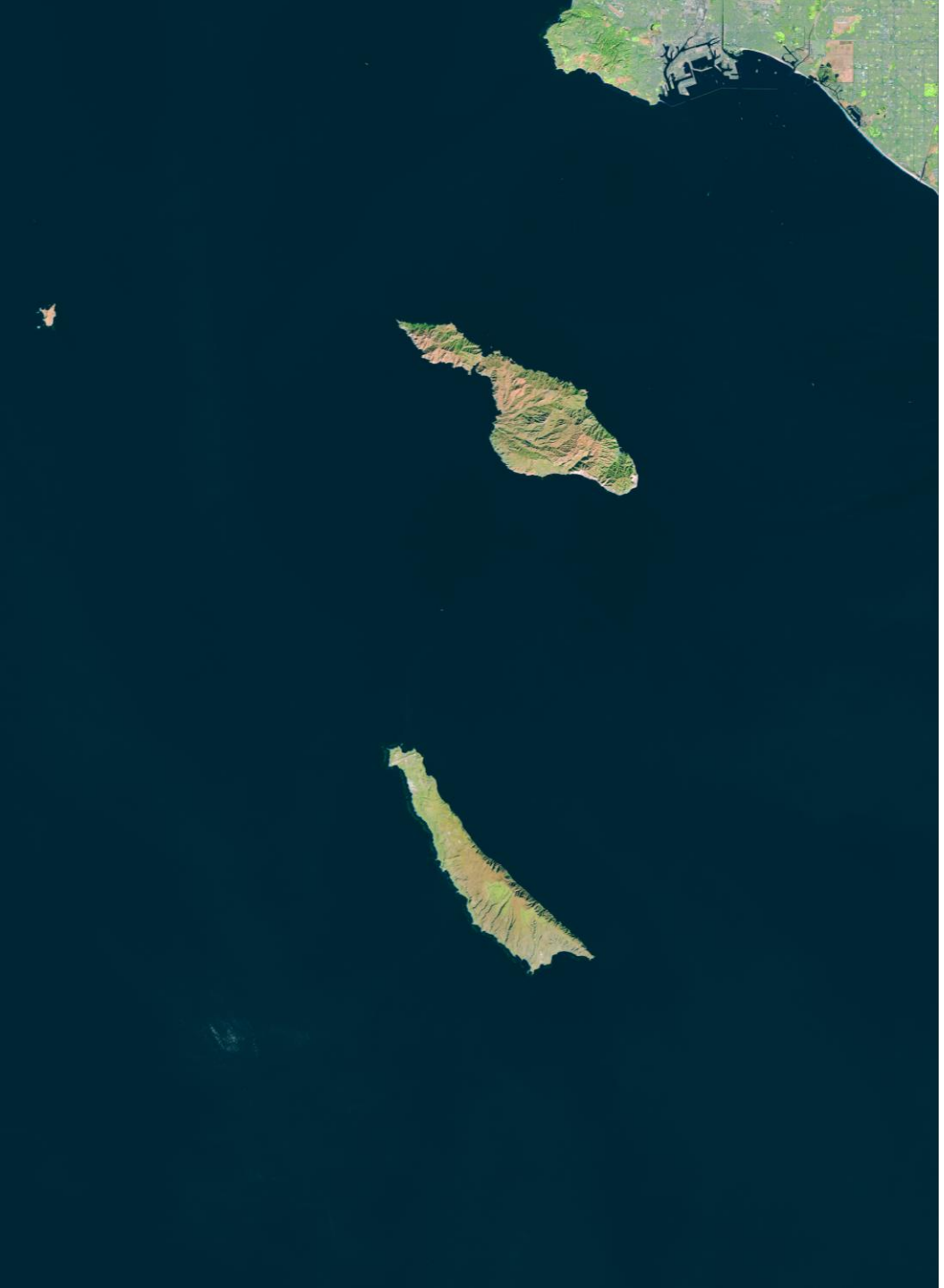
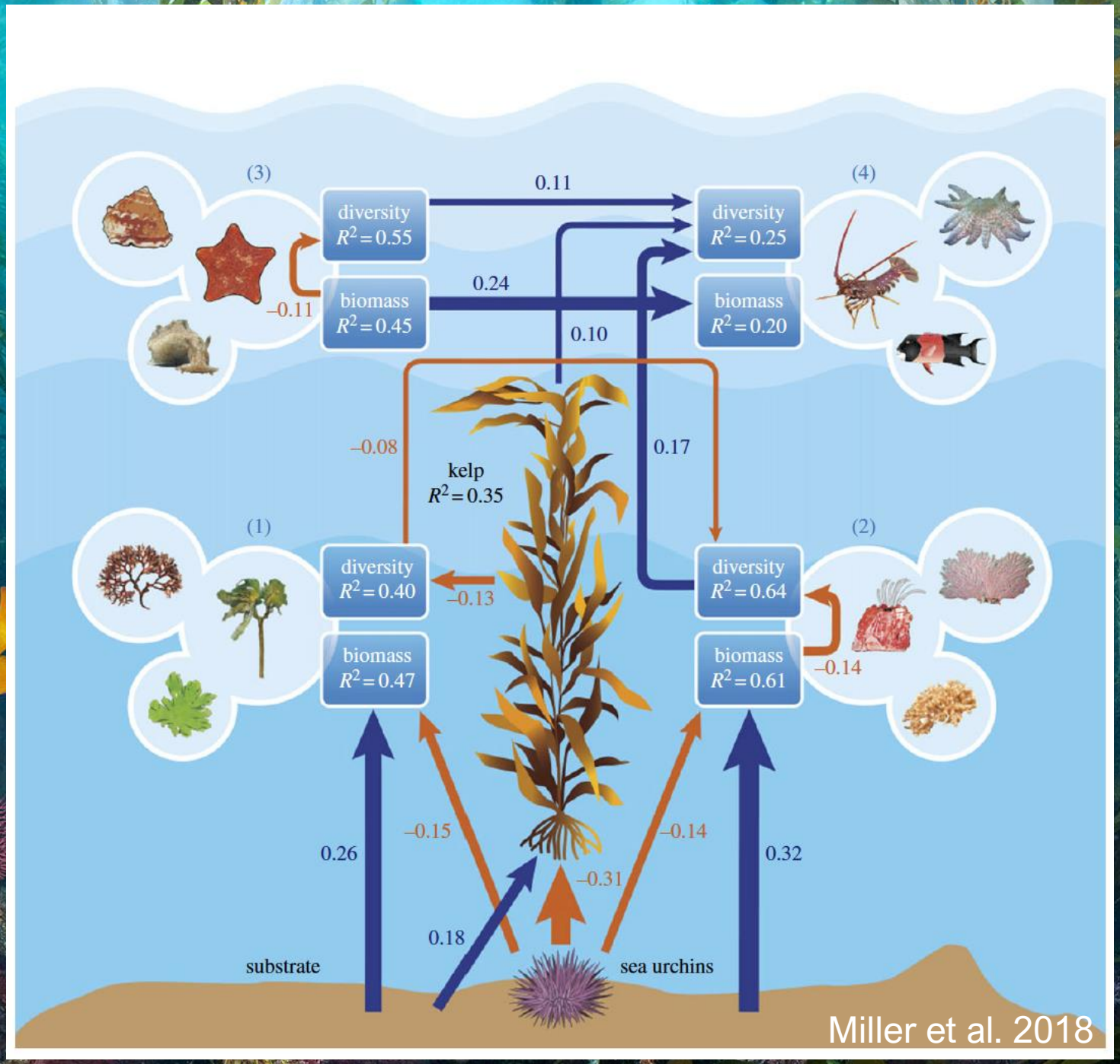


Assessing Spatial Biodiversity Dynamics in Kelp Forest Ecosystems using Spaceborne Remote Sensing

PI: Tom Bell (WHOI), Bob Miller (UCSB)

Postdoc: Dr. Dana Morton

Graduate Student: Billie Beckley



Miller et al. 2018

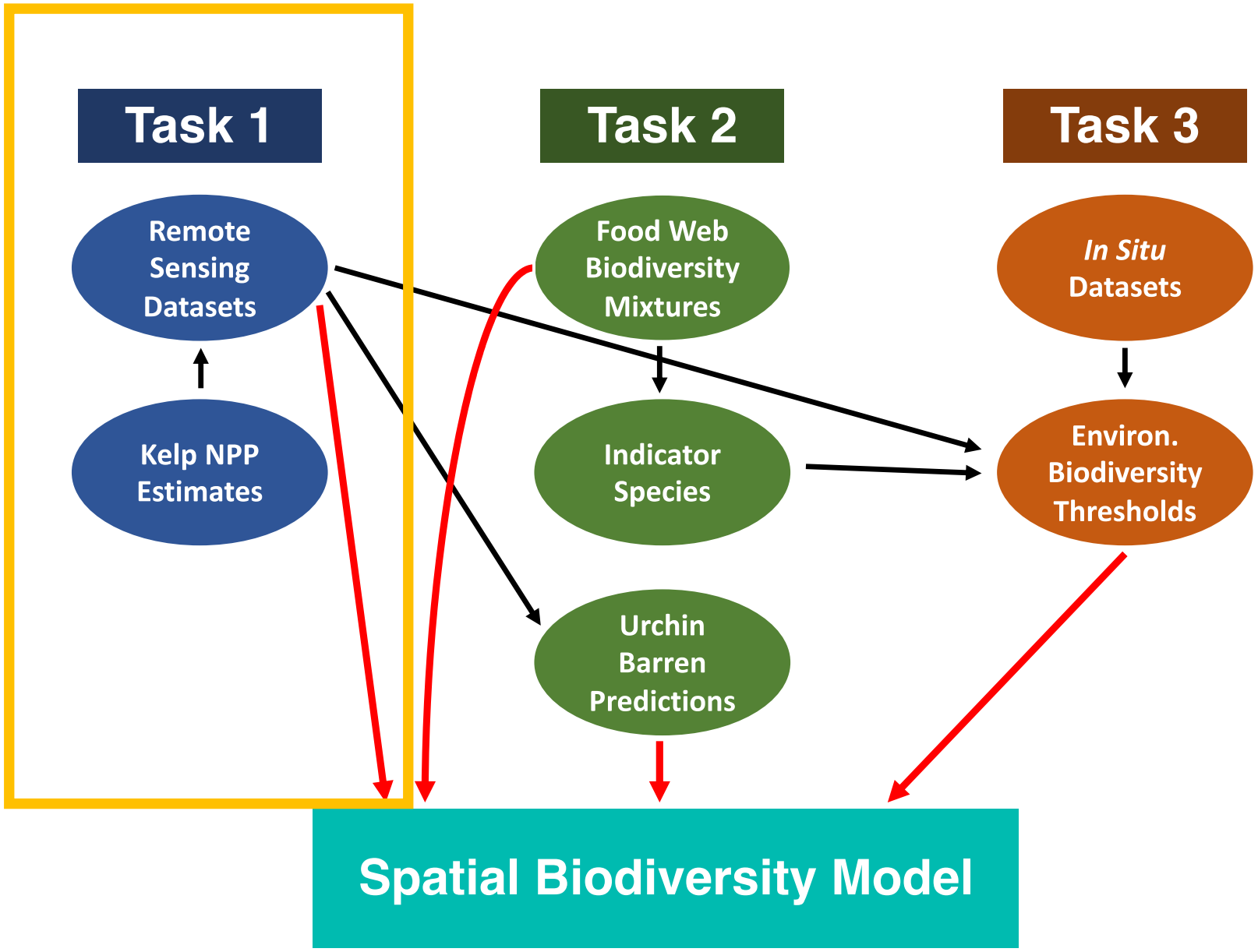
Photo - J. Heller

Overall Project Goals

- Understand the biotic and abiotic drivers of kelp forest community state and develop a spatial model to predict biodiversity dynamics on subtidal rocky reefs in the Southern CA Bight.

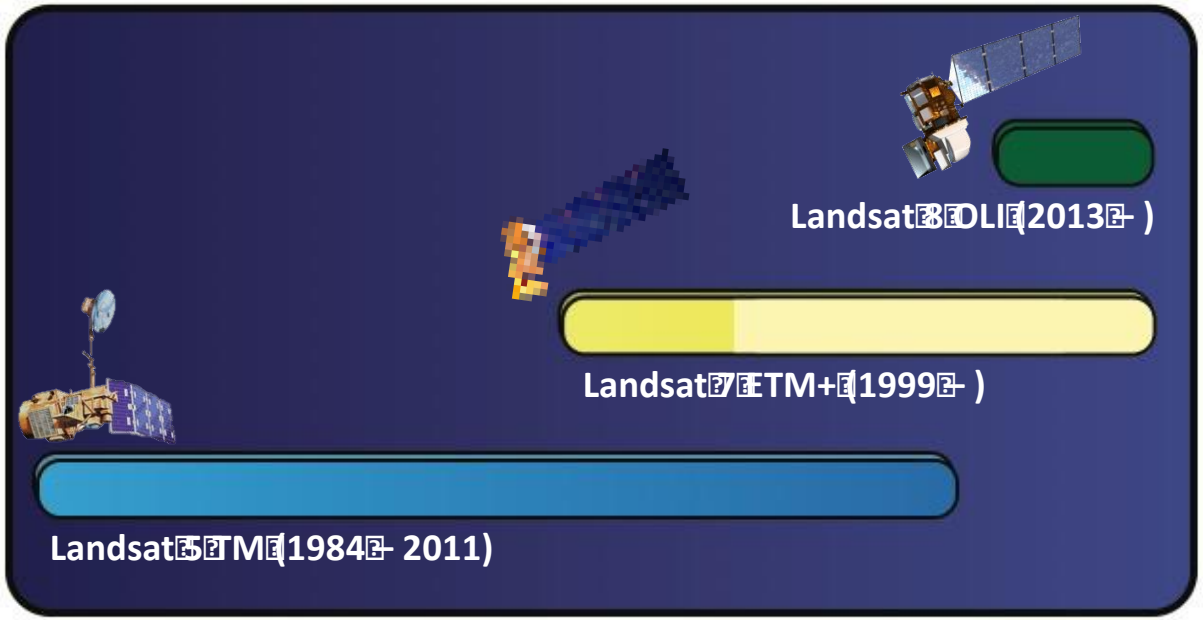
- Leverage the strong foundation of prior work in the system together with remote sensing time series, a novel topological food web model, and multidecadal *in situ* biodiversity surveys.

Overall Project Structure



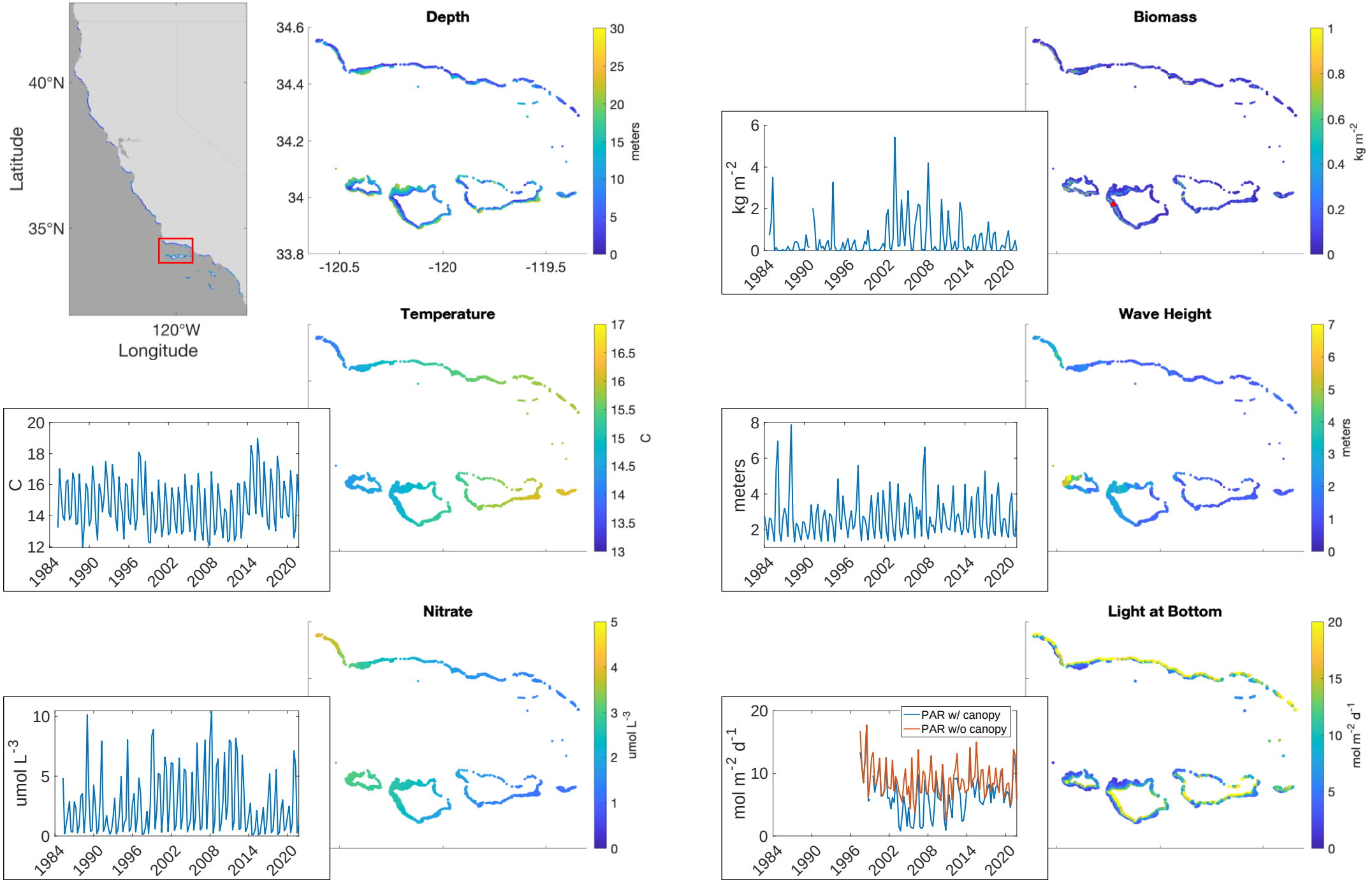
Long-term, large spatial extent monitoring of giant kelp canopy biomass from Landsat satellites

Space + **Time**

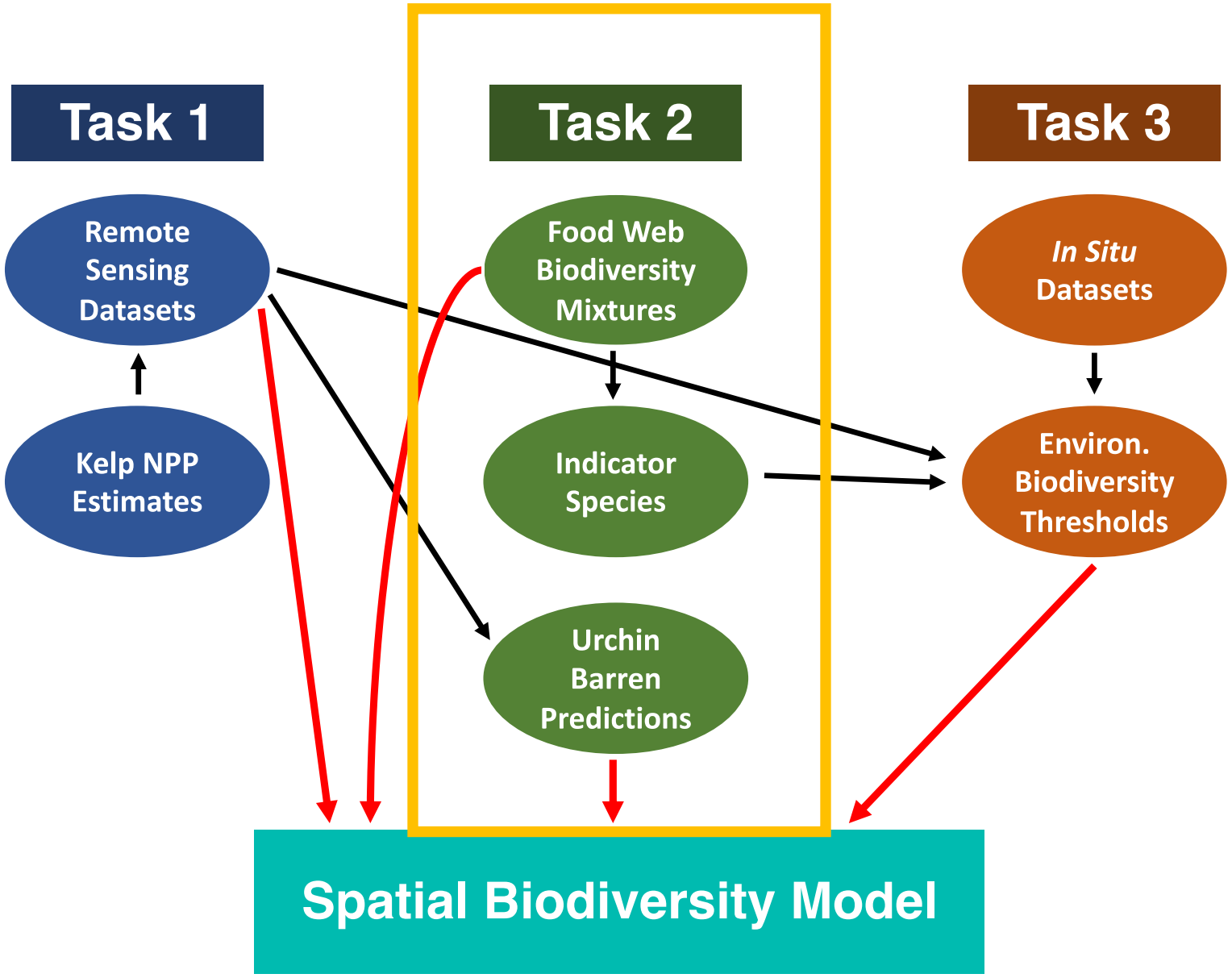


Bell et al. 2020

kelpwatch.org


40°N
35°N
Latitude
120°W
Longitude
Depth
meters
Biomass
kg m-2
Temperature
C
Wave Height
meters
Nitrate
umol L-3
Light at Bottom
mol m-2 d-1
PAR w/ canopy
PAR w/o canopy
1984
1990
1996
2002
2008
2014
2020

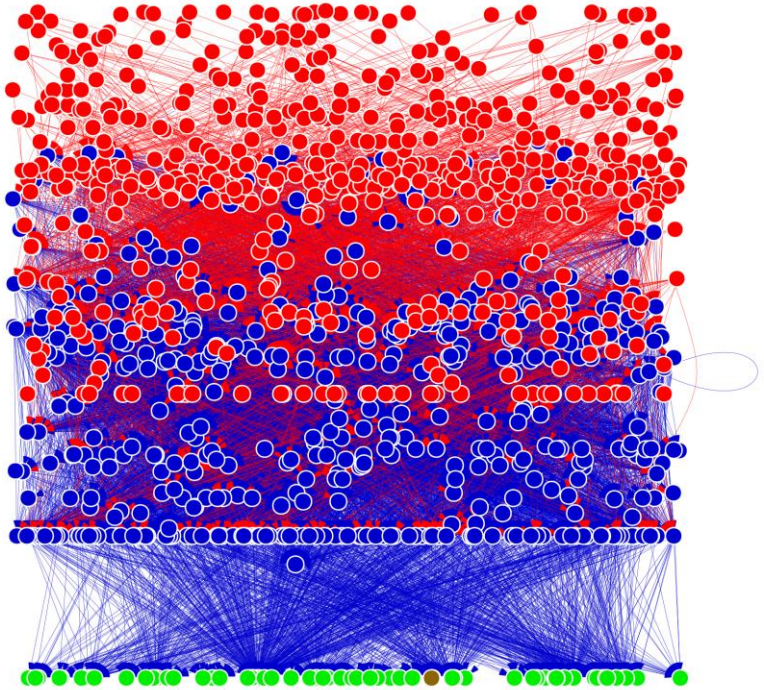
Overall Project Structure



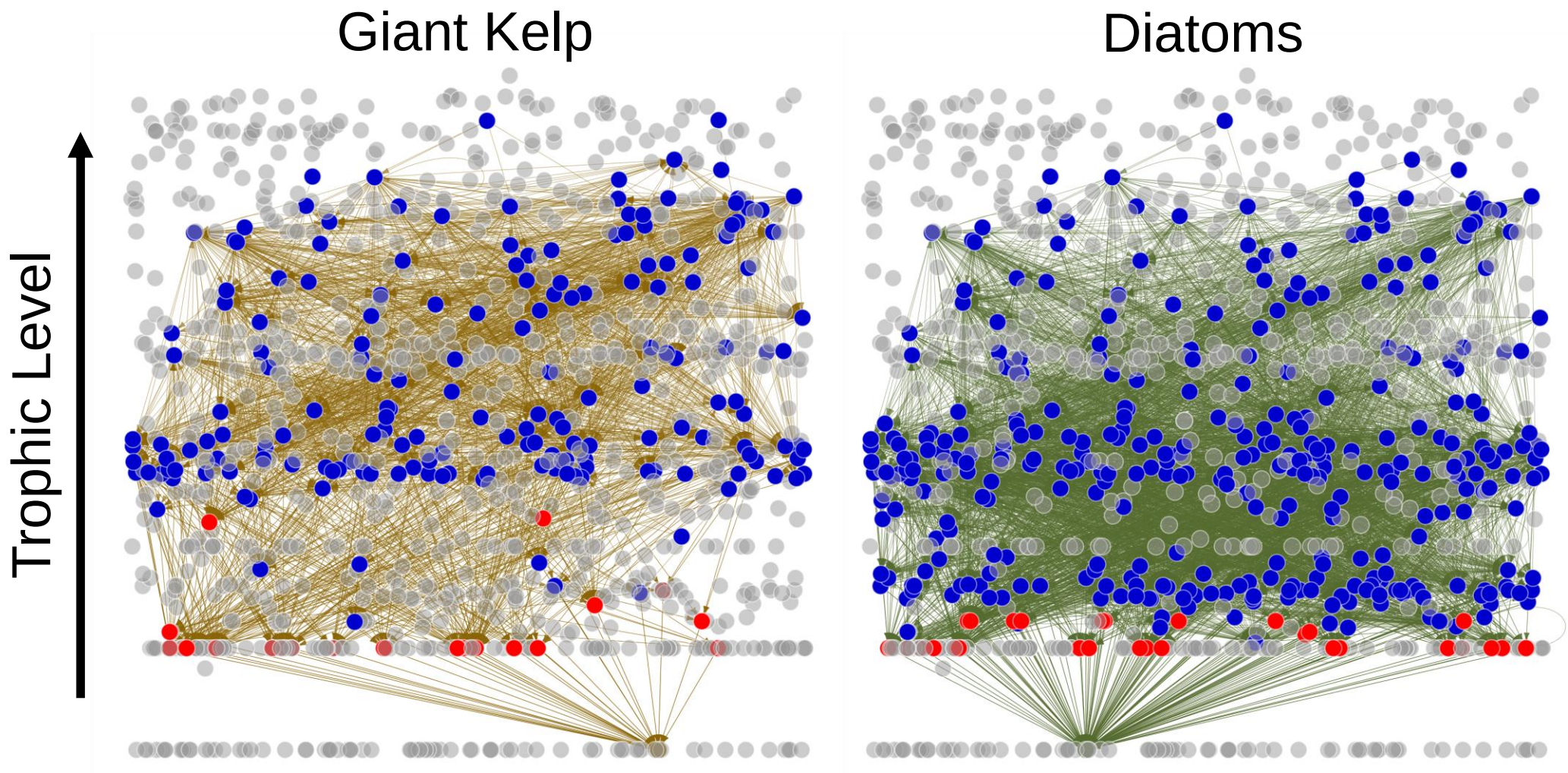
Kelp-forest food web

- Meta-web for the kelp forests of the Southern CA Bight (Morton et al. 2021).
- Resolved to species life-stages for most nodes
- Includes parasites
- Includes meta-data on habitat associations and temperature ranges.

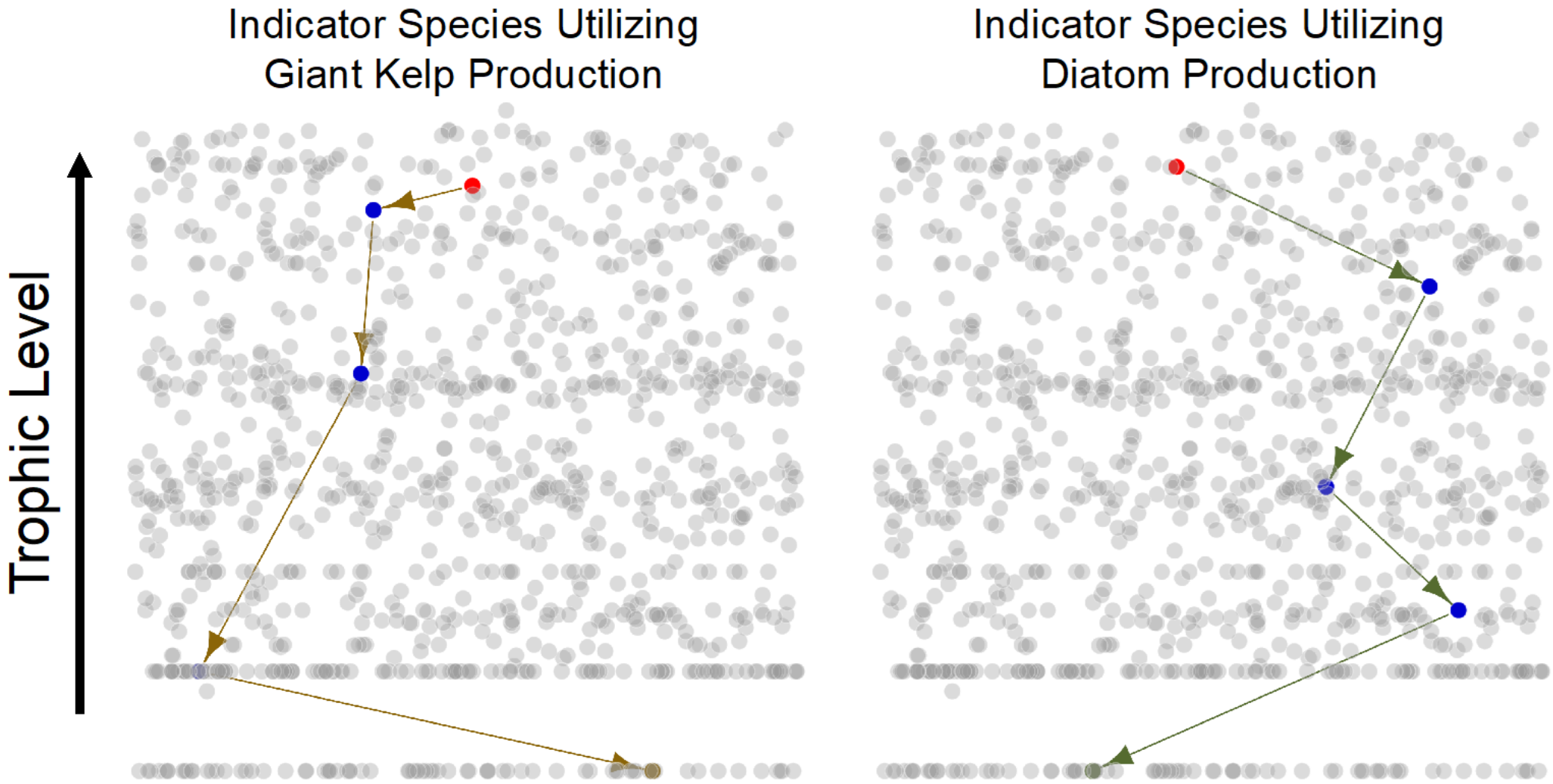
Morton et al. 2021, *Scientific Data*



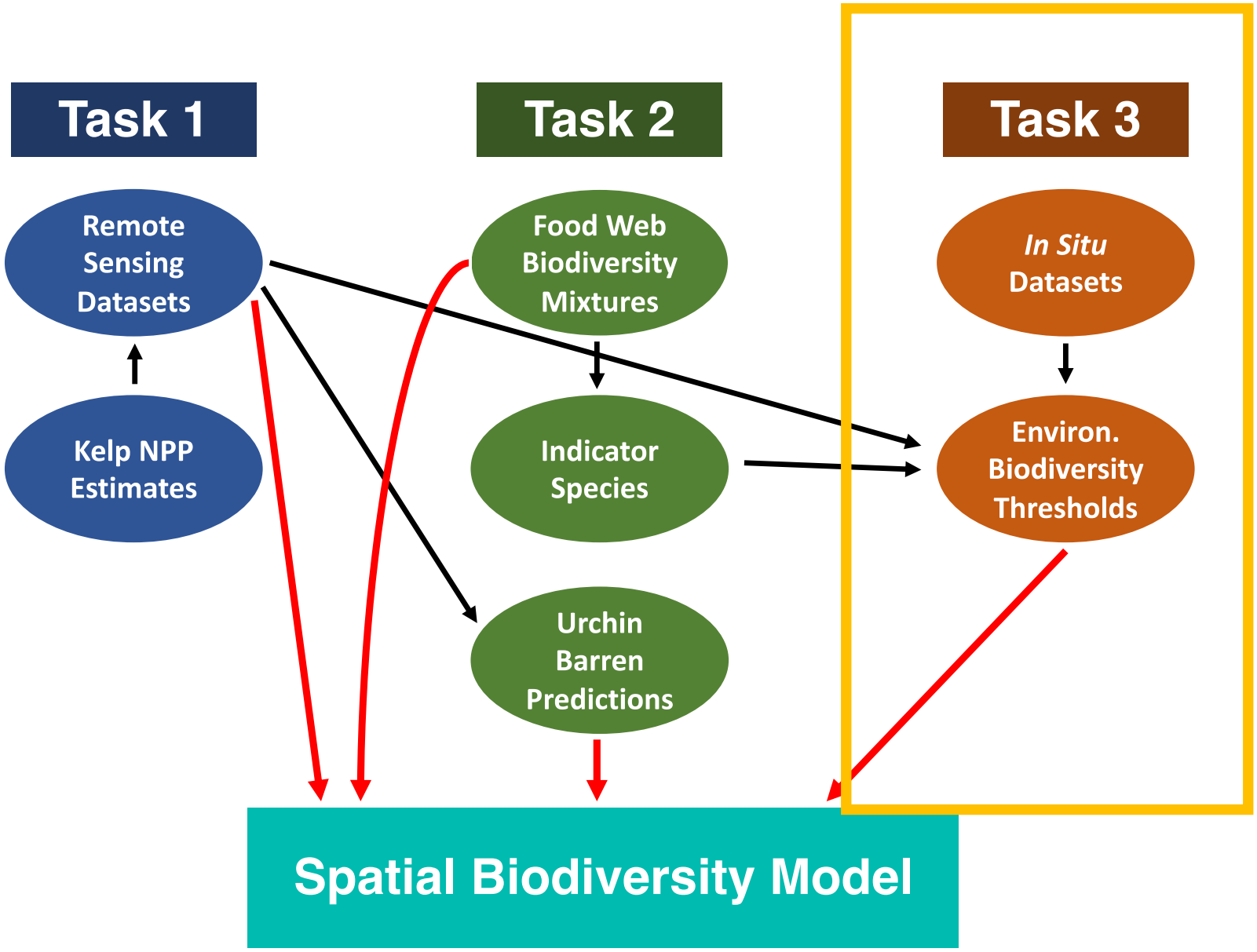
Energy flow from different production sources



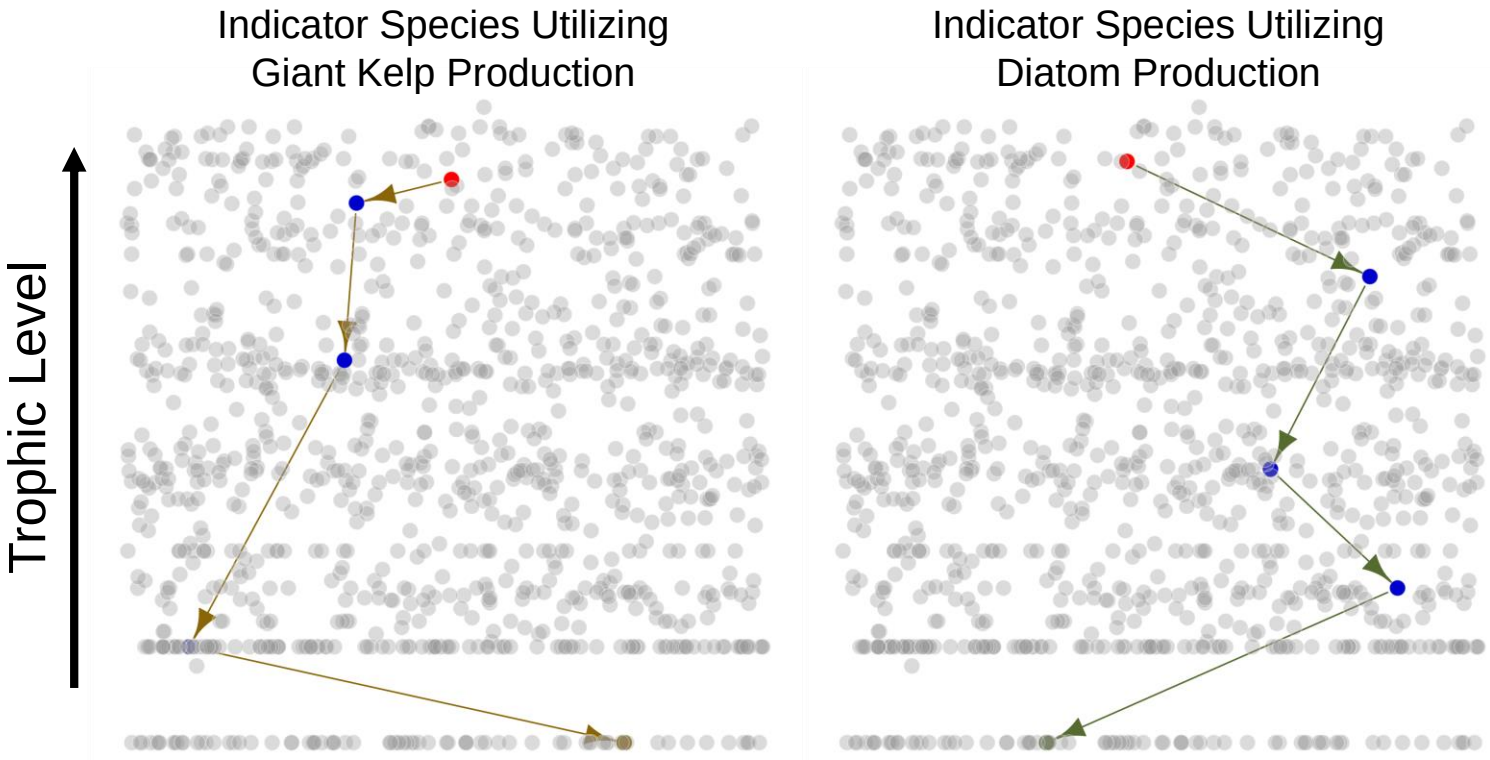
Identify indicator species for each production source

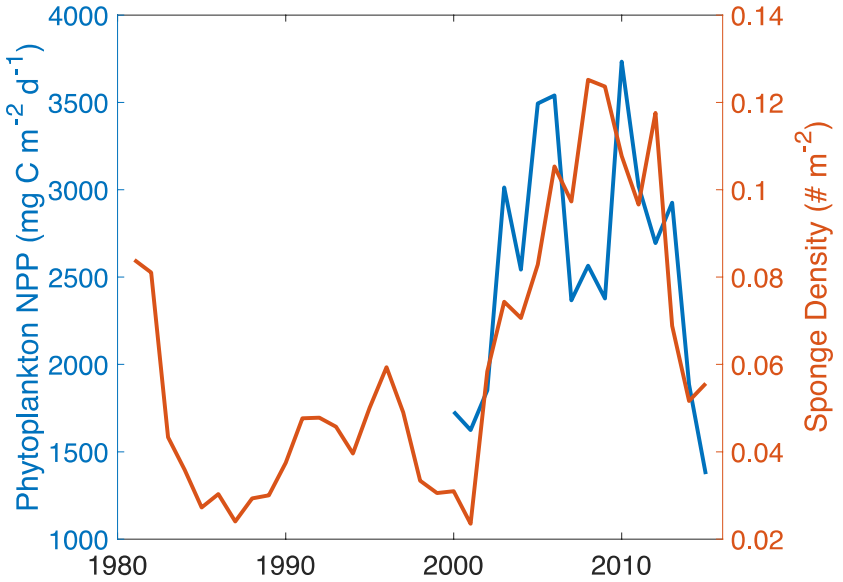


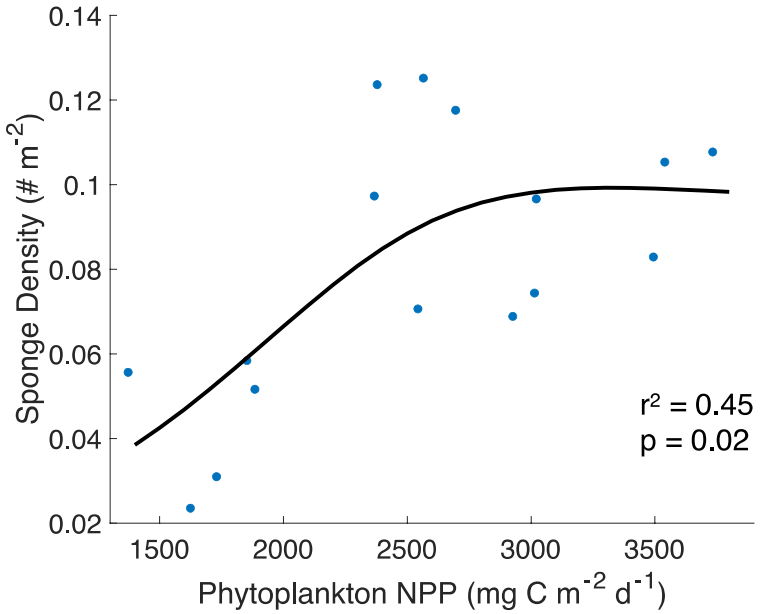
Overall Project Structure



Relate *in situ* time series of species to environmental drivers







What happens to kelp-forest food webs without kelp?

Many “kelp-forest” species are habitat generalists, but a subset are strongly kelp-associated
(e.g. Graham 2004)

Many effects of kelp are structural
(e.g. Miller et al. 2018)

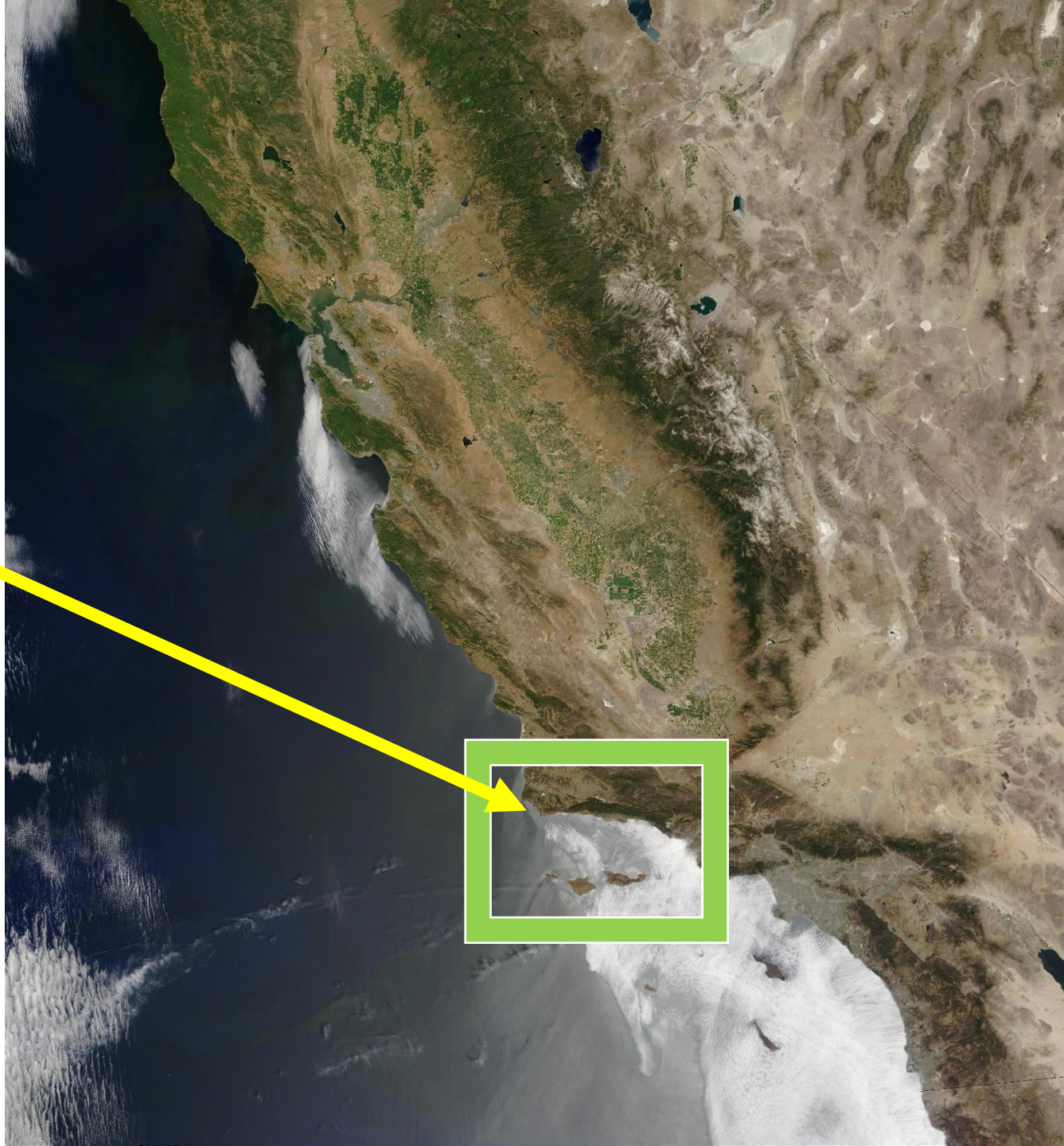
Will ongoing changes in species composition and habitat structure cause co-extinctions?

Research Question

- How will loss of kelps and kelp-associated species influence robustness, does this vary across a thermal gradient? – Landsat kelp canopy biomass, Sea surface temperature

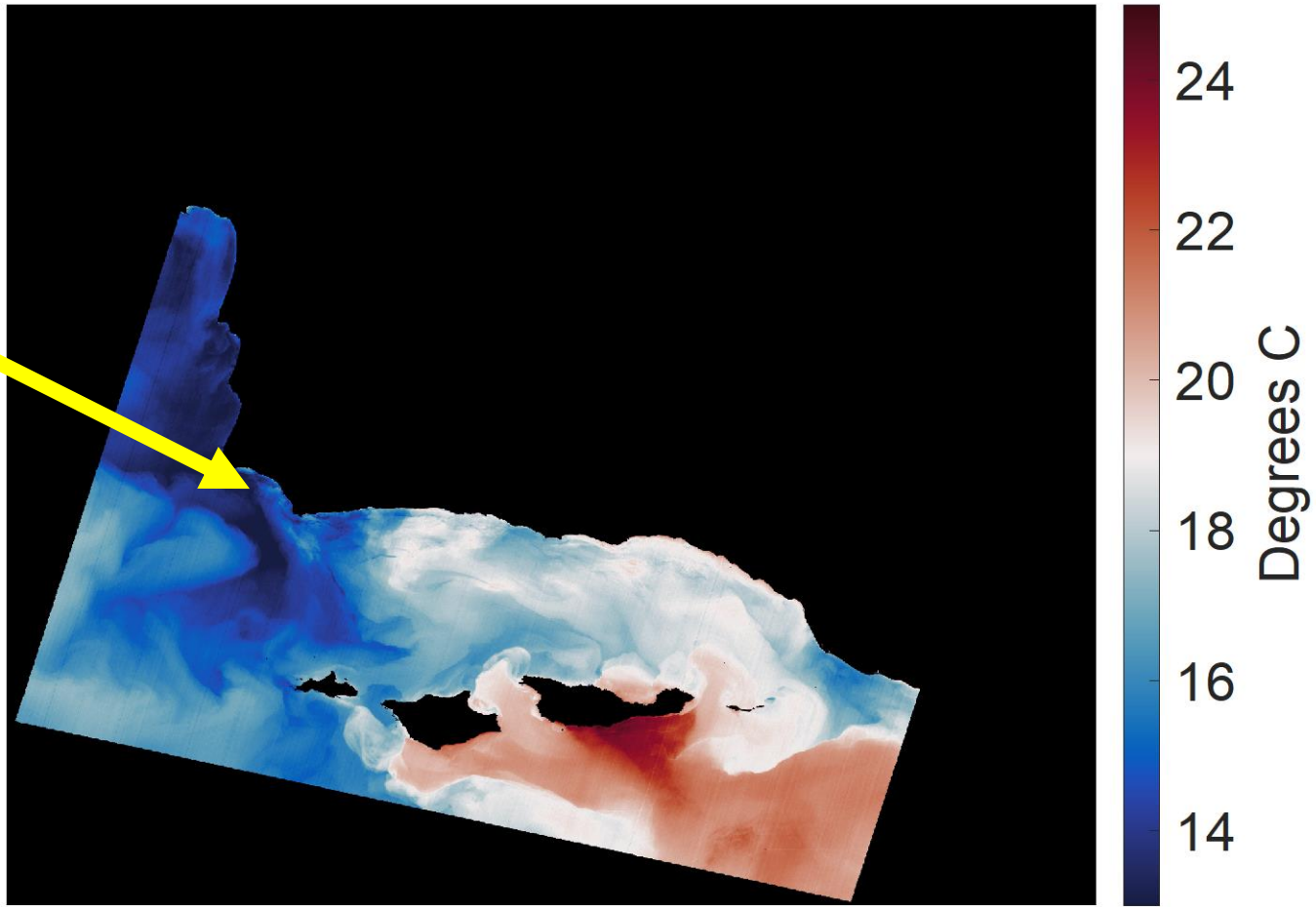
Santa Barbara Channel, CA, USA

- Transition zone between two floristic provinces
  - Point Conception is key barrier
- Ideal zone to look at shifts in species distributions



Santa Barbara Channel, CA, USA

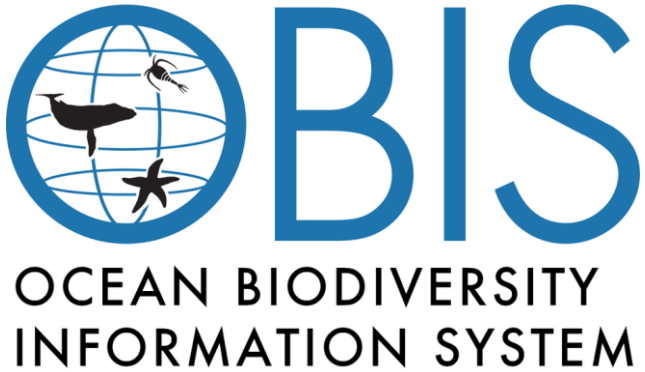
- Transition zone between two floristic provinces
  - Point Conception is key barrier
- Ideal zone to look at shifts in species distributions



Sea surface temperature from Landsat, October 22, 2017

Setting thermal zones

- Occurrence data from OBIS
  - Removed geographical outliers



- Species with at least 10 occurrences were assigned to “thermal zones”:

robis{R}, CoordinateCleaner{R}

Setting thermal zones

- Occurrence data from OBIS
  - Removed geographical outliers

OBIS
OCEAN BIODIVERSITY INFORMATION SYSTEM

- Species with at least 10 occurrences were assigned to “thermal zones”:

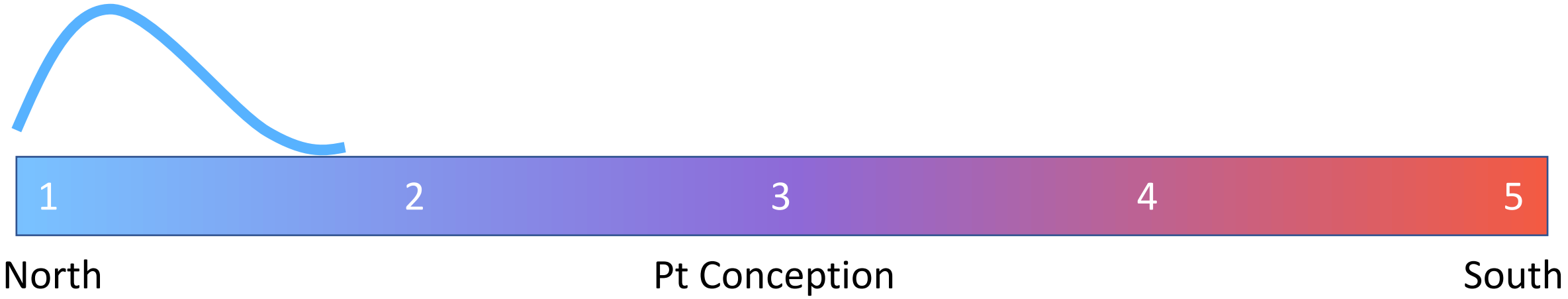
Setting thermal zones

- Occurrence data from OBIS
  - Removed geographical outliers

OBIS
OCEAN BIODIVERSITY INFORMATION SYSTEM

- Species with at least 10 occurrences were assigned to “thermal zones”:

  1: Coldest distribution, all records north of Point Conception.



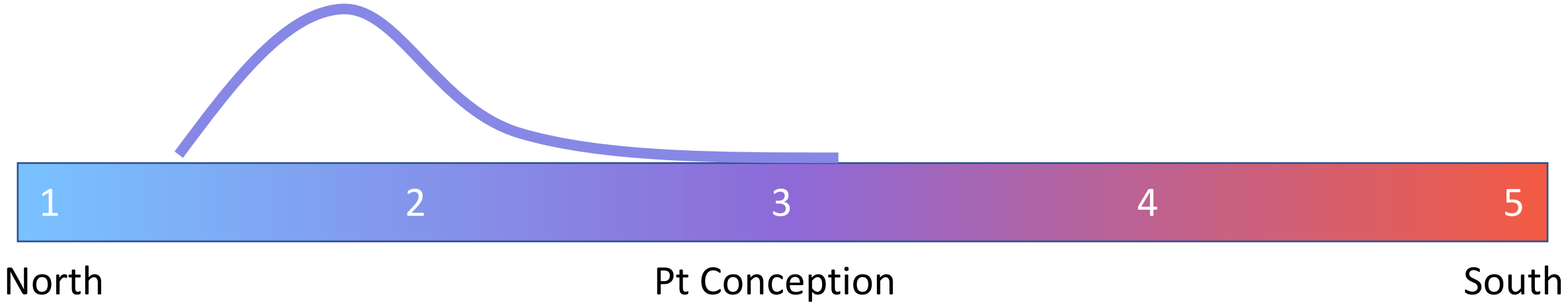
Setting thermal zones

- Occurrence data from OBIS
  - Removed geographical outliers

OBIS
OCEAN BIODIVERSITY INFORMATION SYSTEM

- Species with at least 10 occurrences were assigned to “thermal zones”:

  2: Cold, 95% of occurrences are North of Pt. Conception.



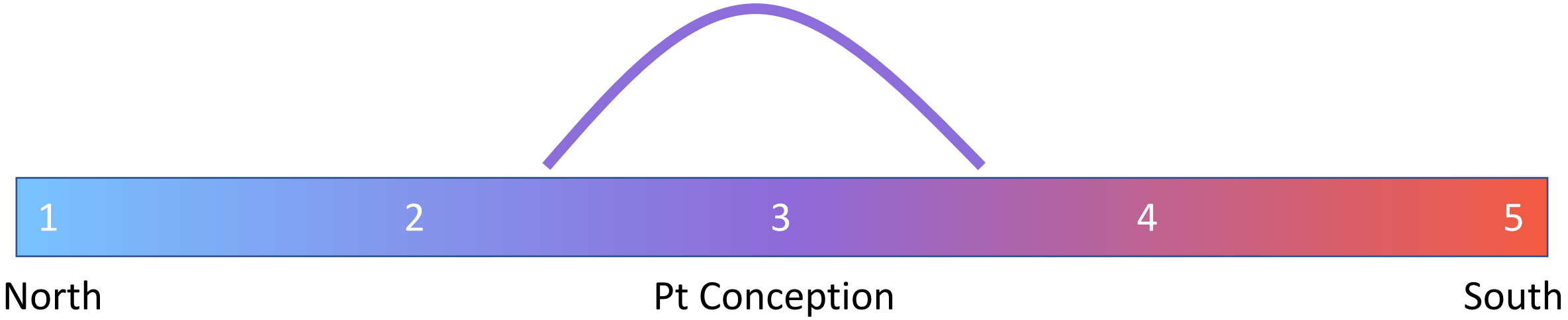
Setting thermal zones

- Occurrence data from OBIS
  - Removed geographical outliers

OBIS
OCEAN BIODIVERSITY INFORMATION SYSTEM

- Species with at least 10 occurrences were assigned to “thermal zones”:

  3: Mixed, >5% of distribution falls both above and below Pt. Conception.



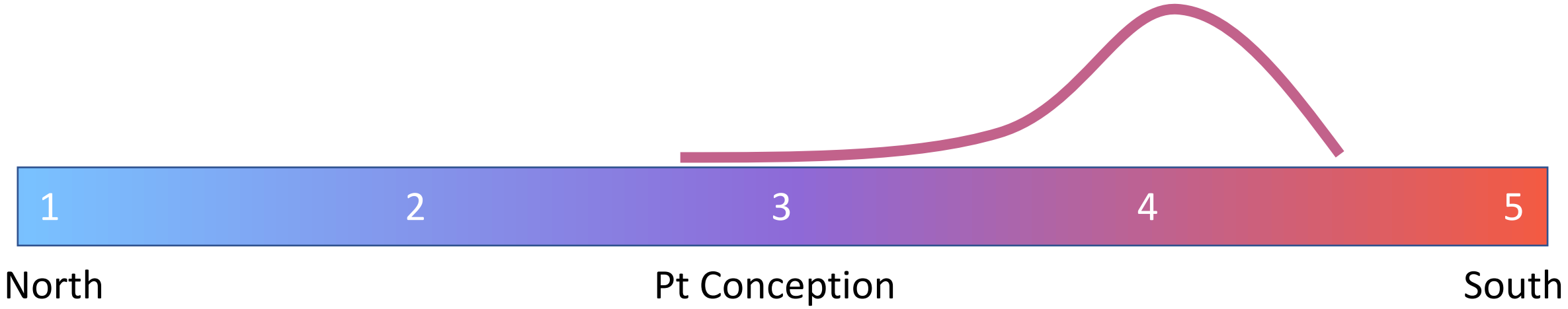
Setting thermal zones

- Occurrence data from OBIS
  - Removed geographical outliers

OBIS
OCEAN BIODIVERSITY INFORMATION SYSTEM

- Species with at least 10 occurrences were assigned to “thermal zones”:

  4: Warm, 95% of occurrences South of Pt. Conception.



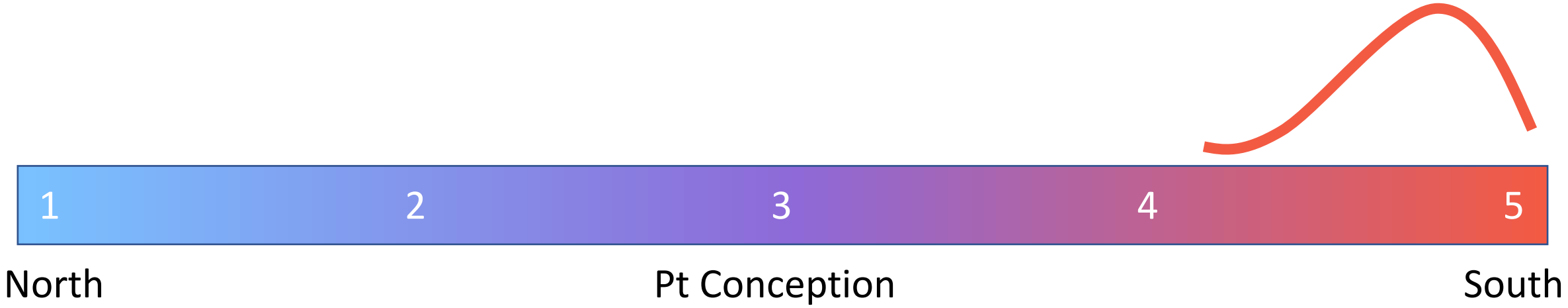
Setting thermal zones

- Occurrence data from OBIS
  - Removed geographical outliers

OBIS
OCEAN BIODIVERSITY INFORMATION SYSTEM

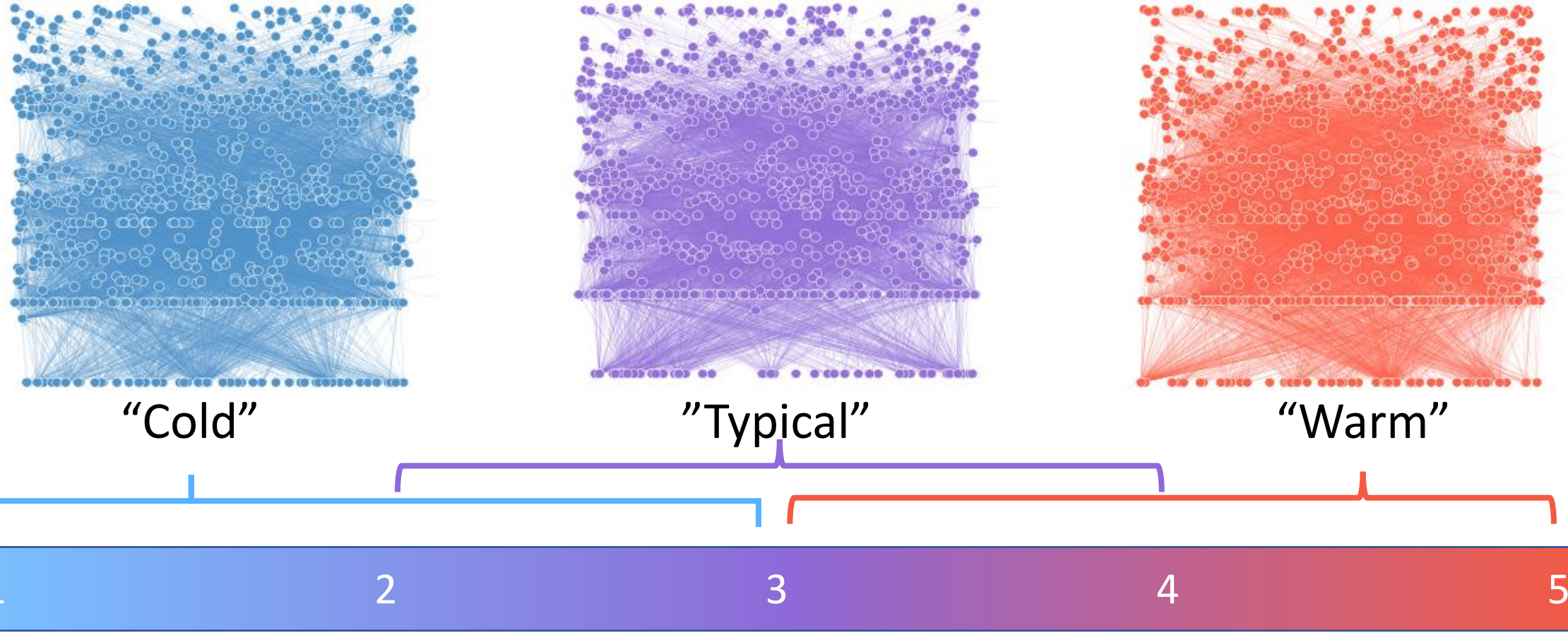
- Species with at least 10 occurrences were assigned to “thermal zones”:

  5: Warmest, all occurrences south of Pt. Conception.



Building thermal zone webs

- Used 5 “thermal zones” to construct 3 web versions:



Species with limited thermal data were assumed present in all three versions.

igraph{R}

Robustness analyses: tracks co-extinction

Area Under Curve (AUC)

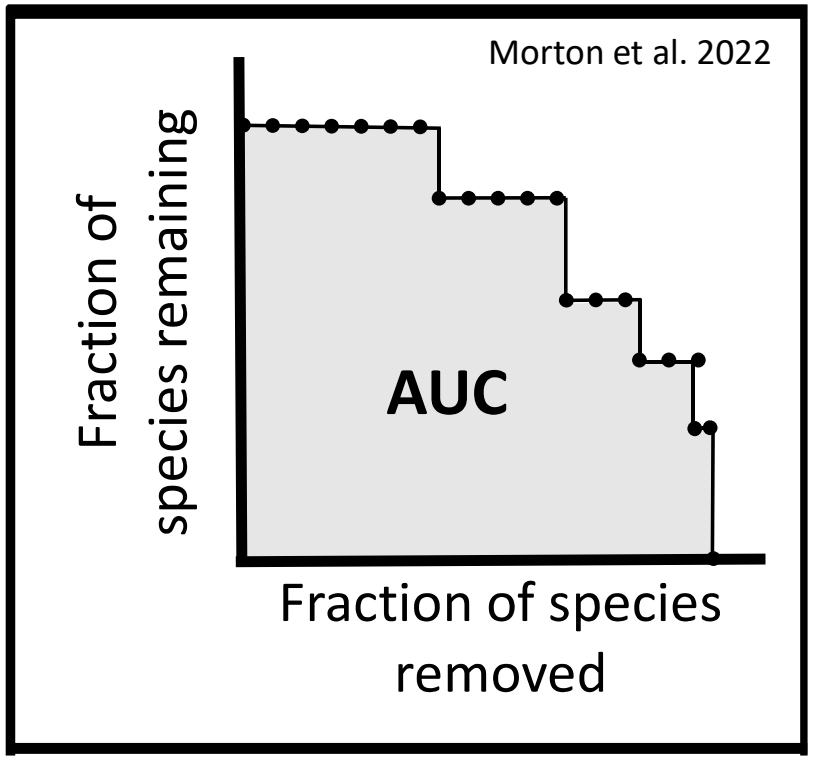
(R package by Barner and Boettiger *in prep*)

Fewer co-extinctions → Higher AUC

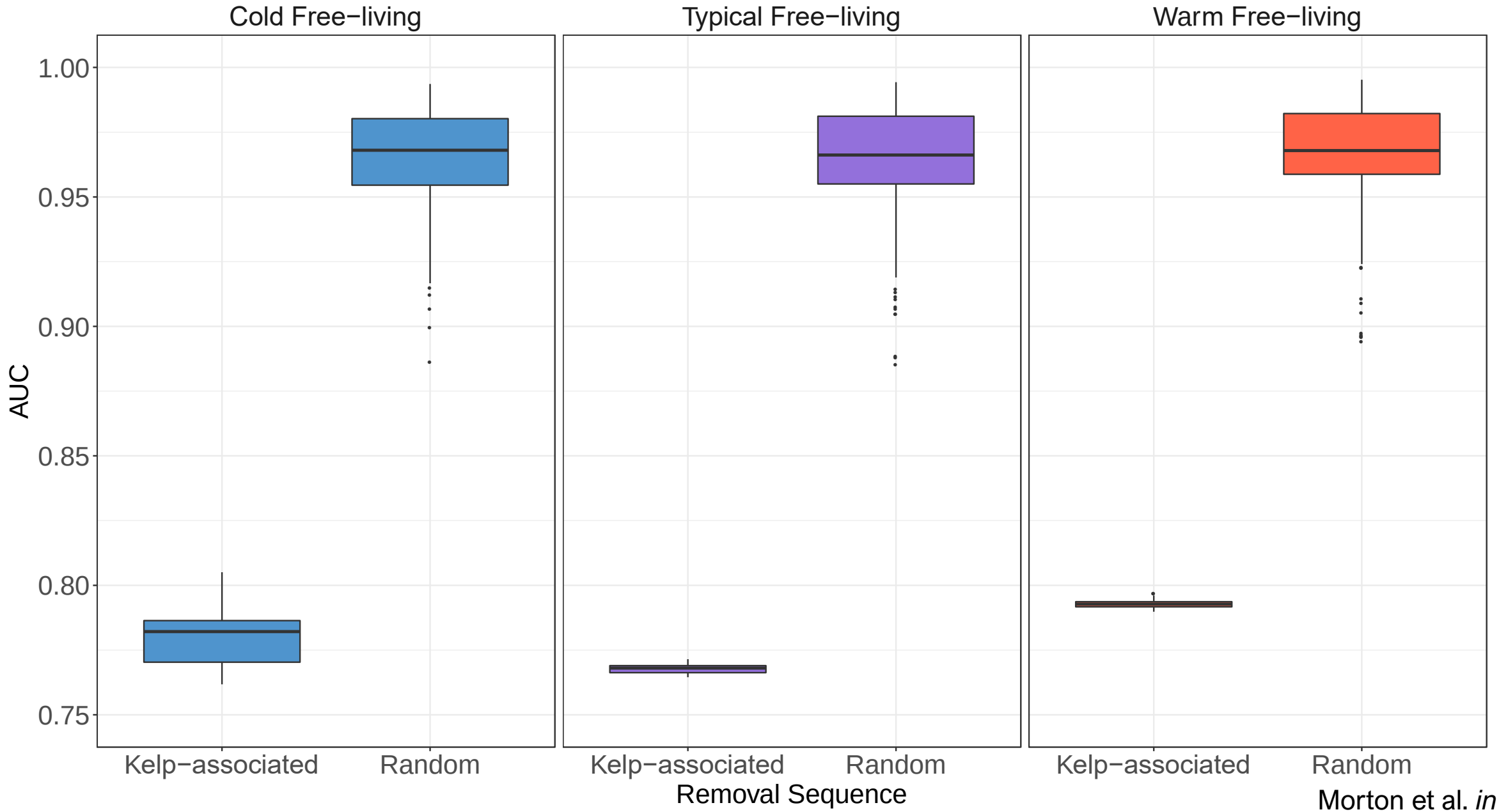
When one life stage went extinct, all life stages went extinct.

Kelps and kelp-associated species:

- 100 random removals of all kelps and kelp-associated species
- Compared with 1000 random subsets, drawn from the full web



Kelps and kelp-associated species loss



Morton et al. *in prep*

Kelp-associated species enhance robustness

Overall robustness was high, but loss of kelp-associated species led to more co-extinctions than random species loss.

Loss of kelp-associated species led to more co-extinctions, likely due to higher vulnerability

Kelp-associated species are prey for more consumers than randomly selected species.

Many are holdfast-associated crustaceans – important food resources for many fish

Questions?
tbell@whoi.edu

Tom Bell

Bob Miller

Dana Morton

Billie Beckley

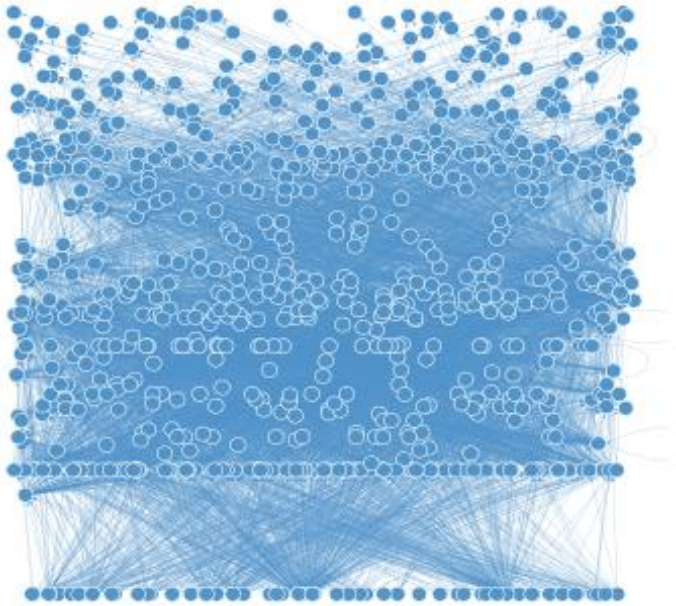
MBON
Marine Biodiversity Observation Network

Santa Barbara Coastal Long Term Ecological Research

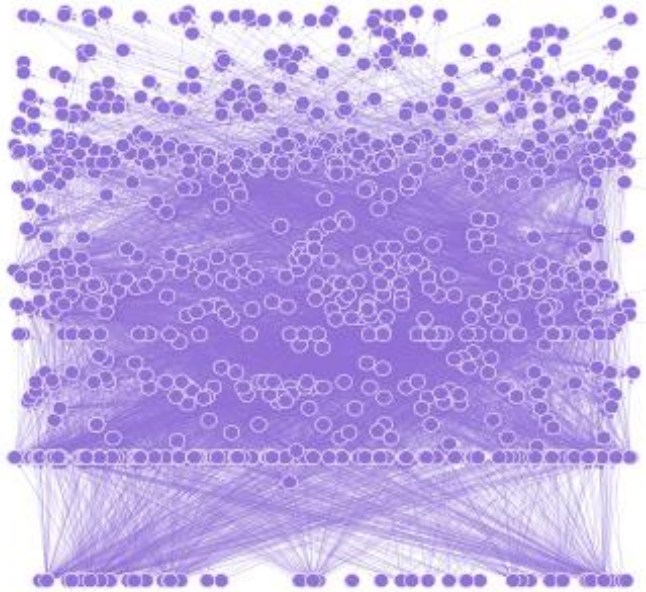
Thermal Webs: extinction sequences

- Random removals of all species:
  - 100 runs, serves as a stochastic extinction
- Degree-based removal of all species (high to low):
  - “worst case” scenario
- Kelps and kelp-associated species:
  - 100 random removals of all kelps and kelp-associated species
  - Compared with 1000 random subsets, drawn from the full web

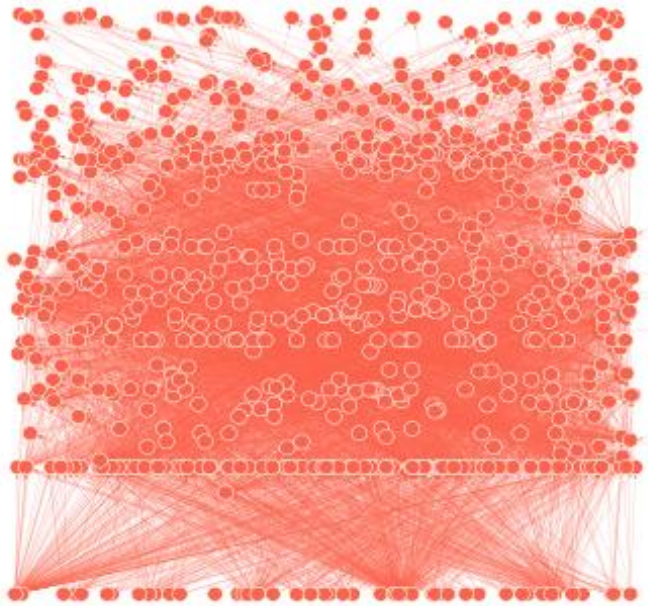
Thermal food-web structure



Nodes = 935
Links = 8985
Connectance = 0.0103
48% parasites
Longest chain= 11



Nodes = 880
Links = 7657
Connectance = 0.01
52% parasites
Longest chain = 12



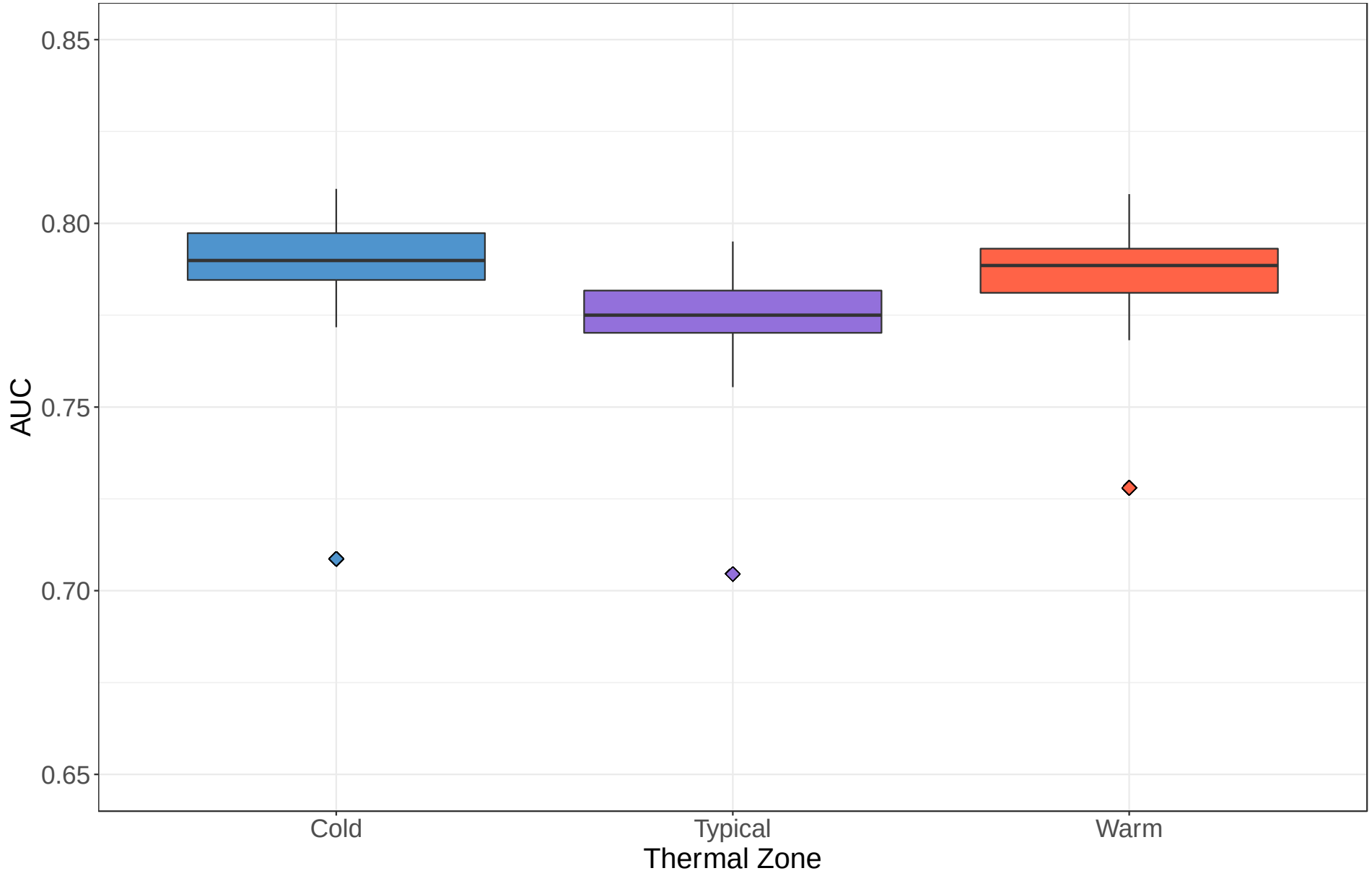
Nodes = 924
Links = 8309
Connectance = 0.0097
52% parasites
Longest chain = 11

Morton et al. *in prep*

Free-living webs

Box plots: random removals

Diamonds: high-to-low degree removal sequence



How does food-web robustness and structure change across a thermal gradient?

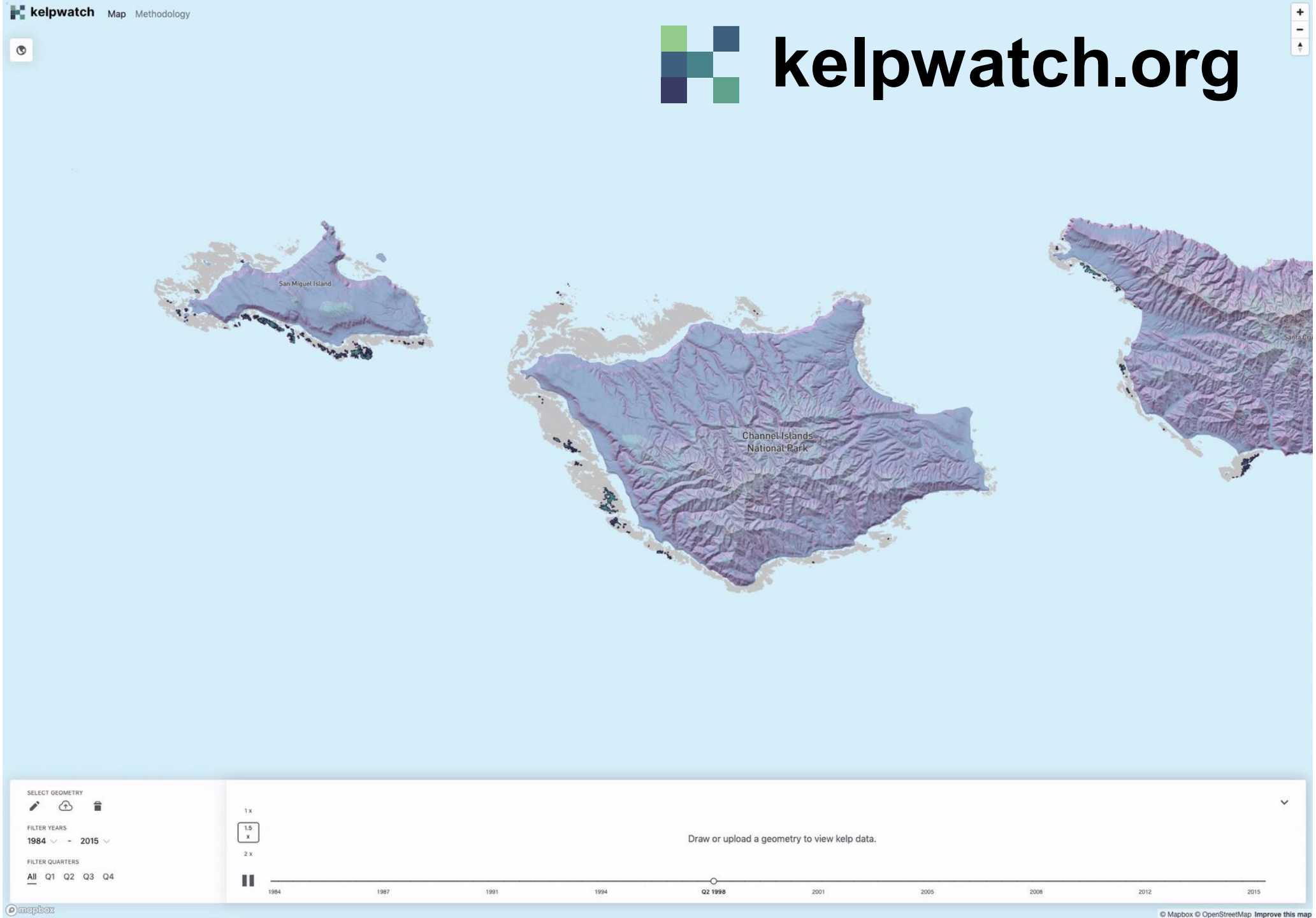
Only slight differences among thermal food webs, all had relatively few co-extinctions.

”Cold” and ”Warm” food webs slightly more robust than “typical”, possibly due to larger size.

“Warm” web more robust to high-degree removals

Highlights the interplay between structural associations and trophic interactions

Future work: explore the importance of different sources of primary production in addition to structural effects of giant kelp


kelpwatch
Map
Methodology
kelpwatch.org
San Miguel Island
Channel Islands
National Park
SELECT GEOMETRY
FILTER YEARS
1984 - 2015
FILTER QUARTERS
All Q1 Q2 Q3 Q4
1 x
1.5 x
2 x
Draw or upload a geometry to view kelp data.
1984
1987
1991
1994
Q2 1998
2001
2005
2008
2012
2015
mapbox
© Mapbox © OpenStreetMap Improve this map