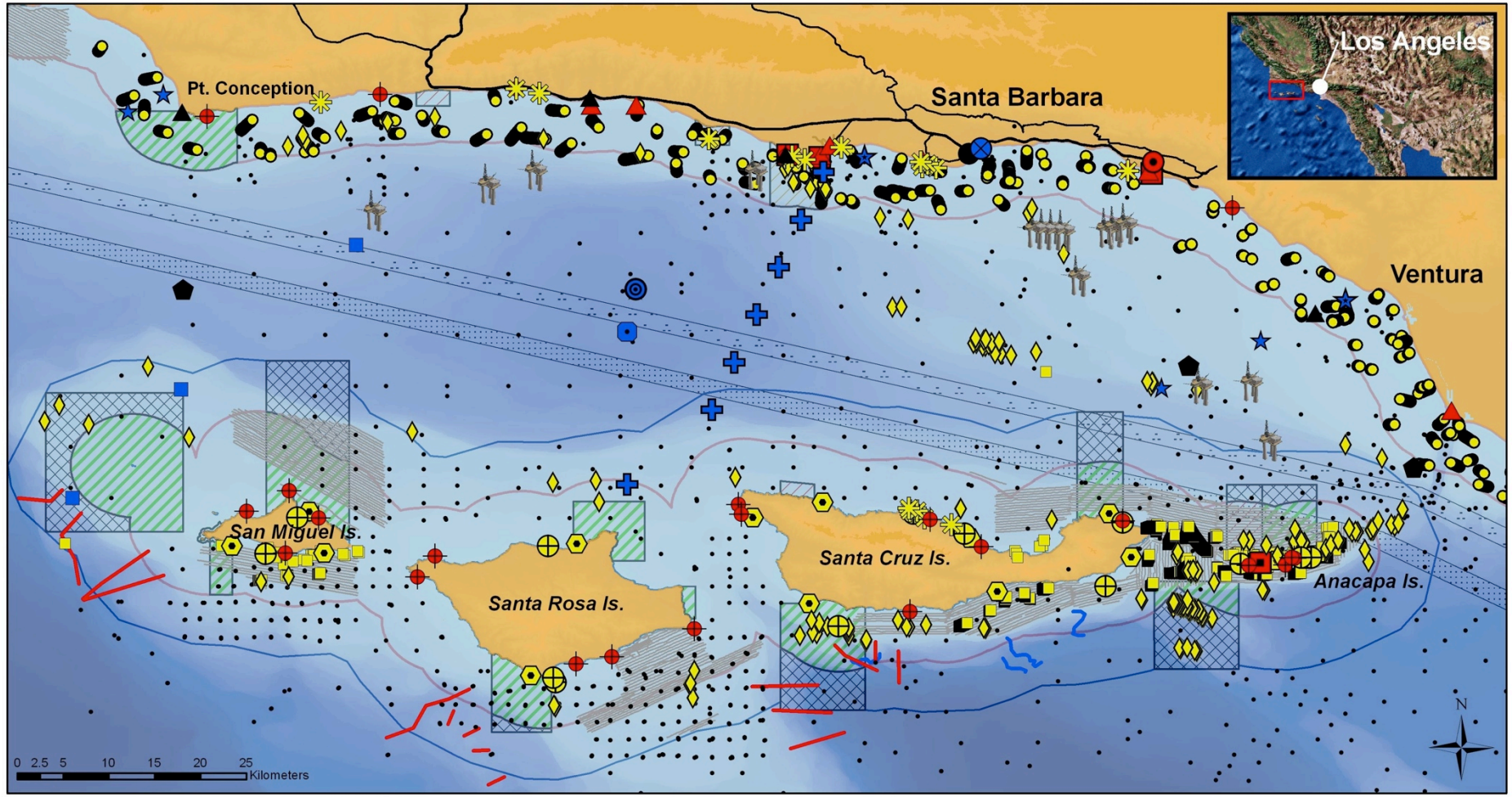
Channel Islands National Park

Gray Whales Count

CalCOFI

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

MARINE BIODIVERSITY OBSERVATION NETWORK
SANTA BARBARA CHANNEL

Goals:

1. Integrate biodiversity data to enable inferences about regional biodiversity

2. Develop advanced methods using imagery and genomics for monitoring biodiversity

3. Implement a tradeoff framework that optimizes allocation of sampling effort

PISCO
Since 1999, frequency varies
23 sites, random transects
Variable taxonomic resolution

NPS KFM
Since 1991, biannual
38 sites, islands fixed/random
Variable taxonomic resolution

SBC LTER
Since 2000, annual
11 reefs, mainland conc.
High taxonomic resolution

USGS SNI
Since 1980, semiannual
5 transects, San Nicolas Is.
Variable taxonomic resolution

Primary Data
4 projects,
16 time series

Data cleaning

Filter records

Harmonize design
- Areas, depth ranges
- Frequency
- Fixed vs random

Harmonize taxonomy
- Std codes (WoRMS)
- Resolve ranks
- Life stage
- Closed/open spp list

Quality Control

Cleaned Data
3 time series

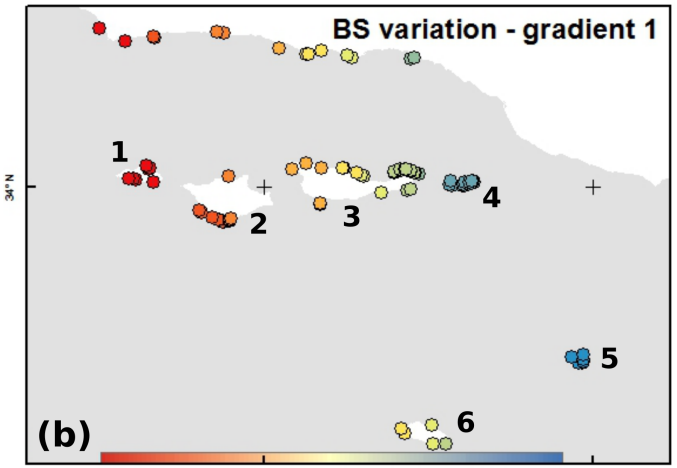
SBC MBON Analysis
- Species distribution
- Community structure
- Environmental drivers
- Species spatial and temporal change

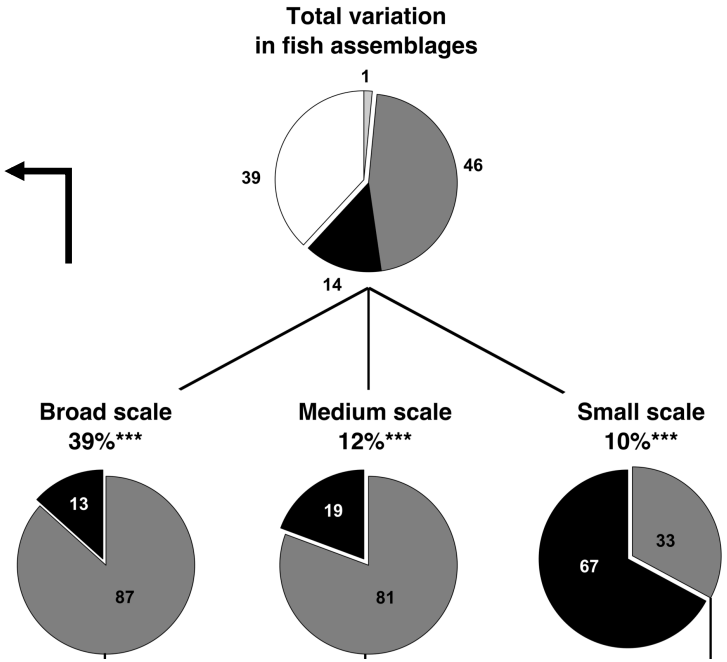
MBON Products

Secondary Data
Biodiversity indices

Uncovering the complex and multiscale drivers of kelp forest communities

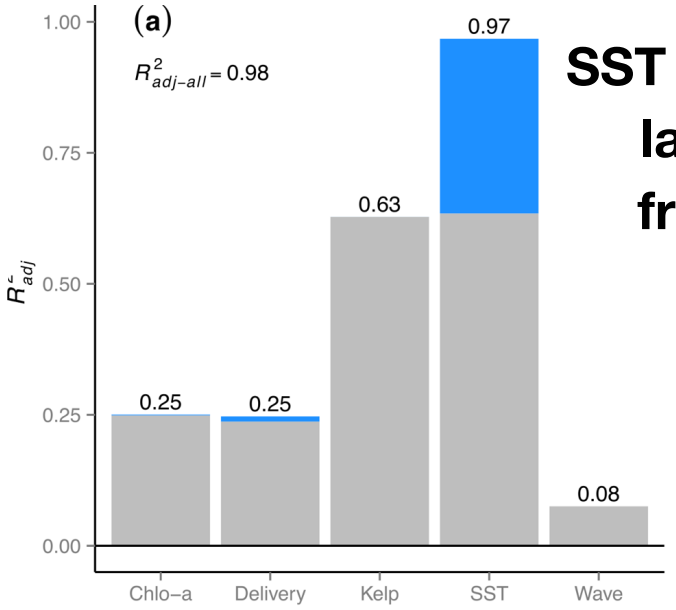
What are the most important scales of variation?





Thomas Lamy

What environmental factor(s) underlie each spatial scale?

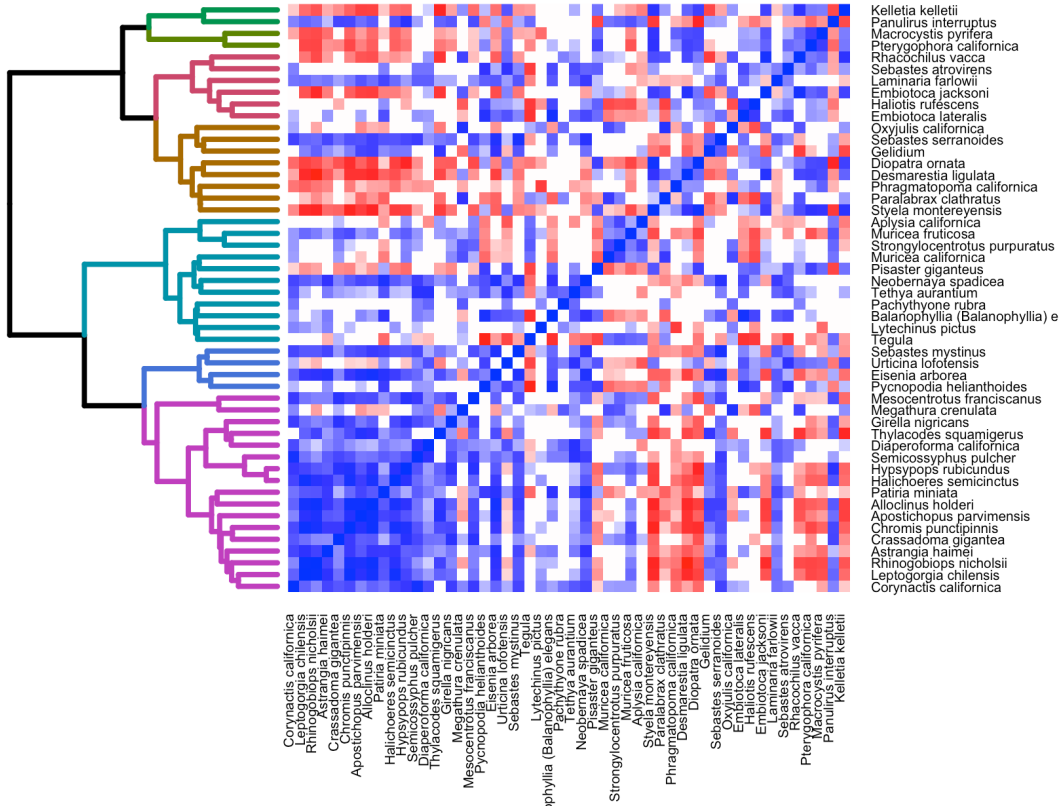


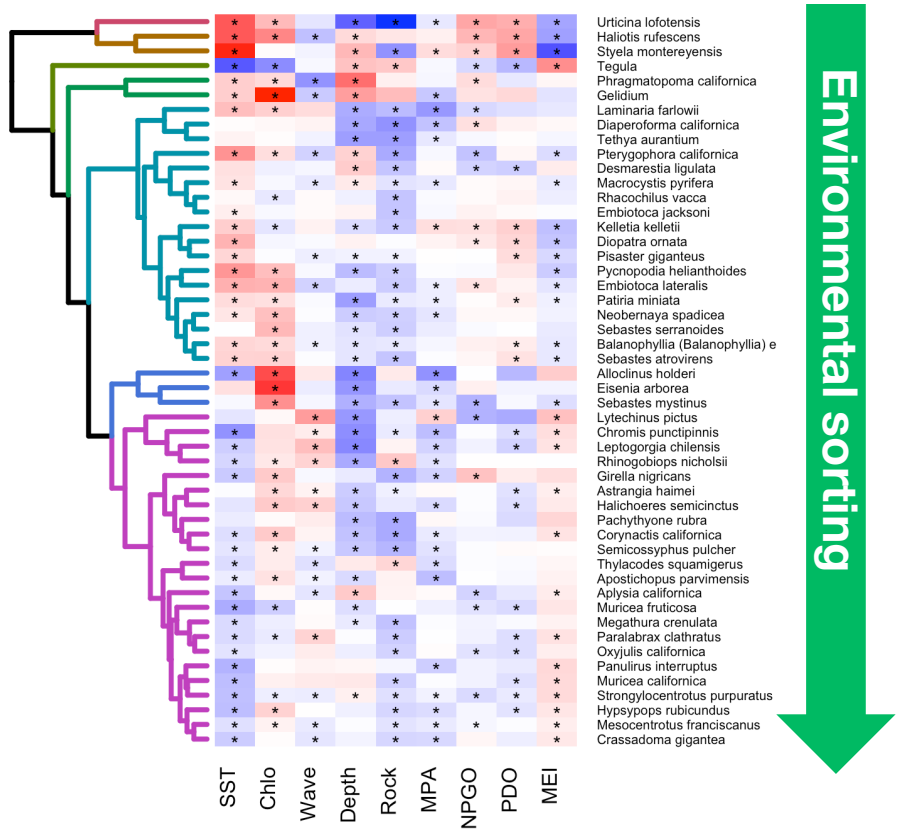
SST explains largest fraction

Lamy et al., in review, *Oecologia*

Explaining non-random patterns of species association in kelp forest communities

Significant association among species that arise due to shared environmental responses

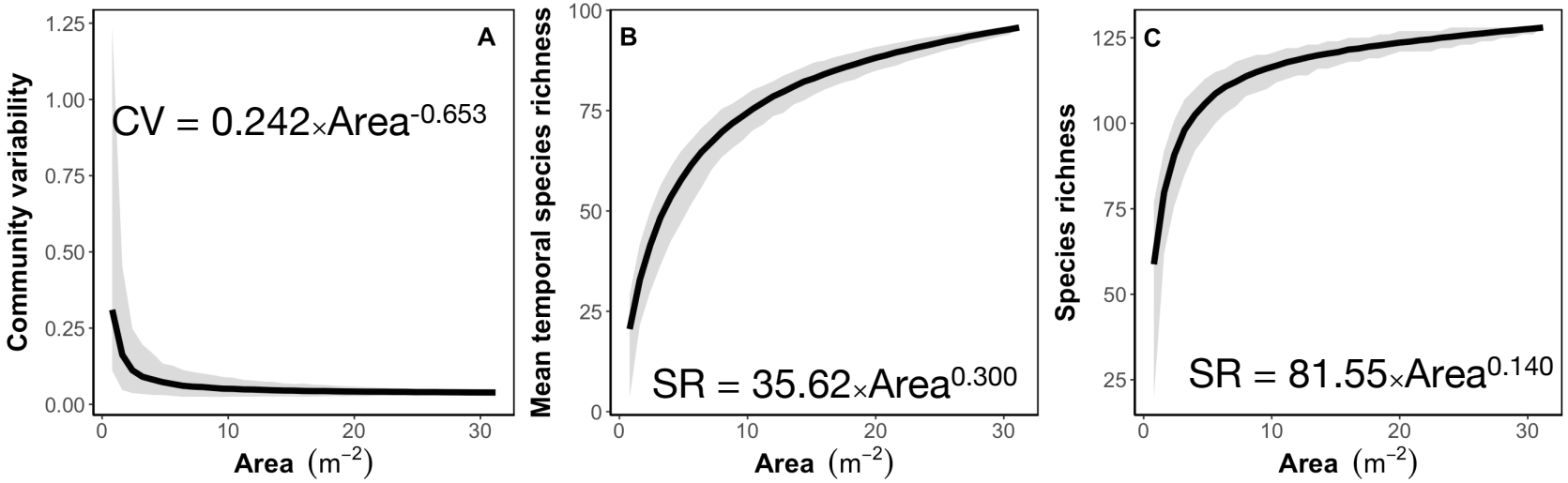


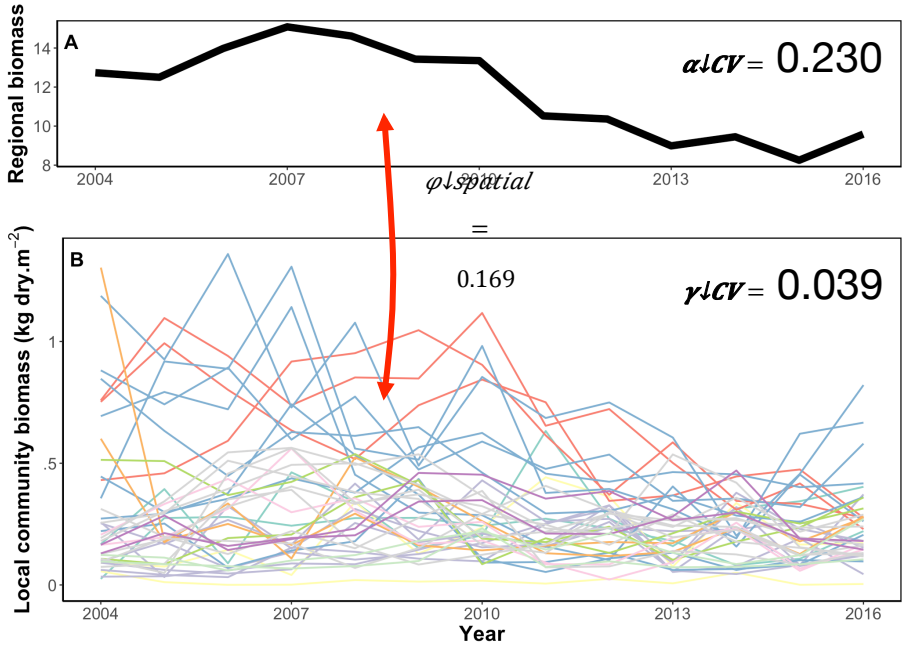


Lamy et al., *in prep*

Diversity-stability relationships in kelp forest communities

How does ecosystem variability and diversity scale with space?





Lamy et al., *in prep*

- Ecosystem spatial variability decreases 2.2 to 4.7 times faster than species richness increases
- Local communities display high spatial synchrony in ecosystem function ($\varphi\downarrow spatial$)
- Spatial synchrony in ecosystem function depends on dominant species

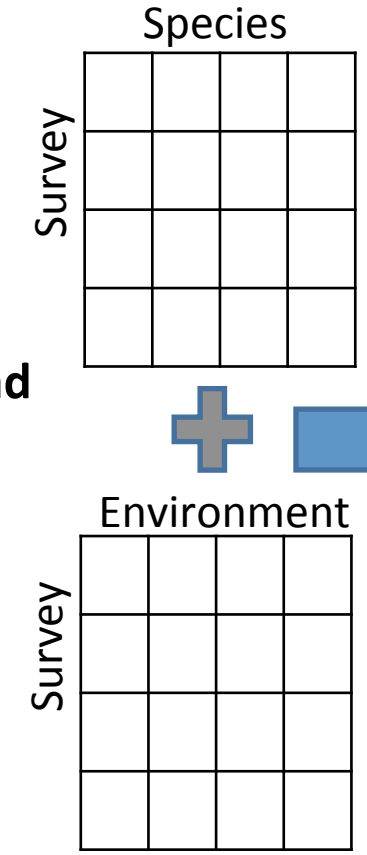
Species Archetype Modelling (SAM) for ecological forecasting

Modelling species response to environmental gradients and reducing dimensionality

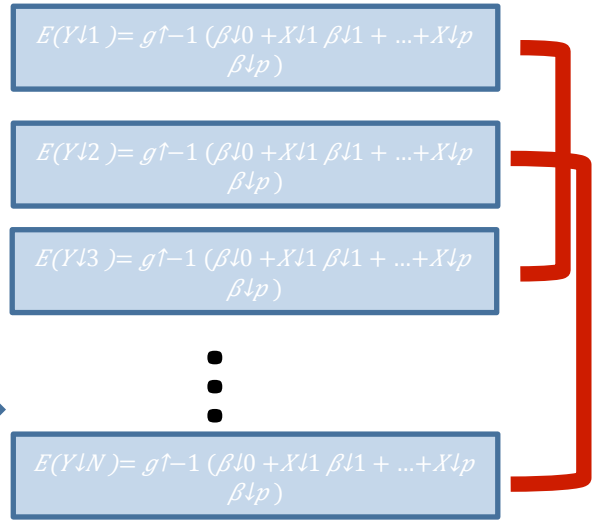
Brian Kinlan

Rhiannon Rognstad

DATA MATRICES



GLMs



CLUSTERING/FITTING

SAM method: Dunstan et al. 2011, 2013

OUTPUT

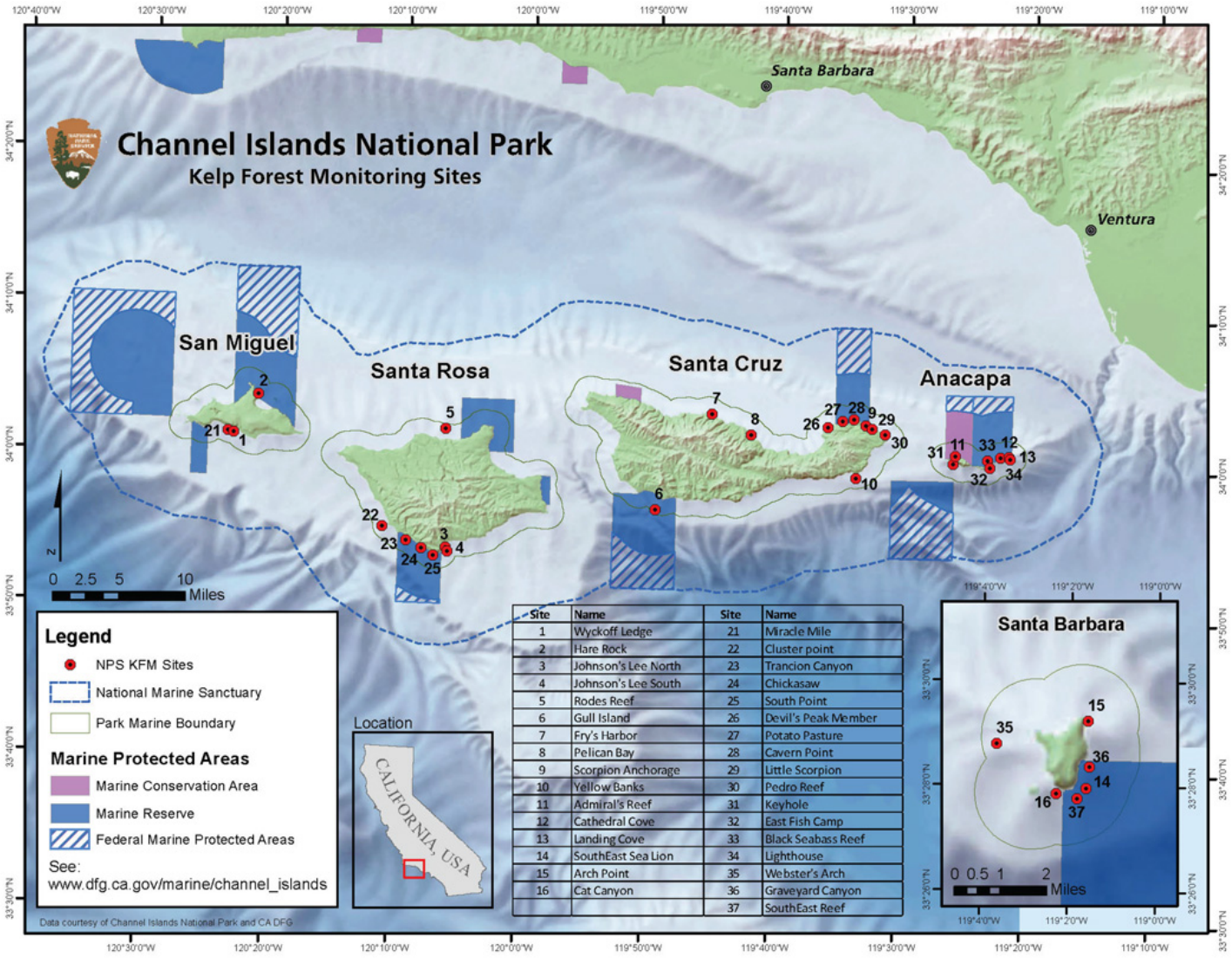
Species	Arch	Prob
A	1	0.02
A	2	0.97
A	3	0.01
...		
N	3	0.95

	Envt1	Envt2	Envt3
Arch1	-0.9	0.5	-0.3
Arch2	0.5	0.9	0.2
Arch3	0.5	-0.2	0

Datasets

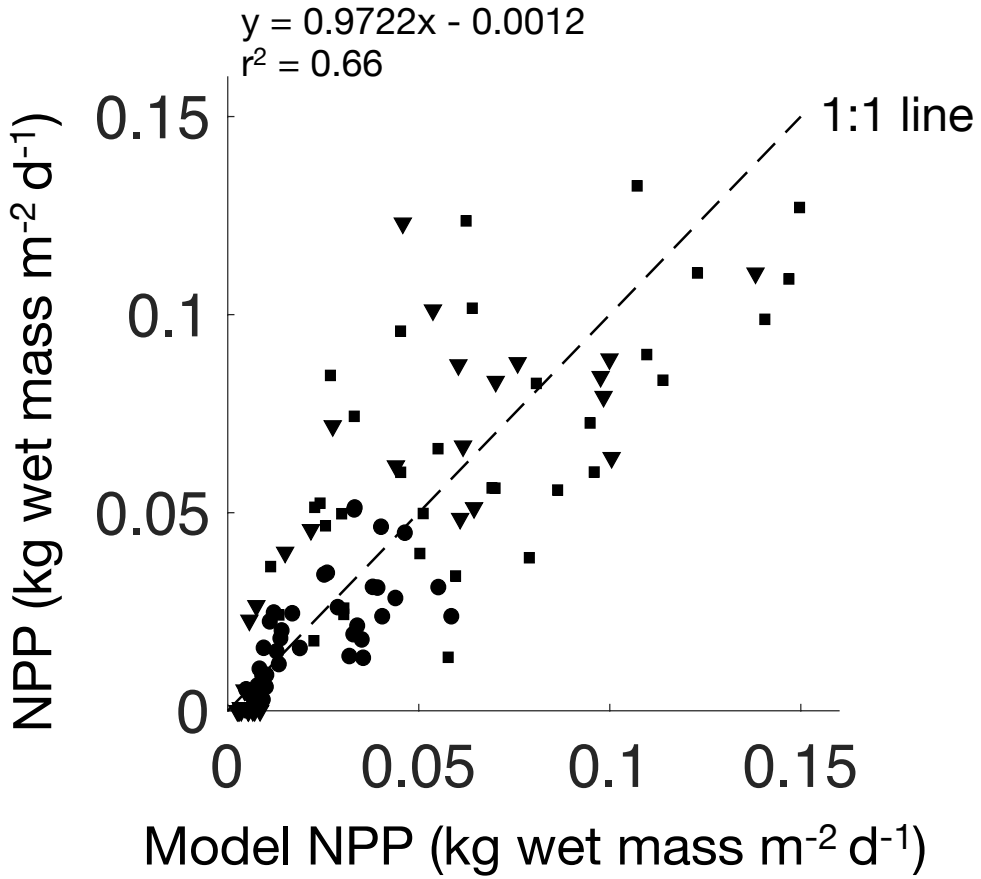
Biological: Kelp forest dataset, 82 taxa at 33 sites, 2004-2014

Environmental: Depth and substrate *(in situ)*, SST (satellite-derived), wave height (interpolated, CDIP), surface chl a (satellite-derived), climate indices, Seascapes



Site	Name	Site	Name
1	Wyckoff Ledge	21	Miracle Mile
2	Hare Rock	22	Cluster point
3	Johnson's Lee North	23	Trancion Canyon
4	Johnson's Lee South	24	Chickasaw
5	Rodes Reef	25	South Point
6	Gull Island	26	Devil's Peak Member
7	Fry's Harbor	27	Potato Pasture
8	Pelican Bay	28	Cavern Point
9	Scorpion Anchorage	29	Little Scorpion
10	Yellow Banks	30	Pedro Reef
11	Admiral's Reef	31	Keyhole
12	Cathedral Cove	32	East Fish Camp
13	Landing Cove	33	Black Seabass Reef
14	SouthEast Sea Lion	34	Lighthouse
15	Arch Point	35	Webster's Arch
16	Cat Canyon	36	Graveyard Canyon
		37	SouthEast Reef

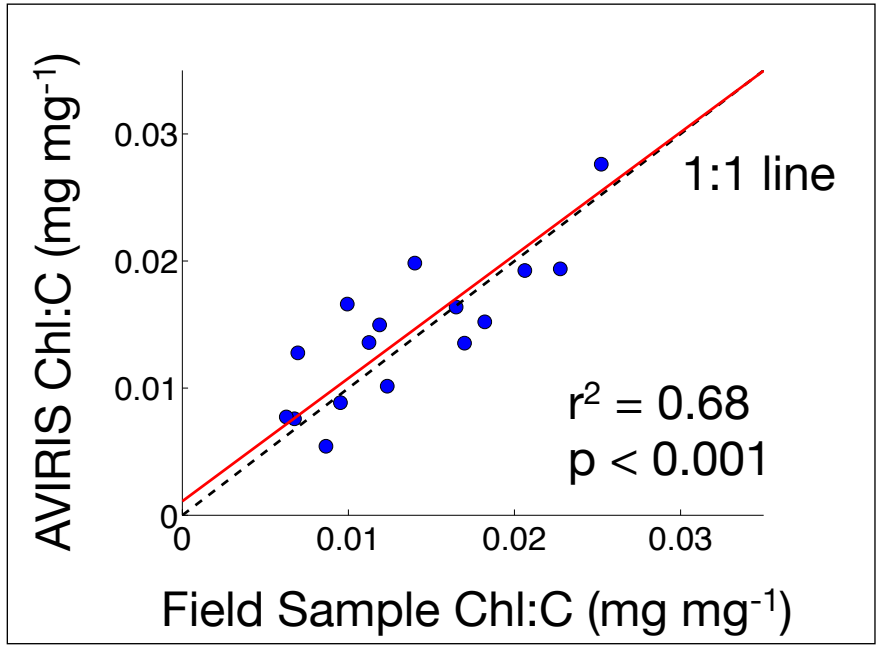
Landsat Kelp Forest Canopy Biomass & NPP



Cavanaugh et al 2010, 2011, 2013, Bell et al. 2015 J Biogeography, Bell et al. L&O in review

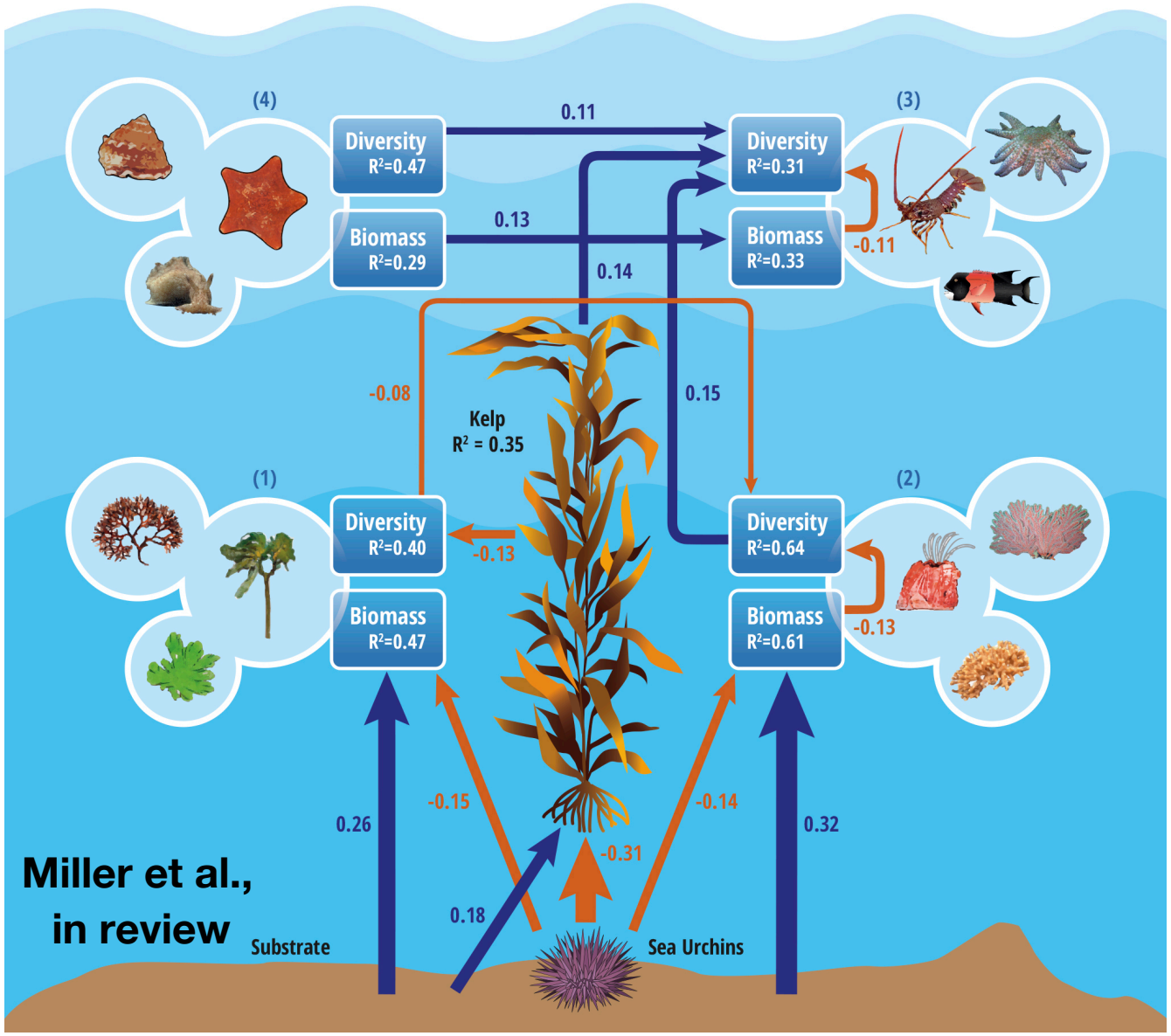
Hyperspectral aerial flights conducted 3x year^{-1} in 2013 – 2015 using the AVIRIS sensor as part of the HyspIRI preparatory campaign

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



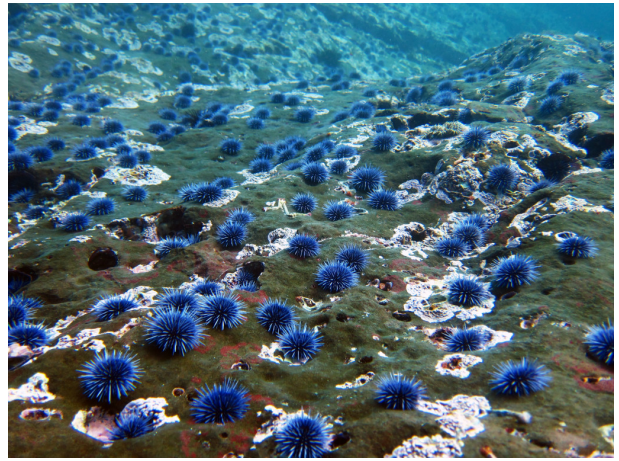
Bell et al. 2015 Remote Sensing Env. and Bell et al. *in prep*

Giant kelp is a foundation species that positively affects reef biodiversity directly and indirectly

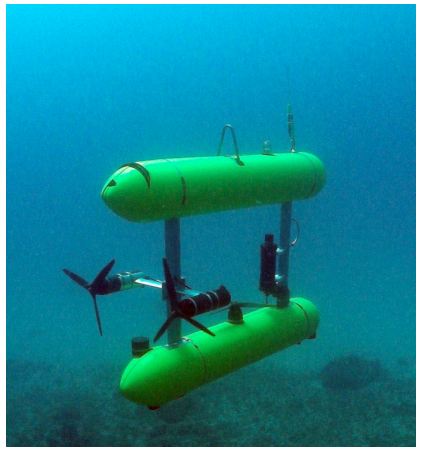


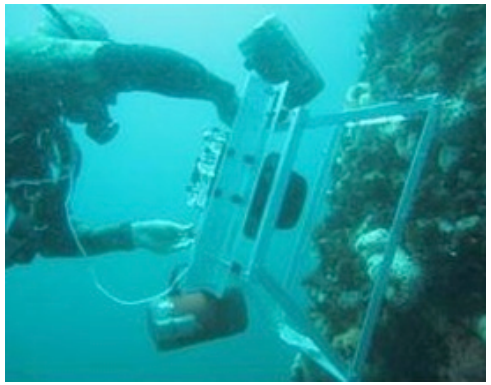
Kelp forest

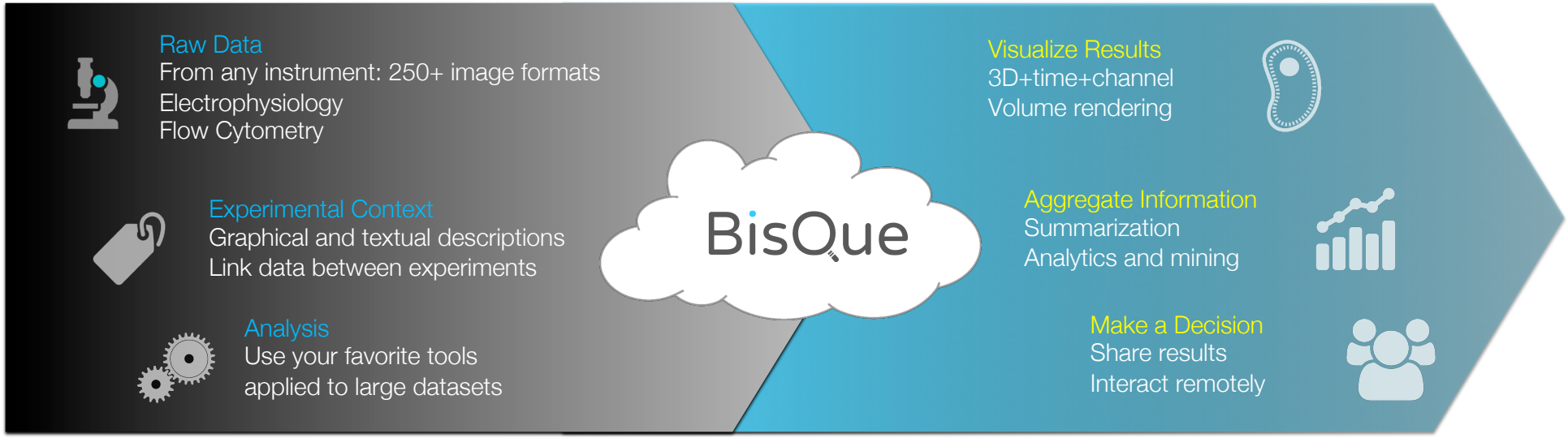
Urchin barren



Deep learning for image analysis





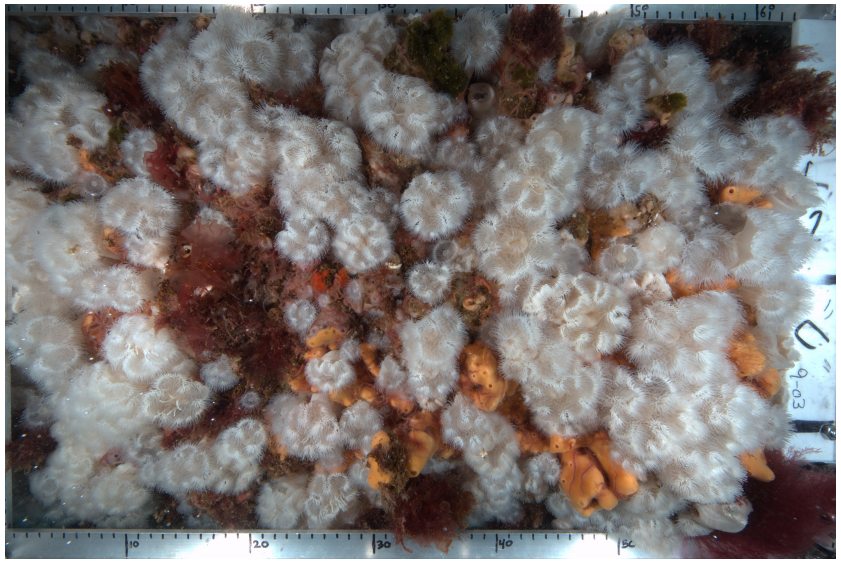


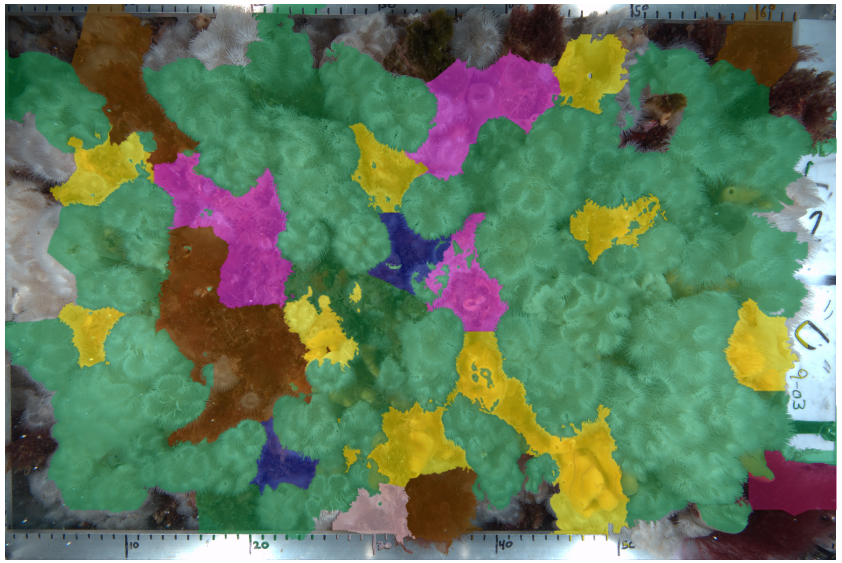
UCSB Center for Bio-Image Informatics supports:

Life sciences, Geography, Ecology, Medical, Marine Science

BisQue | Connoisseur

Deep learning for image analysis





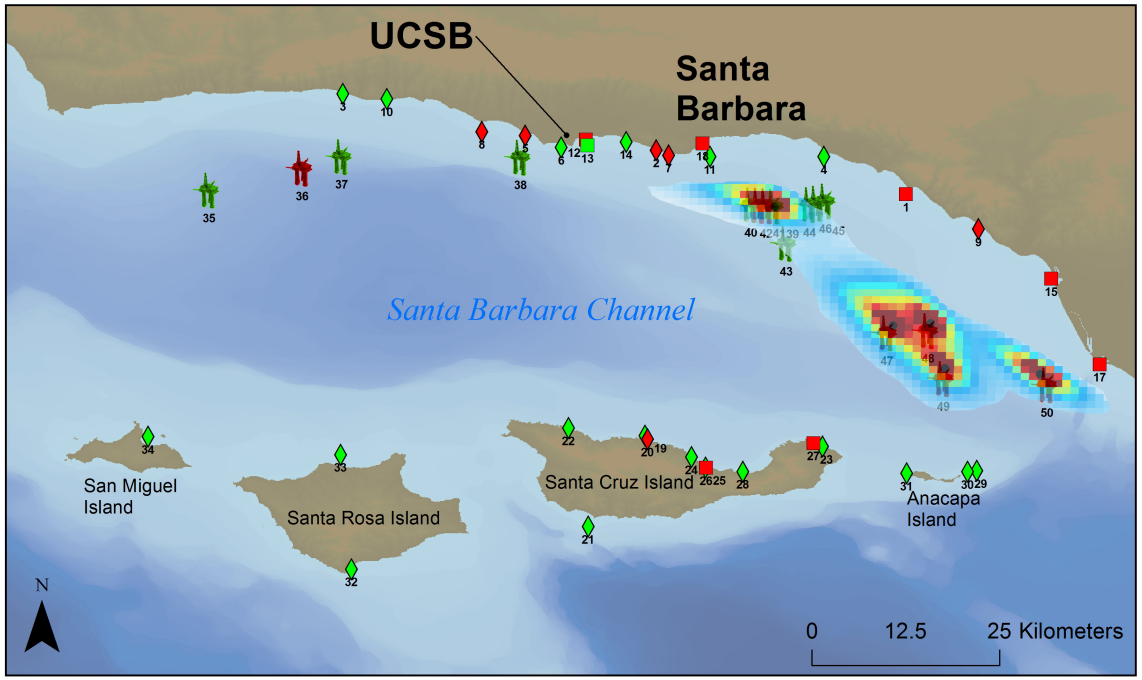
- Scalable deployment
- Hierarchical models
  - Taxonomic: Genus -> Species
  - Ontological: Substrate -> Exact object
- Fully convolutional segmentation

BisQue

Biodiversity and connectivity on offshore oil platforms and natural reefs

Photographically sampling communities on natural reefs and offshore oil platforms

ROMS modeling of potential larval dispersal



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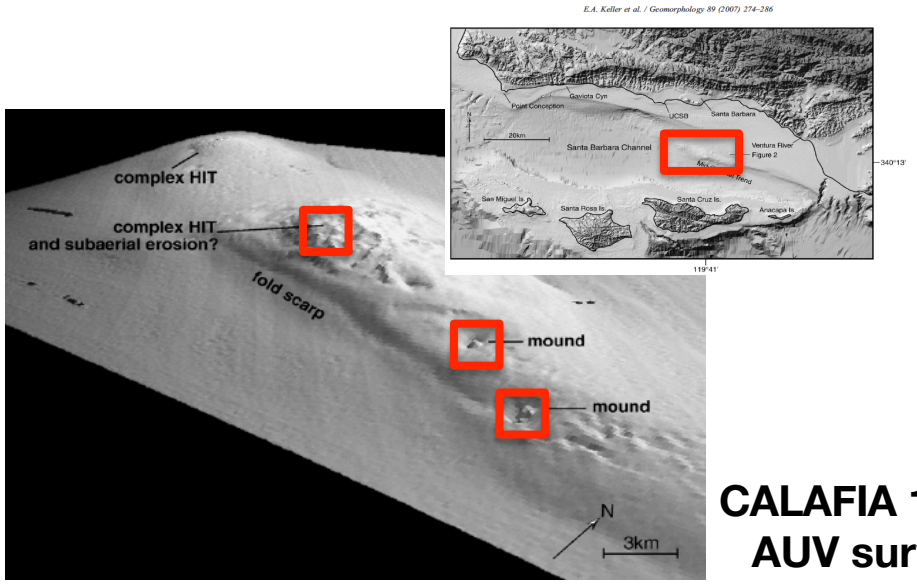
Simons et al. 2016 Plos One, Simons et al. *in prep*, Page et al. *in prep*

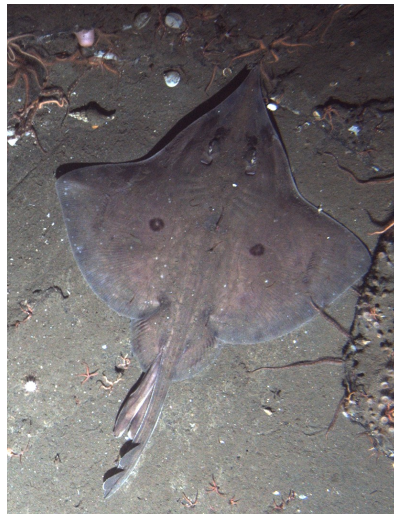
Deepwater biodiversity of the Santa Barbara Channel



- ***AUV surveys in collaboration with NOAA NWFSC Seattle***
- ***Describe variability in biodiversity and relation to environmental factors***

CALAFIA 100-300 m AUV survey, 2016

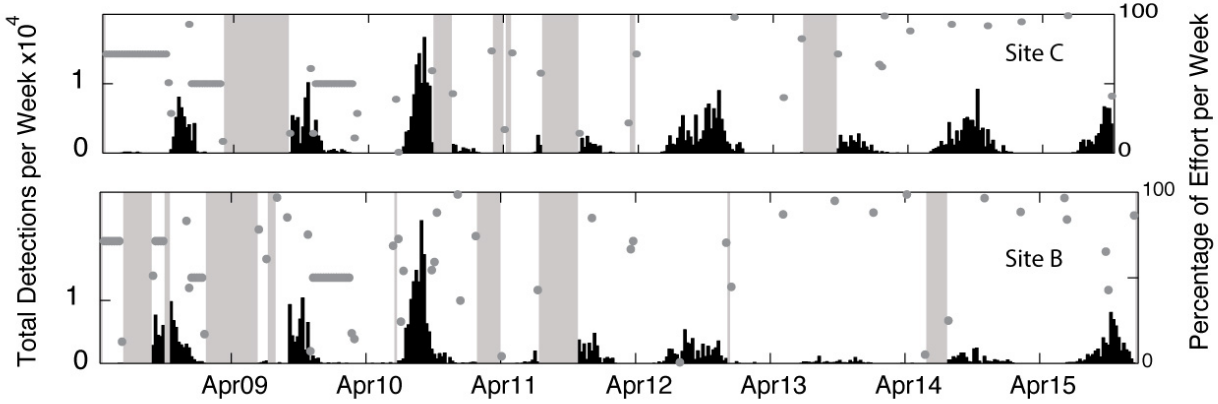
Love et al. in review, Nishimoto et al. *in prep*



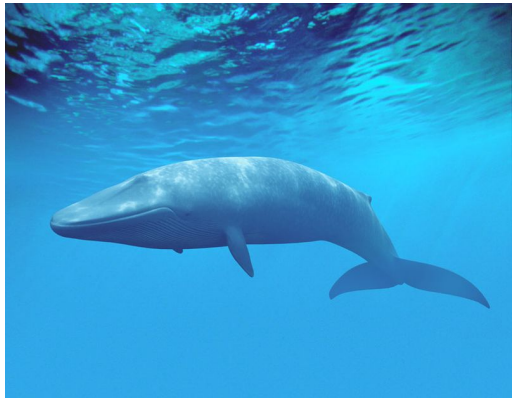
Acoustic Monitoring in Channel Islands

Warm anomaly in 2013-2015 caused baleen whales to move into SBC

Hildebrand et al. *in prep*

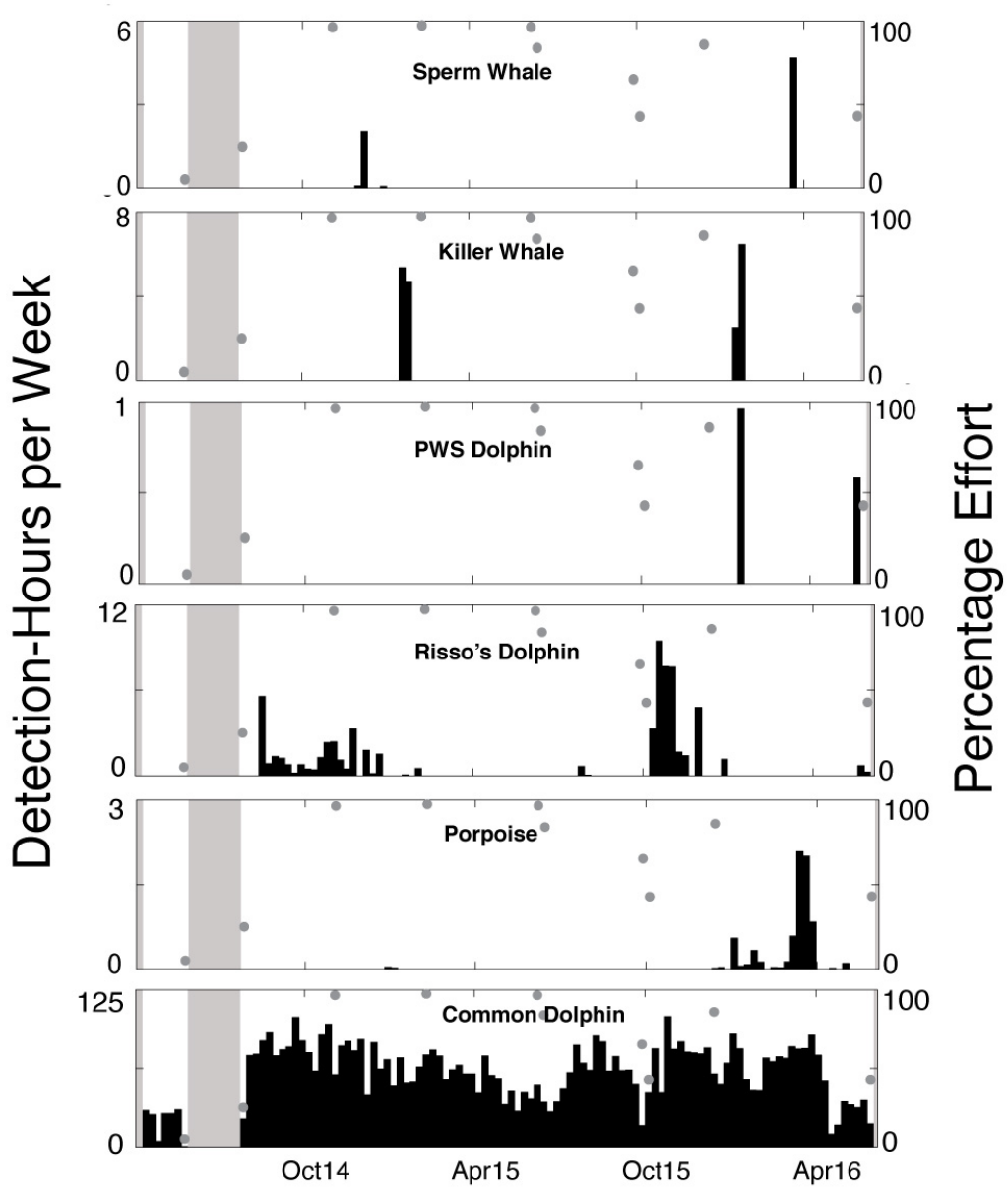


Blue Whale



Fin Whale

Acoustic Detection of Marine Mammals



Pacific White-Sided Dolphin

Dall's Porpoise

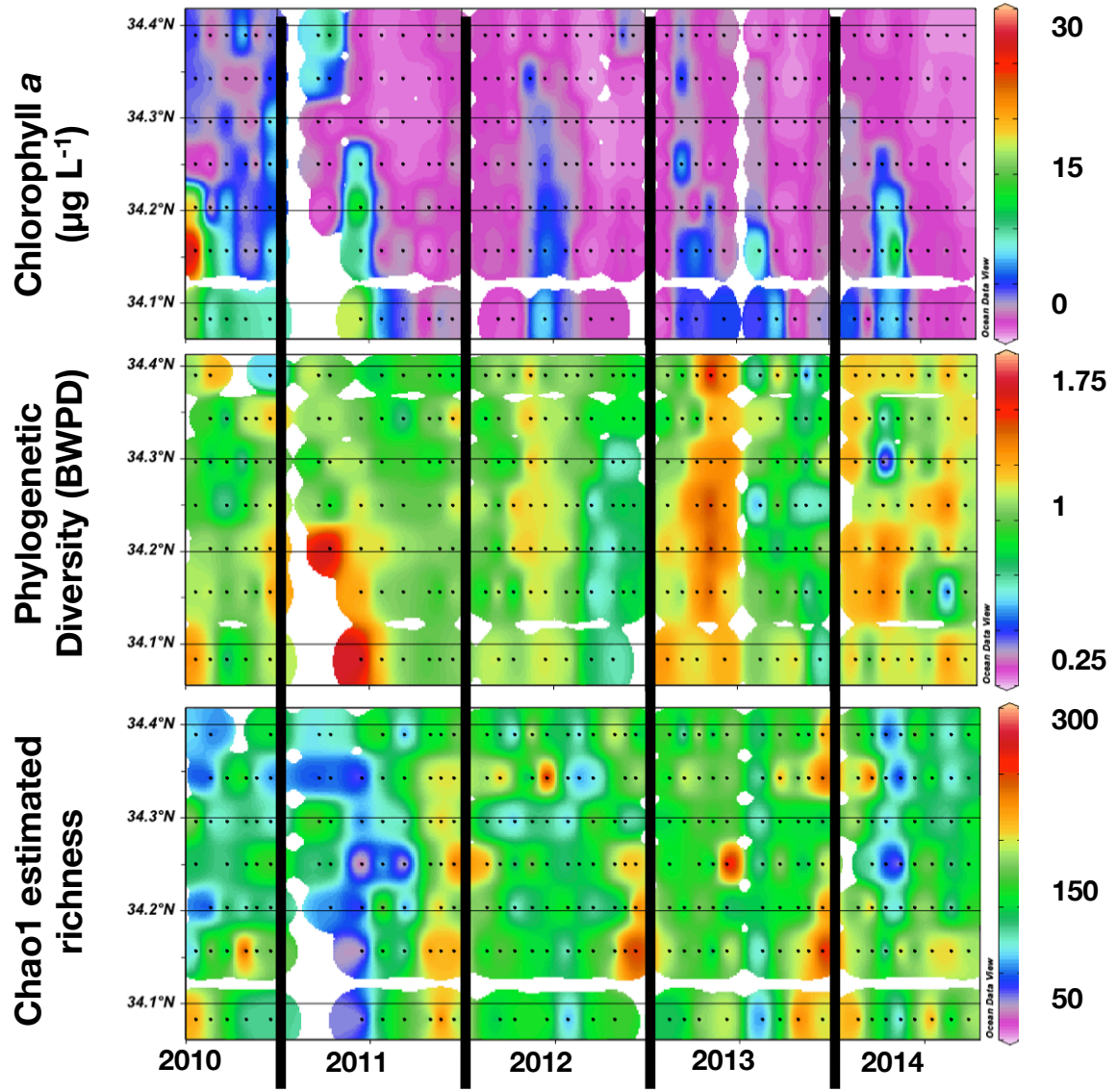
- ***Cold water spp absent in spring 2015***
- ***Common dolphins very abundant***

Short-Beaked Common Dolphin

Hildebrand et al. *in prep*

Prokaryote diversity and richness show distinct temporal patterns in the surface SBC

South → North, or islands → mainland



- Time-series from 2010 –2014
- Bacteria and archaea from 16S rRNA gene (V4 region)
- 578 samples from 43 cruises sequenced

Wear et al. *in prep*

Eukaryotic Plankton Diversity in SBC

Community Composition via High Throughput Sequencing (HTS)

- Archived monthly time series (2011–2014)
- 476 total samples
  - 228 at surface
  - 144 at 75m
- Multiple rDNA primer sets
  - 16S (V4/V5)
  - 18S (V9)
- New time-series (2016–present)

Paul Matson

Dylan Catlett

Use HTS data to validate remote sensing algorithms for phytoplankton community composition

Constructing Mock Eukaryote Communities

Up to 28 phytoplankton species

Diatoms

Dinoflagellates

Haptophytes

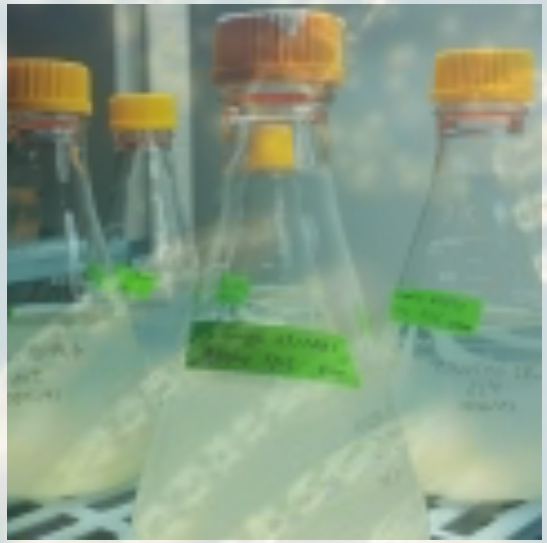
Cryptophytes

Prasinophytes

Raphidophytes

Pelagophytes

Extraction Biases
with mixed
cell assemblages



PCR Biases
with mixed
18S amplicons
from clone library

Sequencing Consistency
using as Positive Control

Bioinformatics Pipeline Comparison

Subset of Sequence Data from FL & MB

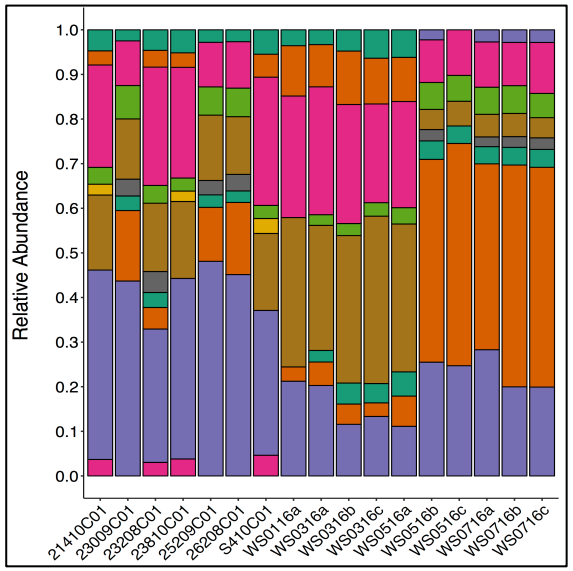
16S & 18S rDNA Sequence Reads (n=17)

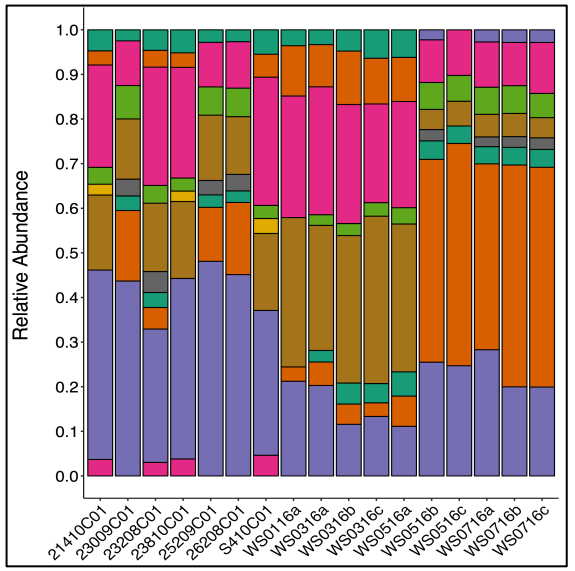
Pipelines

Mothur (SBC)

Banzai (MBARI & USF)

Community Assemblages



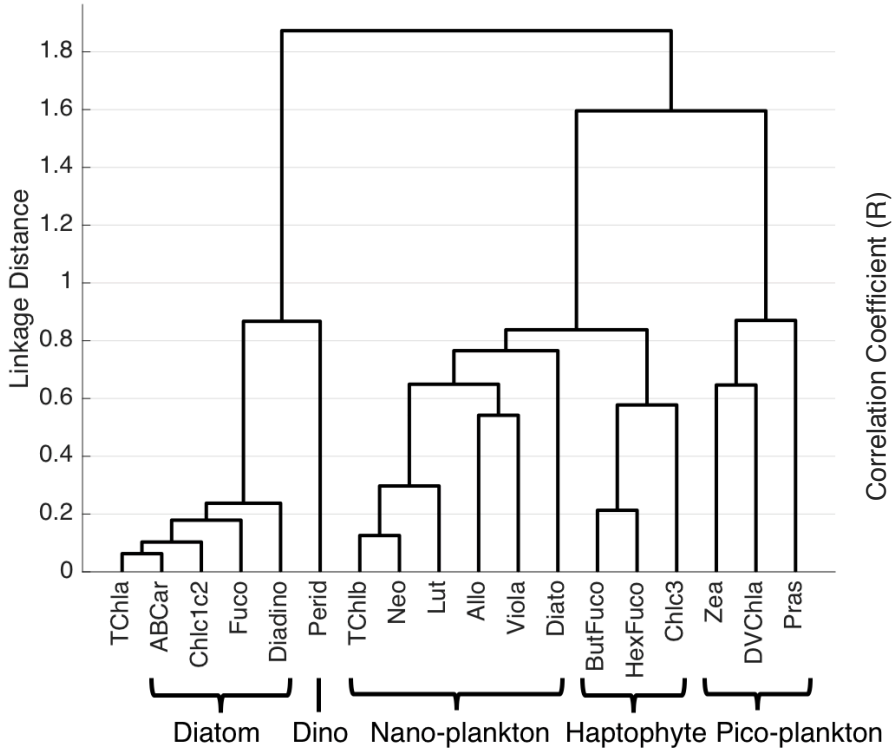


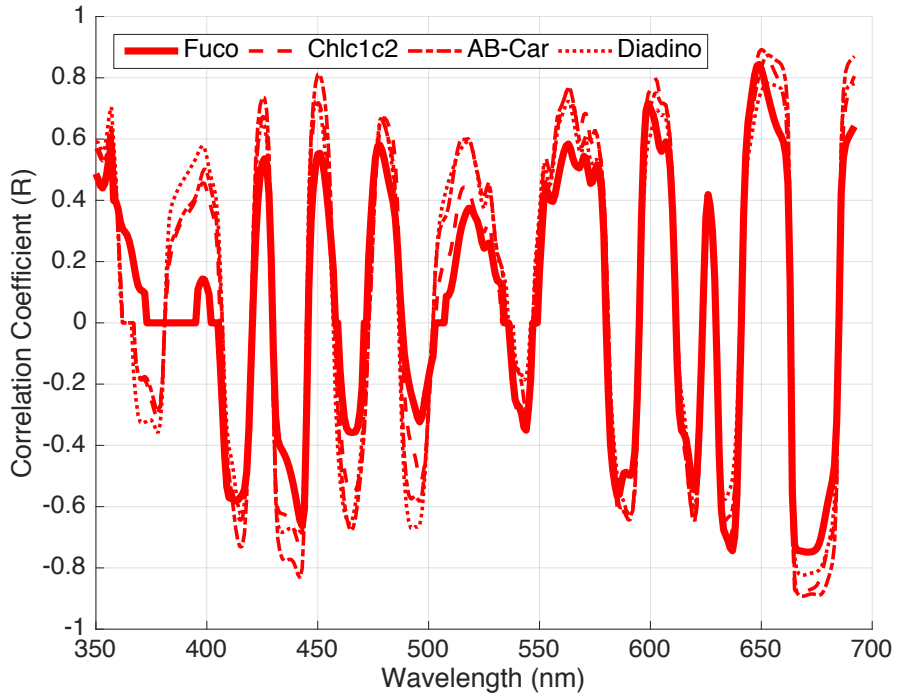
Dr. Anni Djurhuus
USF

Paul Matson

Modeling Phytoplankton Pigment "Communities"

- Derivative analysis of phytoplankton absorption spectra isolates absorption features with robust relationships to phytoplankton pigments and communities
- Pigment communities (defined with cluster, EOF analyses) can be modeled using relationships with spectral absorption signatures



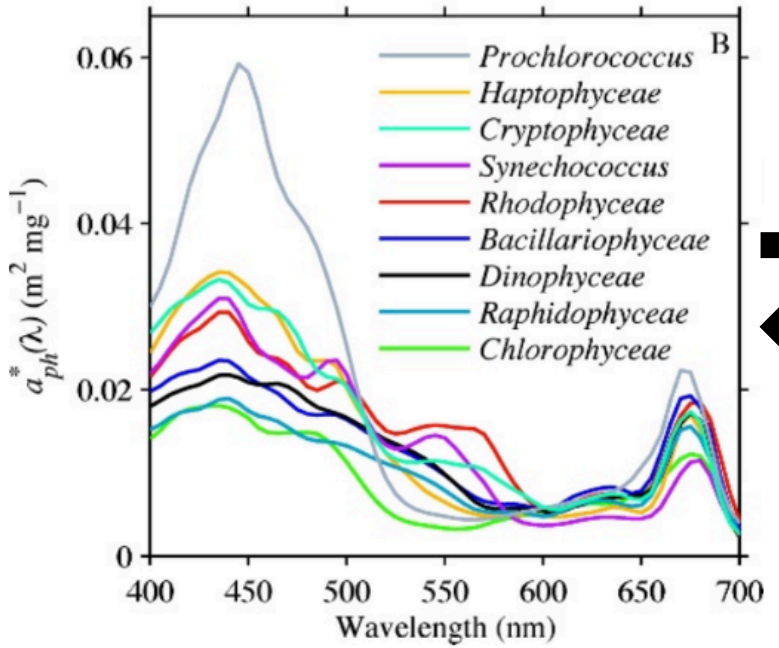


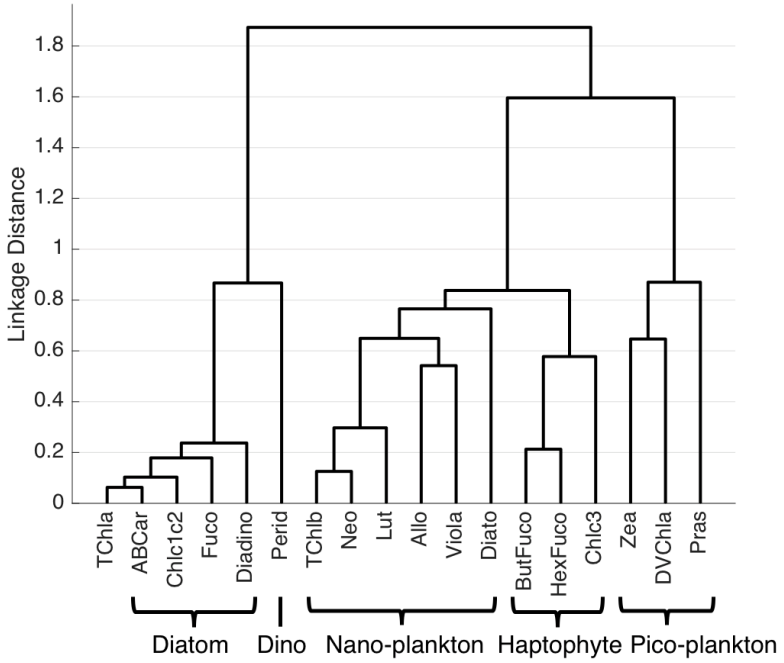
Model Retrievals	R^2
TChlb (green algae)	0.815
HexFuco (haptophytes)	0.733
Fuco (diatoms)	0.856
Perid (dinoflagellates)	0.887
Pigment EOF Mode 1 (Early upwelling mixed bloom)	0.884
Pigment EOF Mode 2 (Diatoms vs. mixed nano-/pico-)	0.852
Pigment EOF Mode 3 (Pico-plankton vs. haptophytes)	0.454
Pigment EOF Mode 4 (Dinoflagellates vs. mixed diatoms/haptophytes)	0.809

*Catlett and Siegel, *in prep.*

Next Steps

- Apply model to hyperspectral remote sensing reflectance observations from AVIRIS and Plumes and Blooms archive
- Incorporate Next-Gen Sequencing observations for validation of phytoplankton community composition retrievals from remote sensing algorithms





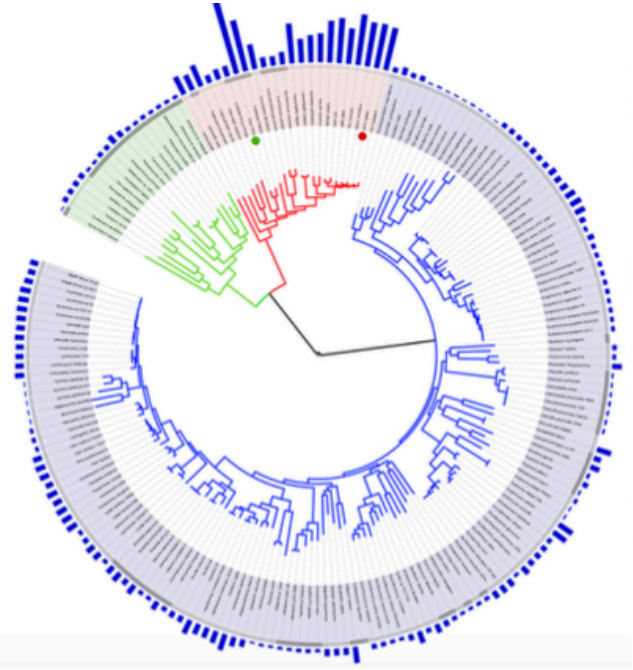
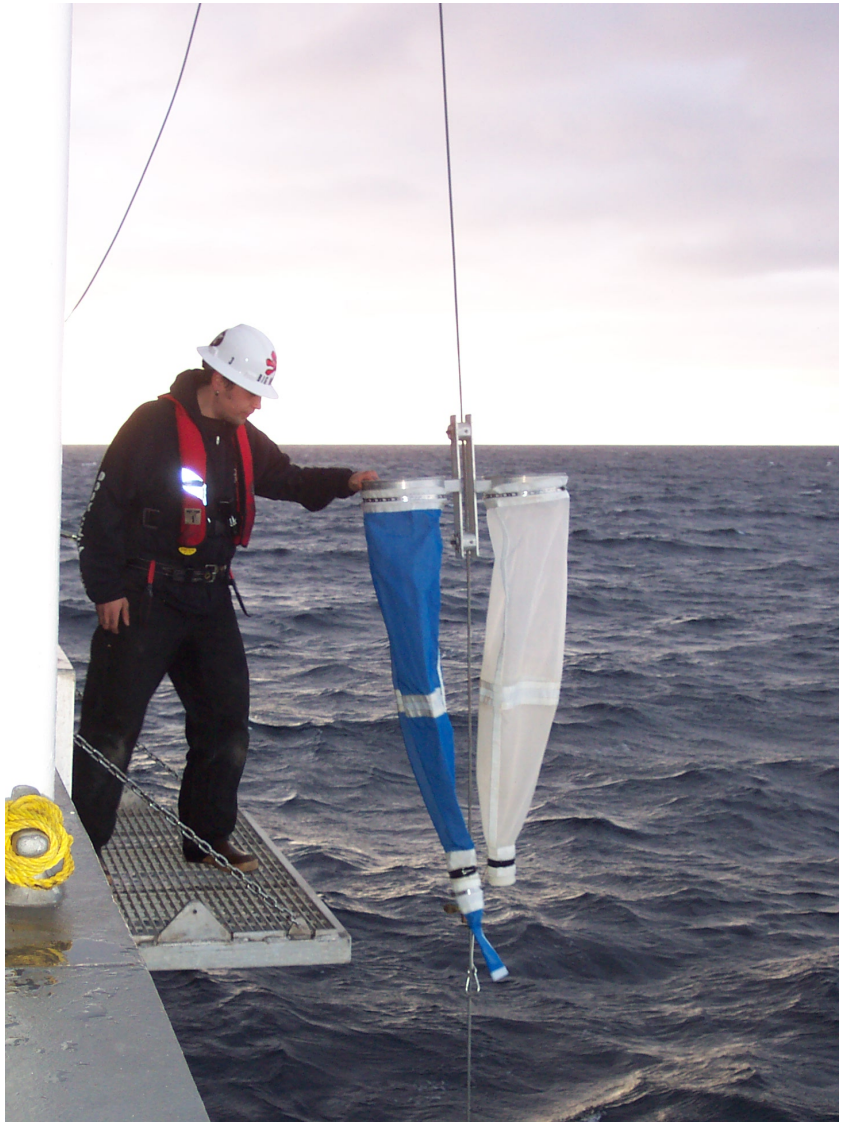


*Figure adapted from Dierssen et al. 2006 (left), Catlett and Siegel *in prep*. (center), and Ciccarelli et al. 2006 (right)

Metabarcoding to identify pelagic ichthyoplankton



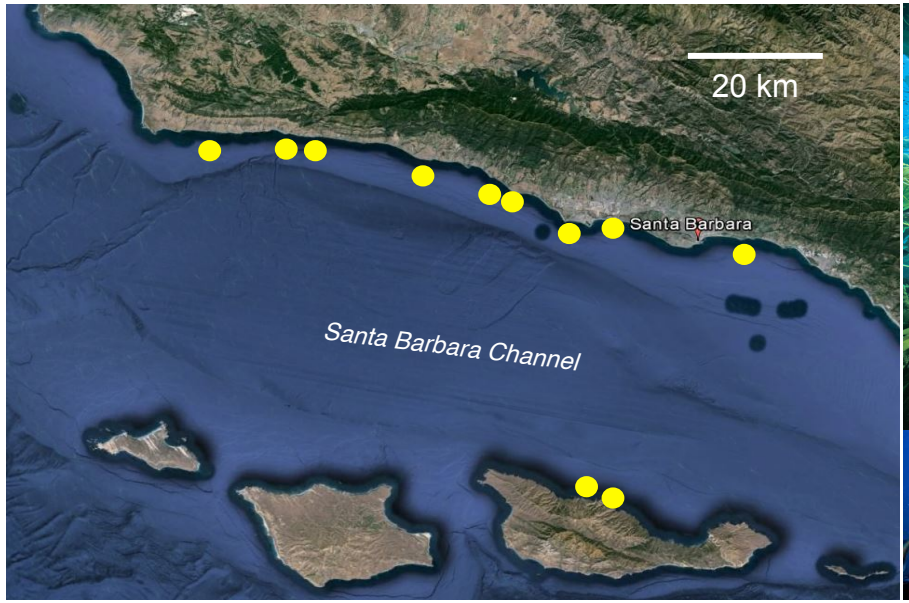
Dovi Kacev

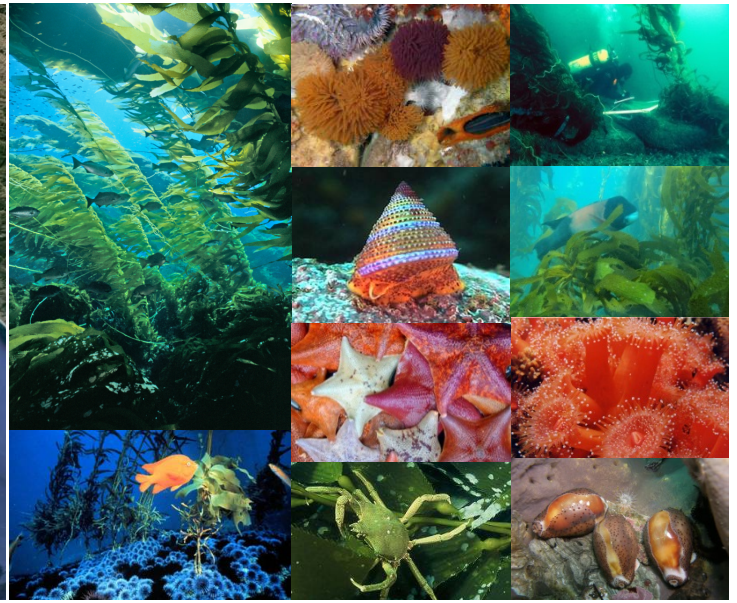
- Collected 74 samples from three coastal cruises
- Morphologically ID all fish
- Confirmed ID with sequencing
- In process of bulk tissue sequencing
- Working with Sanctuaries MBON team

Parallel MBON sampling effort in collaboration with SBC LTER, NPS

MBON
Marine Biodiversity Observation Network

MARINE BIODIVERSITY OBSERVATION NETWORK
SANTA BARBARA CHANNEL





- Data collected from 44 plots (80 m^2) distributed across 11 sites spanning 80 km of coast from 2001-present
- *Ecological variables:* Abundance, size and biomass of ~ 200 species of kelp forest algae, invertebrates, & fish
- Add: eDNA, mosaicked imagery