

**MARINE BIODIVERSITY
OBSERVATION NETWORK**

SANTA BARBARA CHANNEL

***Marine Science Institute
University of California Santa Barbara***



Who we are

Principal/Associate Investigators

UCSB

Robert Miller, David Siegel, Craig Carlson, Daniel Reed, BS Manjunath, Deborah Iglesias-Rodriguez, Doug McCauley, Milton Love



Florida State University

Andrew Rassweiler

USGS

Kevin Lafferty

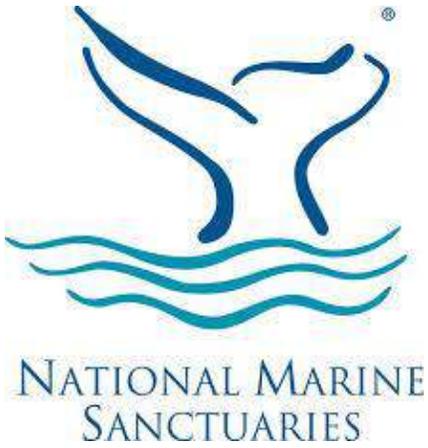
UCSD - SIO

John Hildebrand

NOAA – NMFS SWFSC

Andrew Thompson





Partners

Plumes and Blooms (NASA)

BOEM Pacific Region

Santa Barbara Coastal LTER (NSF)

Channel Islands National Marine Sanctuary

Southern California Coastal Water Research Project

Southern California Coastal Ocean Observing

System (SCCOOS)

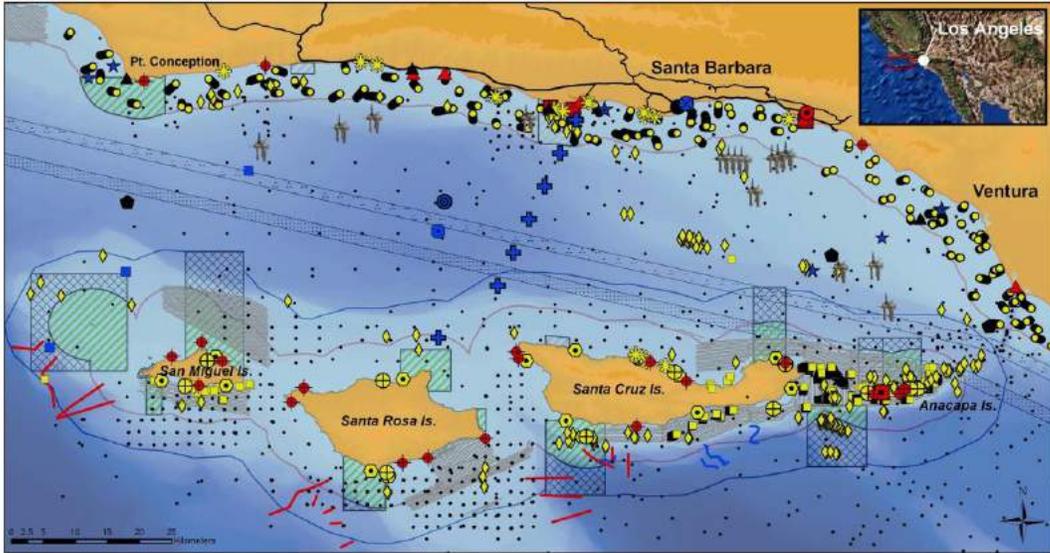
Channel Islands National Park

Gray Whales Count

CalCOFI

Existing Monitoring Partners

Santa Barbara Channel, California





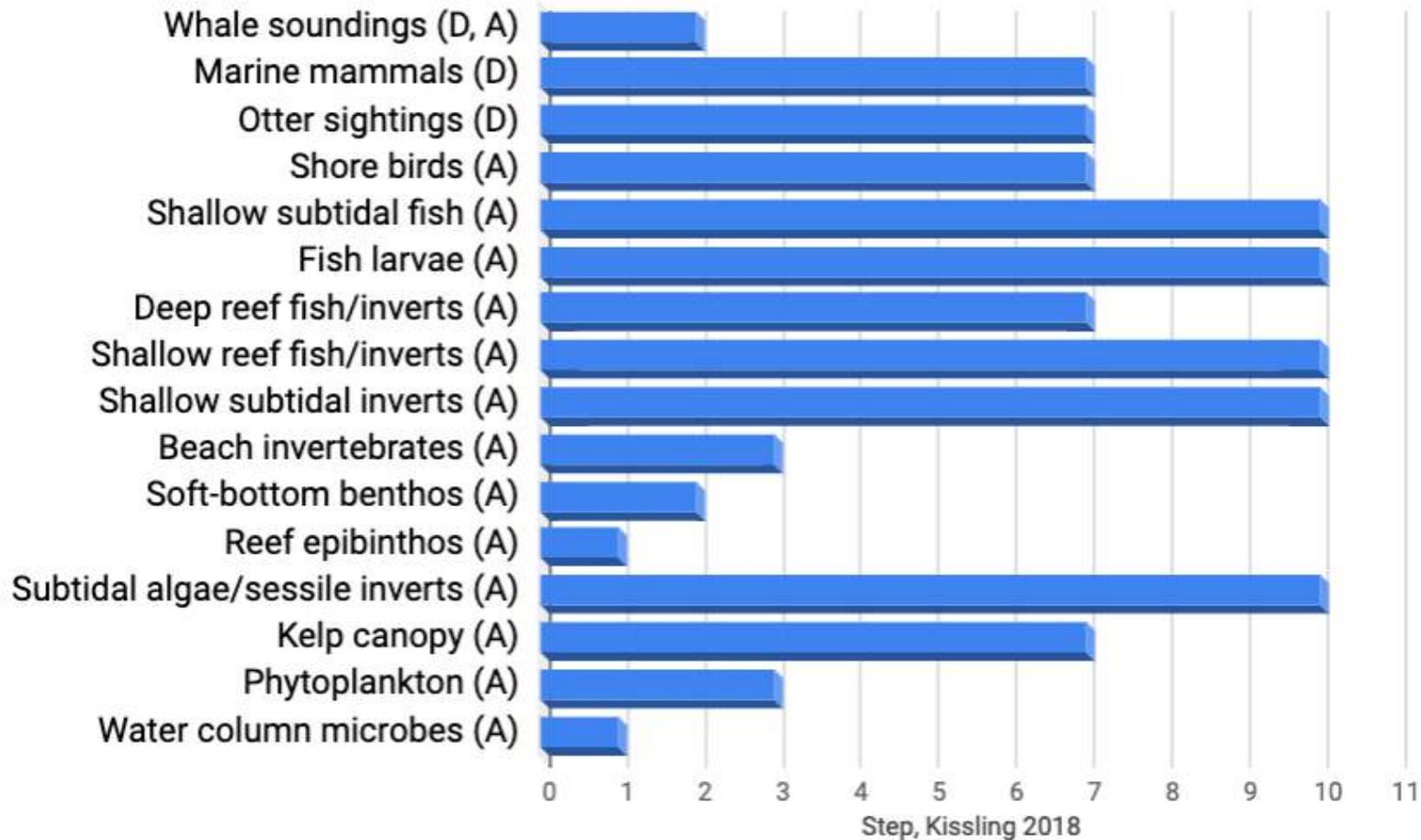
MARINE BIODIVERSITY
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SANTA BARBARA CHANNEL

MBON Prototype:

1. Provide data to inform managers and society about patterns of biodiversity across taxa, space, and time
 - *Integrate existing data*
 - *Develop new methods & products*
2. Build a framework to facilitate MBON development under diverse circumstances



Progress, by Taxonomic Group



Focus on time series
oldest: 35 yrs
youngest: 18 yrs

14 Data packages published

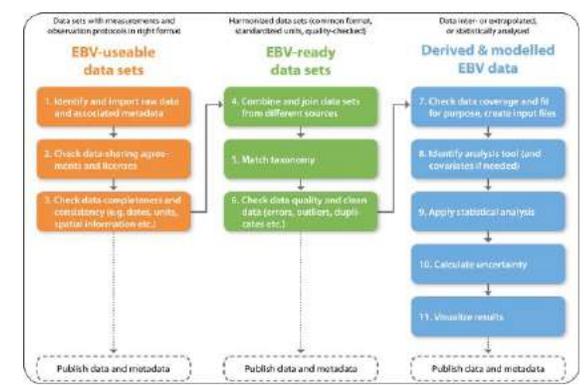
stable, immutable with DOI

Spanning taxa from microbes to whales

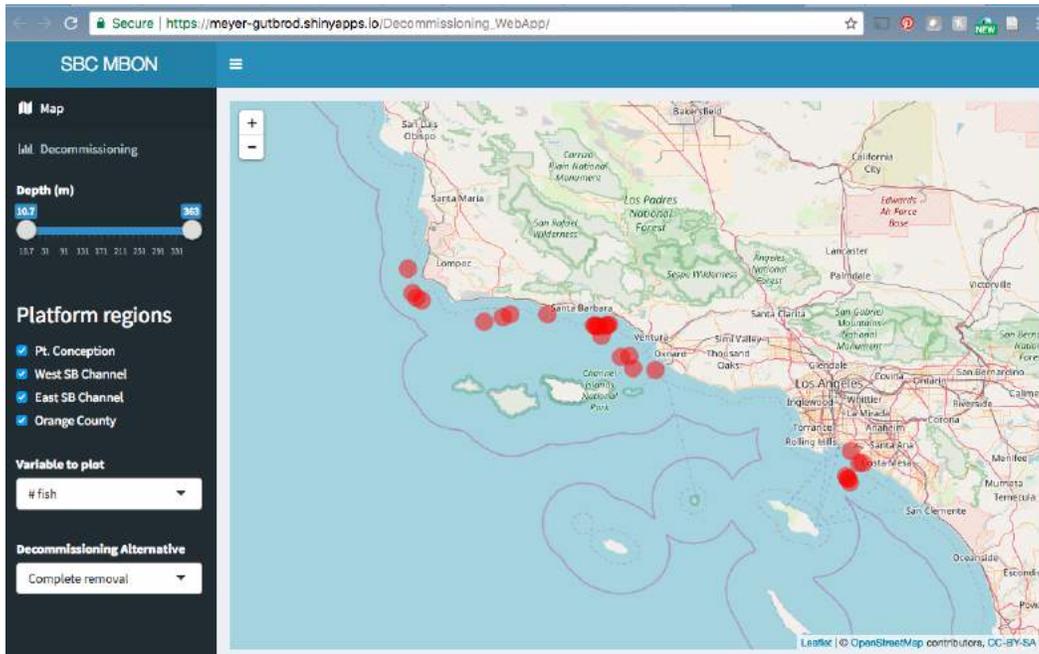
Measurement Class:

D: Occurrence (EBV “distribution”)

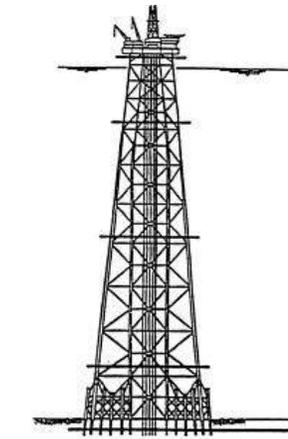
A: abundance or density (EBV “abundance”)



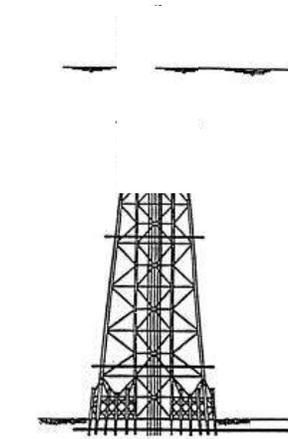
Net Environmental Benefit Analysis of offshore platform decommissioning alternatives



Leave in place



Partial Removal



Total Removal

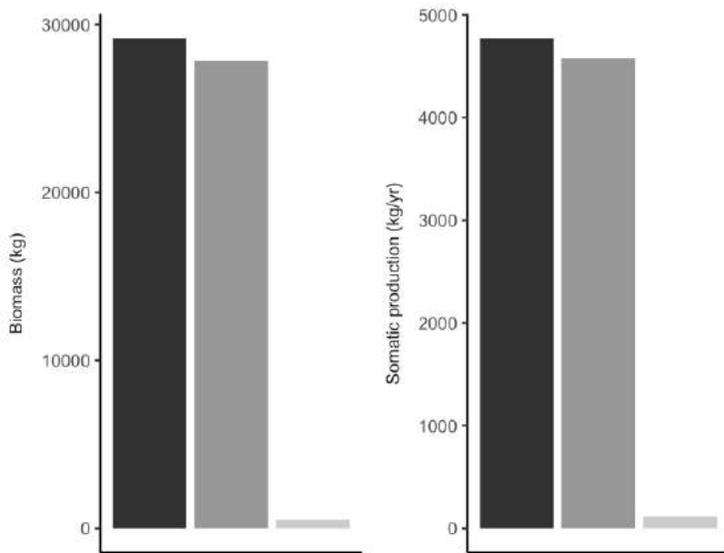
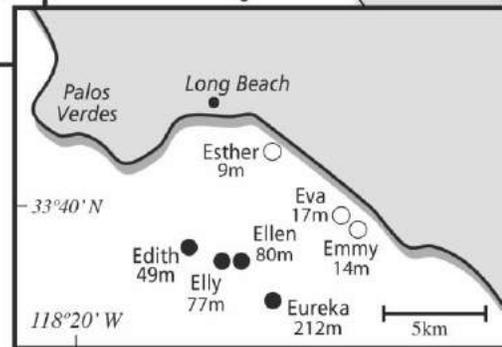
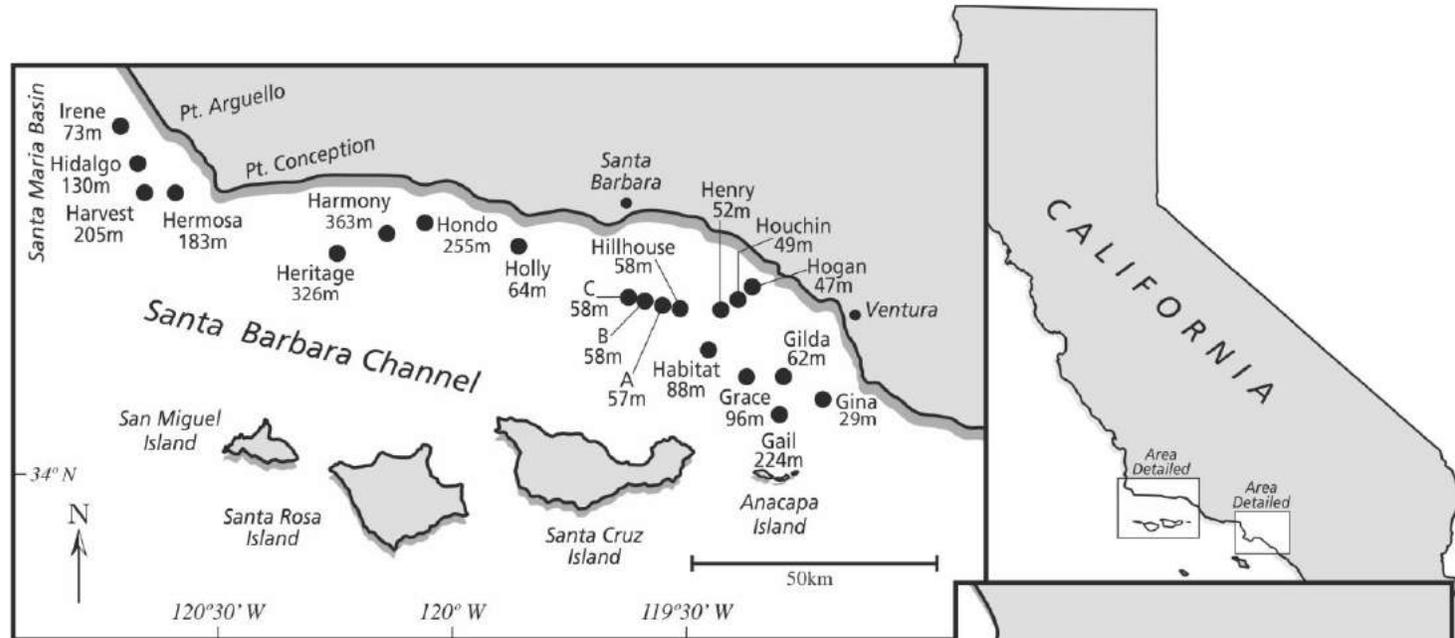


Users:

- US Bureau of Ocean Energy Management
- CA State Lands Commission
- Petroleum industry (e.g. Exxon, Chevron, Venoco)

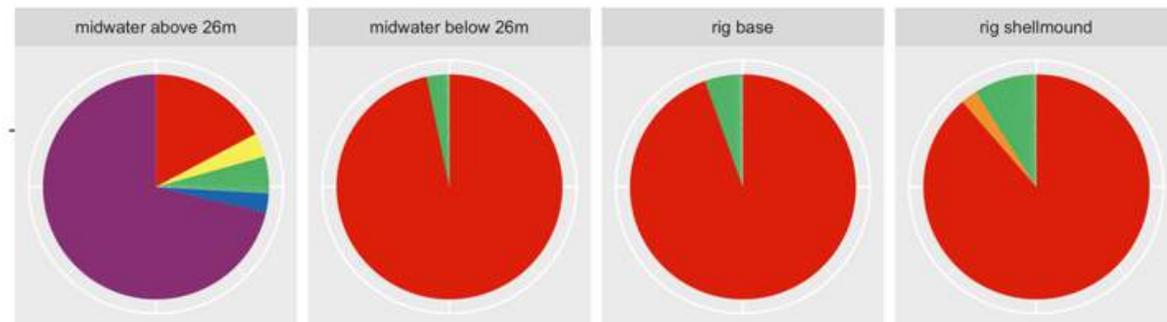
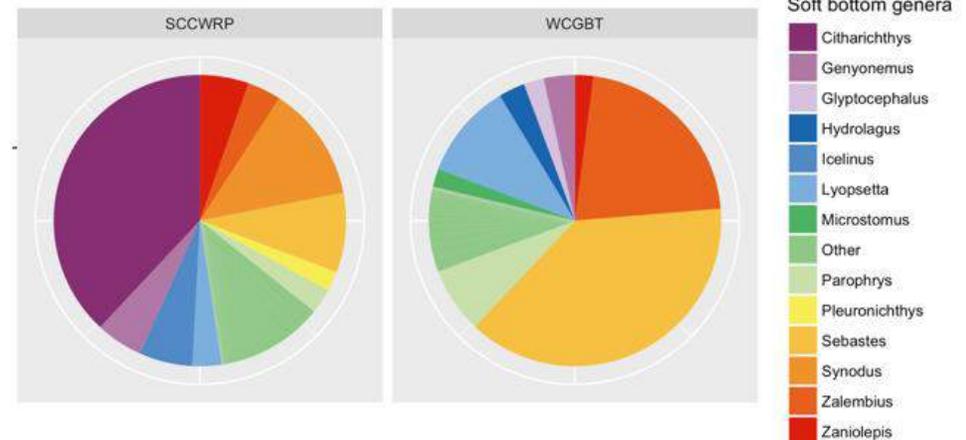
Comparing platform decommissioning scenarios

- Platform structures are dominated by rockfish
- If removed, sites will return to mud inhabited by soft bottom species such as flatfish
- Removal of 24 platforms will result in the loss of 28,700 kg of fish biomass, and an additional loss of 4,700 kg of annual fish production



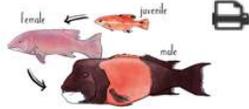
scenario

- Leave in place
- Partial removal
- Complete removal

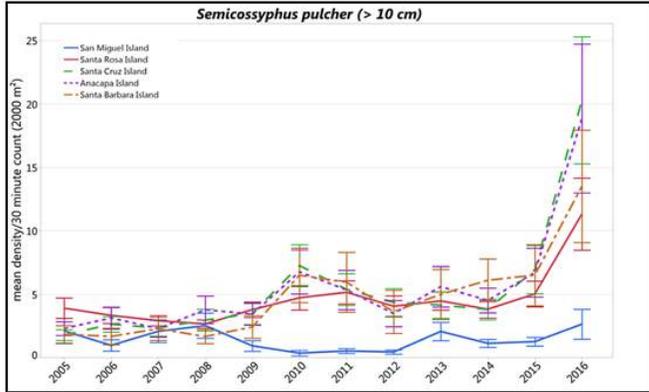


California Sheephead Abundance in CINMS

The California sheephead (*Semicossyphus pulcher*) is a large and beautiful fish that plays an important role in the food web of kelp forests and rocky reefs in southern California. Sheephead are also a popular sport fish for recreational and commercial fishing and a draw for SCUBA divers.

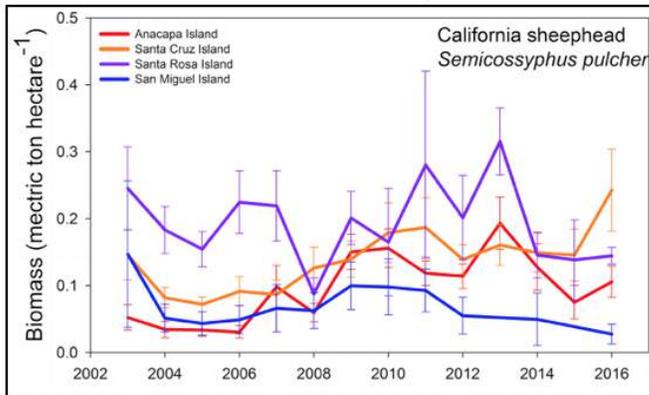


Abundance of California Sheephead



Average density of California sheephead at Channel Island National Park kelp forest monitoring sites at the five islands in CINMS. Sheephead density was averaged across all monitoring sites at each island to examine overall sanctuary trends. Note that juveniles (< 10 cm) were excluded from analysis.

Abundance of California Sheephead



Average density of California sheephead observed by SCUBA divers at 14 sites across four islands in CINMS monitored by the PISCO kelp forest monitoring program. Observed density was averaged across all monitoring sites at each island to examine overall sanctuary trends.

n of Condition Reports

Channel Islands 2b

KELP FOREST & ROCKY REEF INDICATORS

KEY CLIMATE & OCEANOGRAPHIC DRIVERS

- Q1,13: Nitrogen:Phosphorus
- Q3: Sea surface temperature
- Q3: Seafloor temperature
- Q3: pH
- Q3: DO/hypoxic events
- Q3: Wave height & direction
- Q3: Upwelling index

KEY HUMAN ACTIVITIES

- Q2, Q13: Contaminants in fish
- Q14, Q15: Marine debris abundance
- Q15: Commercial fishing activity level
- Q15: Recreational fishing activity level
- Q14/15: Boating activity level

Q7: California Sheephead
Abundance & size structure

Q8, Q10: Kelp forest fish
Species abundance & size structure, diversity indices

Q8: Nesting birds
Colony size & fledging rate

Q5: Kelp canopy
Areal extent

Q7: Spiny lobster
Abundance & size structure

Q8: YOY rockfish
Abundance/density

Q5: Understory algae
Abundance

Q5, Q10: Biogenic invertebrates
Cover & diversity indices

Q9: Non-indigenous species
sites & abundance

Q7: Sea urchin (red & purple)
Abundance & size structure

Q7: Sea star (*Pycnopodia* & *Pisaster*)
Abundance & size structure

Q8: Abalone
Abundance & size structure

deep seafloor kelp forest and rocky reef

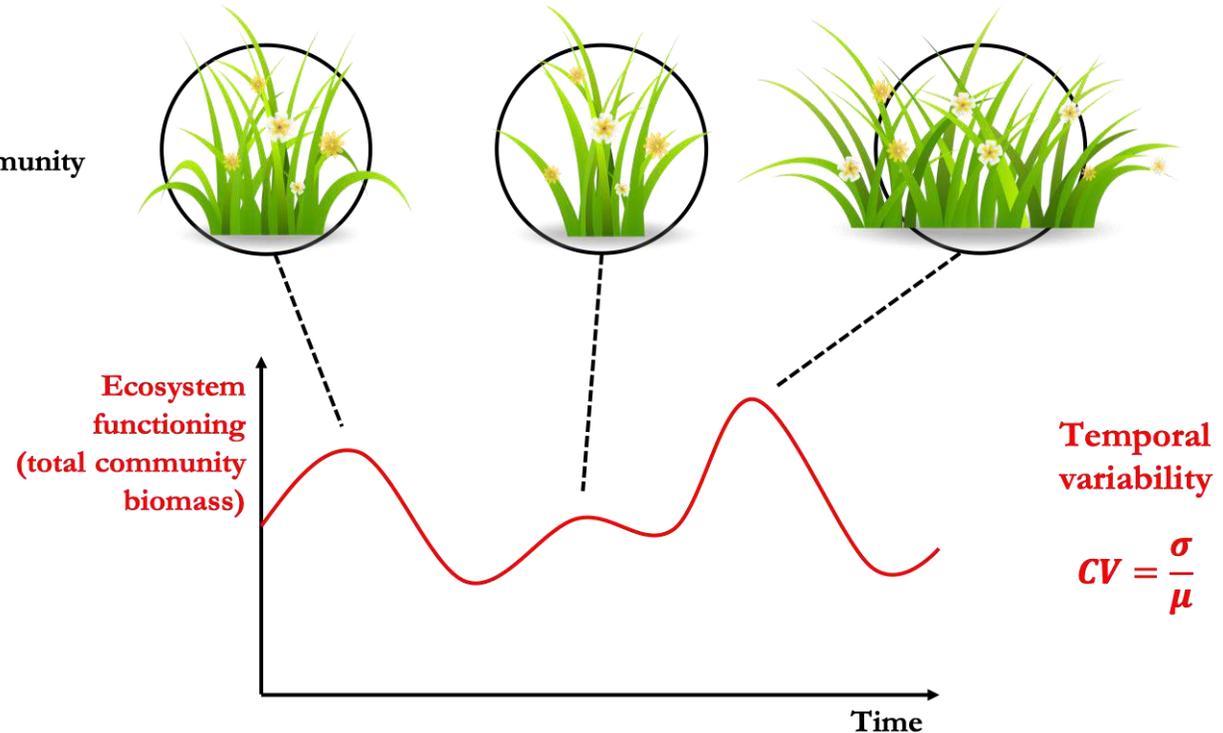
NOAA FISHERIES
National Marine Fisheries Service
SCIENCE CENTER

How does biodiversity affect ecosystem function and stability?

Understanding the factors that dampen variability of biomass production is a core concept of Ecology



local community



However, most empirical and theoretical studies which have investigated ecological variability and its relation with biodiversity have focused on **local scales**

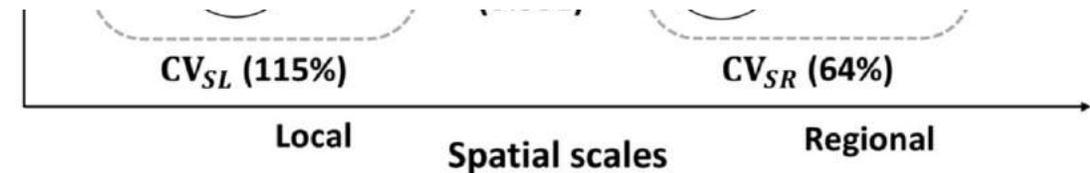
Species diversity begets stability

Real-world ecosystems are complex:
from populations of single species to
multi-species communities to



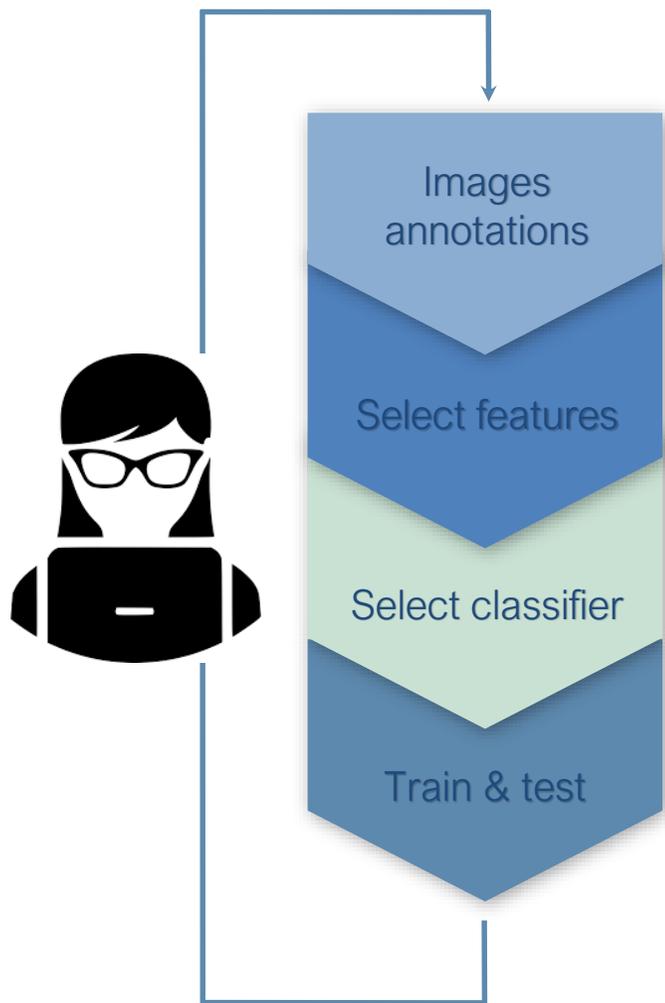
Recommendation: data integration and management needs science involvement

.....



New Products: Deep learning for image analysis

Typical machine learning



Engineer required throughout

Time consuming (months)

Only works on specific type of data

Deep learning

Benefits

- Generalizes to your data
- Fully automated - no feature selection
- High accuracy

Leverages

- Scalable services
- Annotation system
- Cluster processing
- Fast classification on GPUs

Image management & annotation

The screenshot displays the BisQue web interface for image management and annotation. The main window shows an image of a reef with numerous small, colored circular markers overlaid on it, indicating annotations. The interface includes a top navigation bar with options like 'Create', 'Upload', 'Download', 'Analyze', and 'Browse'. A right-hand sidebar contains a 'Metadata' panel with tabs for 'Annotations', 'Graphical', 'Metadata', and 'Analysis'. The 'Annotations' tab is active, showing a list of 101 children with their respective taxonomic names and checkboxes for visibility and deletion.

Image: 5496x3670 ch: 3/16bits Scale: 25%

Watersipora-Reef image: IMG_4886.CR2

Current children: 101

Visibility Add Delete Color Stats

Type:Name

- Porifera - Acamus erithacus
- Porifera - pale orange sponge unidentified
- Porifera - pale orange sponge unidentified
- Porifera - pale orange sponge unidentified
- Mollusca - Chaceia ovoidea
- Porifera - pale orange sponge unidentified
- Cnidaria - Astringia halmei
- Porifera - pale orange sponge unidentified
- Porifera - pale orange sponge unidentified
- Porifera - Tethya californiana
- Cnidaria - Balanophyllia elegans
- Substrate - Bare Rock
- Substrate - Sand
- Cnidaria - Astringia halmei
- Cnidaria - Astringia halmei
- Echinodermata - Cucumaria piperata
- Echinodermata - Strongylocentrotus purpuratus
- Echinodermata - Strongylocentrotus purpuratus
- Echinodermata - Cucumaria piperata
- Echinodermata - Patiria miniata
- Cnidaria - Astringia halmei

Model building & usage

BisQue | Create | Upload | Download | Analyze | Browse | Find resources using tags | Bisque admin

Connoisseur | Sea creatures

Author: Dmitry Fedorov
License: unrestricted
© UCSB
Model designed for natural image recognition

Dataset: Watersipora-Reef (13 images)

24 Number of samples | 50% Class accuracy | 50% Sample goodness

D Select dataset | **F** Filter classes | **S** Create samples | **T** Train | **V** Validate

Train & Validate

ID	Sample	Label	Ignore
29	176	Cnidaria - Corynactis californica	
105	154	Rhodophyta - Encrusting coralline spp.	
10	113	Arthropoda - Barnacles (Unidentifiable)	
9	56	Arthropoda - Barnacle (DEAD)	
114	53	Rhodophyta - Rhodymenia spp.	
68	34	Ectoprocta - Thalamoporella californica	
118	33	Substrate - Hydroid/Bryozoan complex	
83	30	No Data - Shells	
103	28	Rhodophyta - Chondracanthus spp.	
20	27	Chordata - Trididemnum spp	
49	27	Echinodermata - Strongylocentrotus franciscanus	
69	27	Ectoprocta - Watersipora subatra	
3	19	Arthropoda - Salpinnix bilineolata	
26	19	Cnidaria - Aequorea victoria	
63	18	Ectoprocta - Peach Bryozoan (Unknown)	
107	18	Rhodophyta - Filamentous red spp (Unidentifiable)	
119	18	Substrate - Sand	
58	17	Ectoprocta - Cirrip A	
113	17	Rhodophyta - Red Turf spp (Unidentifiable)	
59	16	Ectoprocta - Diaporoforma californica	
120	16	Substrate - amphipod tube complex	
116	15	Substrate - Bare Rock	
8	14	Arthropoda - Balanus spp.	
51	14	Ectoprocta - Bugula californica	
82	14	No Data - Shadow	
15	11	Chordata - Diplotosoma listerianum	
52	11	Ectoprocta - Rugula auritina	
73	11	Heterokontophyta - Dictyosphaera undulata	
85	11	Green algae	
27	10	Cnidaria - Clavularia spp.	
28	9	Cnidaria - Coenocytus loweryi	



BisQue | Create | Upload | Download | Analyze | Browse | Find resources using tags | Bisque admin

Connoisseur: automated image annotation

Version: 1 | Author: Dmitry Fedorov
The module automatically annotates selected images.

1. Select data for processing:

Images to classify:
Select an image | Select a set of images | Upload local images

Classification mode:
Select a connection
Sea Fruits

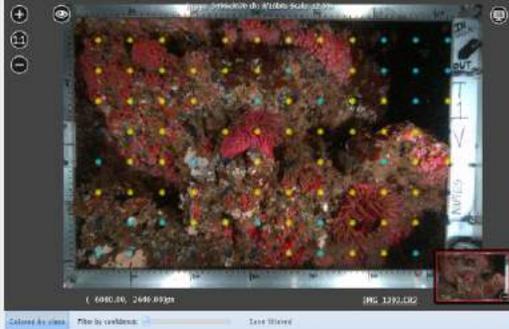
2. Parameters:

The classification method: Uniformly distributed points
Number of points to classify: 100
Maximum confidence: 0
Margin: 1.0
Store annotations on the image: []

3. Run algorithm:
Run This may take some time, progress will be shown on the button.

4. Results:
The module ran in 40 seconds

Classified image



Help and workflow

The module annotates an image with its embedded metadata.

Identification & segmentation

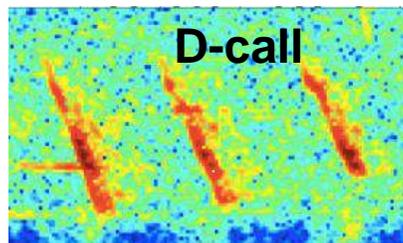


Recommendation: machine learning requires time but saves work in the long run

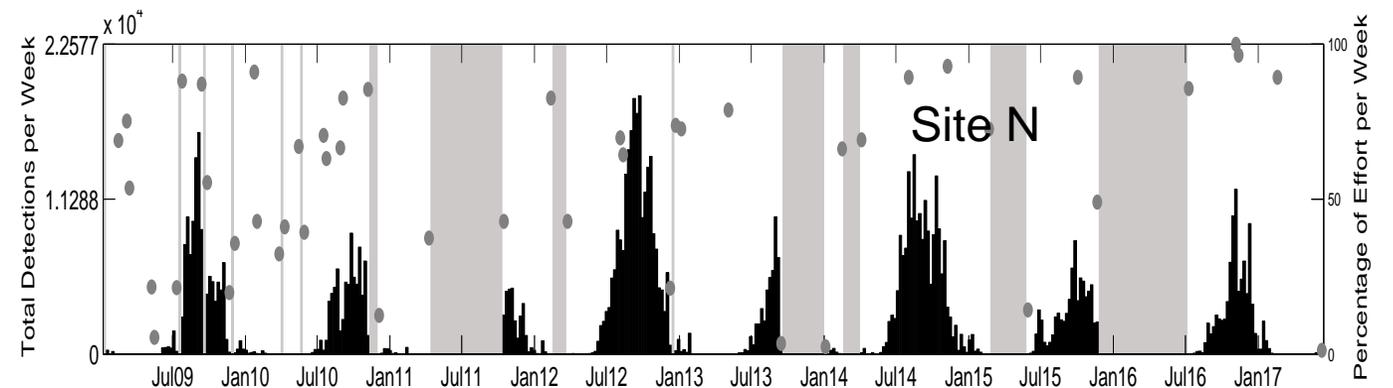
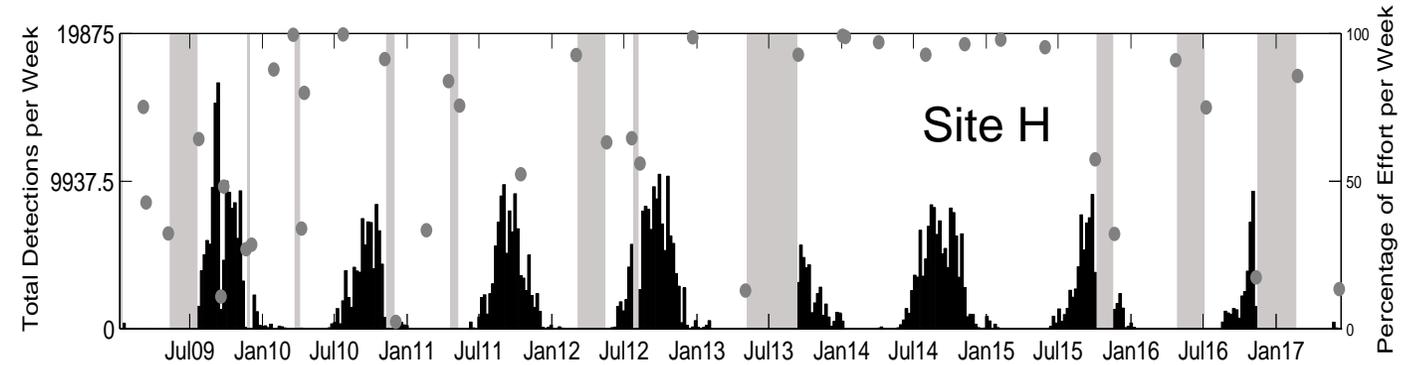


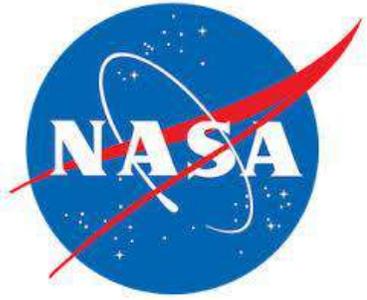
New Products: Acoustics

Acoustic Detection of Marine Mammals



Seasonal patterns of blue whale song



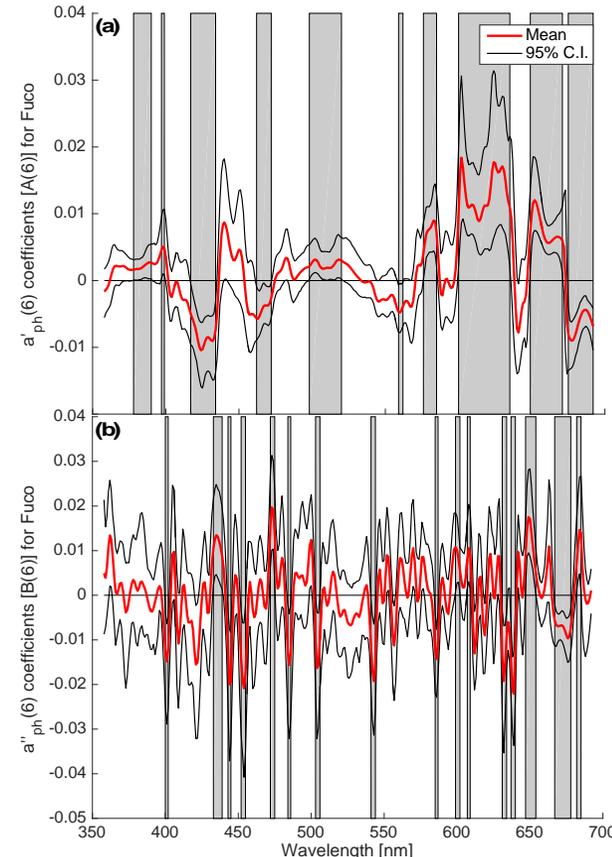
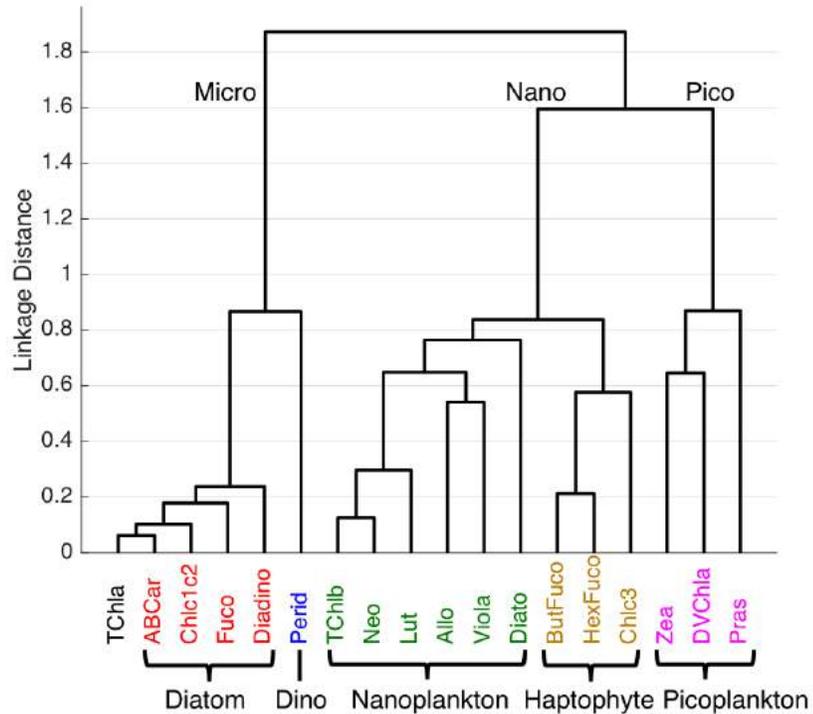


New Products: Remote Sensing

Phytoplankton functional diversity

Phytoplankton pigment community clusters define five clusters

Bio-optically modeled PFTs give us the links to PACE/ESBG



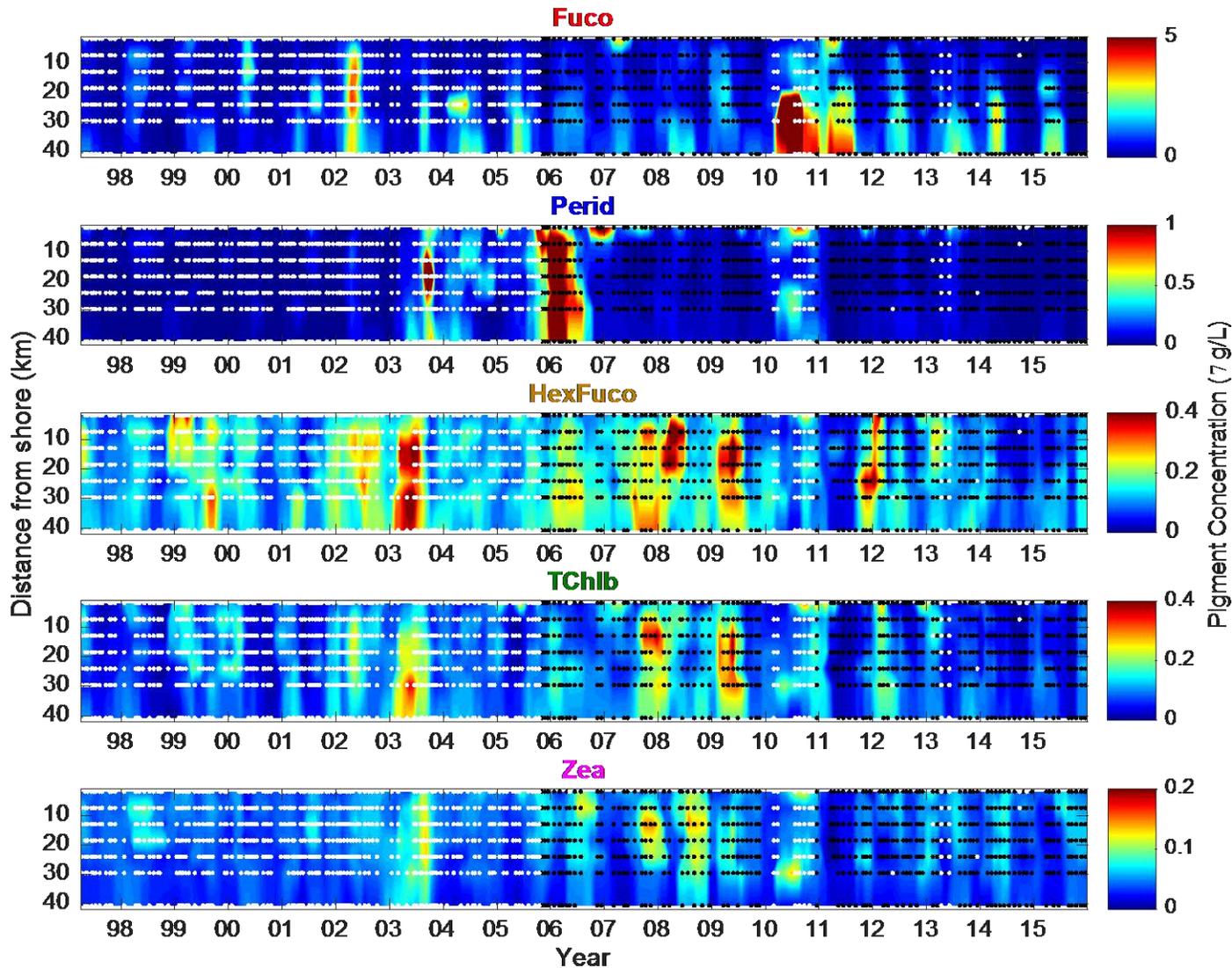
Prediction of fucoxanthin (diatom marker) from optical derivative spectra

Works well - $r^2 = 0.86$

Similar performance for other marker pigments'

Requires info from the entire spectrum

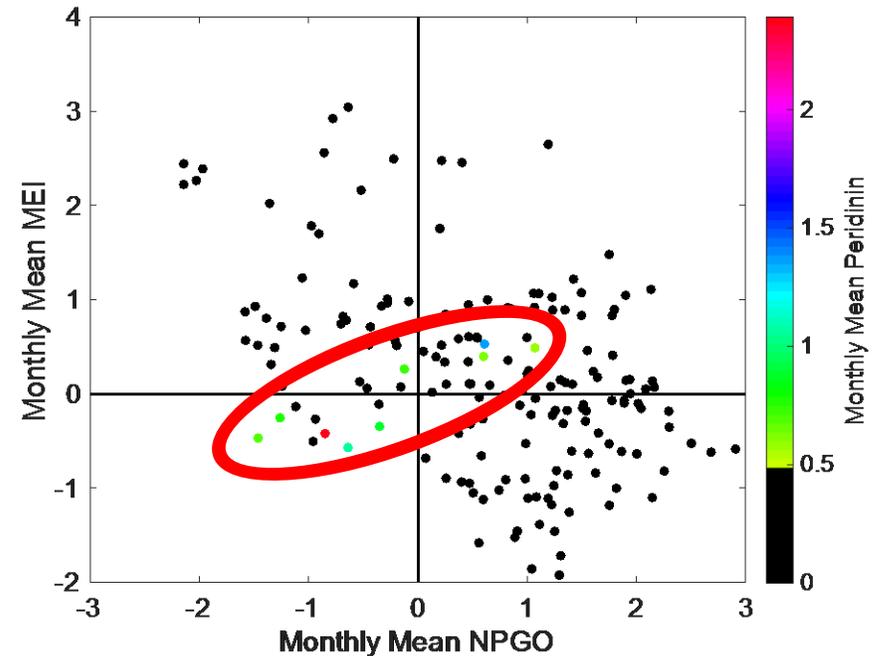
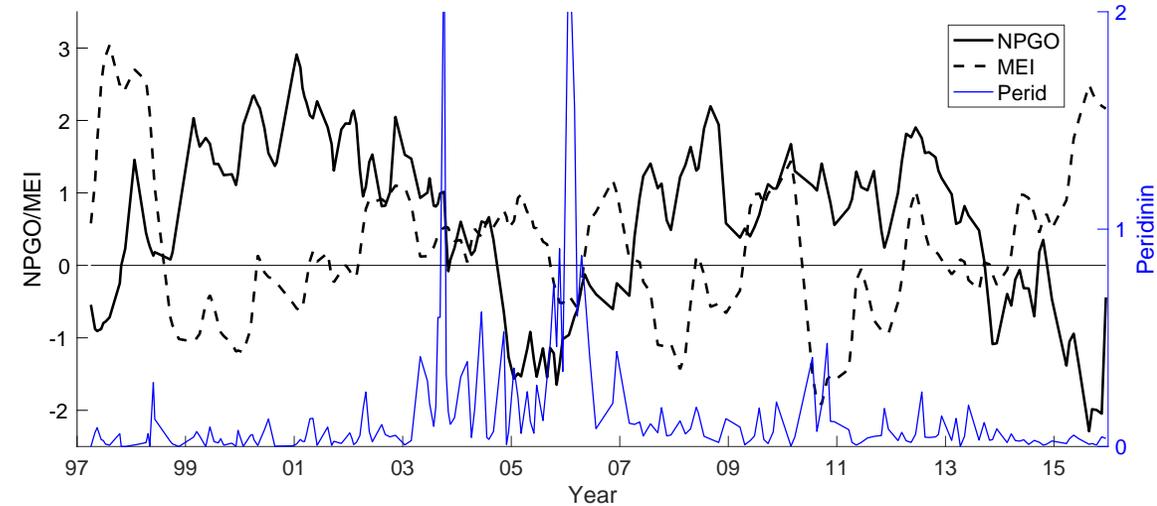
Bio-Optical Model Extends Biomarker Pigment Time Series



Model Retrievals	R ²
TChlb (green algae)	0.815
HexFuco (haptophytes)	0.733
Fuco (diatoms)	0.856
Perid (dinoflagellates)	0.887
Zea (picoplankton)	0.541
Pigment EOF Mode 1 (Early upwelling mixed bloom)	0.884
Pigment EOF Mode 2 (Diatoms vs. mixed nano-/pico-plankton)	0.852
Pigment EOF Mode 3 (Pico-plankton vs. haptophytes)	0.454
Pigment EOF Mode 4 (Dinoflagellates vs. mixed diatoms/haptophytes)	0.809

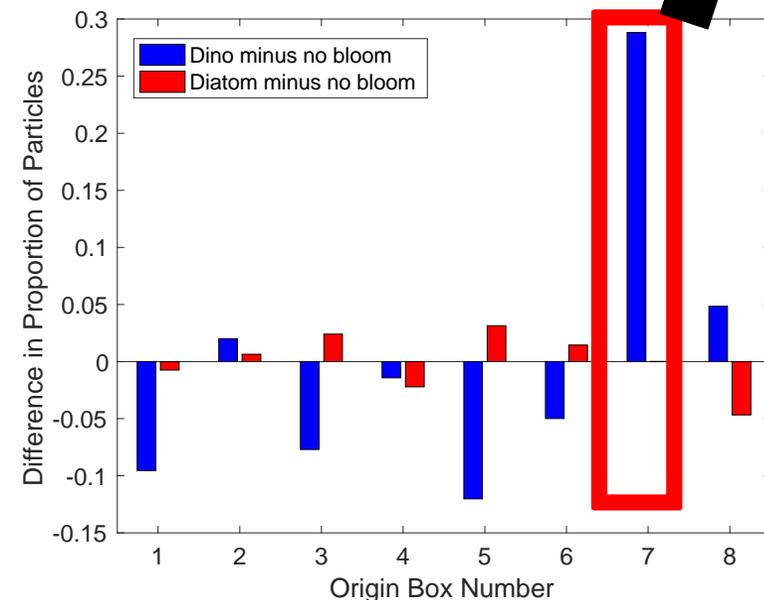
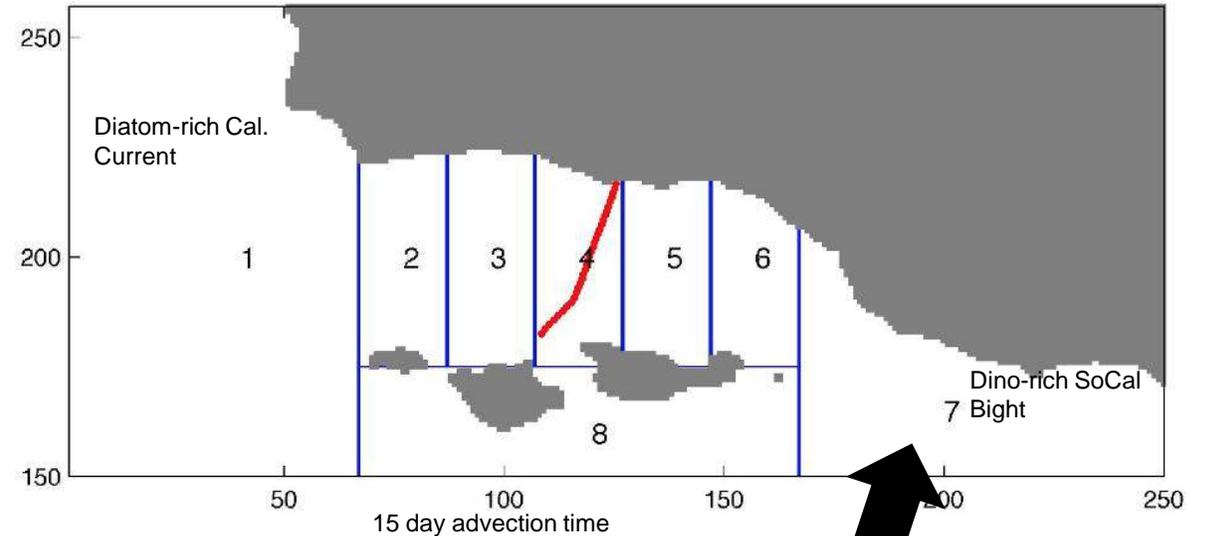
PFTs and Climate

- Investigating PFT associations with climate 1997-2015
- SBC dinoflagellate blooms associated with low or negative NPGO + MEI
- Hypothesis: climate-driven variations in surface-ocean circulation drive variations in PFTs
 - Low/negative NPGO = weaker equatorward flows in Cal Current, dino-rich SoCal Bight waters can be transported North into SBC to seed blooms
 - Low/negative MEI = weak El Nino/La Nina provides favorable conditions for dino blooms

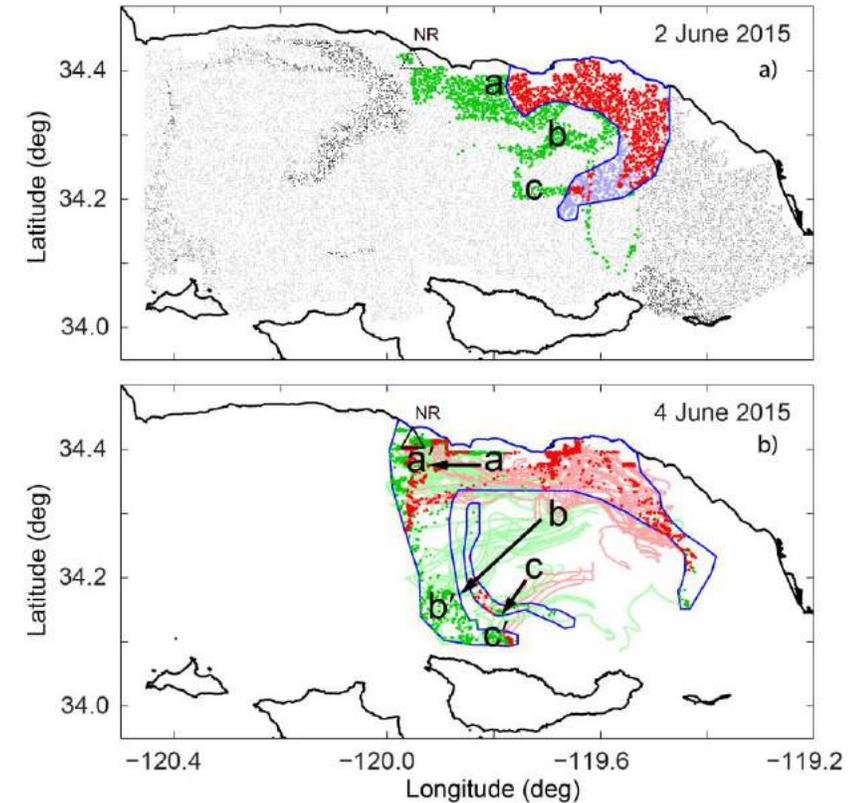
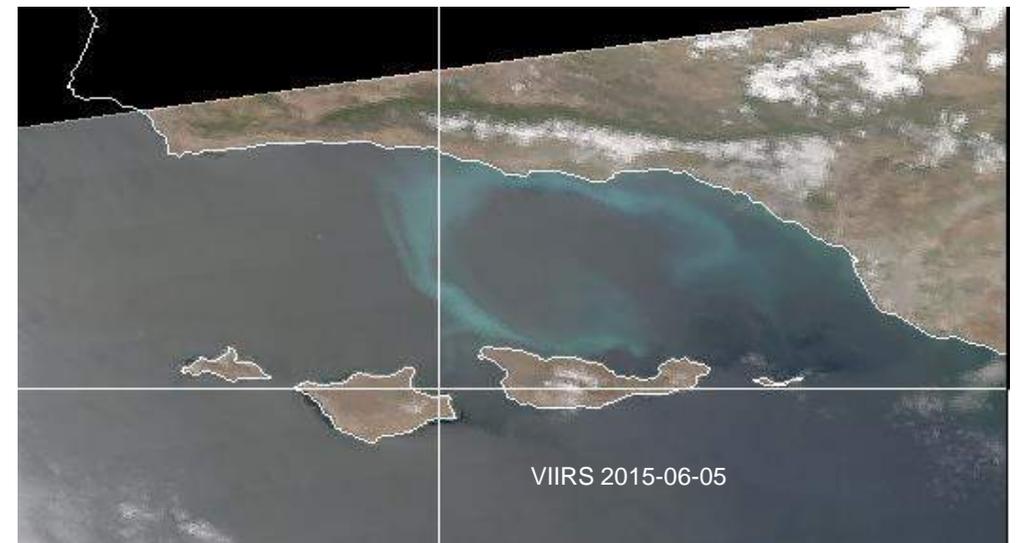
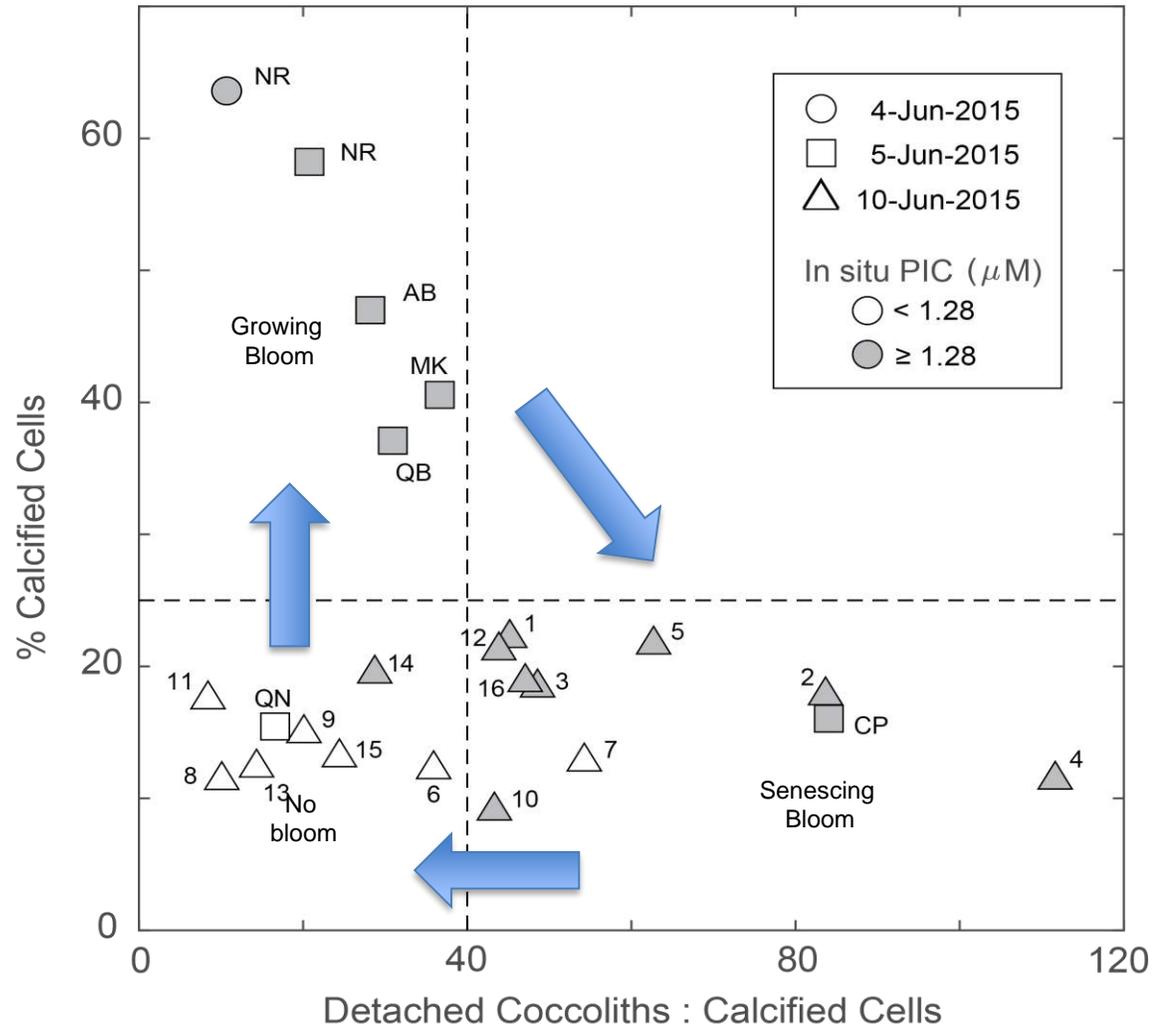


PFTs and Surface Ocean Circulation

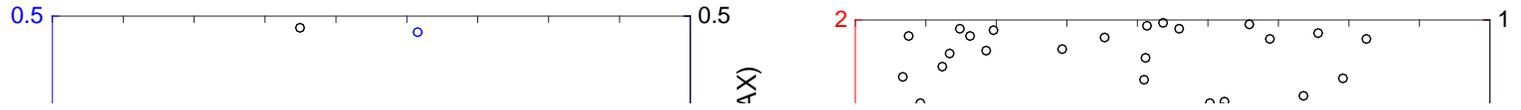
- ROMS particle trajectory modeling used to quantify water mass origins for each PnB cruise
- Particles released back in time from the PnB transect (red), count how many originated in each box (blue)
- ~30% increase in proportion of particles from Box 7 for dino blooms relative to diatom or no bloom
- (Climate-driven) surface ocean circulation may be important in biodiversity monitoring



Formation, Development, and Propagation of a Coastal Coccolithophore Bloom

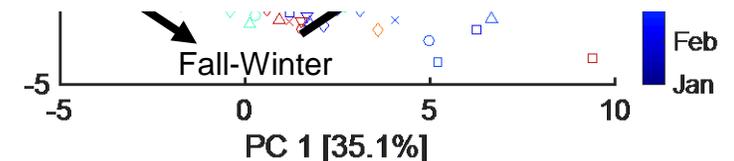
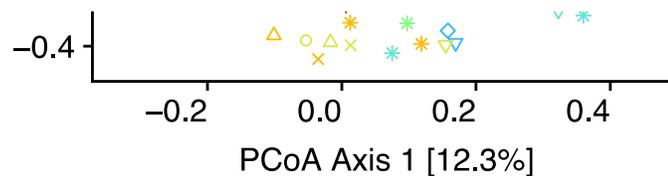


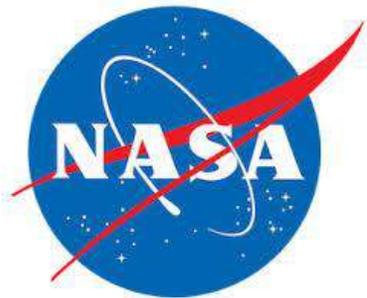
Genomic Links with Pigment PFTs + Bio-optics



Recommendation:

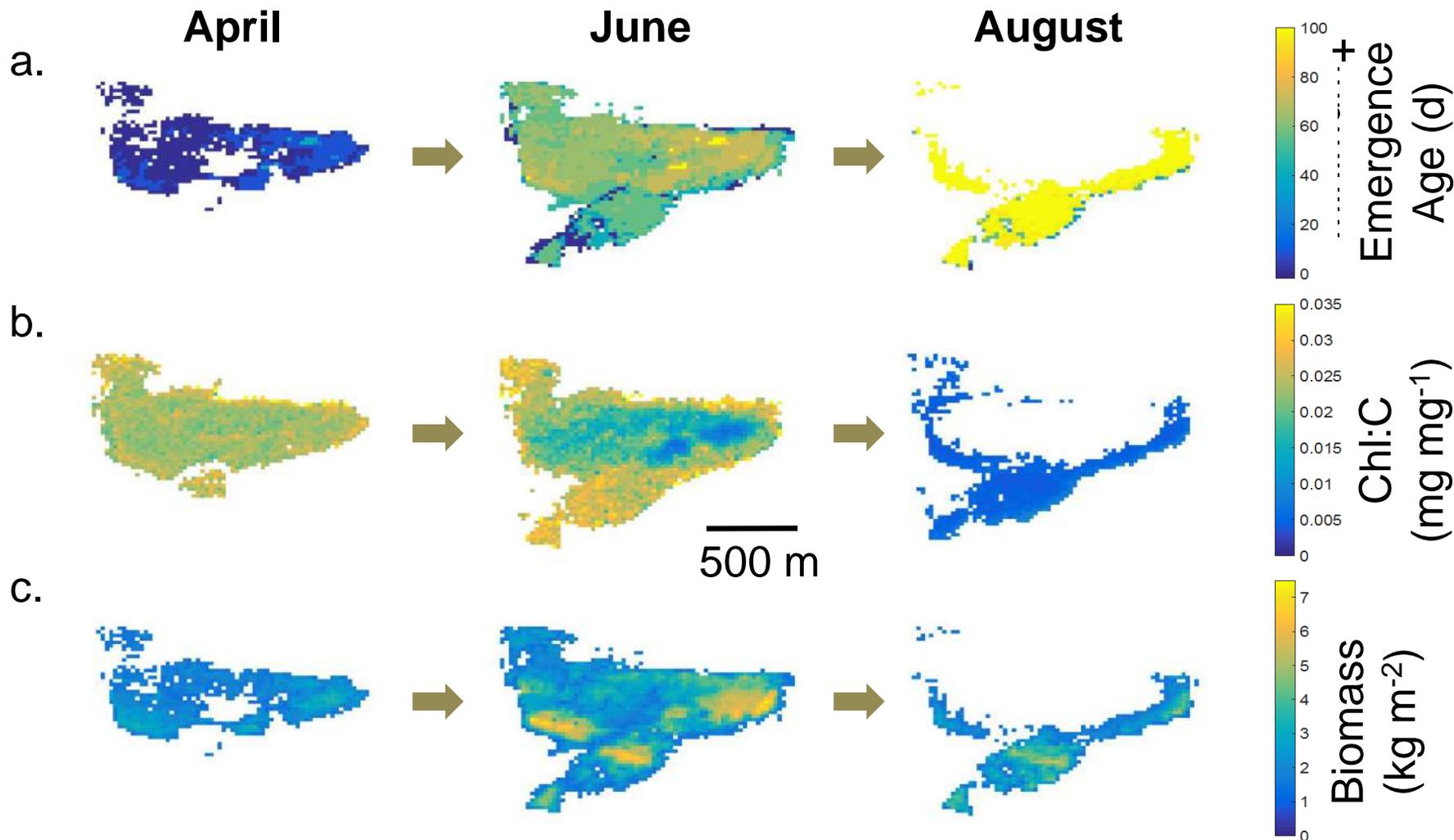
Determine remotely sensible and validated PFTs





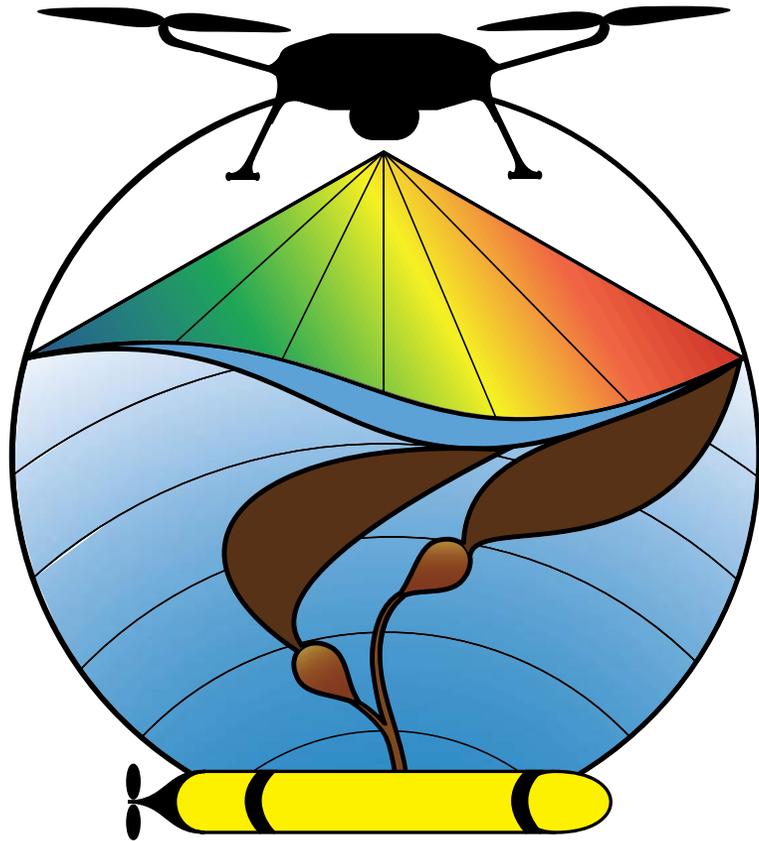
New Products: Remote Sensing

Kelp condition, age, and forest extent



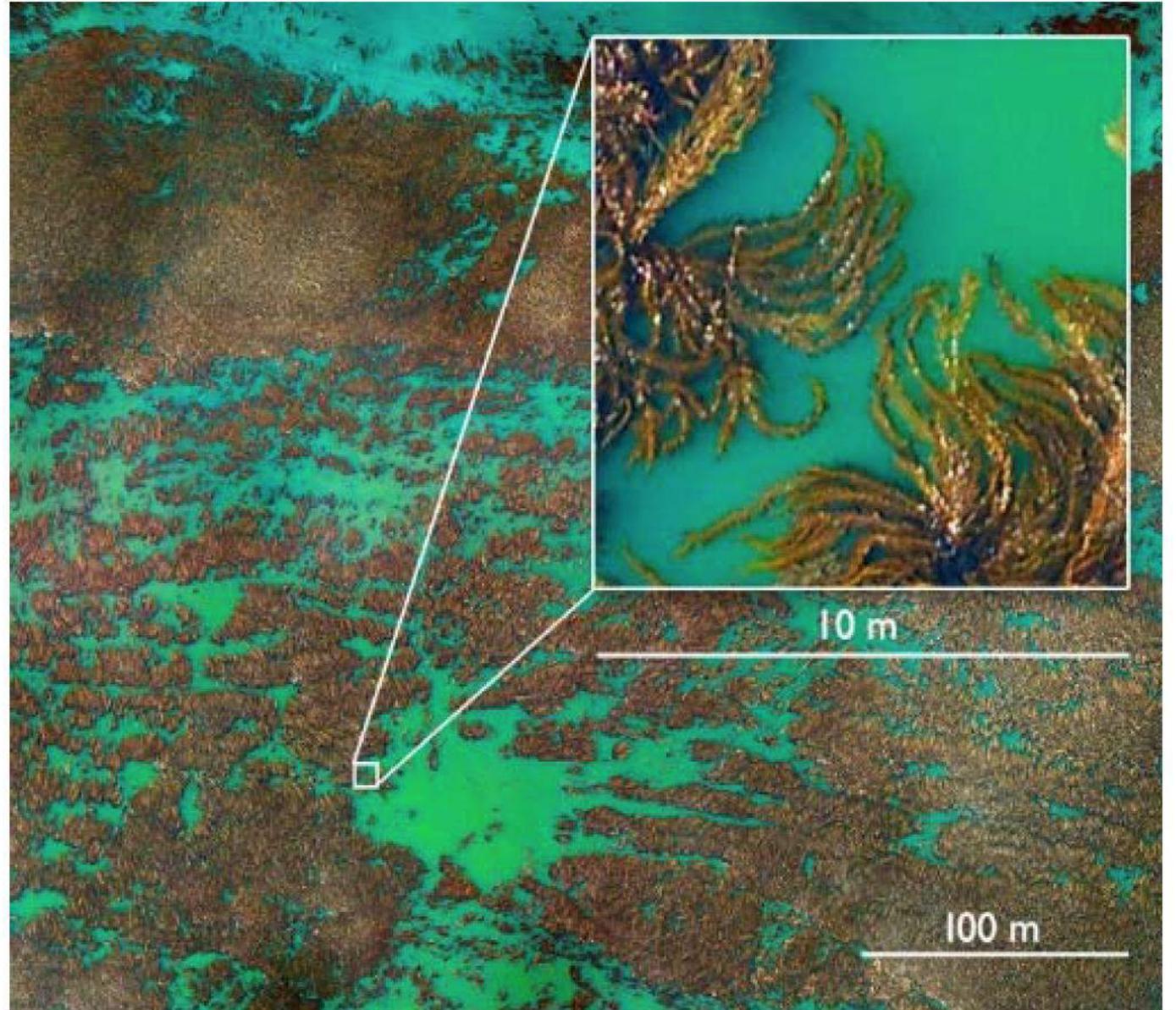
Bell & Siegel in prep
Bell et al. L&O 2018

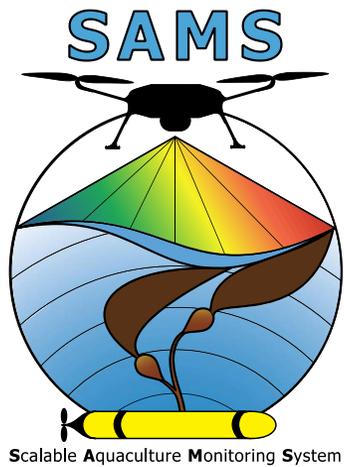
SAMS



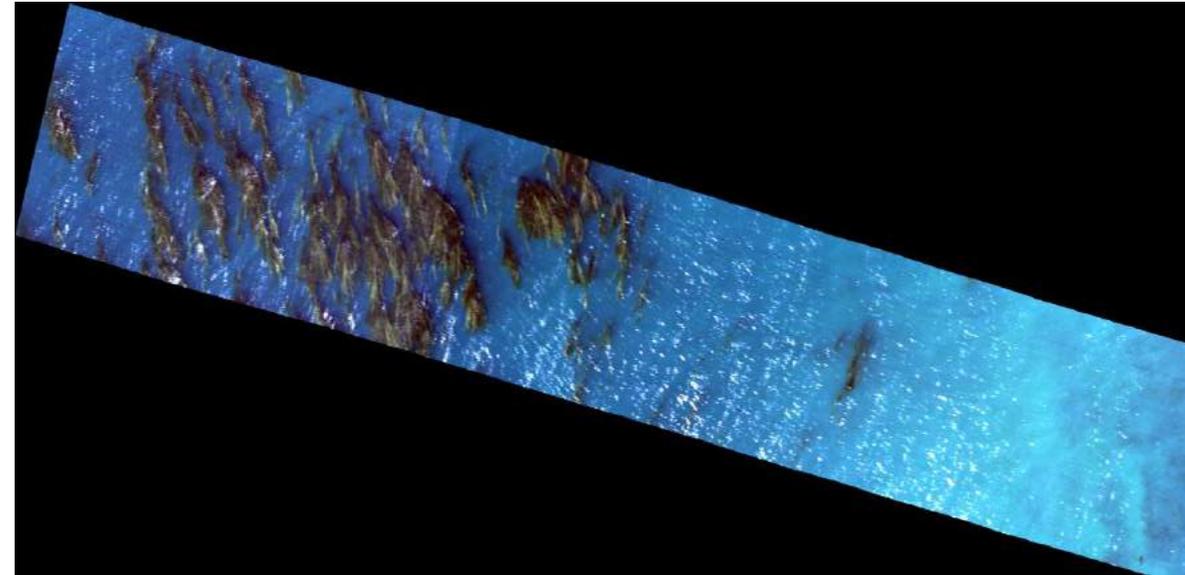
Scalable **A**quaculture **M**onitoring **S**ystem

PIs: Siegel, Bell, Cavanaugh, Miller, Nidzieko, Nelson, Reed

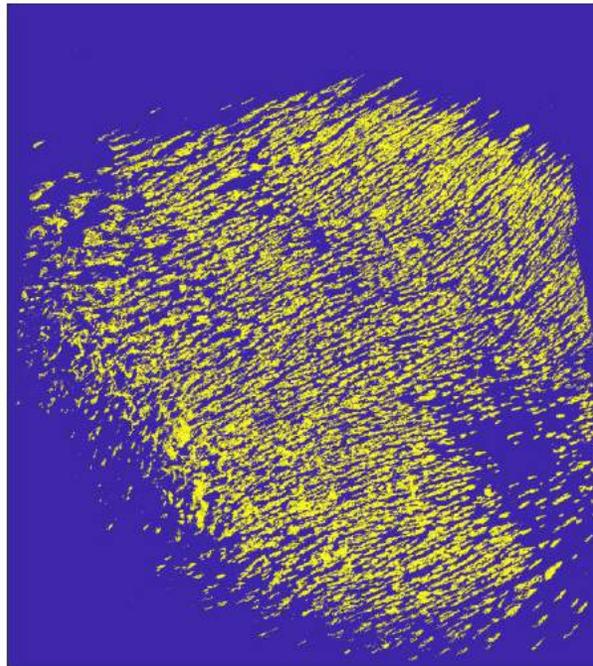
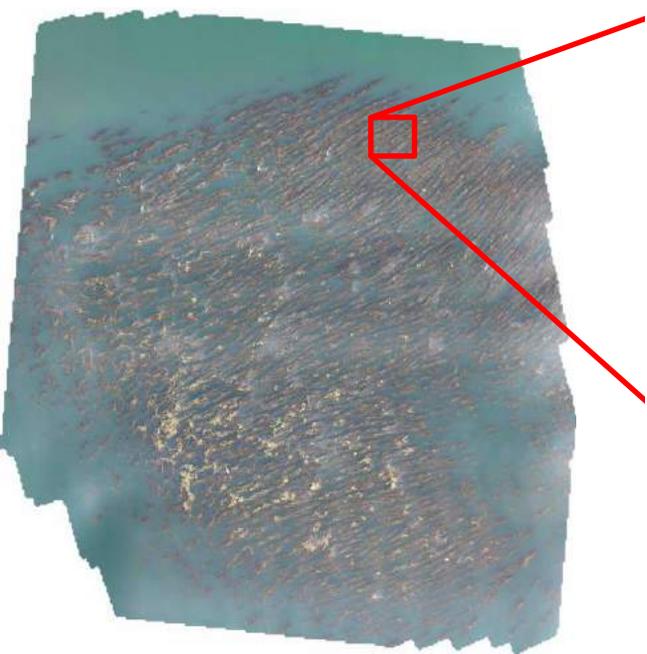




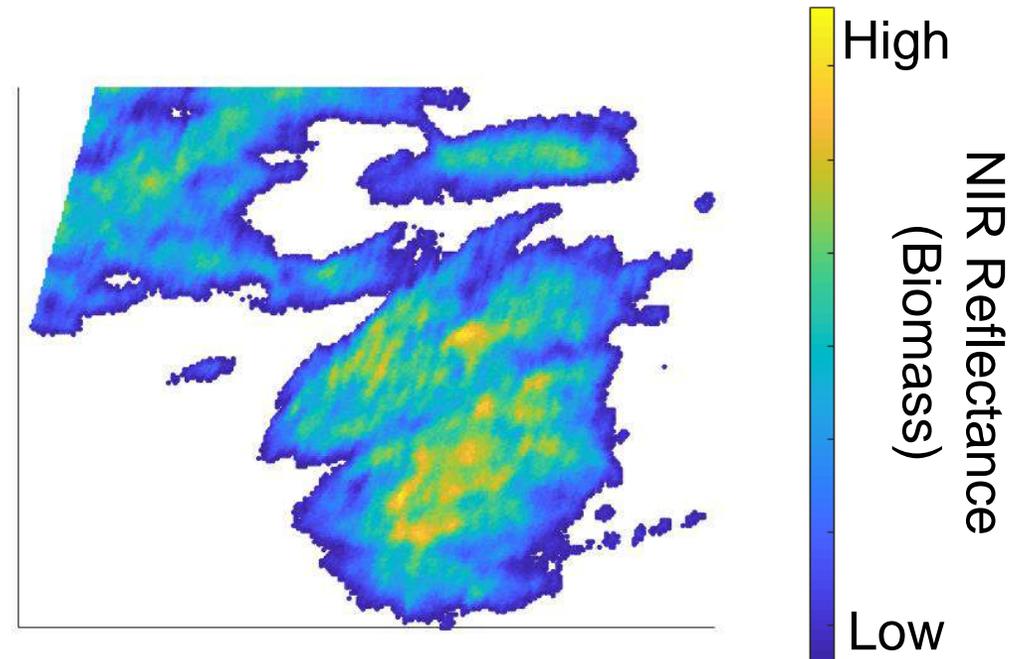
Biomass and condition: multispectral



Aerial extent: color imagery



Bell et al. in prep



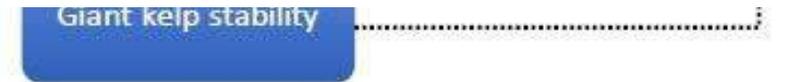
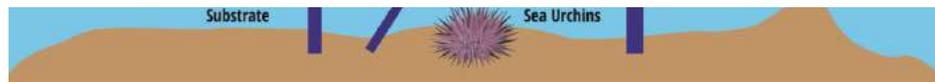
Giant kelp creates a diverse ecosystem

Giant kelp increases biodiversity through physical engineering

Giant kelp stability indirectly stabilizes the community via its effect on biodiversity



Recommendation: focus on dynamics of foundation species (best with RS!)



New Products: Genomics

Microbial diversity & community structure

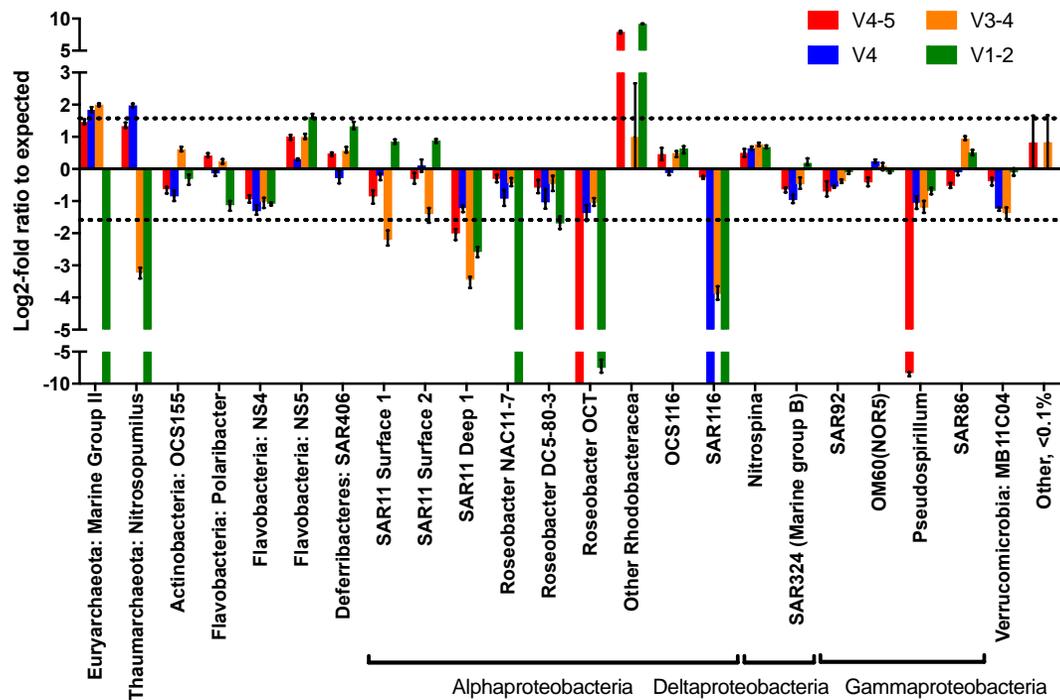
environmental
microbiology



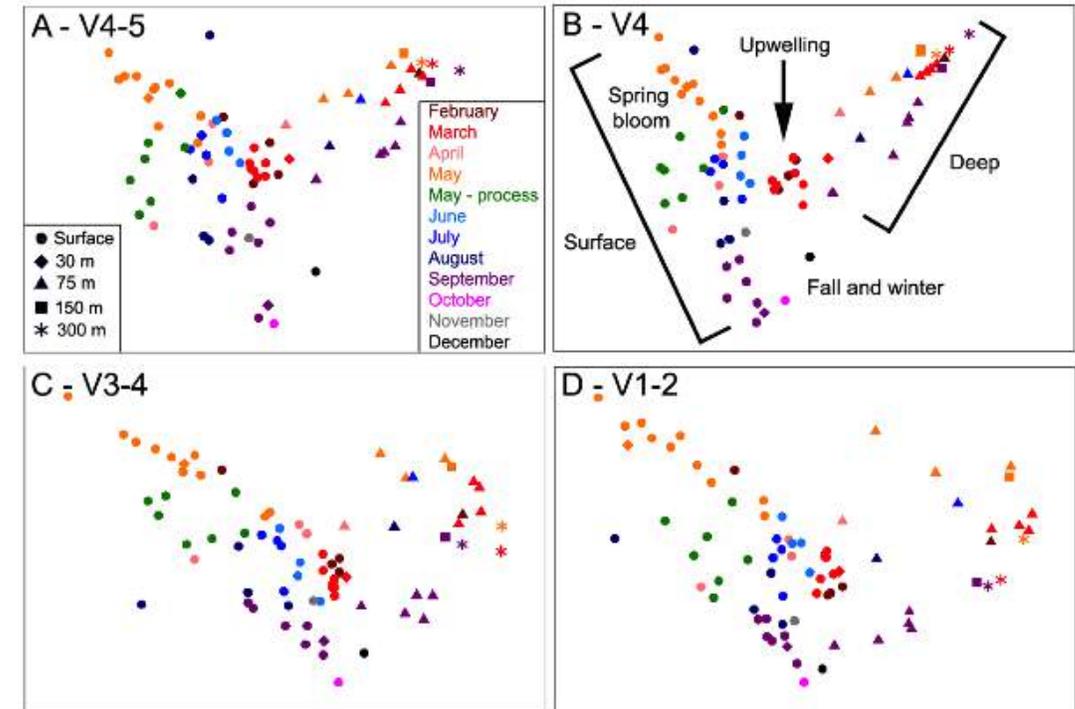
Environmental Microbiology (2018) 00(00), 00–00

doi:10.1111/1462-2920.14091

Mock community deviation from expected abundance with four different primer sets:



Ordination plots of the same marine time-series samples sequenced with four primer sets



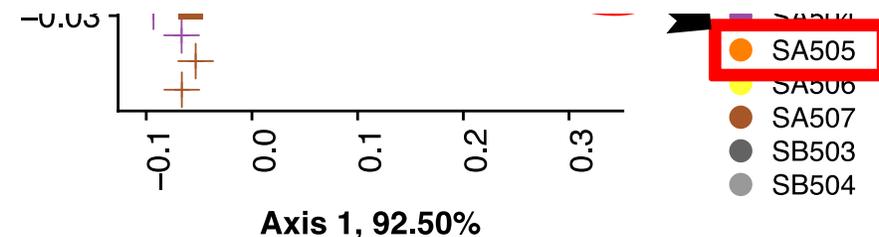
Phytoplankton Genomics Method Validation

- Mock communities

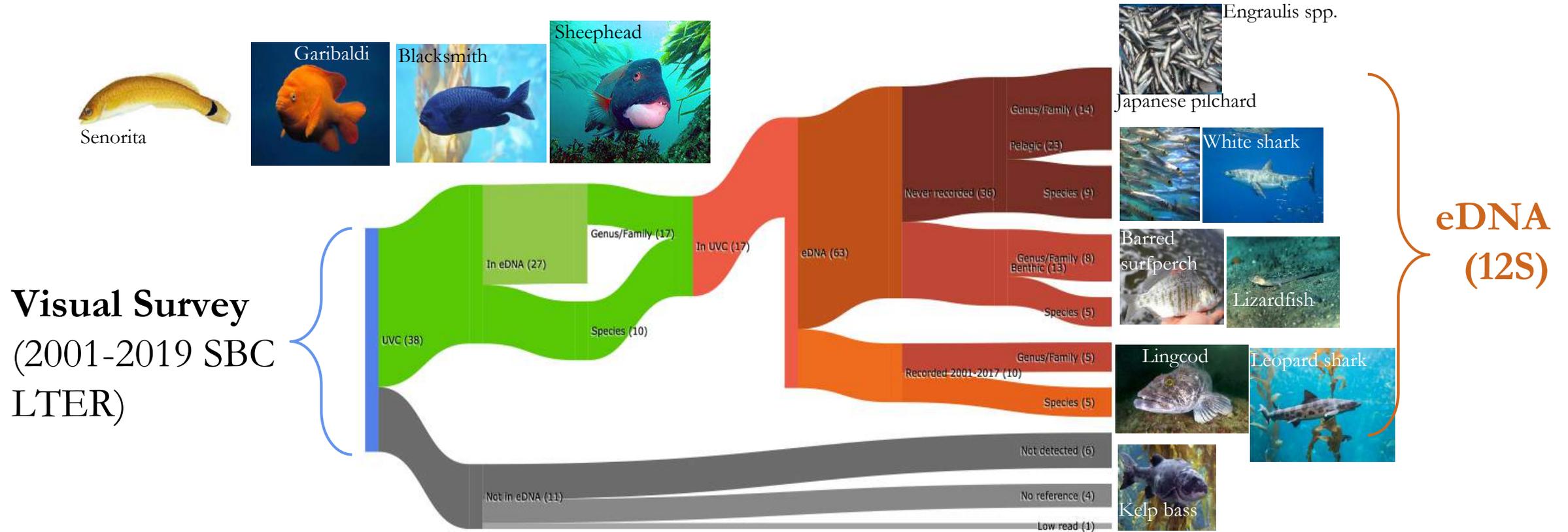


Recommendation: method validation is critical for genomic surveys

dramatically reduce accuracy + precision

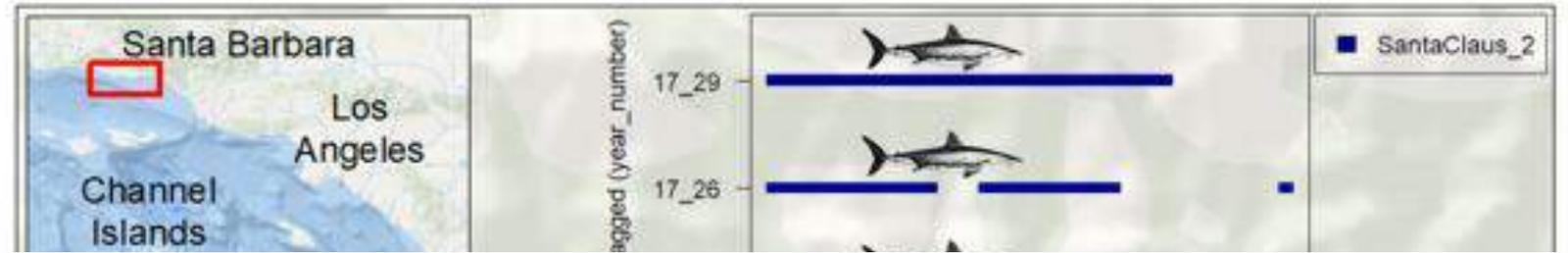


Environmental DNA captures the fine scale and hierarchical spatial structure of kelp forest fish communities

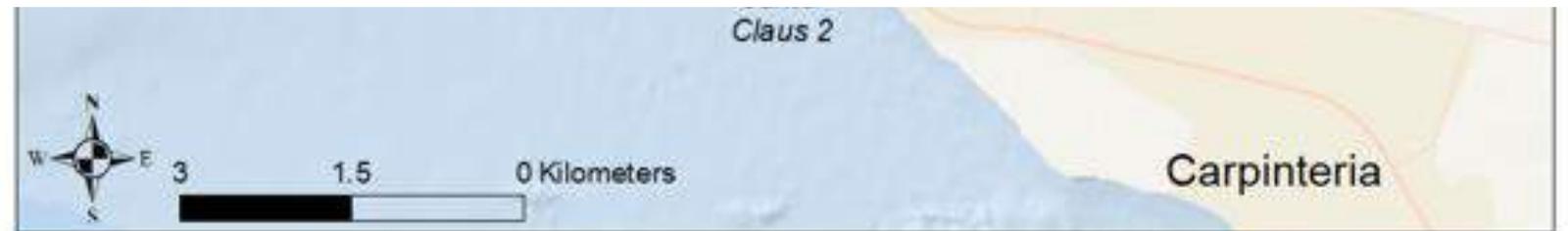


Spatially stratified sampling of 49 water samples on 27 transects across 11 rocky reefs

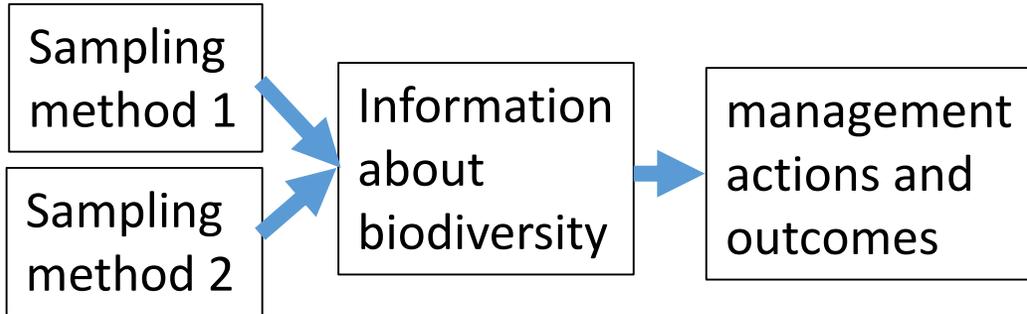
eDNA and Acoustic Telemetry Detection of Great White Sharks



**Recommendation: eDNA
useful especially for known
targets**



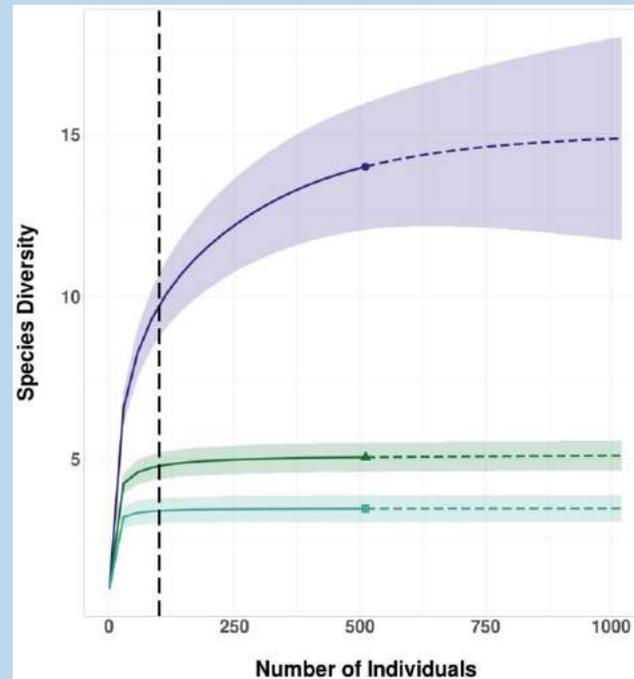
Comparing the efficiency of alternative methods of monitoring biodiversity



Biodiversity information:
status of rare species
richness and evenness
Trends in abundance
Spatial patterns of diversity

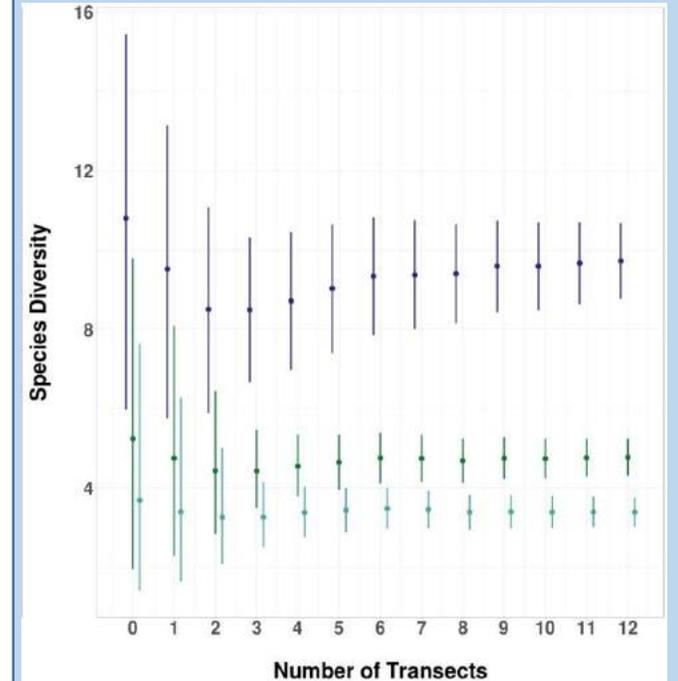
For each method:

- Rarefy biodiversity to 100 individuals observed
- Calculate associated confidence intervals (CI)
- Uncertainty is CI/mean



Uncertainty-effort curves:

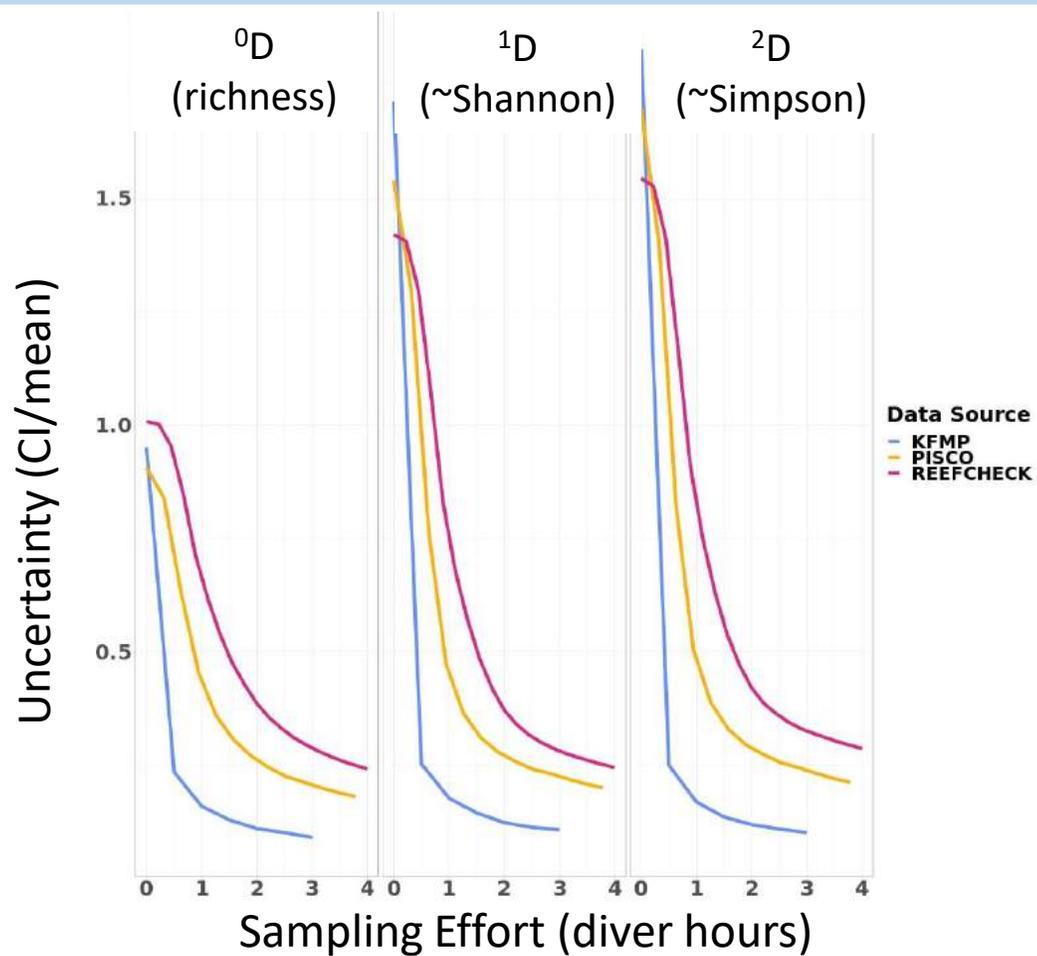
- Randomly subsample replicates
- Calculate expected CI and uncertainty



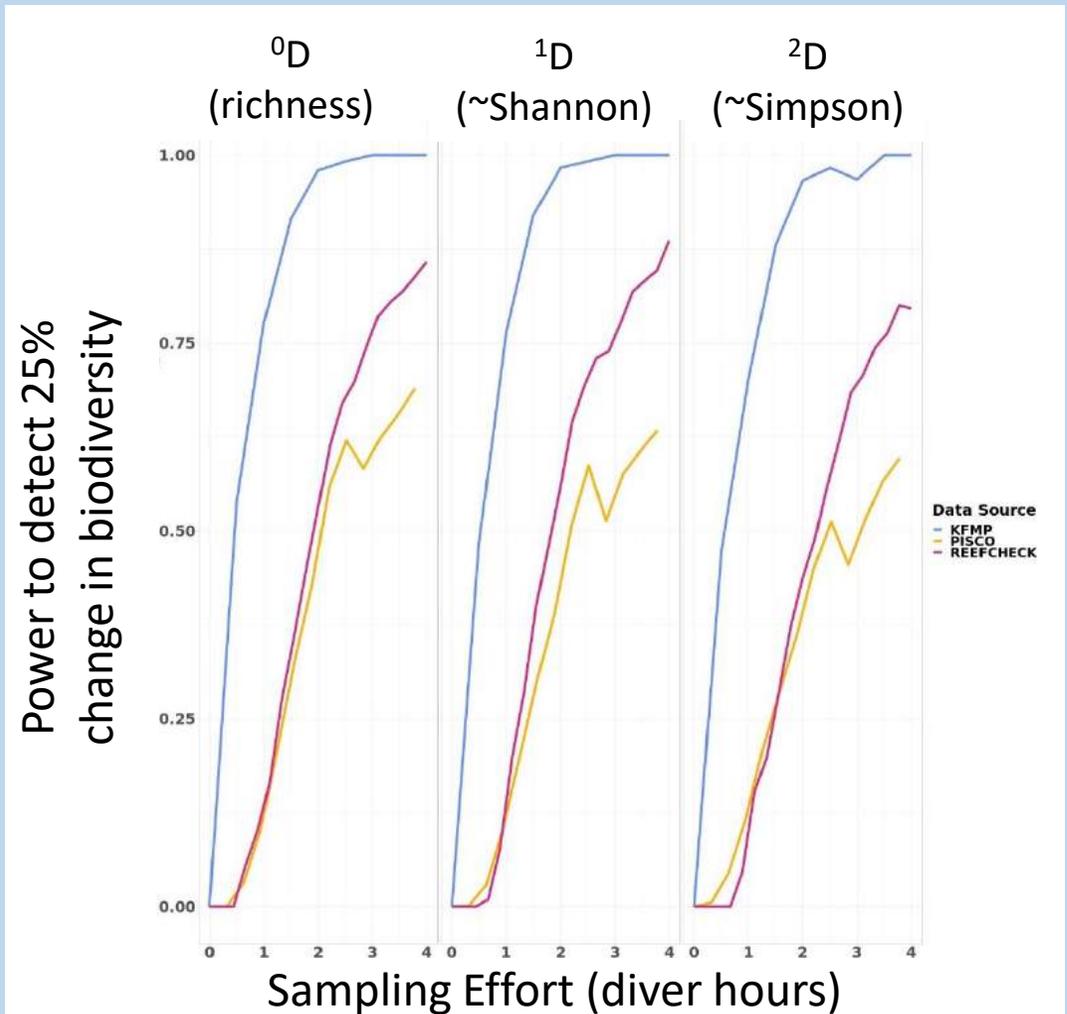
0D = Richness, 1D \approx Shannon Diversity, 1D \approx Simpson Diversity



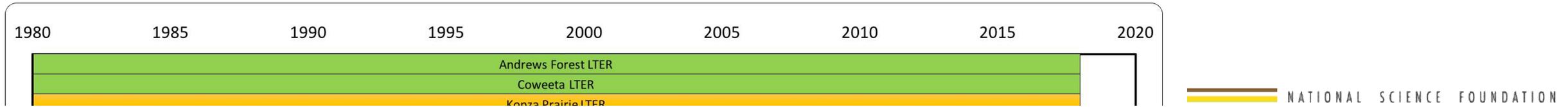
Compare sampling efficiency across methods:



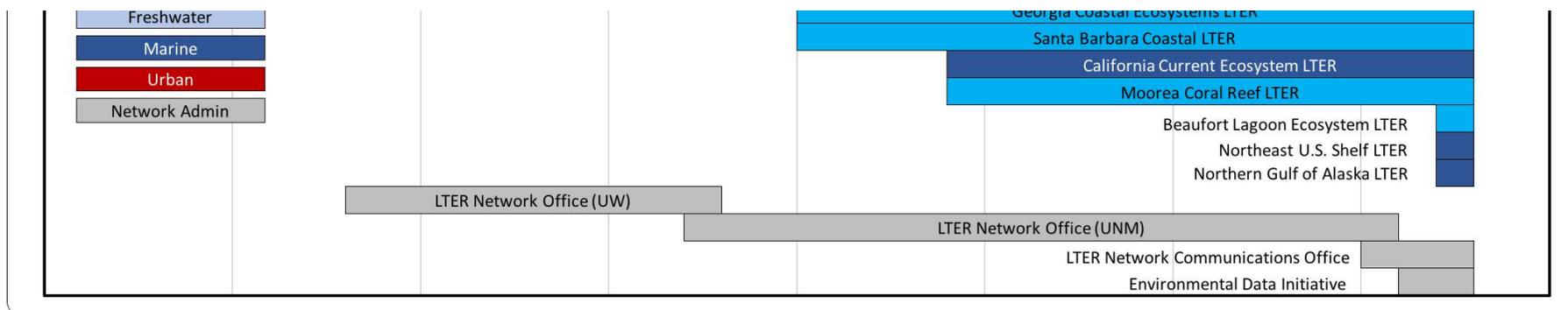
Compare power to detect change:



Program Development



Recommendation: MBON
support should be
competitive but predictable



SBC MBON: by the numbers

- Publications: **47**
- Undergraduate Students: **67**
- Graduate students: **17**
- Postdocs: **7**

