April 2013 Workshop Presentations

Project Overview

Matt Ferner, Mid-Project Workshop, April 17, 2013

Planning for Olympia oyster conservation and restoration in the face of climate change

San Francisco Bay NERR
- Matt Ferner
- Andy Chang
- Anna Deck

Elkhorn Slough NERR
- Kerstin Wasson

University of California, Davis
- Ted Grosholz
- Chela Zabin
- Brian Cheng
- Jill Bible

State Coastal Conservancy
- Marilyn Latta

NERRS Science Collaborative
- Dolores Leonard

Intended Users of project results
- Yes, this is YOU!

www.oysters-and-climate.org

National Estuarine Research Reserve System

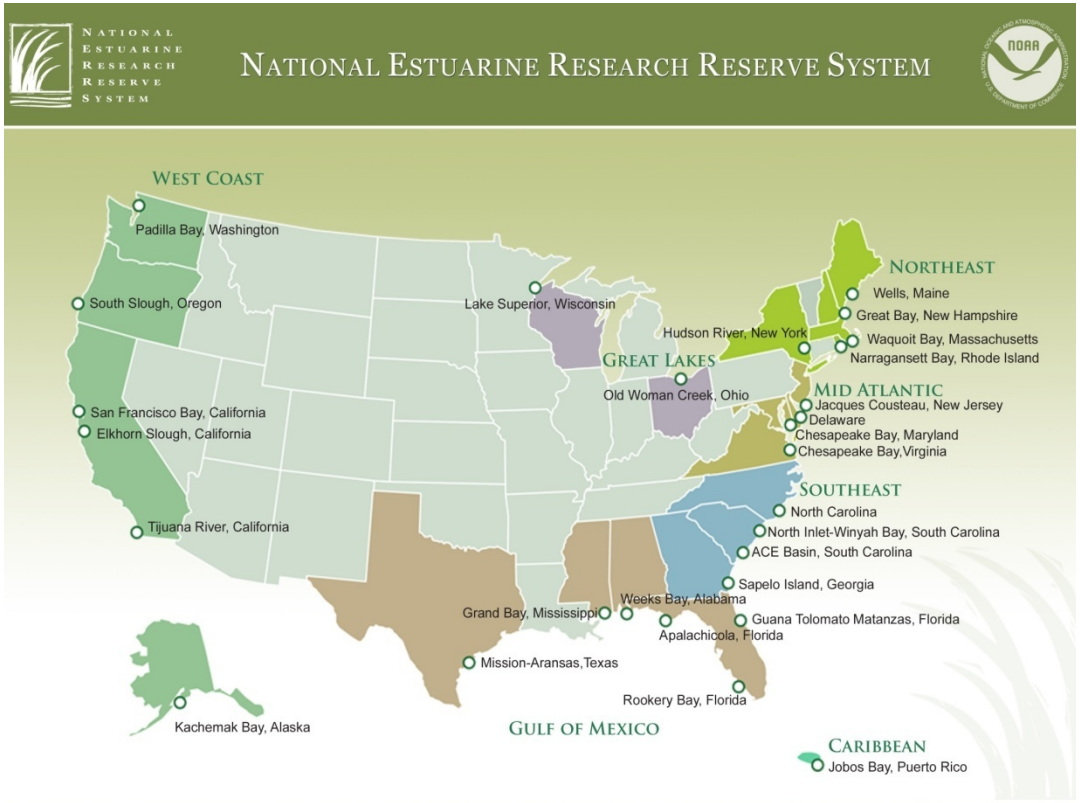
Network of 28 NOAA reserves

Nationally coordinated programs:

- Monitoring & research
- Education & training
- Stewardship

Dedicated to making science relevant and accessible to:

- Natural resource managers
- Land owners & public
- Planners & policy makers



NERRS Science Collaborative funds projects to improve coastal management

Goals of our Olympia oyster project

Sustainable, resilient oyster populations

1. Conservation: Identify sites with healthy oyster populations that are resilient to climate-driven changes and other stressors

2. Restoration: Identify sites and/or conditions where oyster populations probably could be successfully restored or enhanced


Photo: Anna Deck


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Photo: Anna Deck


Photo: Brian Cheng

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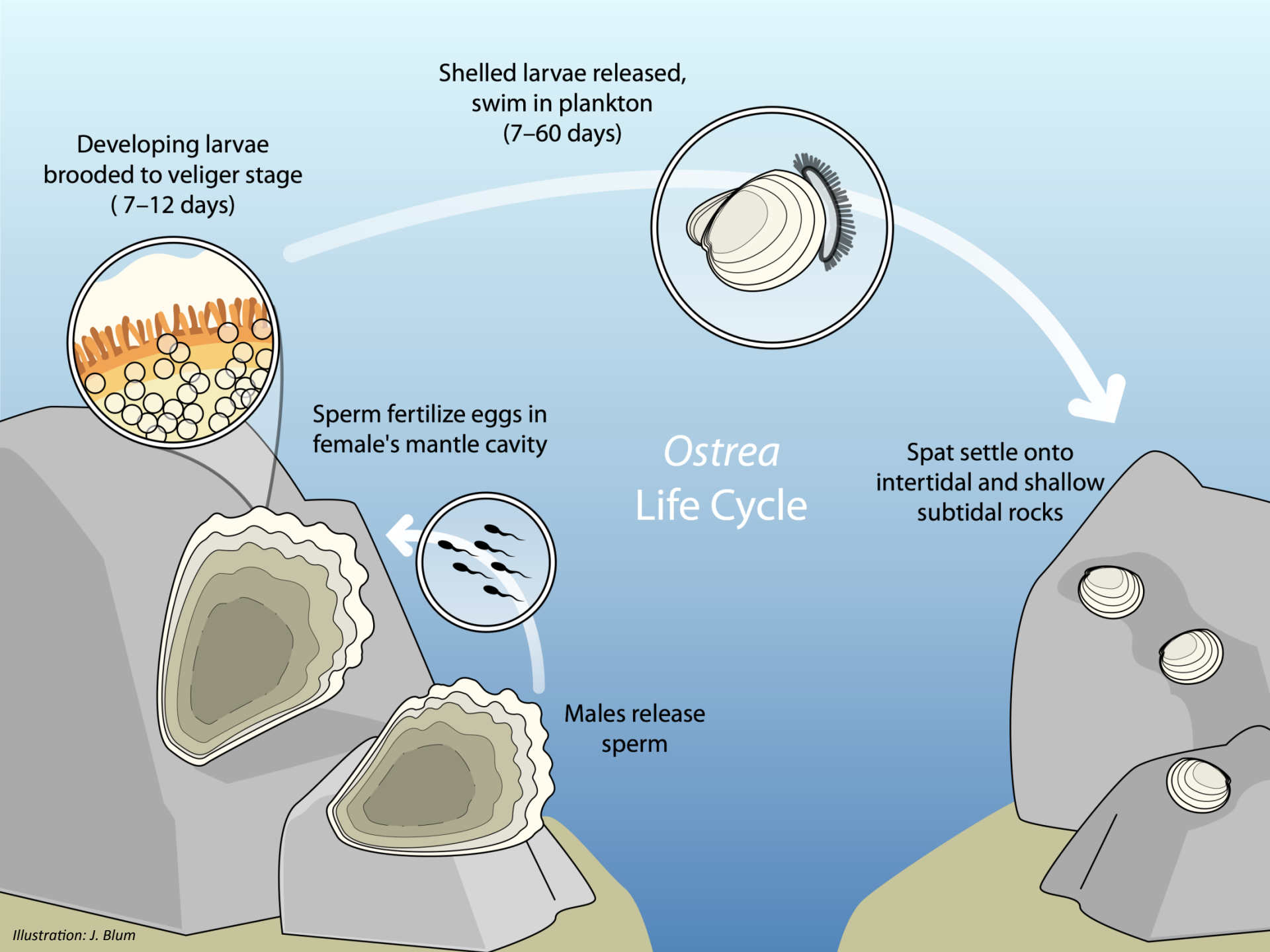
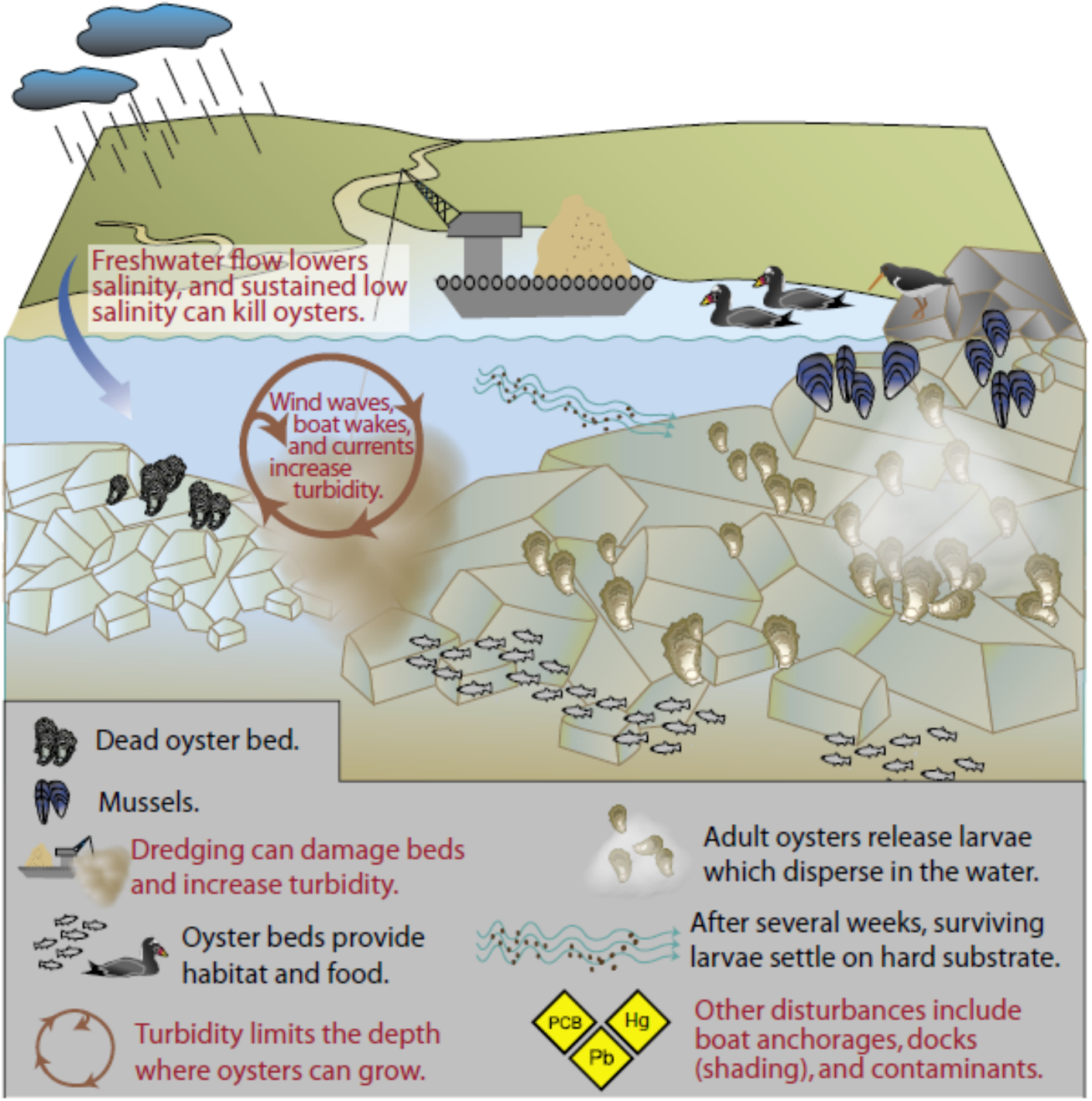
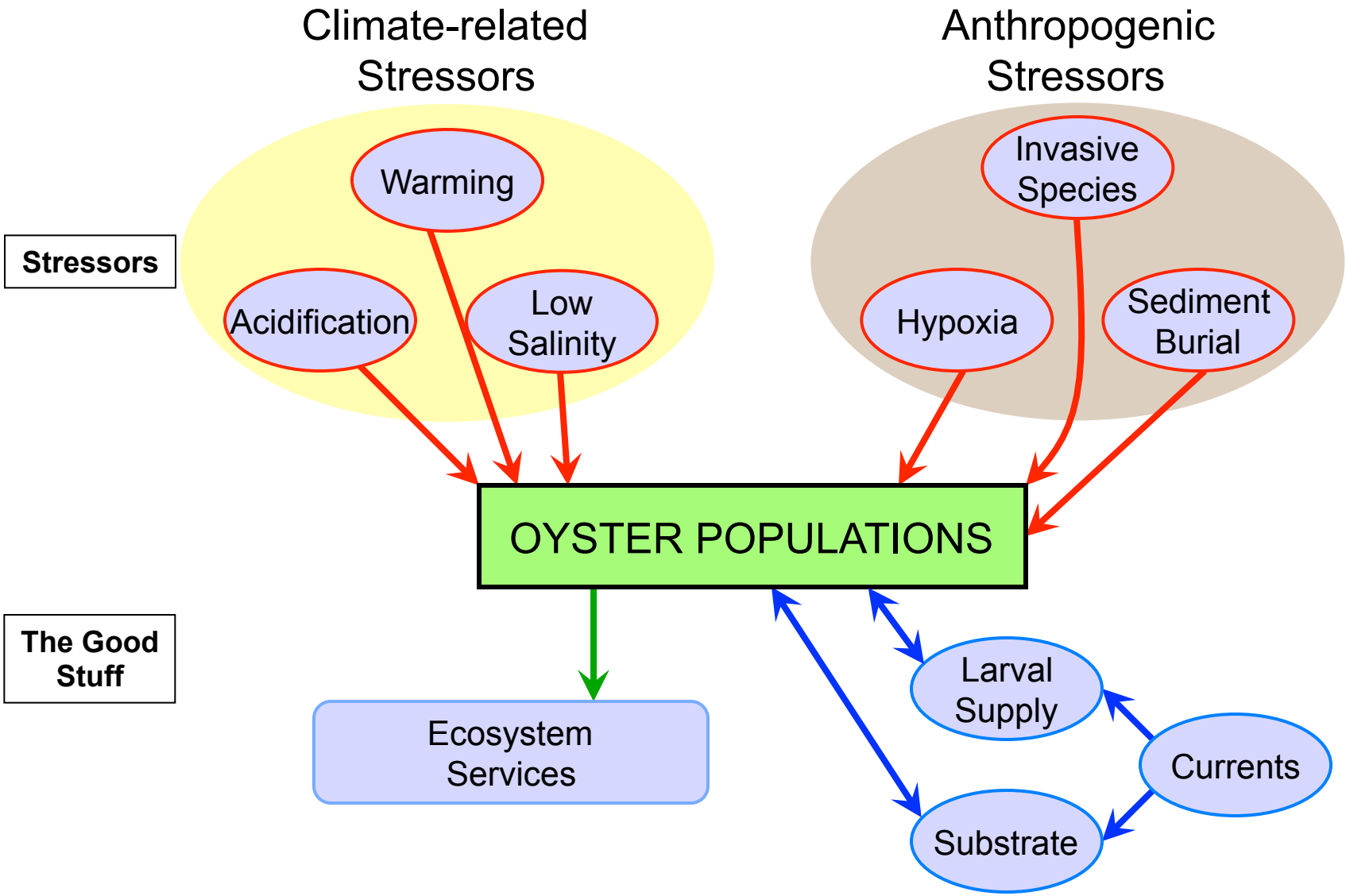
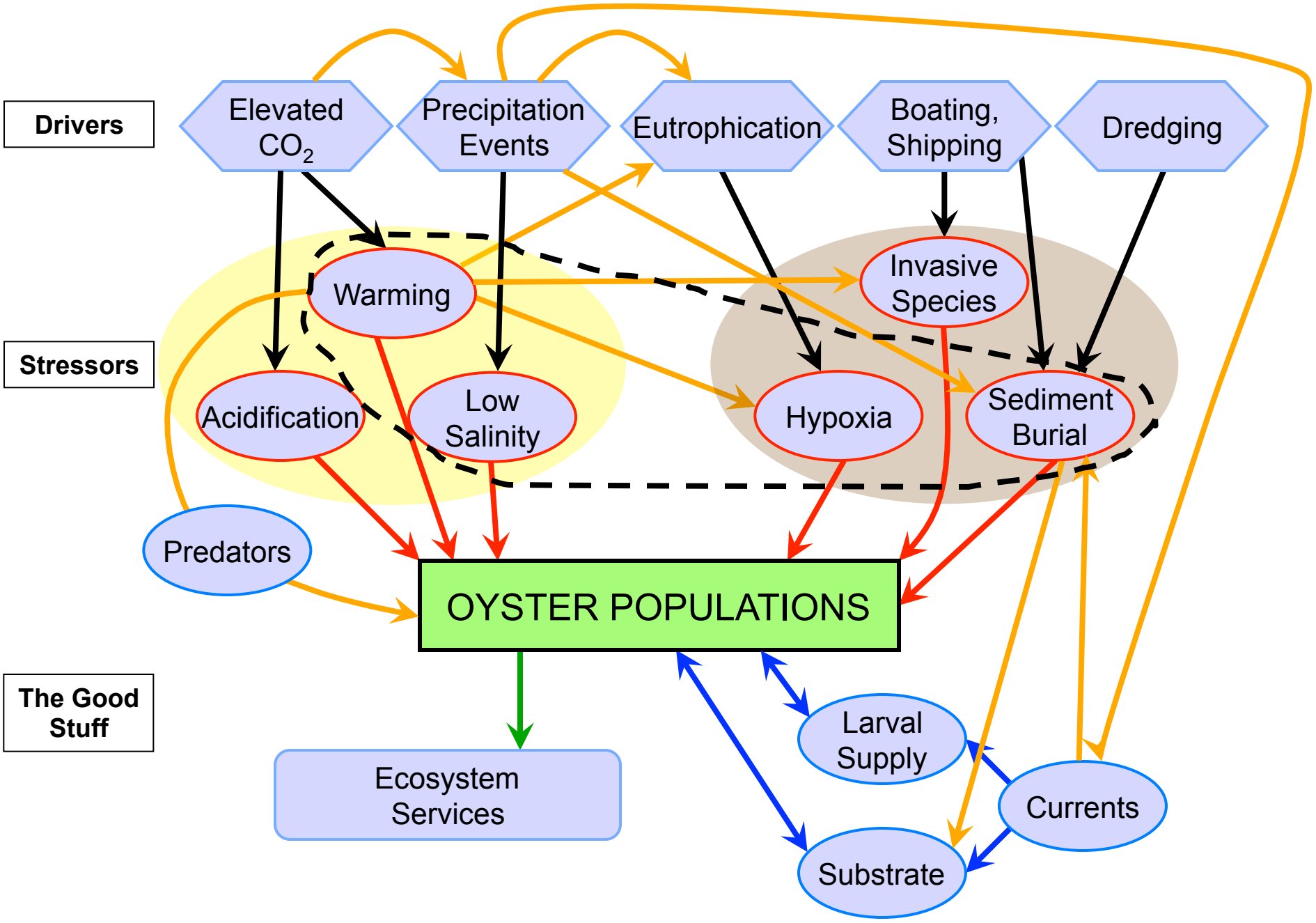
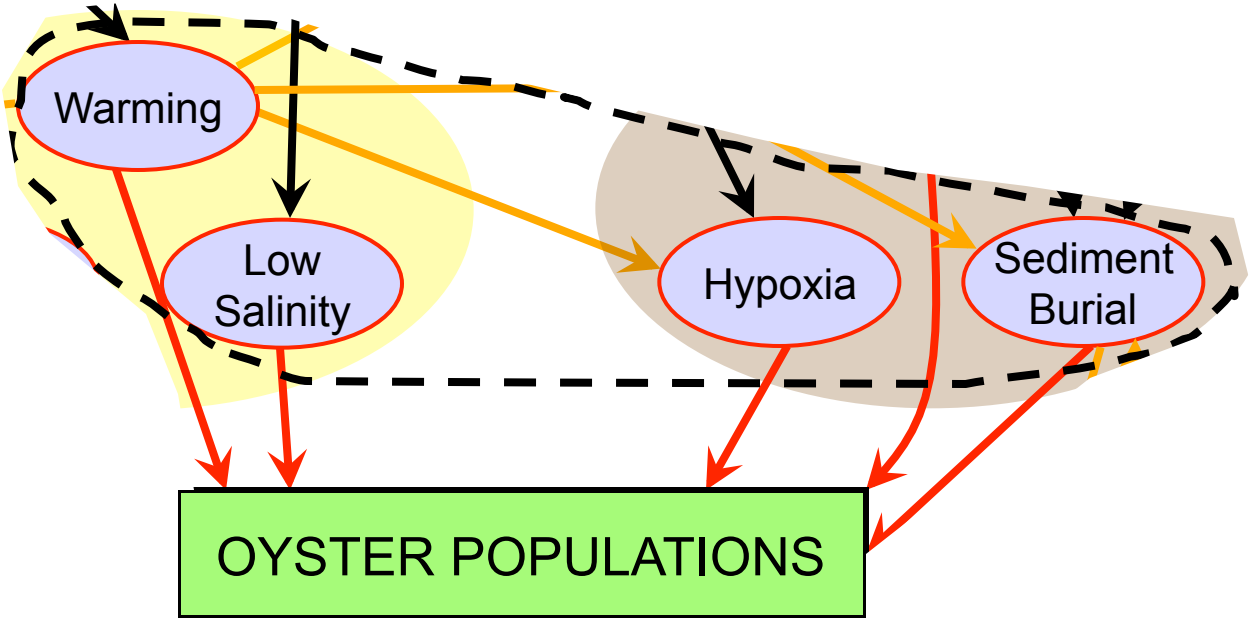

Shelled larvae released,
swim in plankton
(7–60 days)
Developing larvae
brooded to veliger stage
(7–12 days)
Sperm fertilize eggs in
female's mantle cavity
Ostrea
Life Cycle
Spat settle onto
intertidal and shallow
subtidal rocks
Males release
sperm
Illustration: J. Blum


Freshwater flow lowers salinity, and sustained low salinity can kill oysters.
Wind waves, boat wakes, and currents increase turbidity.
Dead oyster bed.
Mussels.
Dredging can damage beds and increase turbidity.
Oyster beds provide habitat and food.
Turbidity limits the depth where oysters can grow.
Adult oysters release larvae which disperse in the water.
After several weeks, surviving larvae settle on hard substrate.
PCB
Hg
Pb
Other disturbances include boat anchorages, docks (shading), and contaminants.

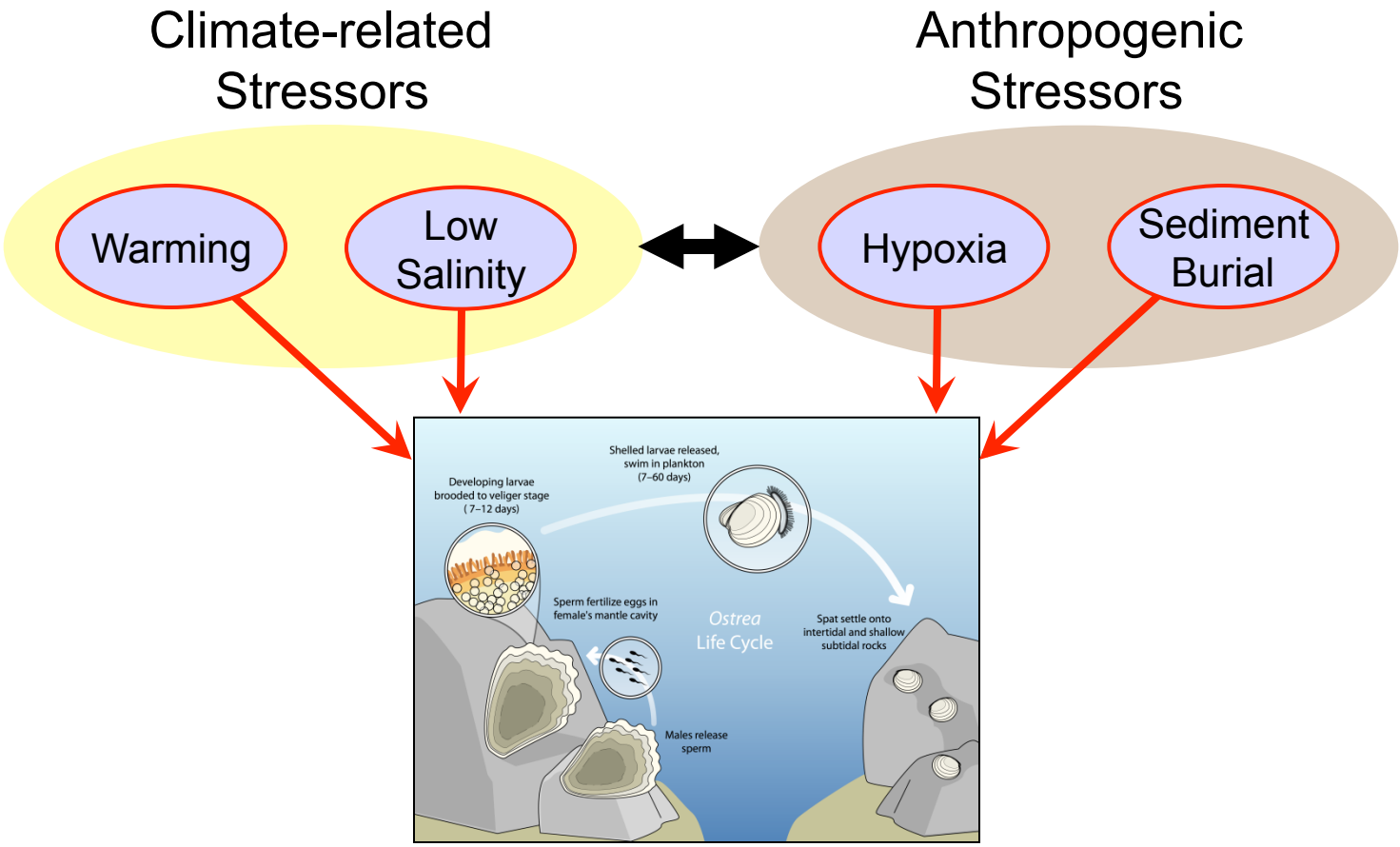
Conceptual model




Drivers
Stressors
The Good Stuff
Elevated CO_2
Precipitation Events
Eutrophication
Boating, Shipping
Dredging
Warming
Invasive Species
Acidification
Low Salinity
Hypoxia
Sediment Burial
Predators
OYSTER POPULATIONS
Ecosystem Services
Larval Supply
Currents
Substrate


Warming
Low Salinity
Hypoxia
Sediment Burial
OYSTER POPULATIONS

Simplified conceptual model

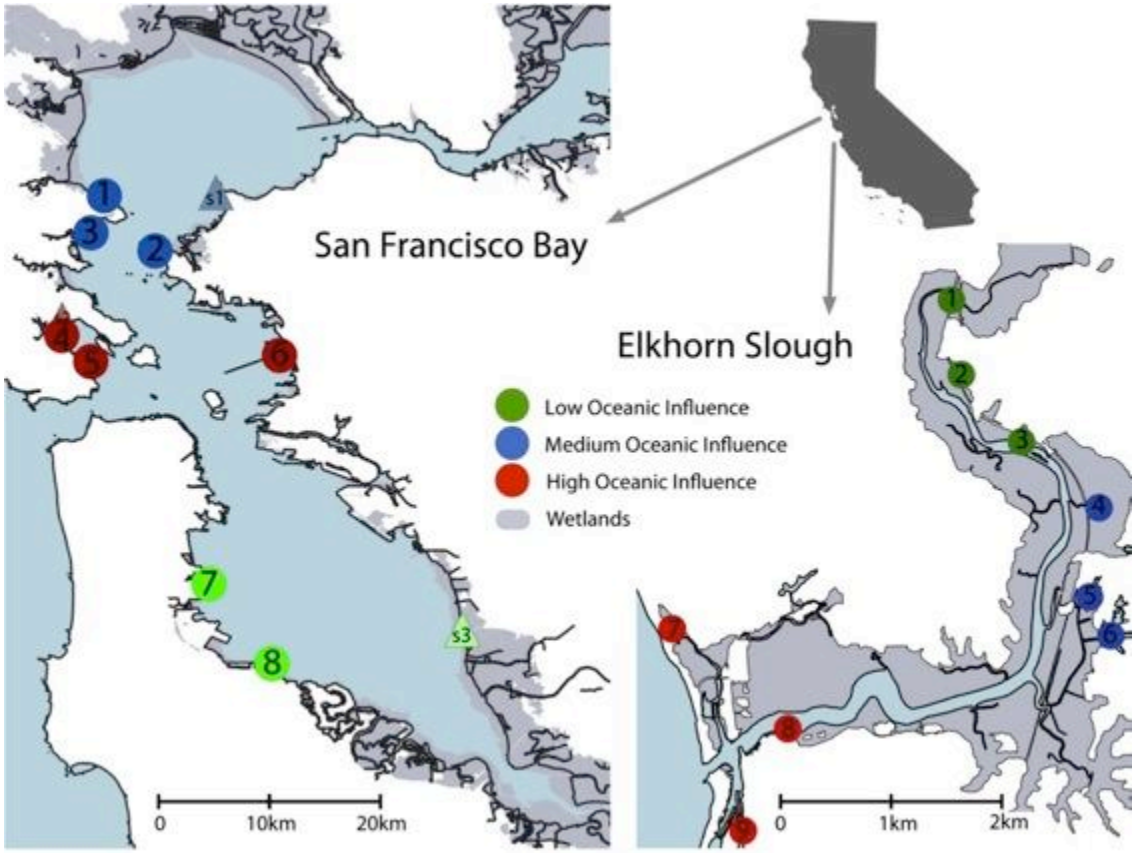


“A Tale of Two Estuaries”

Large

Urban

High but intermittent input of freshwater



Small

Agricultural

Low input of freshwater

High nutrient loading

Study sites span a wide range of physical and biotic variables, making results broadly applicable along the coast

Collaboration with oyster restoration "end-users"

Restoration **practitioners**

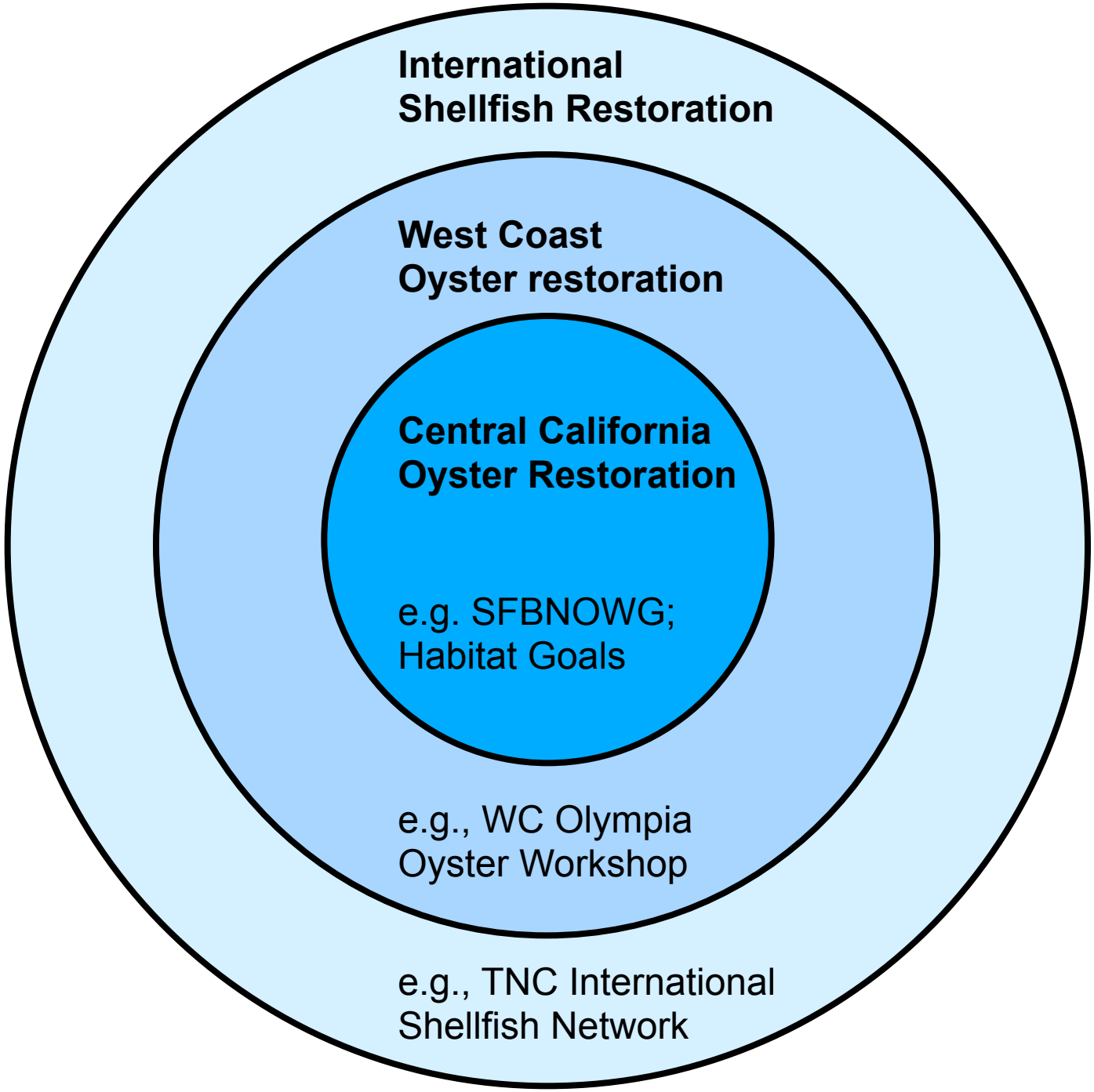
Restoration **scientists**

Regulatory and **permitting** agencies

Funders of restoration projects

Federal and state **resource agencies**

Non-profit conservation/restoration organizations


International
Shellfish Restoration
West Coast
Oyster restoration
Central California
Oyster Restoration
e.g. SFBNOWG;
Habitat Goals
e.g., WC Olympia
Oyster Workshop
e.g., TNC International
Shellfish Network

Collaborative milestones

Adapting project to formative feedback

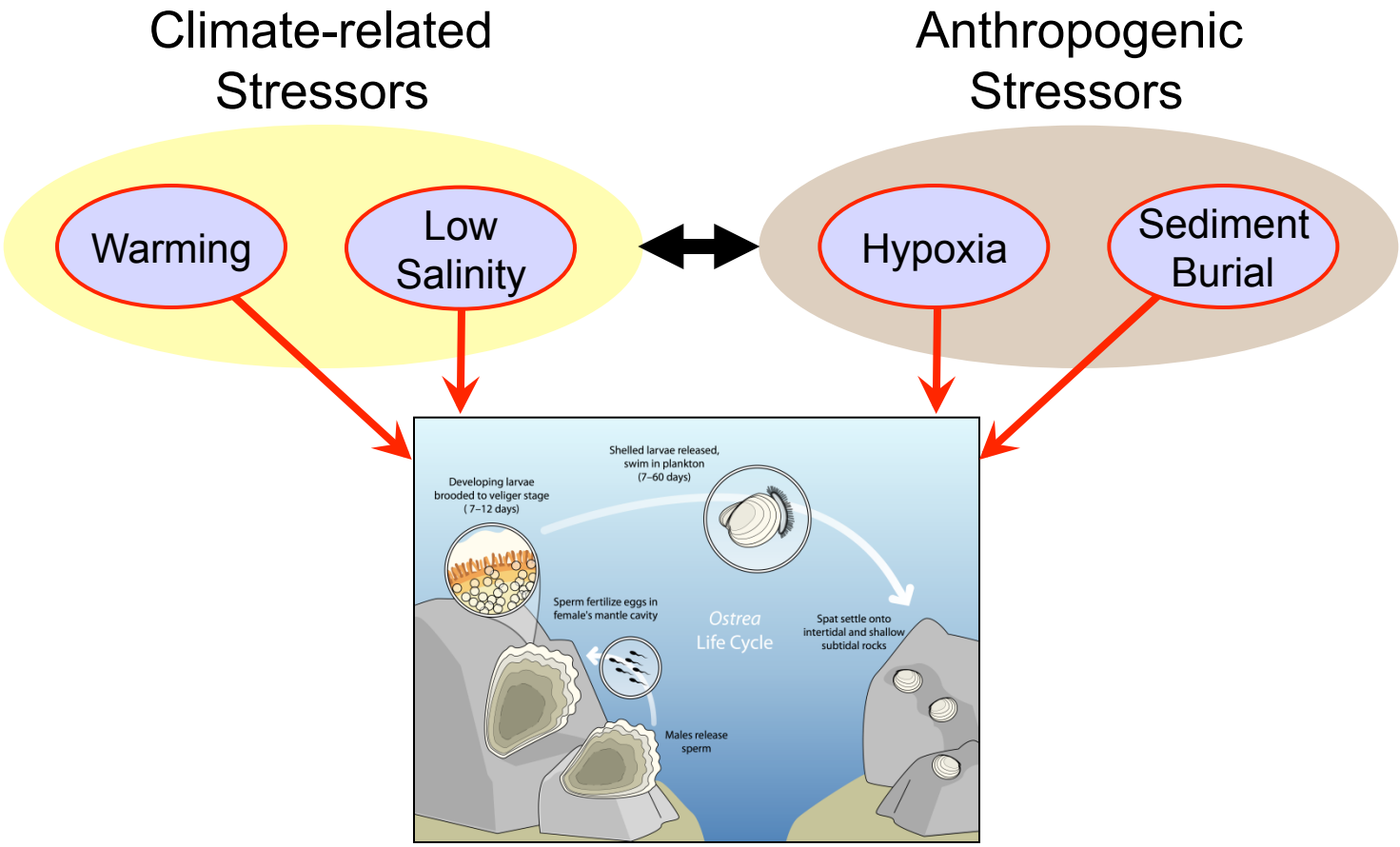
- **End-user survey (January 2012)**
  - Guided site and stressor selection for field and lab studies
- **Decision-maker interviews (January 2013)**
  - Determined what sorts of decisions are being made and what information and products are used
- **Early workshop (April 2013)**
  - Examining types of new data being generated by this project and provide feedback on management applications

Collaborative milestones

Adapting project to formative feedback

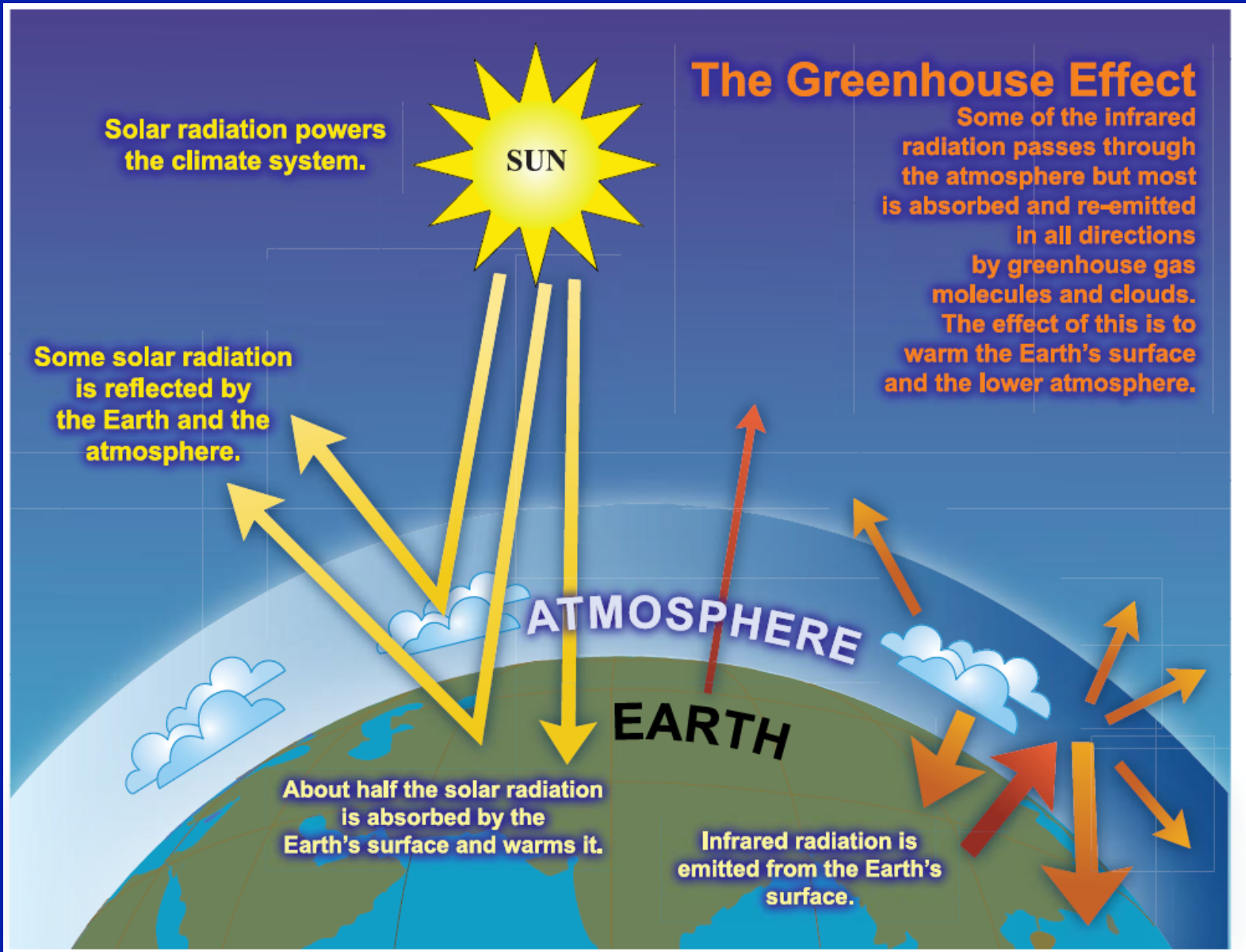
- **Develop and test products (Fall 2013)**
  - Gather feedback on formats and content of draft products
- **Final workshop (Summer 2014)**
  - Train end-users on products and share lessons learned

Questions?


Climate-related Stressors
Anthropogenic Stressors
Warming
Low Salinity
Hypoxia
Sediment Burial
Shelled larvae released, swim in plankton (7–60 days)
Developing larvae brooded to veliger stage (7–12 days)
Sperm fertilize eggs in female's mantle cavity
Ostrea Life Cycle
Spat settle onto intertidal and shallow subtidal rocks
Males release sperm

Climate Change Primer for Central California

Ted Grosholz
Dept. of Environmental Science and Policy
University of California, Davis



FAQ 1.3, Figure 1. *An idealised model of the natural greenhouse effect. See text for explanation.*

IPPC 4th Assessment Report 2007

Sources of Climate Change

- Global climate change due to increasing atmospheric temperatures
- Caused by increasing levels of carbon dioxide, methane and other gases (IPPC 4th Assessment 2007)
- Increased air temperatures affect many coastal processes

Increasing Air Temperatures

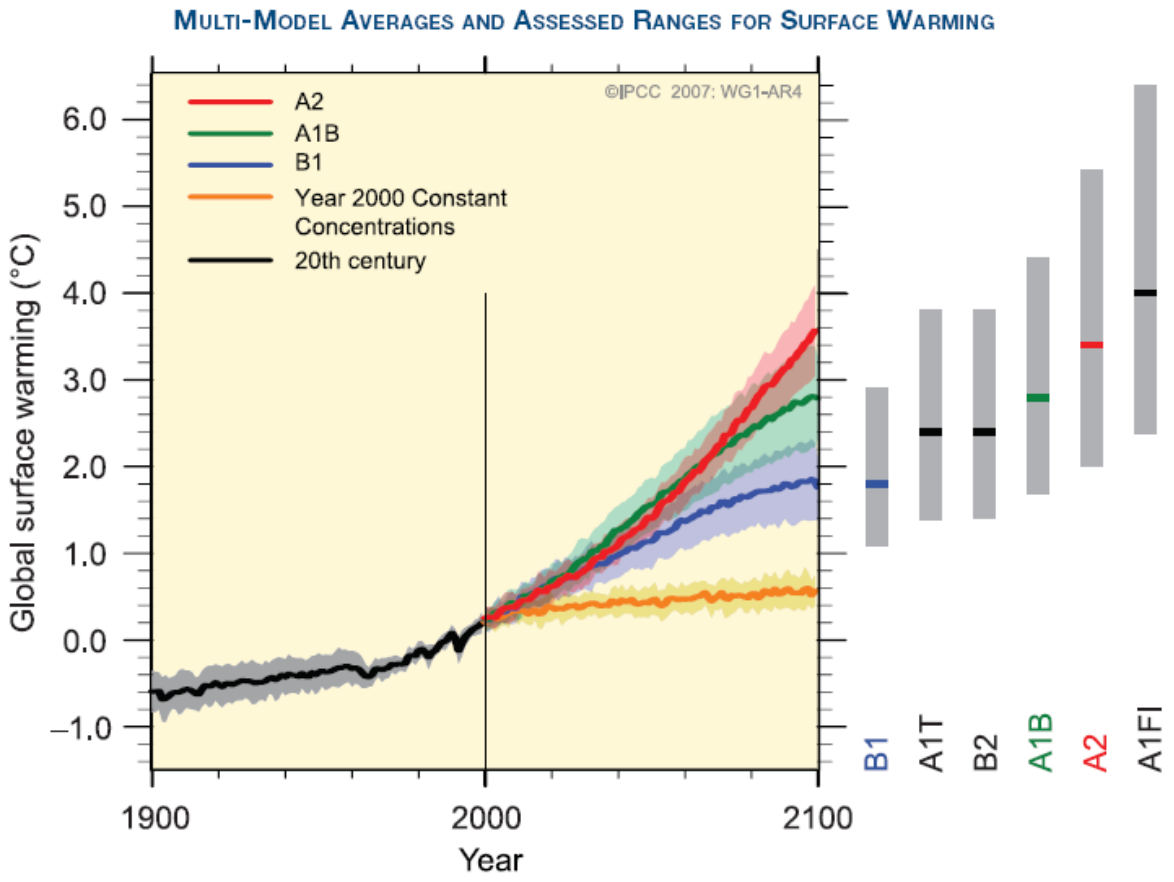
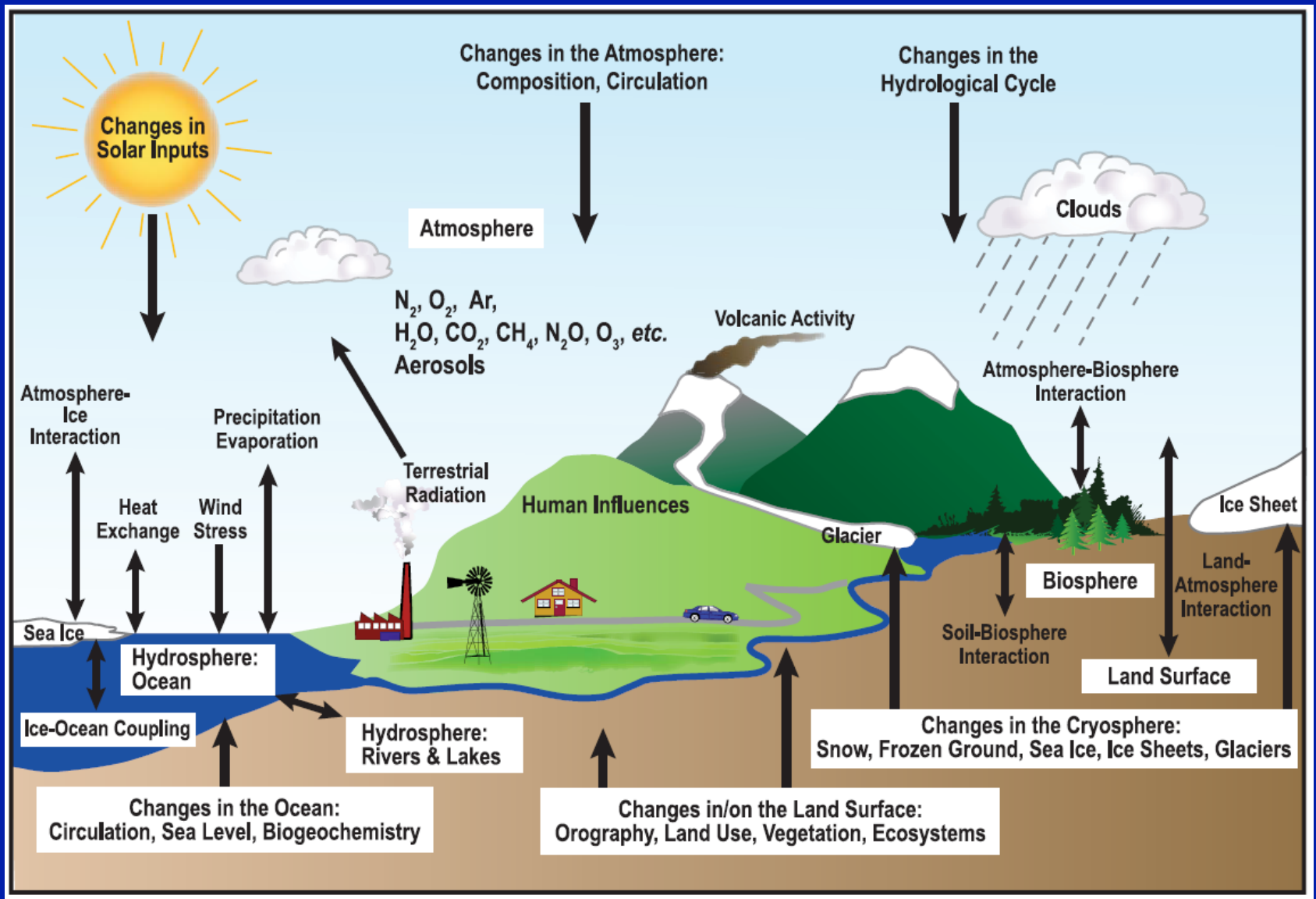


Figure SPM.5. *Solid lines are multi-model global averages of surface warming (relative to 1980–1999) for the scenarios A2, A1B and B1, shown as continuations of the 20th century simulations. Shading denotes the ±1 standard deviation range of individual model annual averages. The orange line is for the experiment where concentrations were held constant at year 2000 values. The grey bars at right indicate the best estimate (solid line within each bar) and the* ***likely*** *range assessed for the six SRES marker scenarios. The assessment of the best estimate and* ***likely*** *ranges in the grey bars includes the AOGCMs in the left part of the figure, as well as results from a hierarchy of independent models and observational constraints. {Figures 10.4 and 10.29}*

IPPC 4th Assessment Report 2007



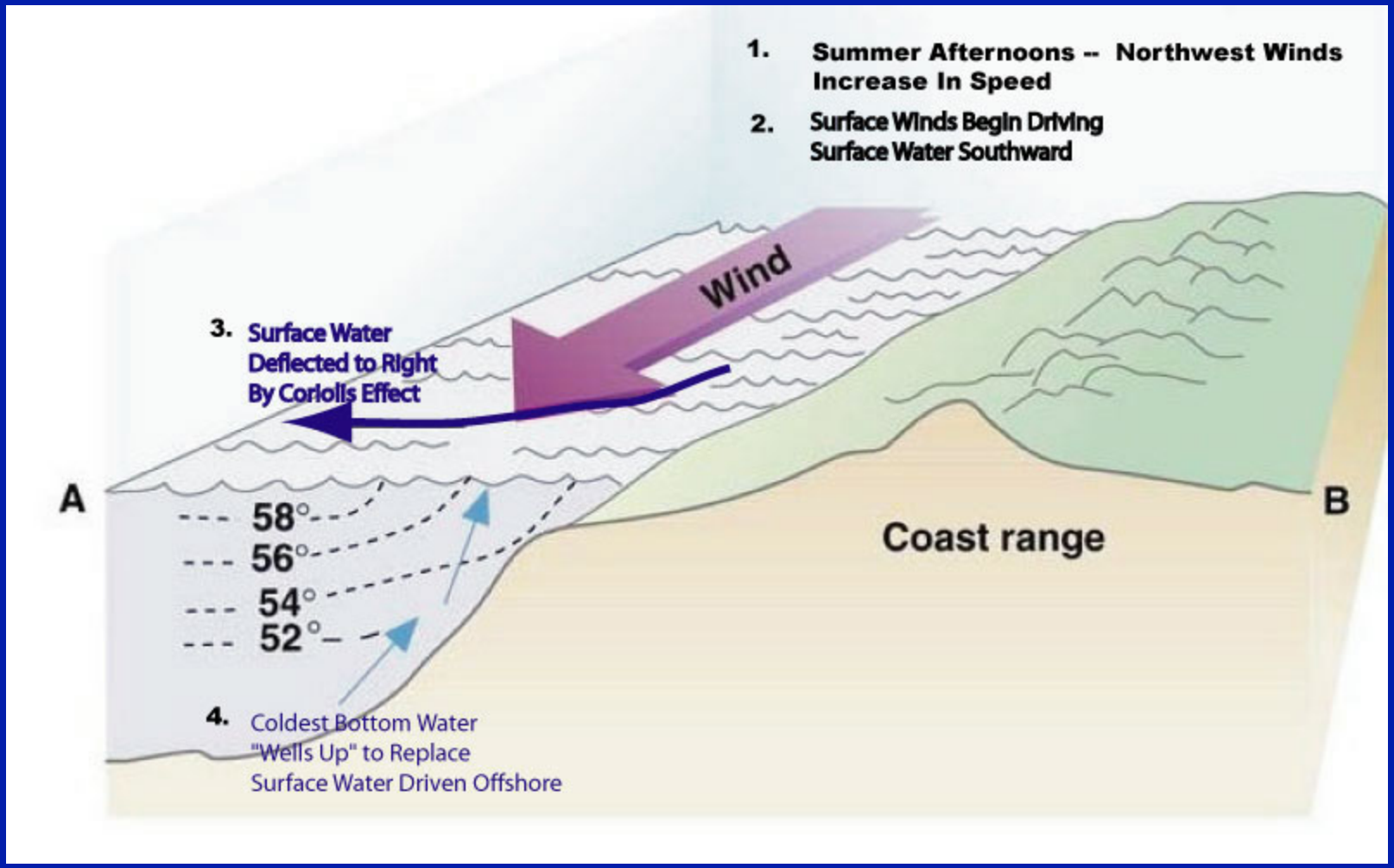
FAQ 1.2, Figure 1. *Schematic view of the components of the climate system, their processes and interactions.*

IPPC 4th Assessment Report 2007

Global Models to Local Water Temperatures

- Primary models are global or regional scale models
- Understanding future conditions in local bays/estuaries requires ‘downscaling’ from larger scale models
- Models provide air temperature data
- Need wind and current information to project water temperatures

Increased Upwelling



Increased Coastal Upwelling

- Alongshore winds will increase
- Increasing along shore winds will increase depth and magnitude of upwelling
- Upwelling zone will have colder and nutrient rich water
- Shallow bays/estuaries will be warmer and more stratified
- Increasingly likelihood of low DO events

Increased Variability in Precipitation

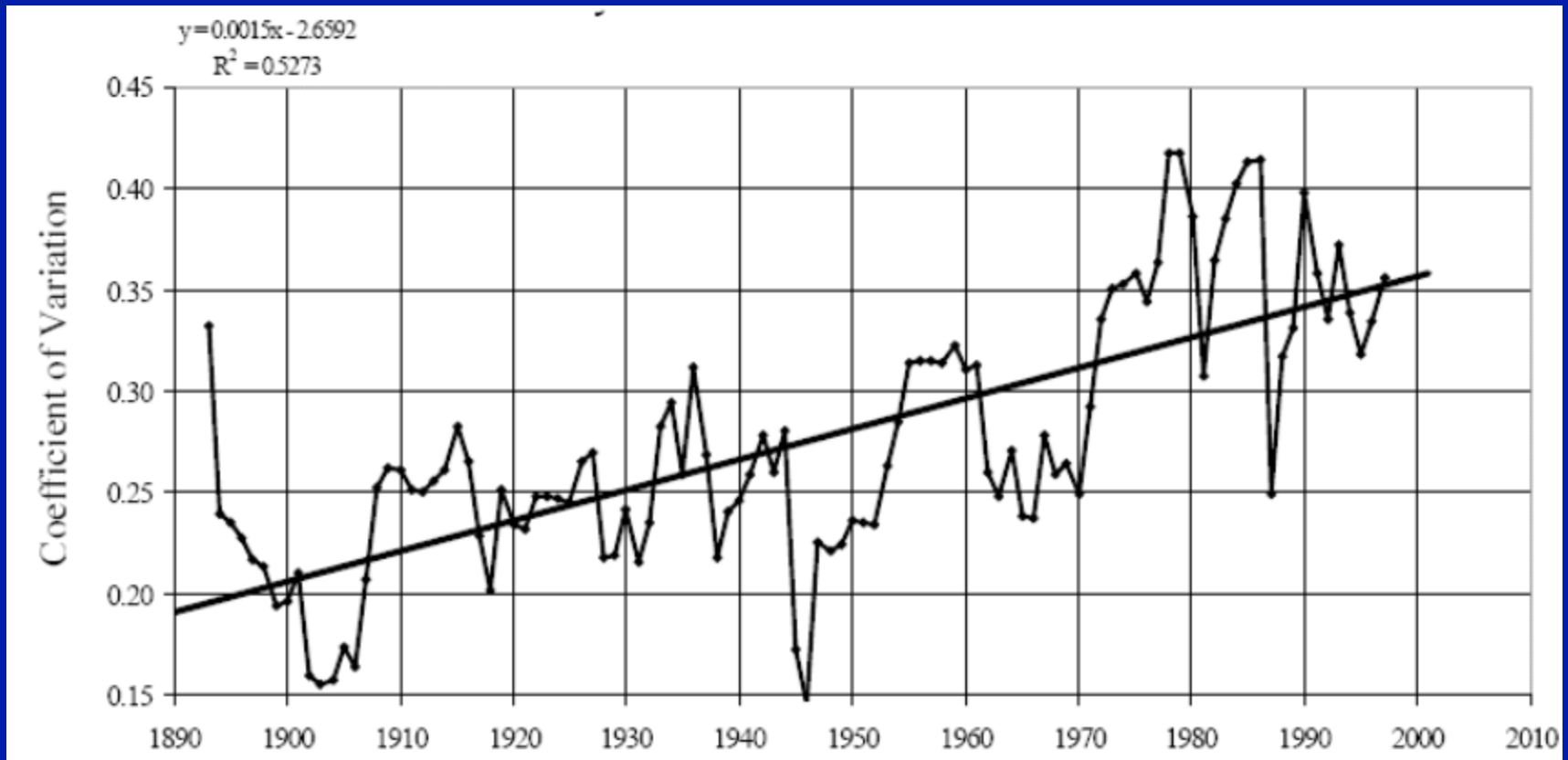


Figure 3.3. *Variation in precipitation over time in California. The solid line is the best-fit regression line. DWR (2006).*

DWR Report 2006

More Variable Precipitation and Runoff

- Large river watersheds influenced by reduced snowpack (less snow melt into rivers) and winter storms with more rain
- Stronger winter inflows and reduced spring inflows in coastal watersheds
- Greater variability in annual precipitation (both drier and wetter years)

Consequences of Changing Runoff

- More variable runoff can influence several important variables:
  - Salinity
  - Nutrients
  - Dissolved oxygen
  - Alkalinity
  - Sediments and contaminants

Sea Level Rise in CA

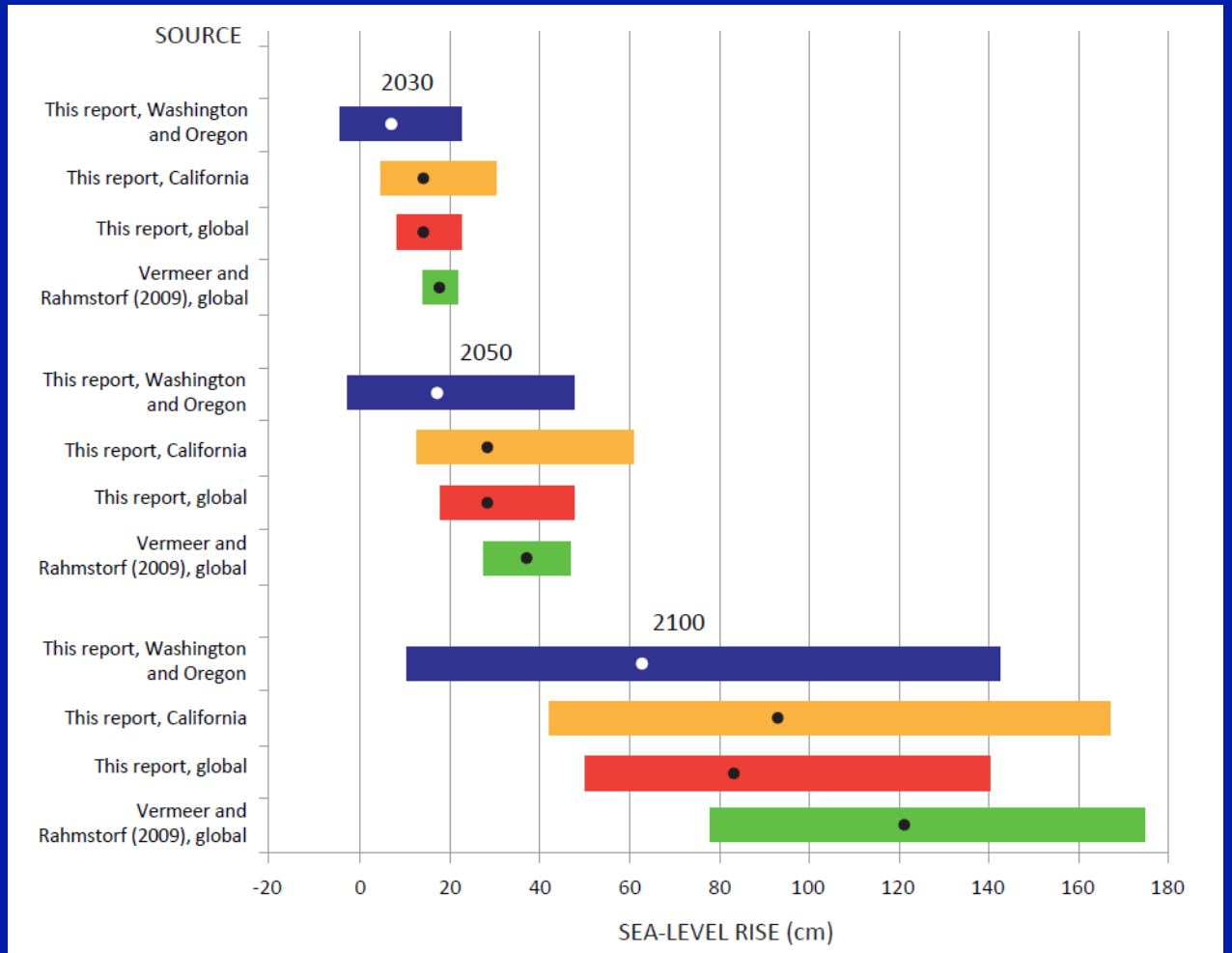


FIGURE 5.10 Committee's projected sea-level rise for California, Oregon, and Washington compared with global projections. The dots are the projected values and the colored bars are the ranges. Washington and Oregon = coastal areas north of Cape Mendocino; California = coastal areas south of Cape Mendocino.

NRC Committee Report 2012

Expected SLR in Central CA

- Dramatic sea level rise (SLR) is expected in central CA where land is subsiding
- Recent estimates for central and southern CA have increased to 75 cm by 2050 and 190 cm by 2100 (NRC Committee 2012)
- SLR can affect ocean and river inputs, timing of tidal cycles, and overall circulation in bays and estuaries

Increasing Ocean Acidification

- Ocean water pH is strongly influenced by atmospheric levels of carbon dioxide
- Increasing atmospheric carbon dioxide results in increased acidity (carbonic acid in water)
- Deeper ocean waters are more acidic than surface waters
- Thus, projected increases in upwelling will contribute to decreases in pH of offshore waters

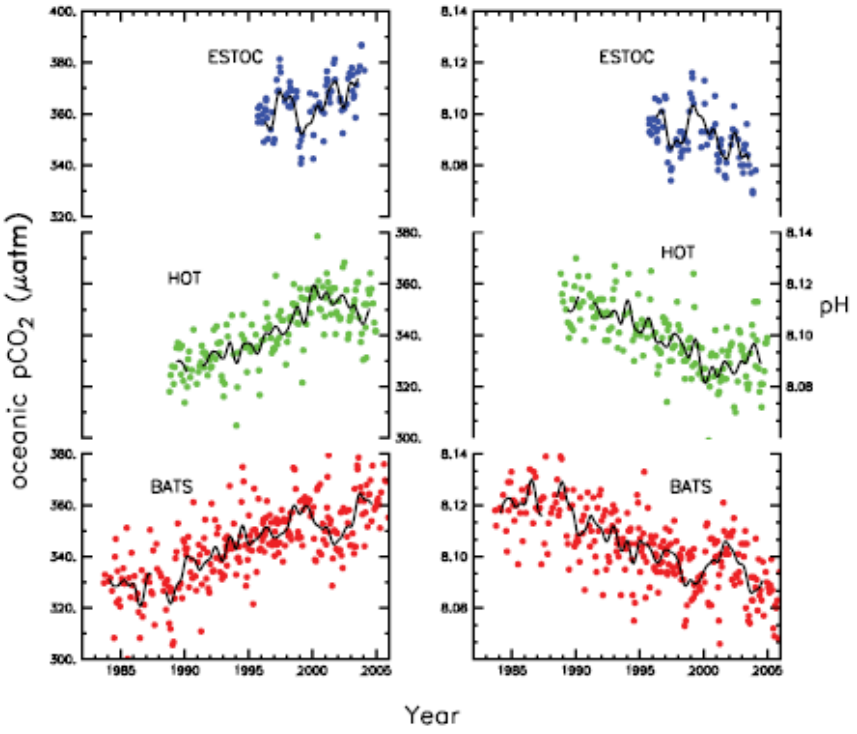
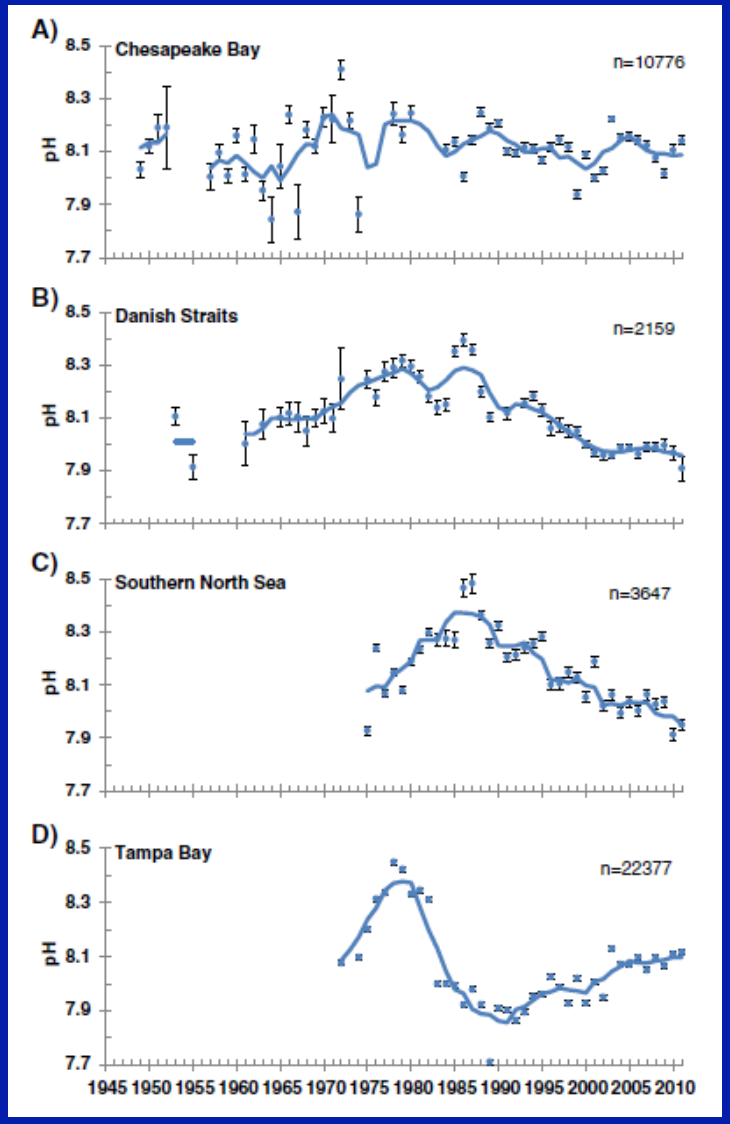


Figure 5.9. *Changes in surface oceanic pCO_2 (left; in μatm) and pH (right) from three time series stations: Blue: European Station for Time-series in the Ocean (ESTOC, 29°N, 15°W; Gonzalez-Dávila et al., 2003); green: Hawaii Ocean Time-Series (HOT, 23°N, 158°W; Dore et al., 2003); red: Bermuda Atlantic Time-series Study (BATS, 31/32°N, 64°W; Bates et al., 2002; Gruber et al., 2002). Values of pCO_2 and pH were calculated from DIC and alkalinity at HOT and BATS; pH was directly measured at ESTOC and pCO_2 was calculated from pH and alkalinity. The mean seasonal cycle was removed from all data. The thick black line is smoothed and does not contain variability less than 0.5 years period.*

IPPC 4th Assessment Report 2007

Estuarine Acidification?

- Projected pH changes in bays and estuaries more complicated
- Inputs from watersheds can outweigh atmospheric inputs
- Increases in alkalinity, eutrophication (plant photosynthesis) can increase pH levels
- Future levels difficult to project



Duarte et al. Estuaries & Coasts 2013

Direct Consequences of Climate Change for Oysters

- Increased surface water temperatures may increase growth rates
- Low DO could decrease growth or survival
- Low pH can reduce growth (Hettinger et al. 2012) can ‘potentially’ reduce survival
- Variable precipitation/runoff and salinity could reduce growth/survival
- Rising sea levels could influence ocean inputs and estuarine circulation

Indirect Consequences of Climate Change for Oysters

- Variable runoff/outflow may influence larval dispersal and connectivity
- Increased temps could have several affects
  - Increased overgrowth by algae and space competitors
  - Increased phytoplankton abundance
  - Increased consumption by predators
- Spatial variability means changes in refugia and optimal sites

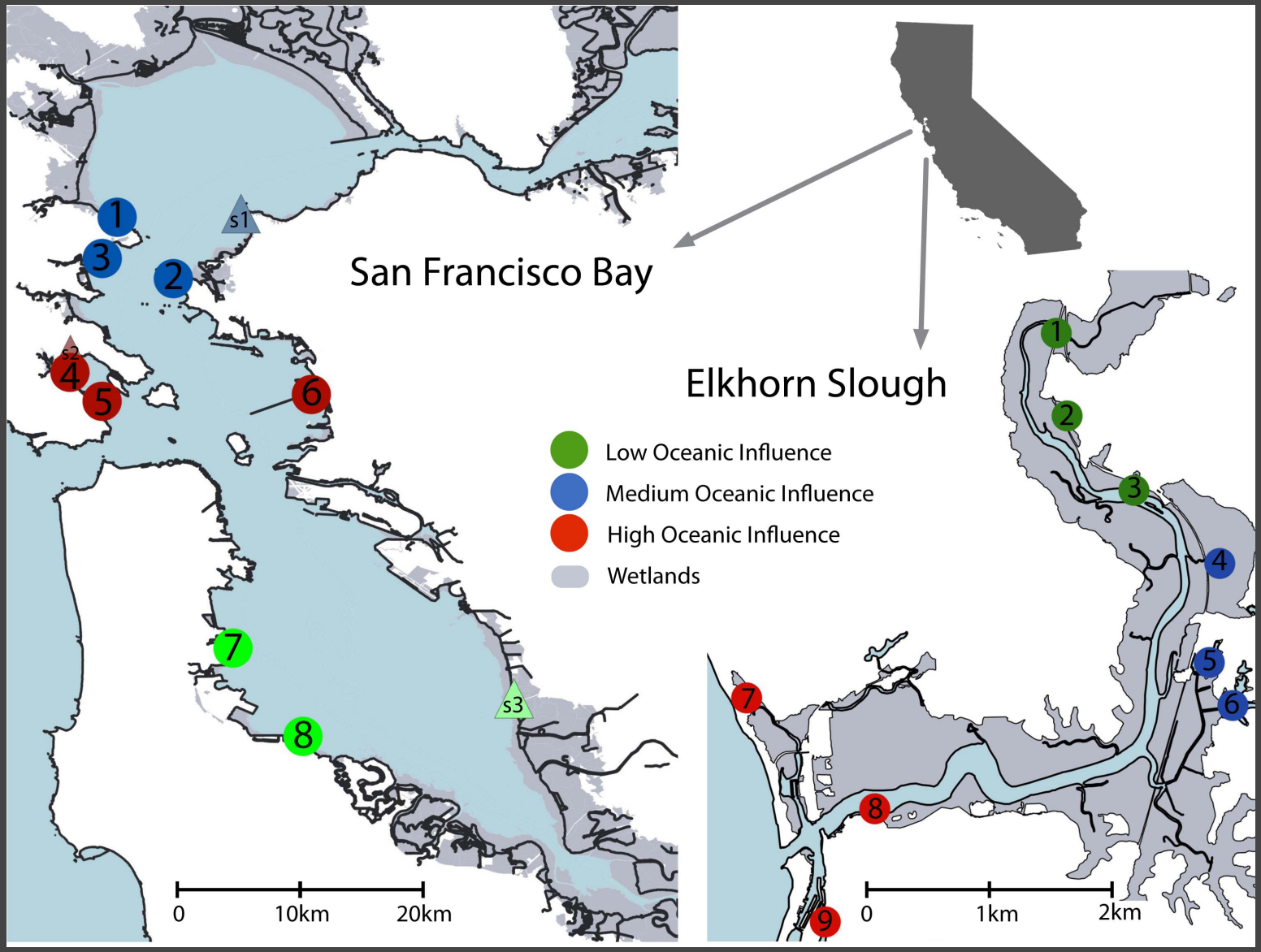
Field Studies

Measuring environmental changes and oyster performance

Goals: Field studies

1. Quantify current population status
2. Measure physical and biological parameters that might affect oyster performance
3. Use these data to guide decisions

Study sites


San Francisco Bay
Elkhorn Slough
Low Oceanic Influence
Medium Oceanic Influence
High Oceanic Influence
Wetlands
s1
s2
s3
1
2
3
4
5
6
7
8
9
0
10km
20km
0
1km
2km

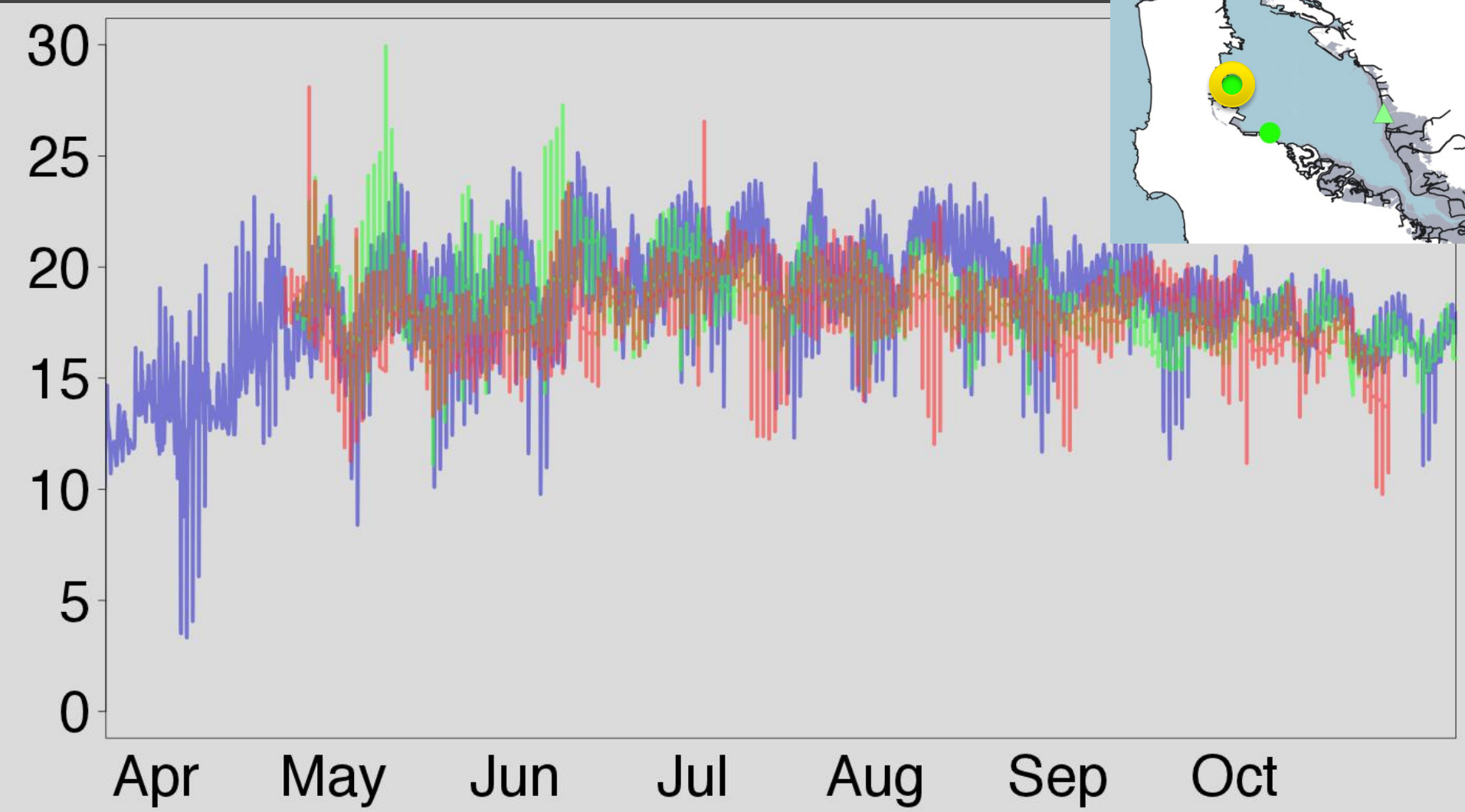
Environmental factors

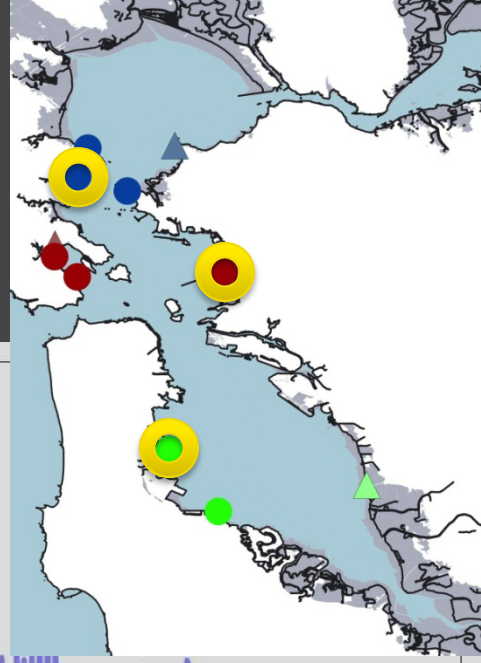
- Water and air temperature
- Salinity
- Dissolved oxygen
- Turbidity
- Chl A
- Sedimentation
- Substrate (amount and size)
- Presence and abundance of sessile organisms

Measuring Physical Conditions

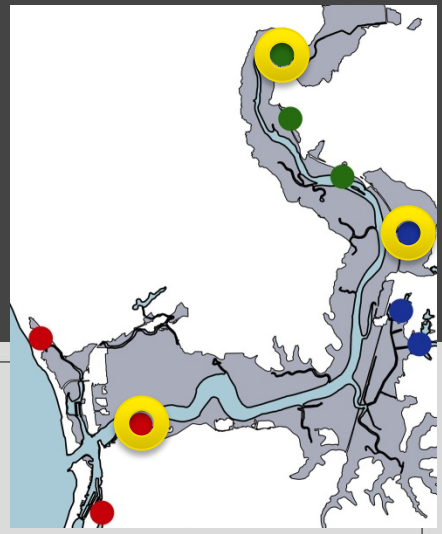
- Monthly site visits
- Loggers
- Continuous data stations (NERRs, CENCOOS, LOBOs)

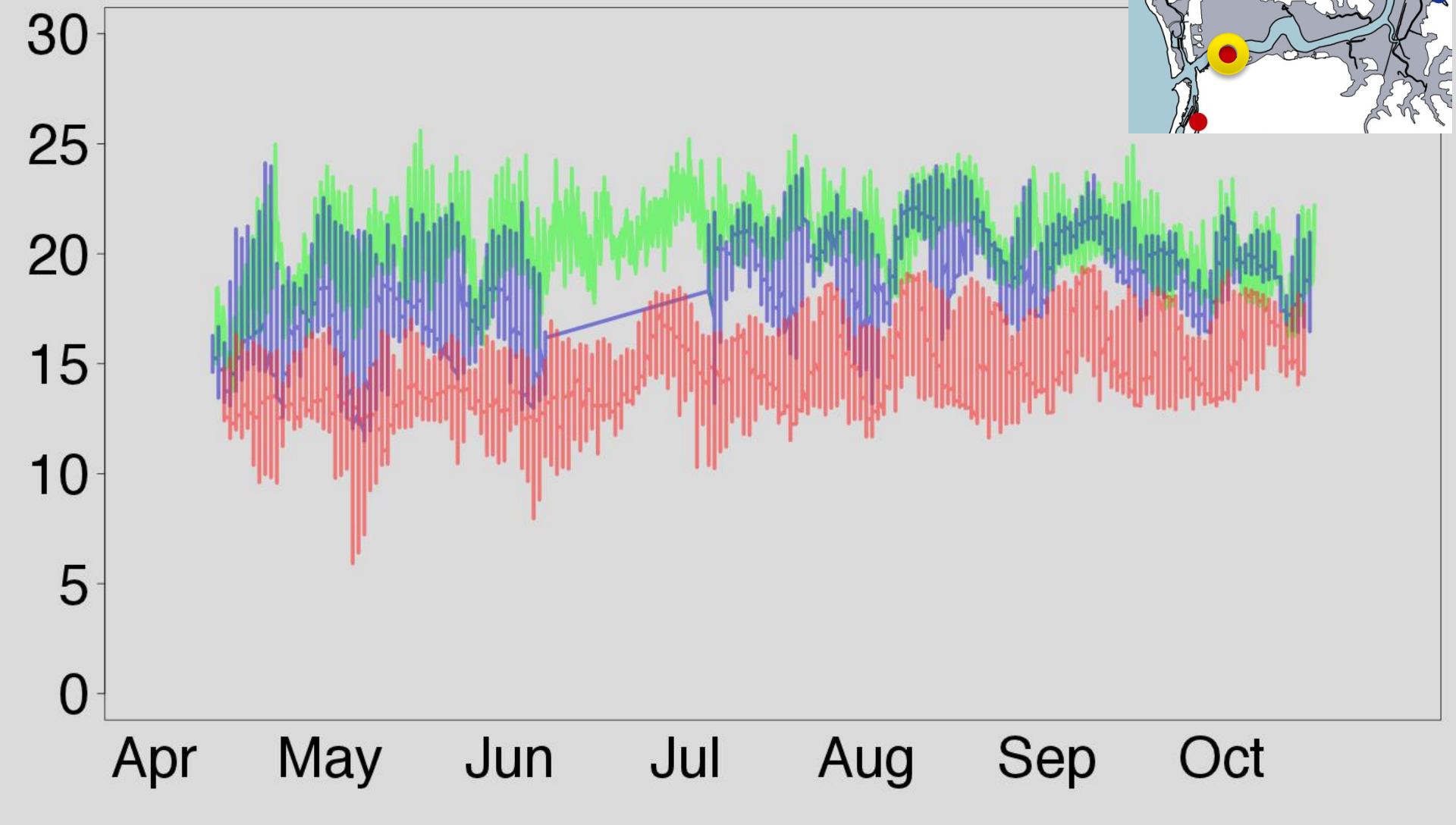
2012 Water Temperature: SF



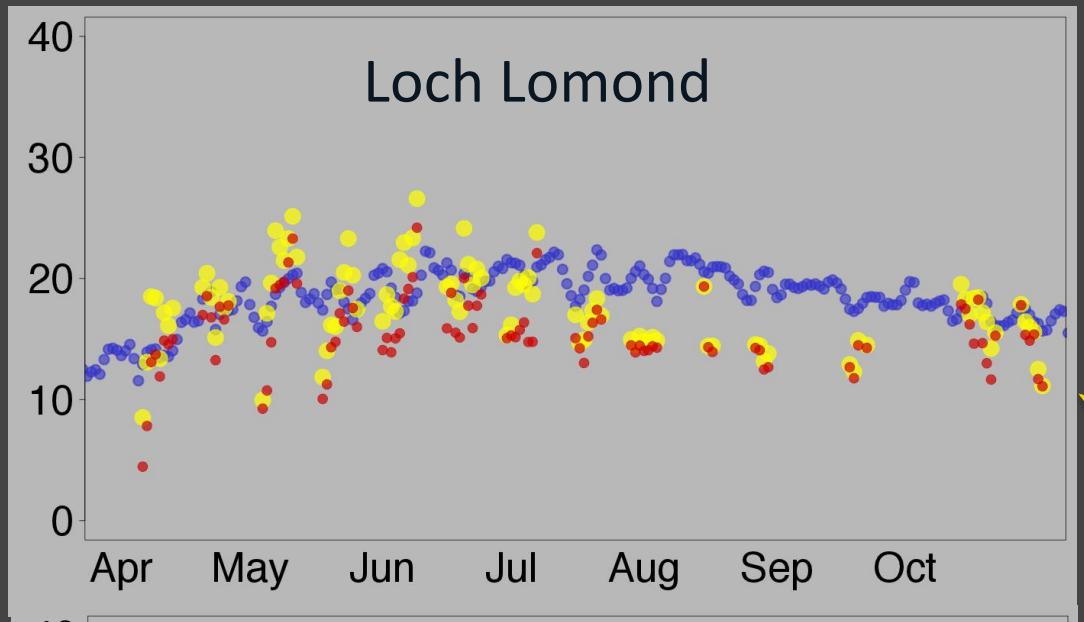


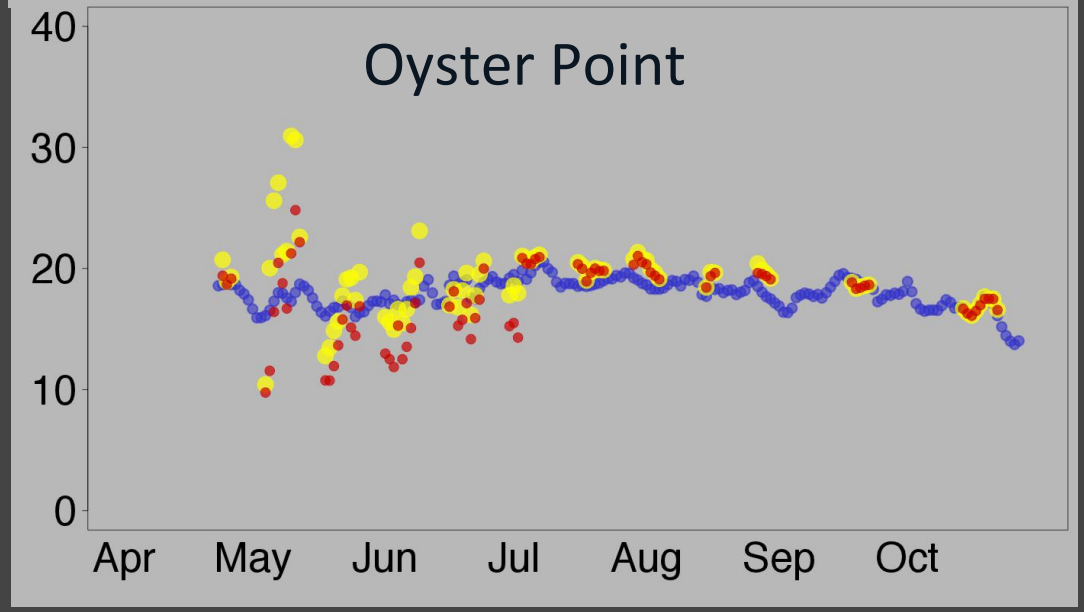
2012 Water Temperature: ES



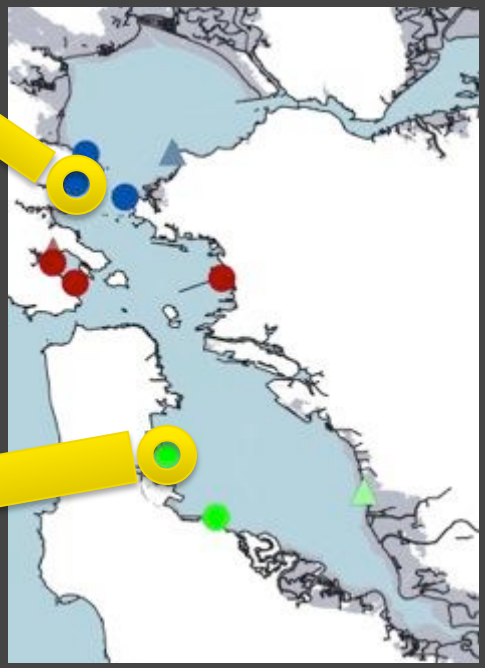


2012 Air Temperature: SF Bay

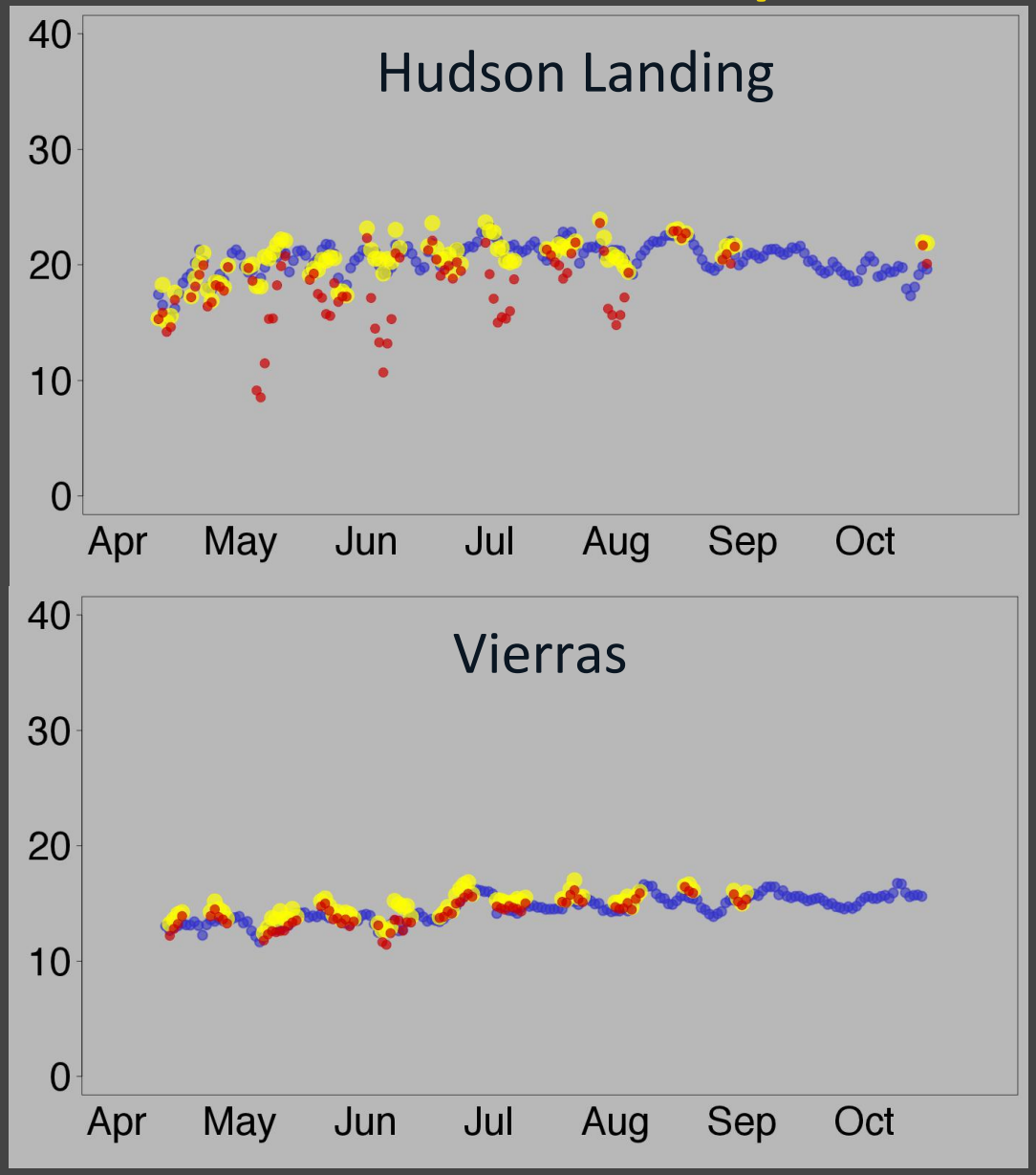




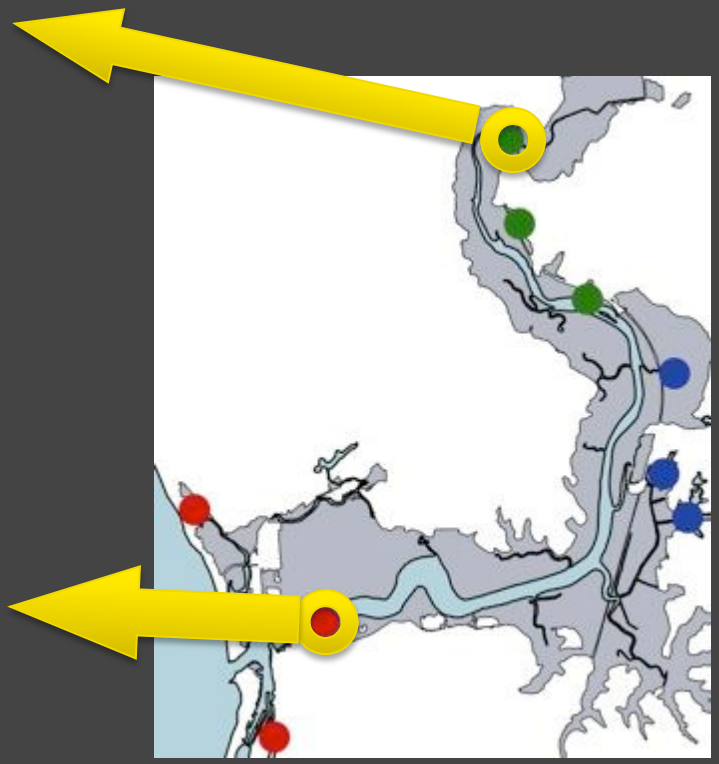
Mean Daily Air Temperature
MAX Daily Air Temperature
Mean Daily Water Temperature



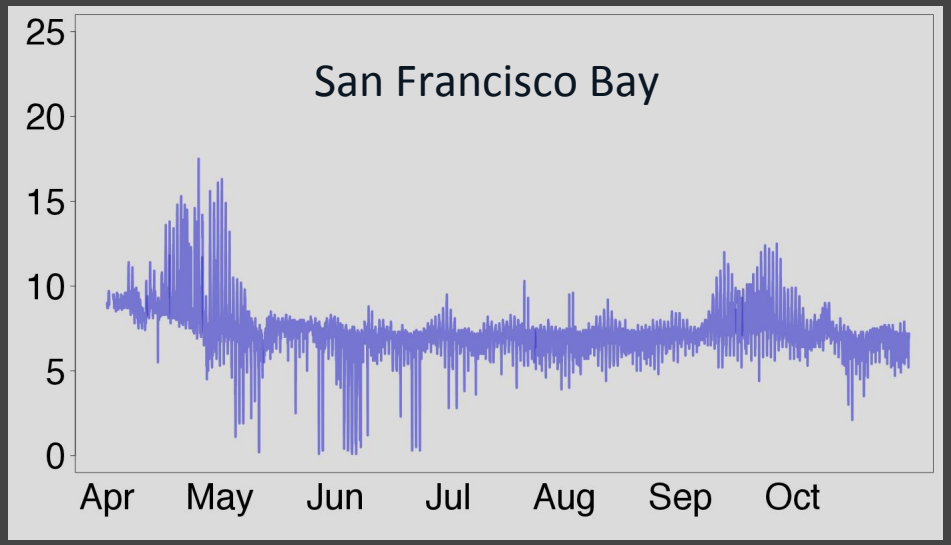
2012 Air Temperature: Elkhorn

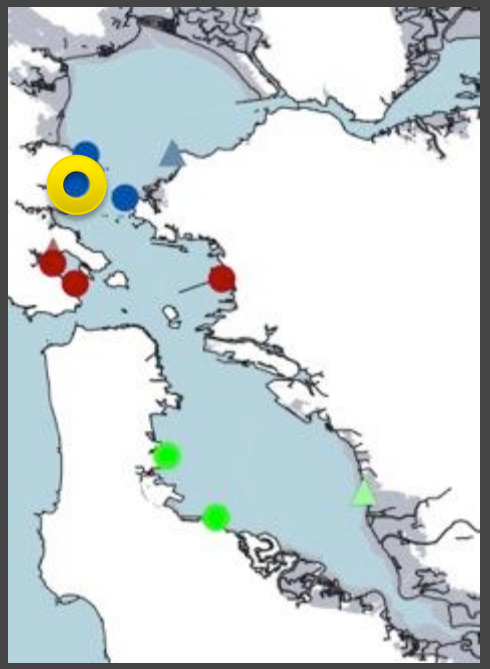


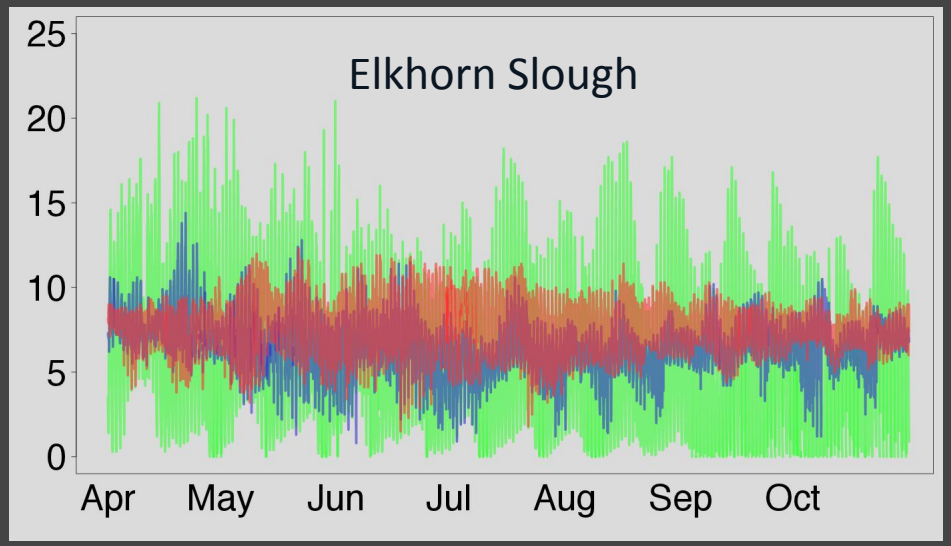
Mean Daily Air Temperature
MAX Daily Air Temperature
Mean Daily Water Temperature

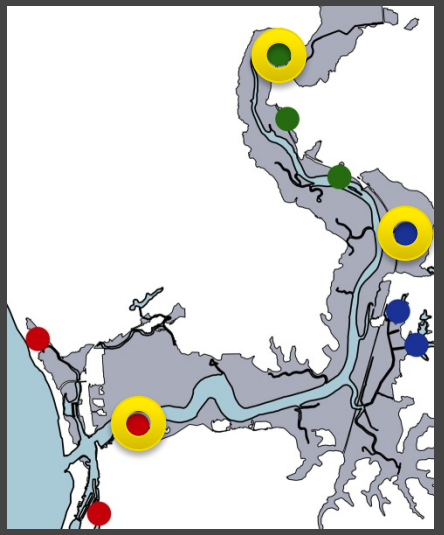


2012 Dissolved Oxygen

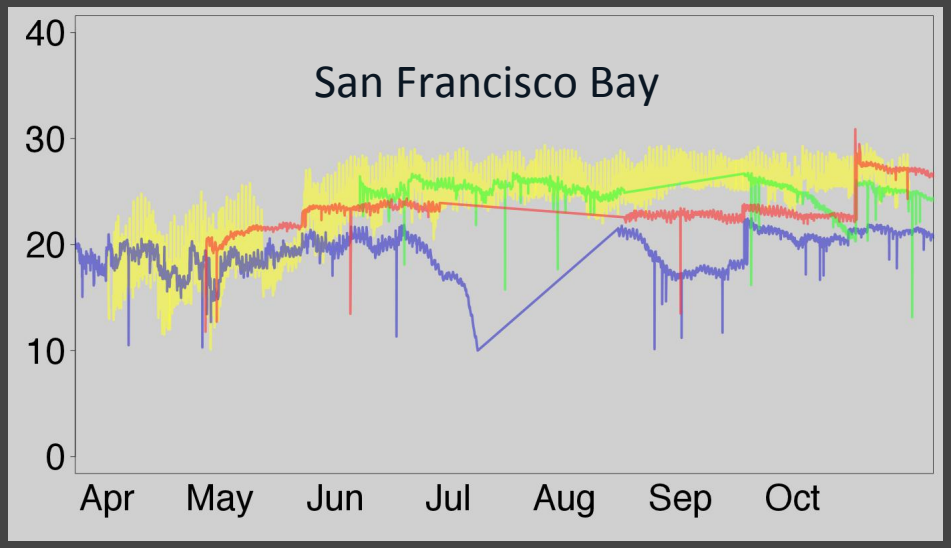


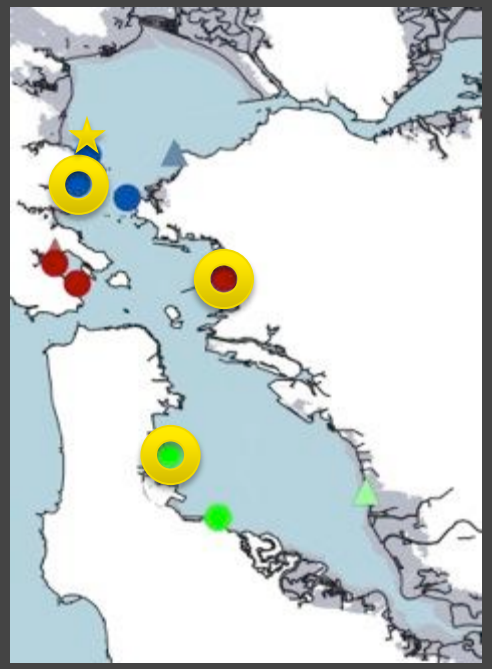


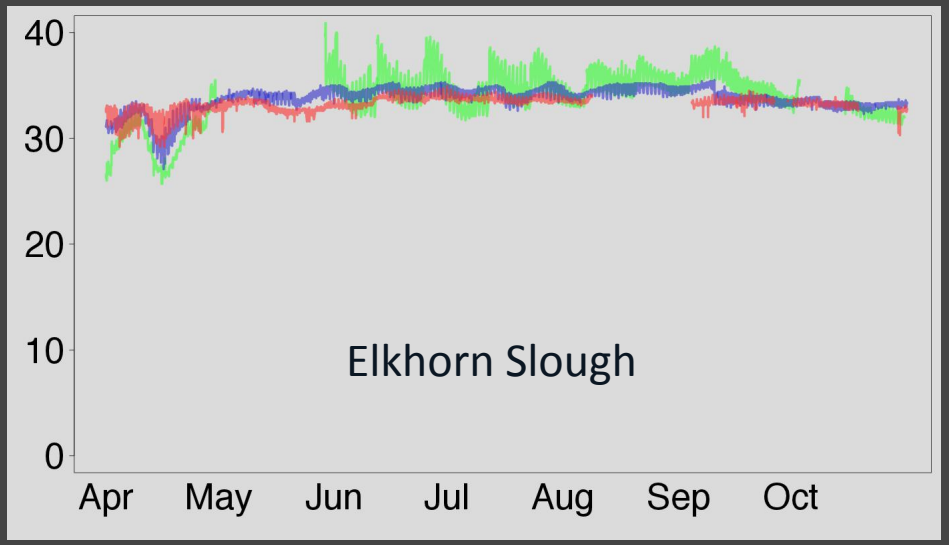


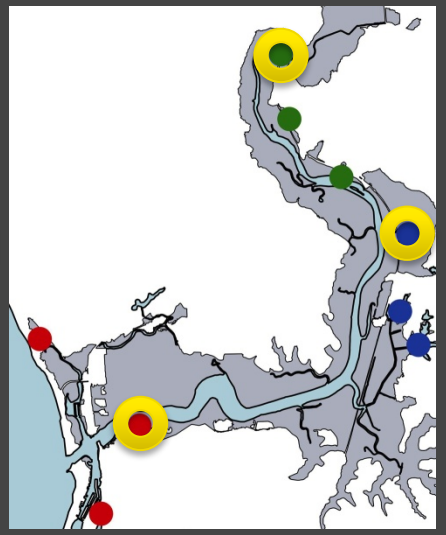


2012 Salinity

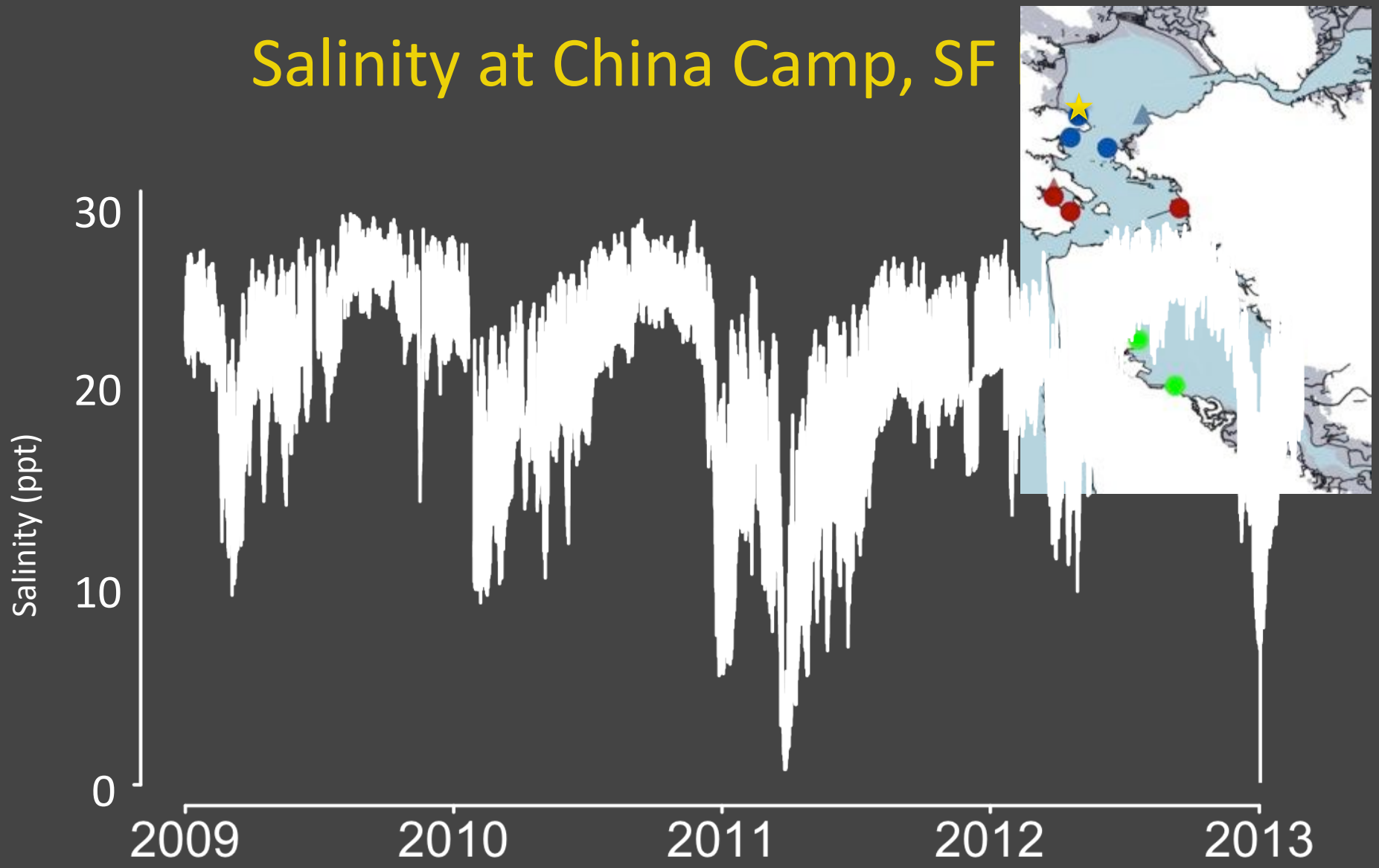








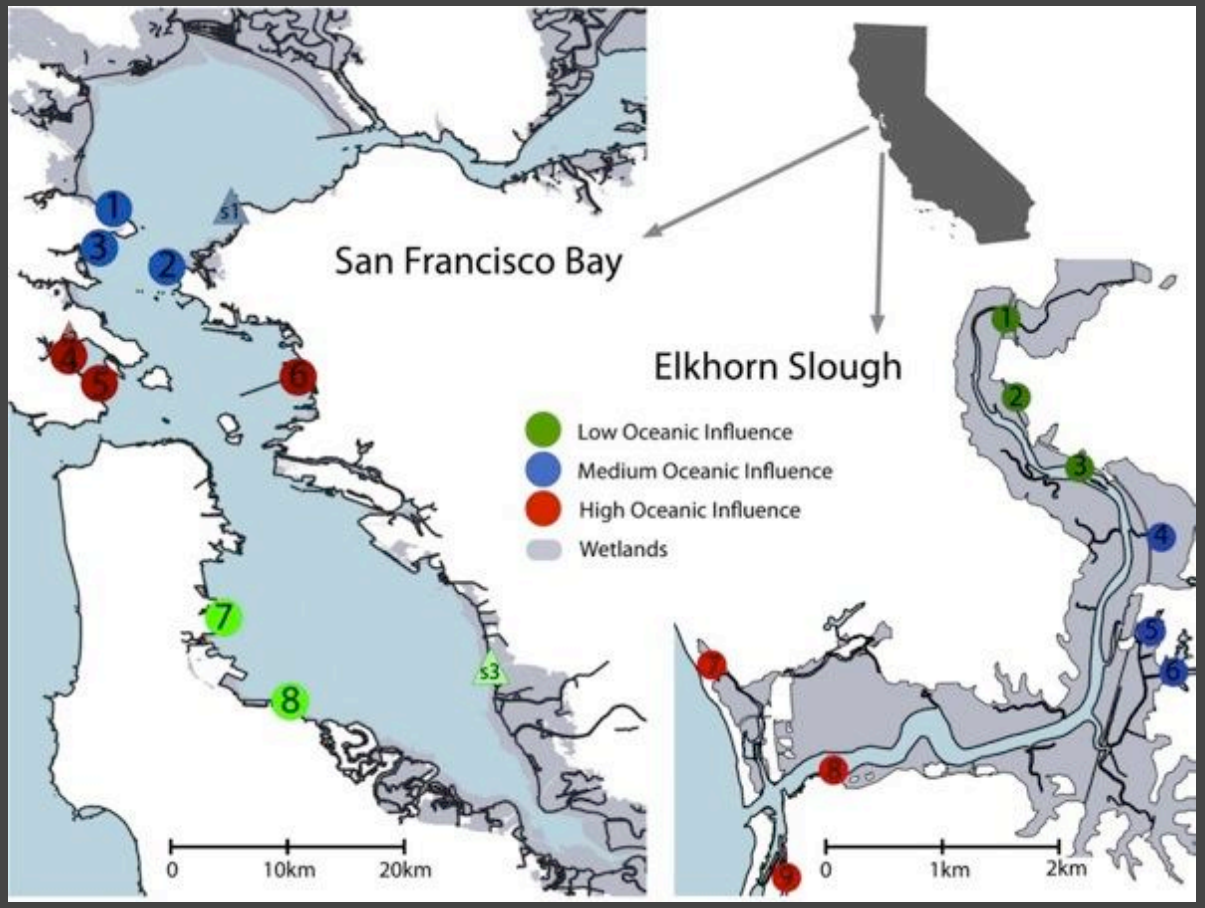
Salinity at China Camp, SF



Wet years and dry years – lots of variation

Basic information from existing populations along stressor gradients

- Density
- Sizes

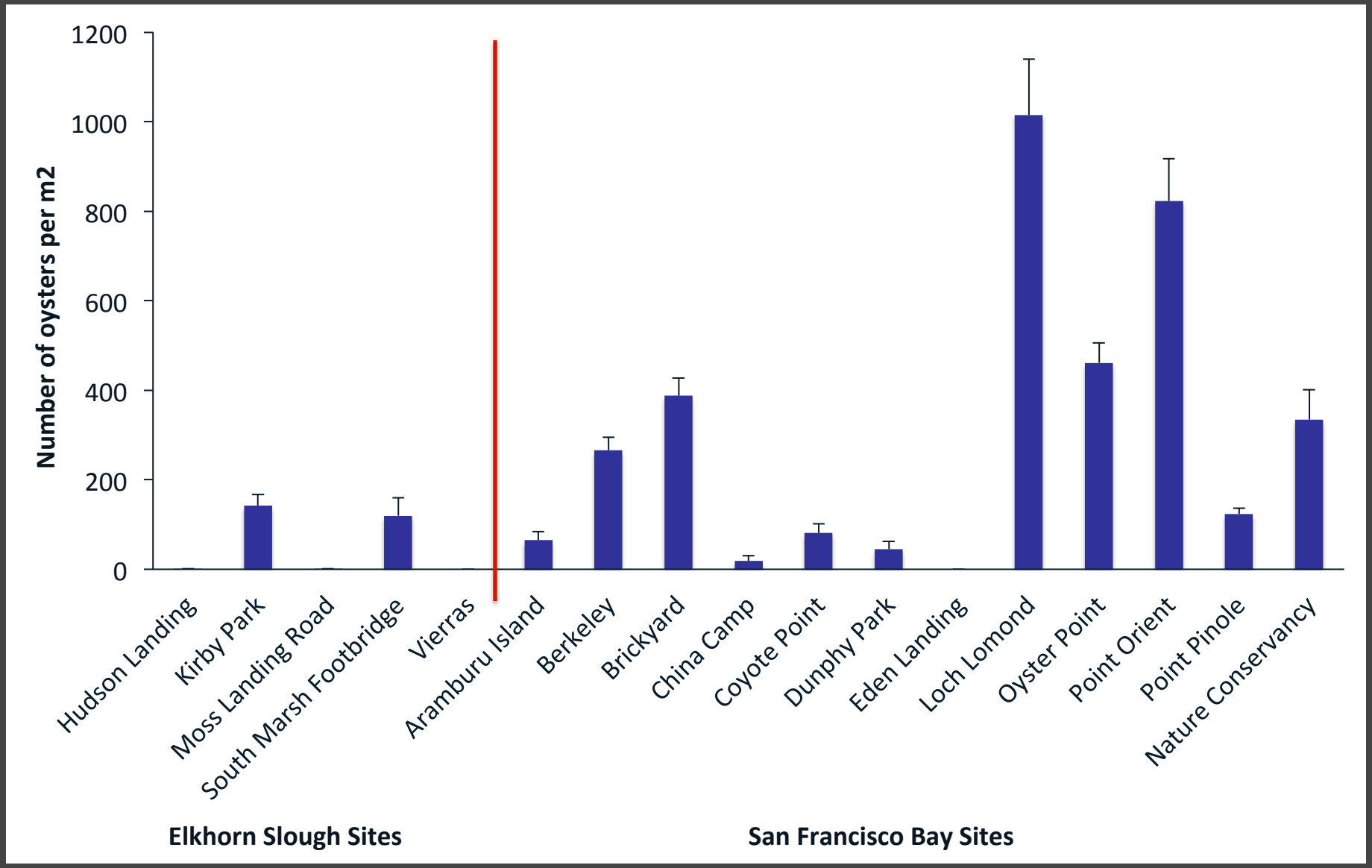


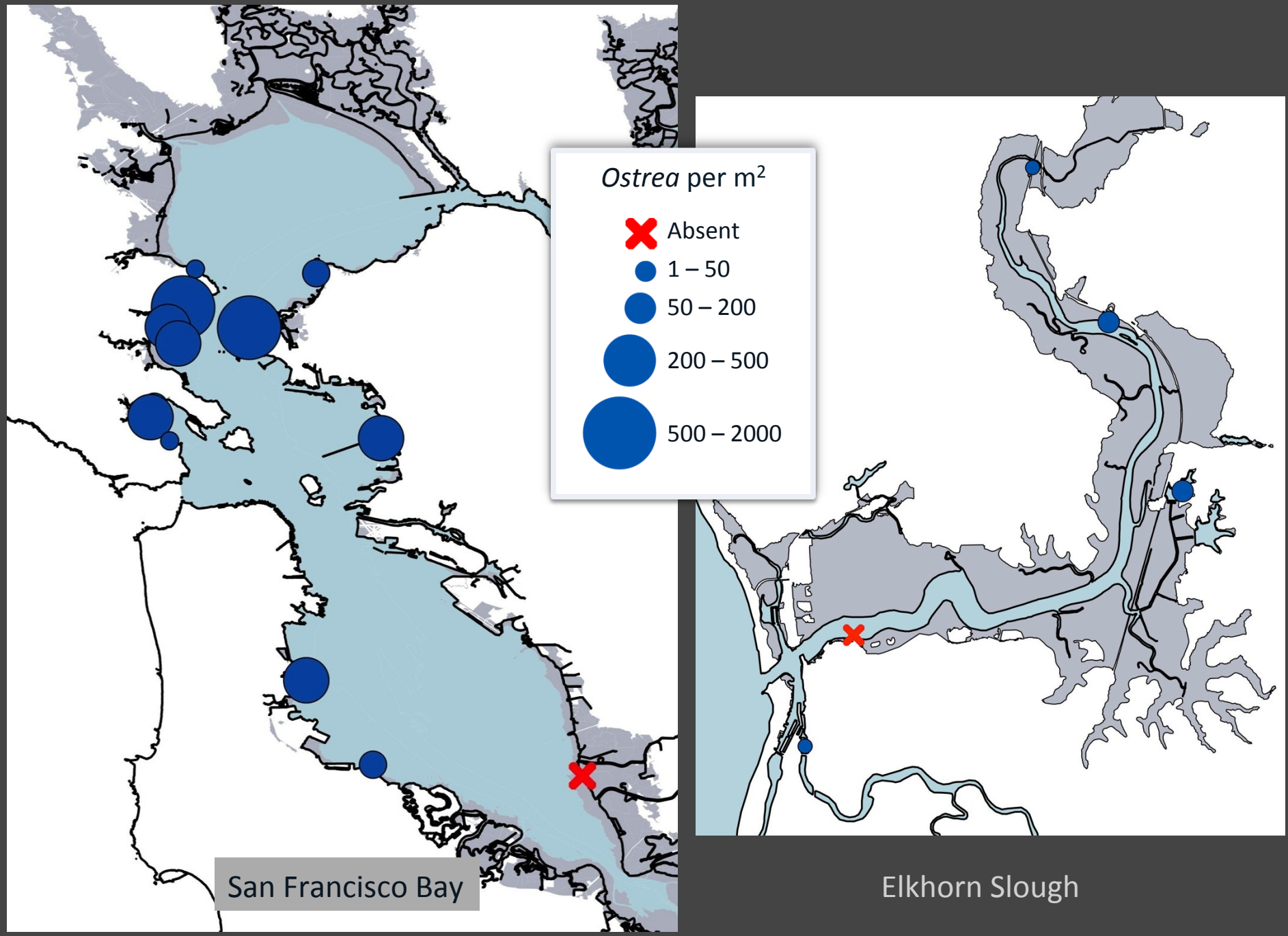
How abundant are *Ostrea*?

30m transect at each site at 0’ MLLW

China Camp

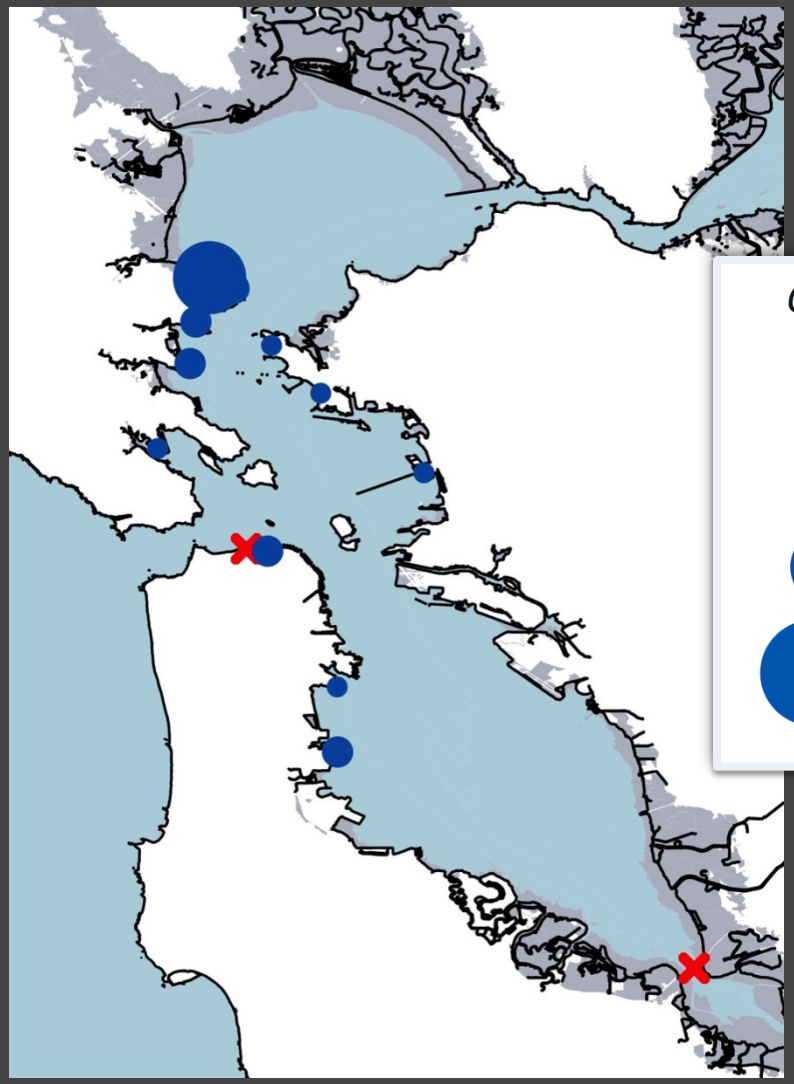
How abundant were *Ostrea* in 2012?




Ostrea per m²
Absent
1 – 50
50 – 200
200 – 500
500 – 2000
San Francisco Bay
Elkhorn Slough

Is this always the way things are? No.

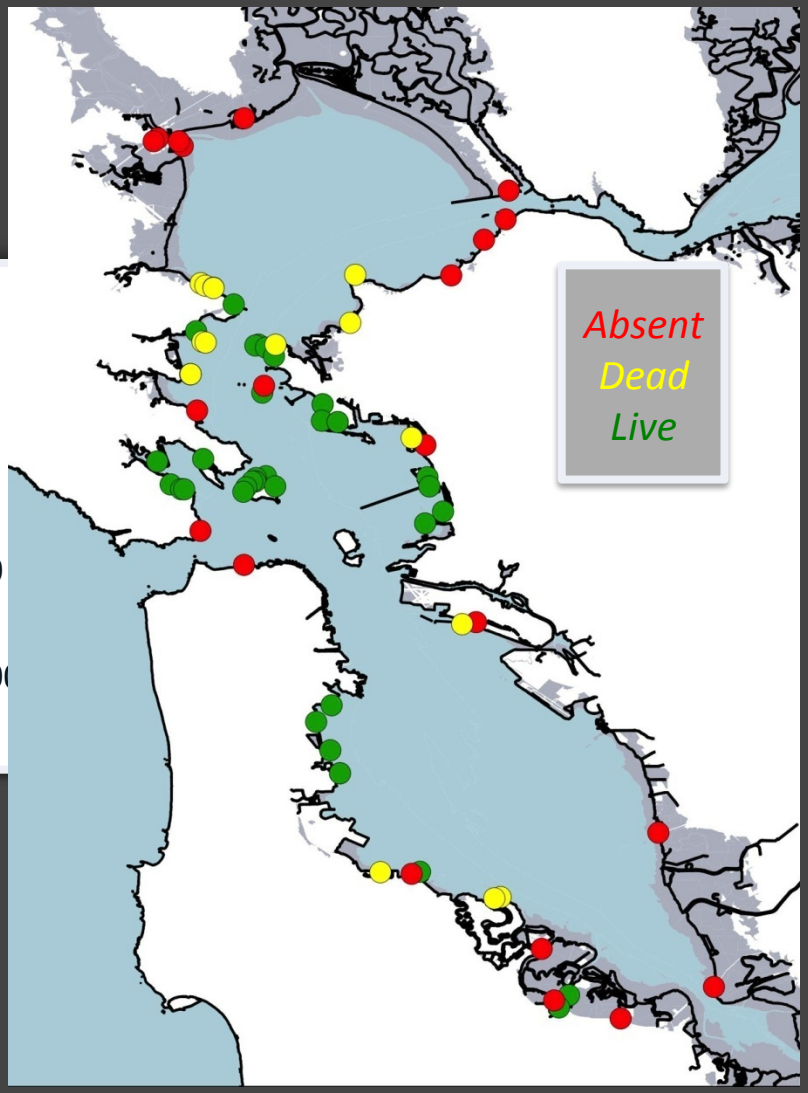
April 2010



Ostrea per m²

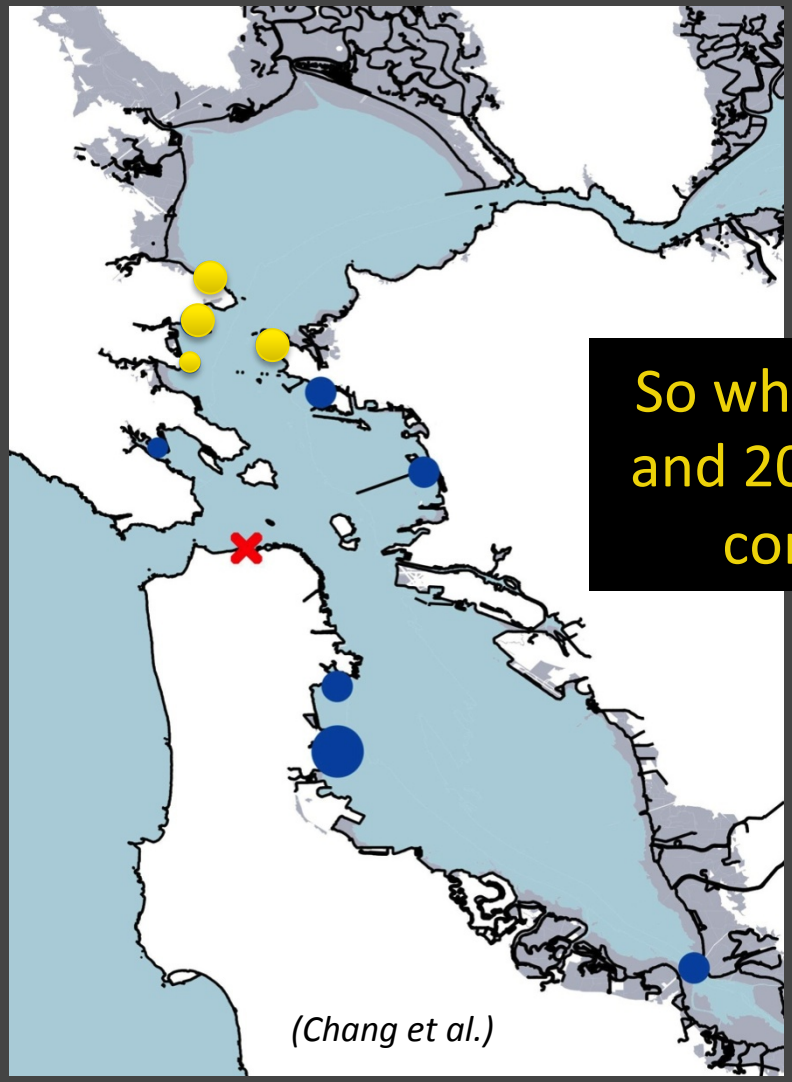
- Absent
- 1 – 50
- 50 – 200
- 200 – 500
- 500 – 200(

April 2016



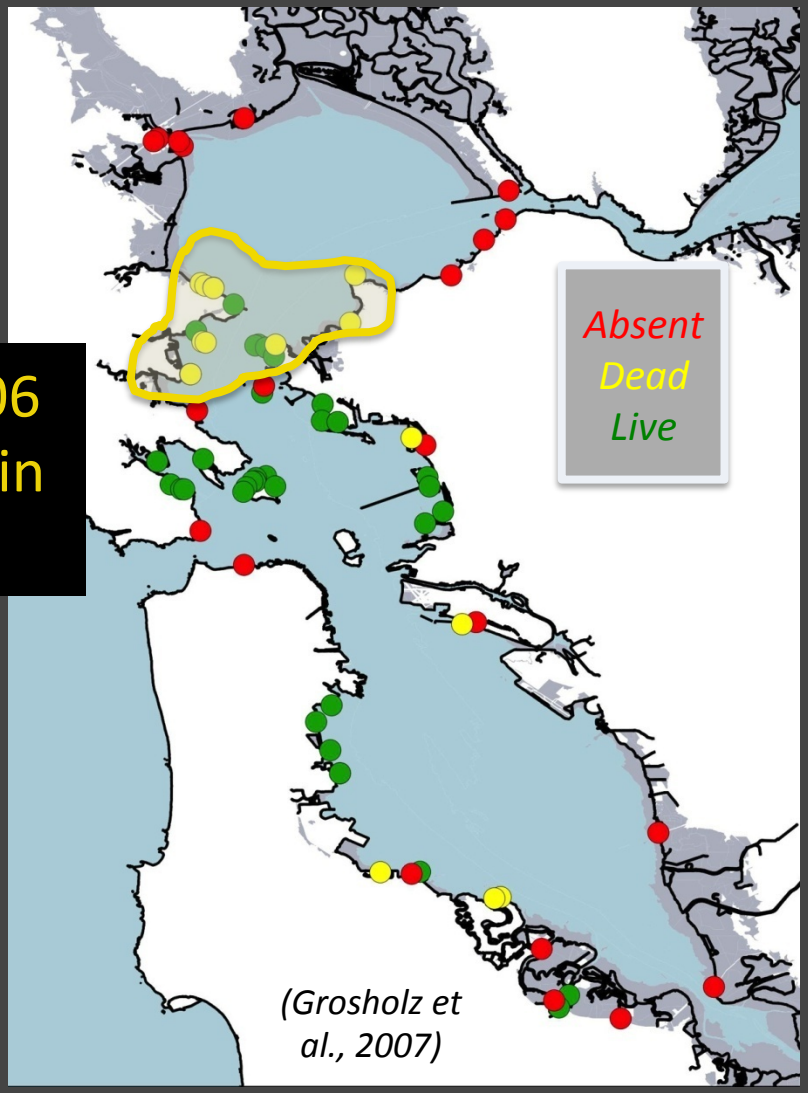
Is this always the way things are? No.

April 2011

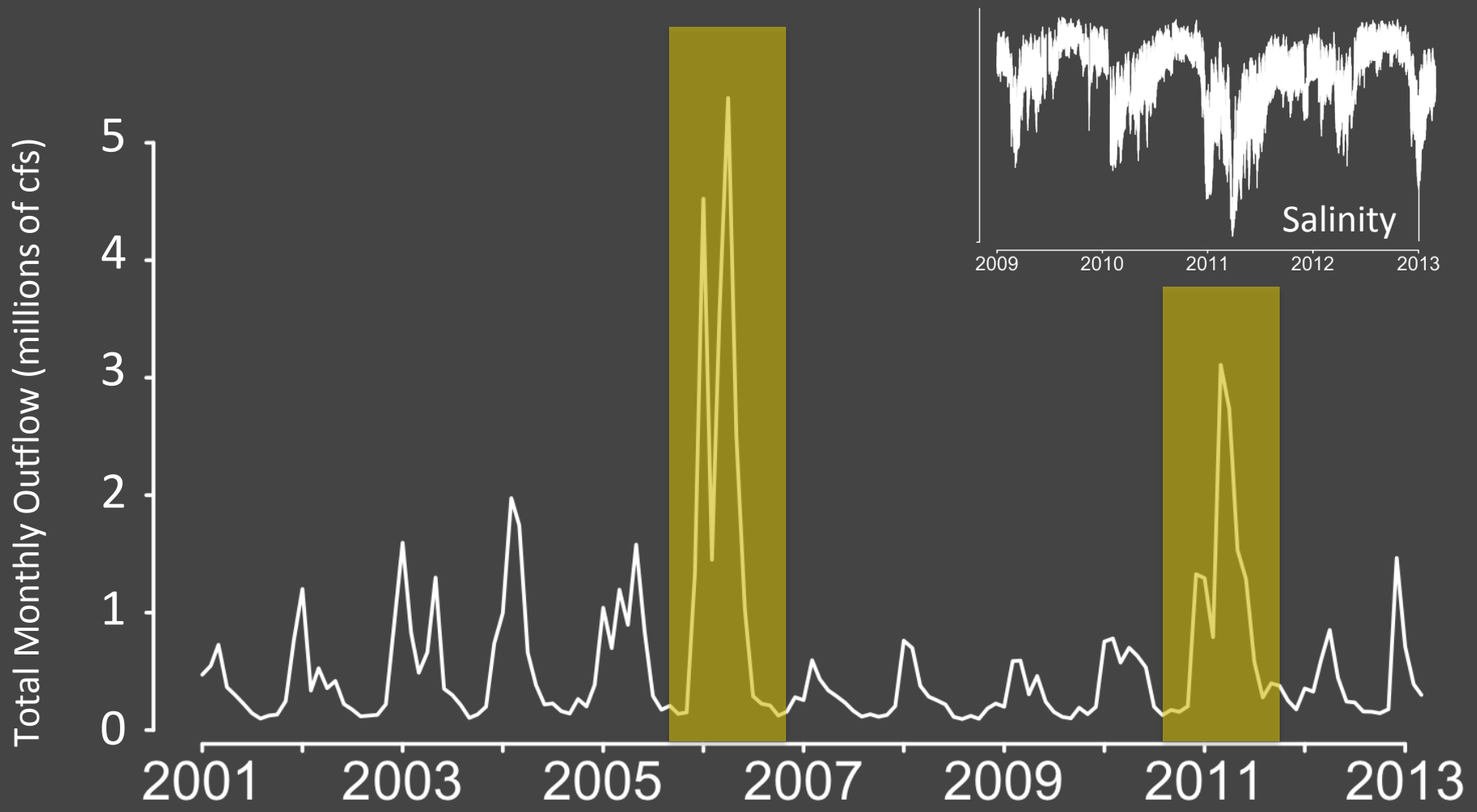


So what do 2006 and 2011 have in common?

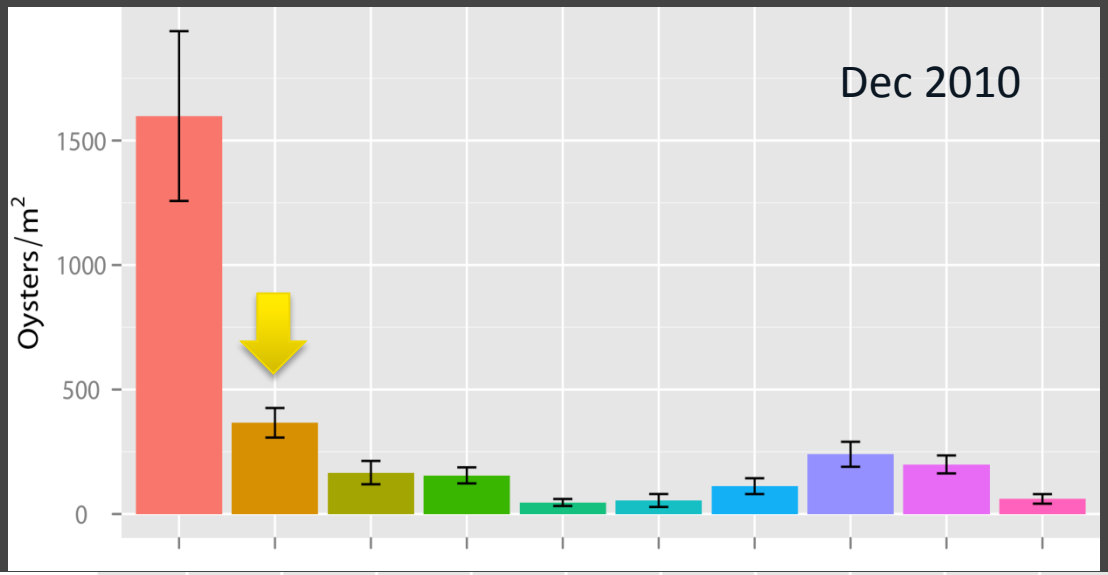
July 2006

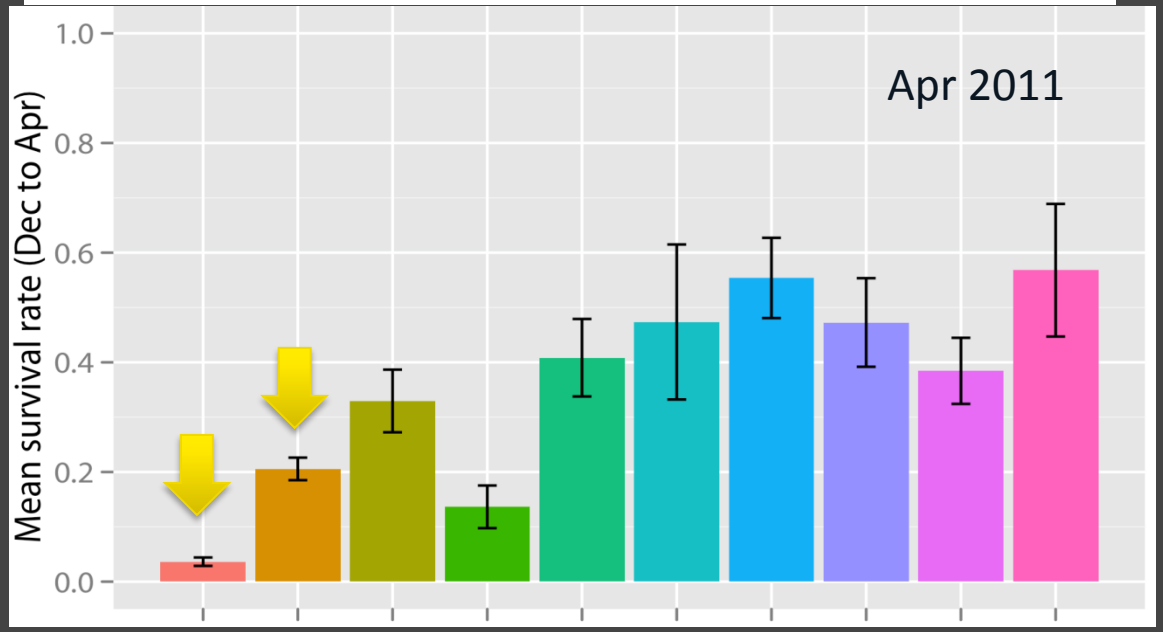


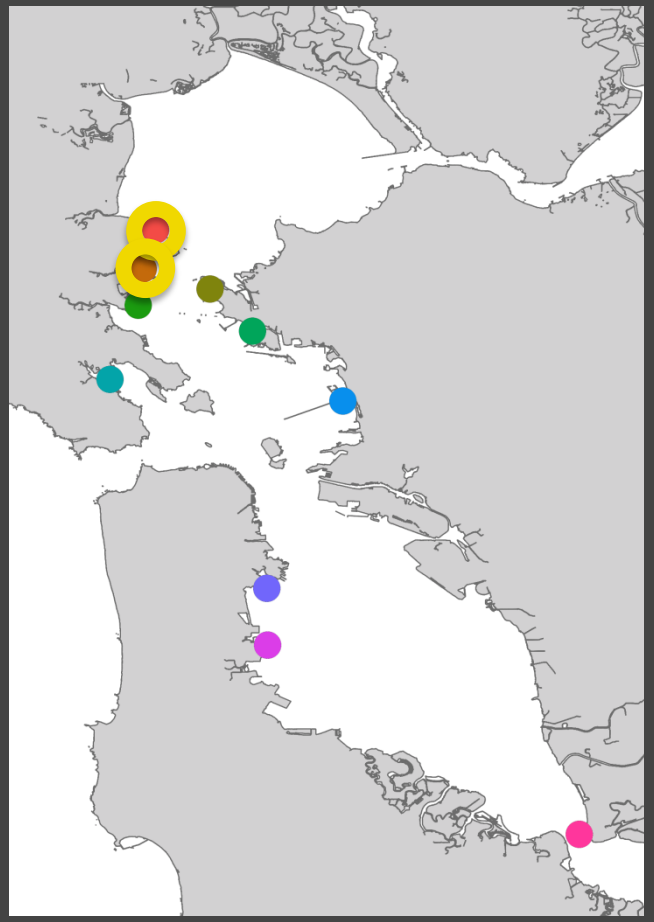
Fresh water entering San Francisco Bay



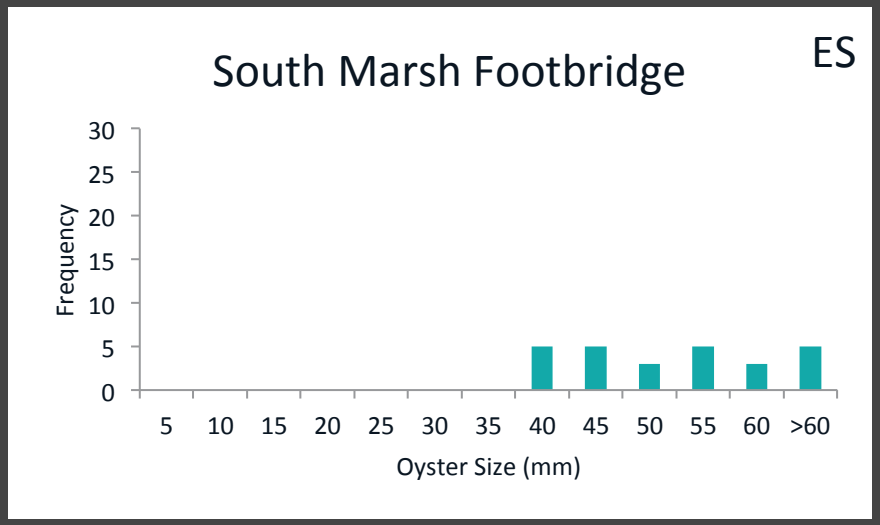
2011 wet winter killed North Bay *Ostrea*

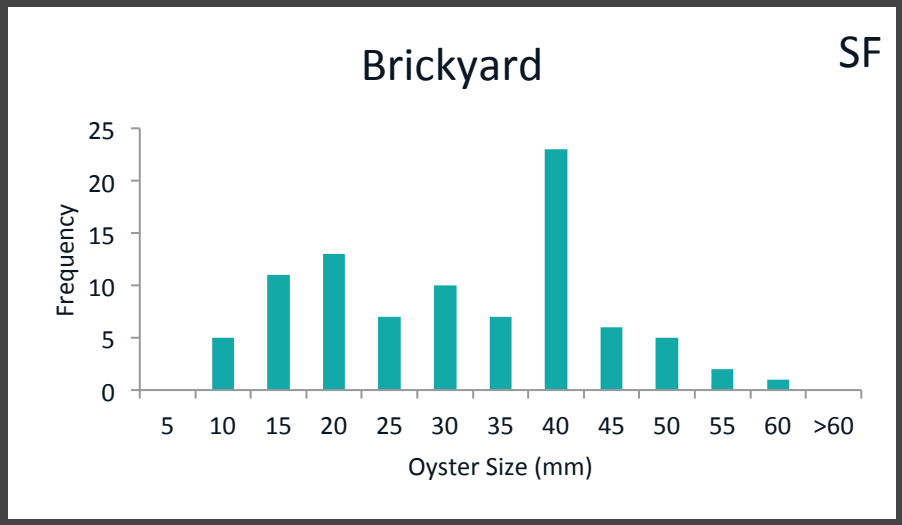


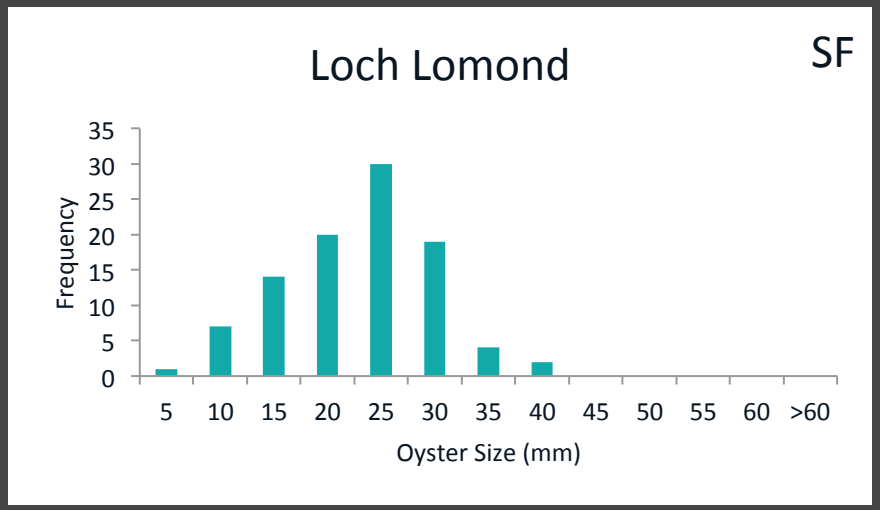


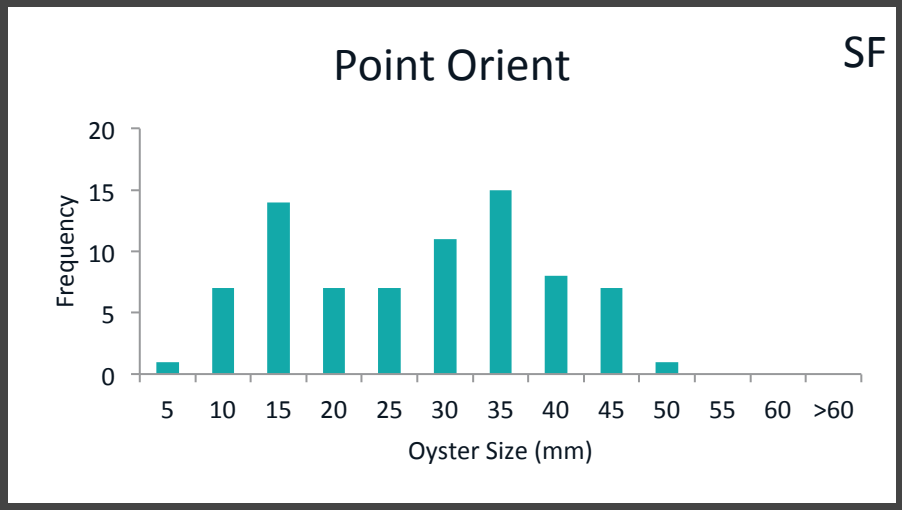


Size classes of *Ostrea:* Spring 2012



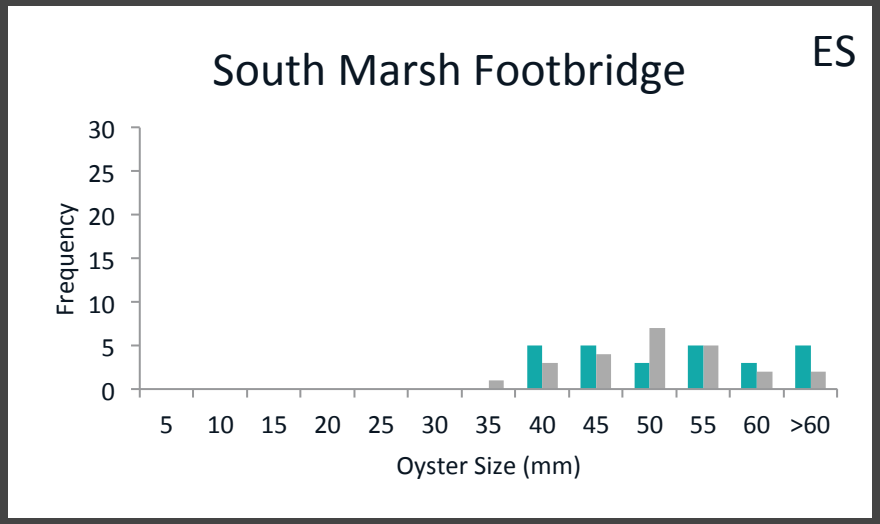


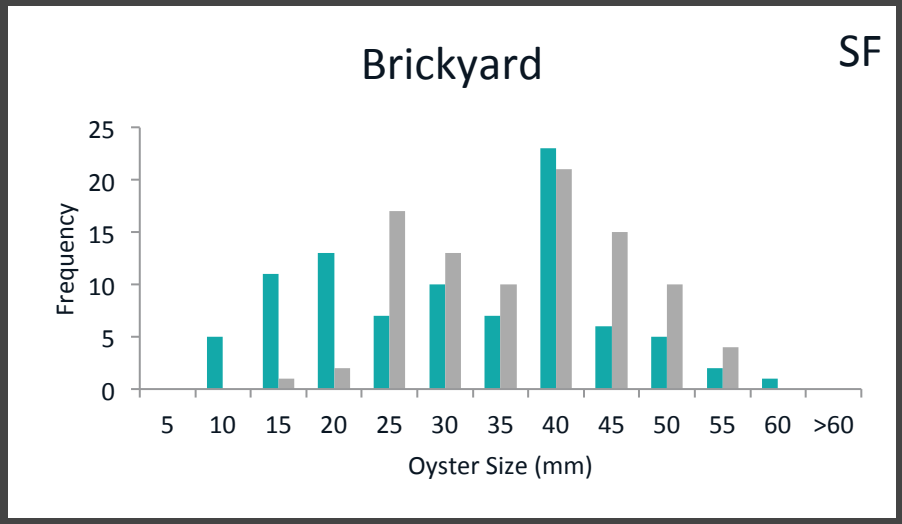


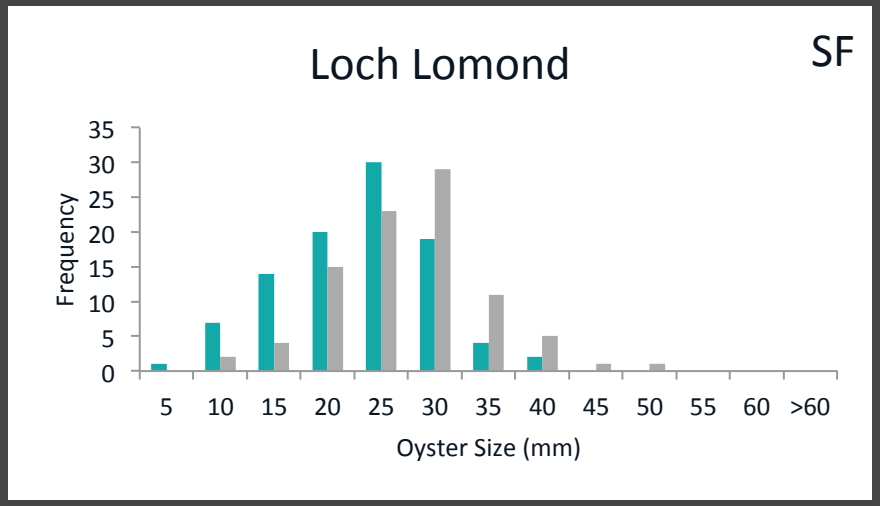


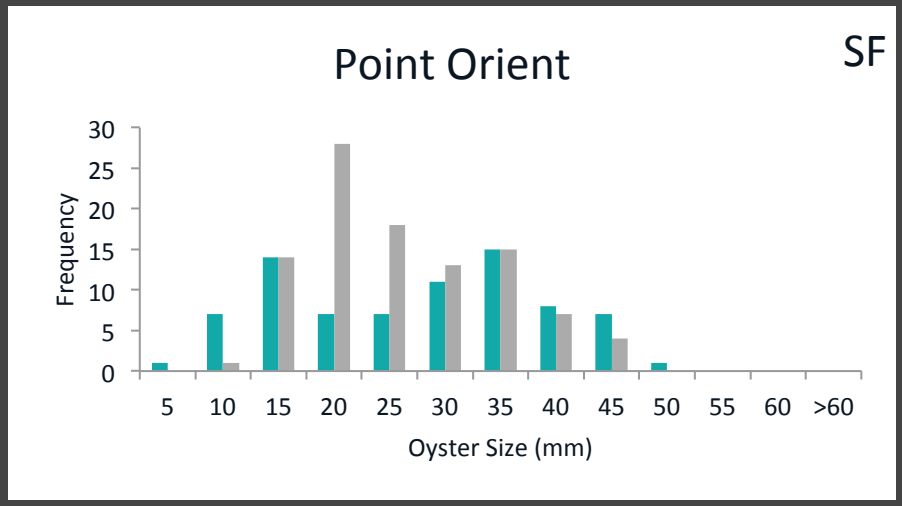
Spring 2012 Summer 2012 Fall 2012

Size classes of *Ostrea:* Summer 2012



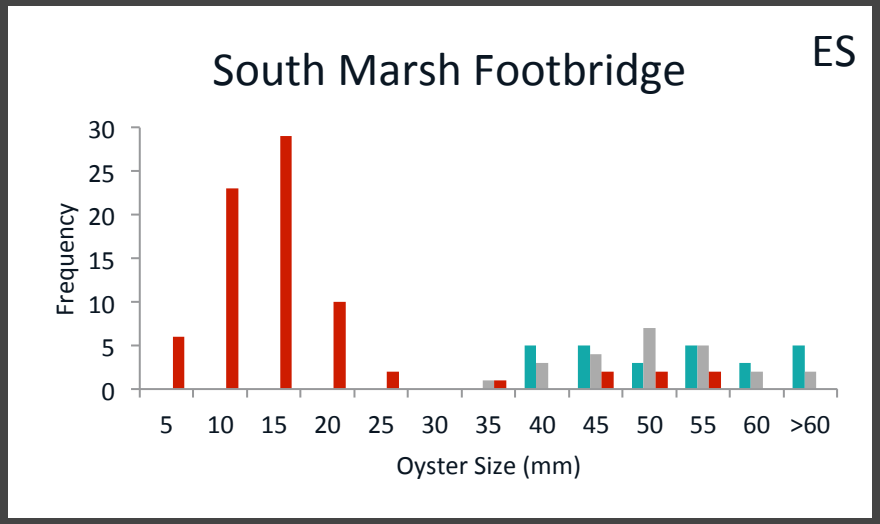


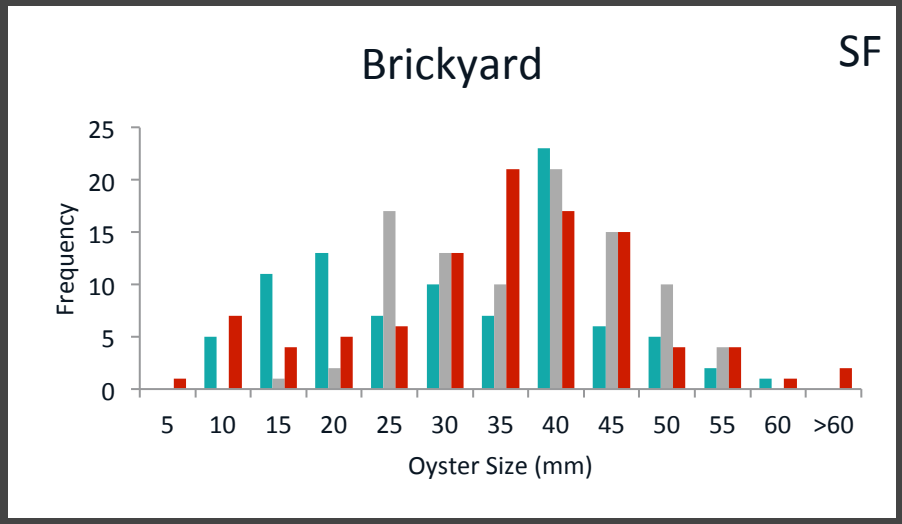


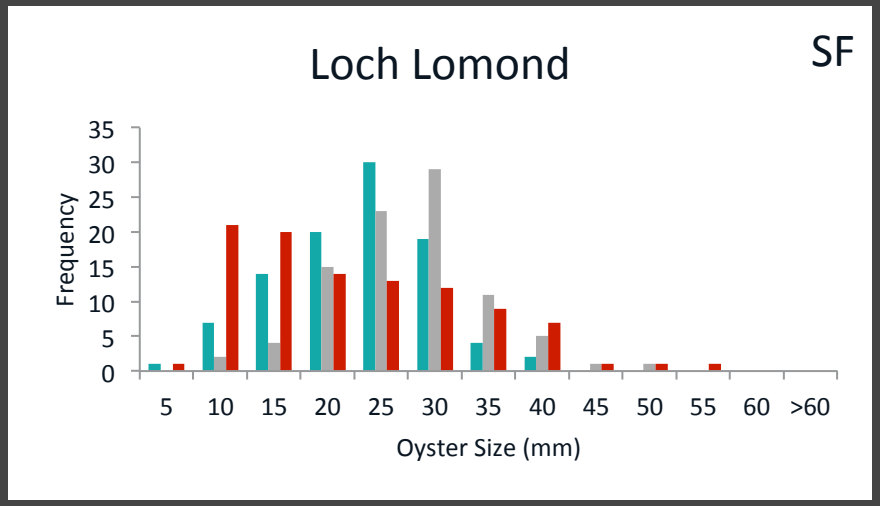


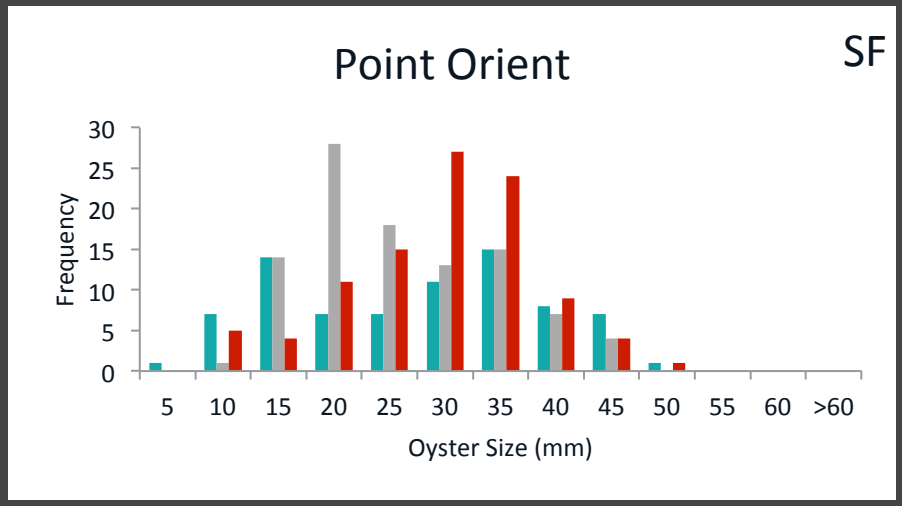
Spring 2012 Summer 2012 Fall 2012

Size classes of *Ostrea*: Fall 2012









Spring 2012 Summer 2012 Fall 2012

Summary

- Wide variation in temperature, salinity, DO
  - Across sites
  - Over time (daily, seasonal, interannual)
  - Links to survival, adult density

- Size class distributions show recruitment and survival vary over time across sites

Stressors & oyster performance

Oyster life cycle

- Free-swimming larvae
- Recruitment
- Growth to maturity
- Reproduction

Photos above, below: Jim Moore

How do stressors affect these life stages?

Oyster parameters we are measuring

- Reproduction (brooding)
- Recruitment
    - *larvae arrive
    - *larvae survive
- Connectivity between sites
- Growth
- Survivorship

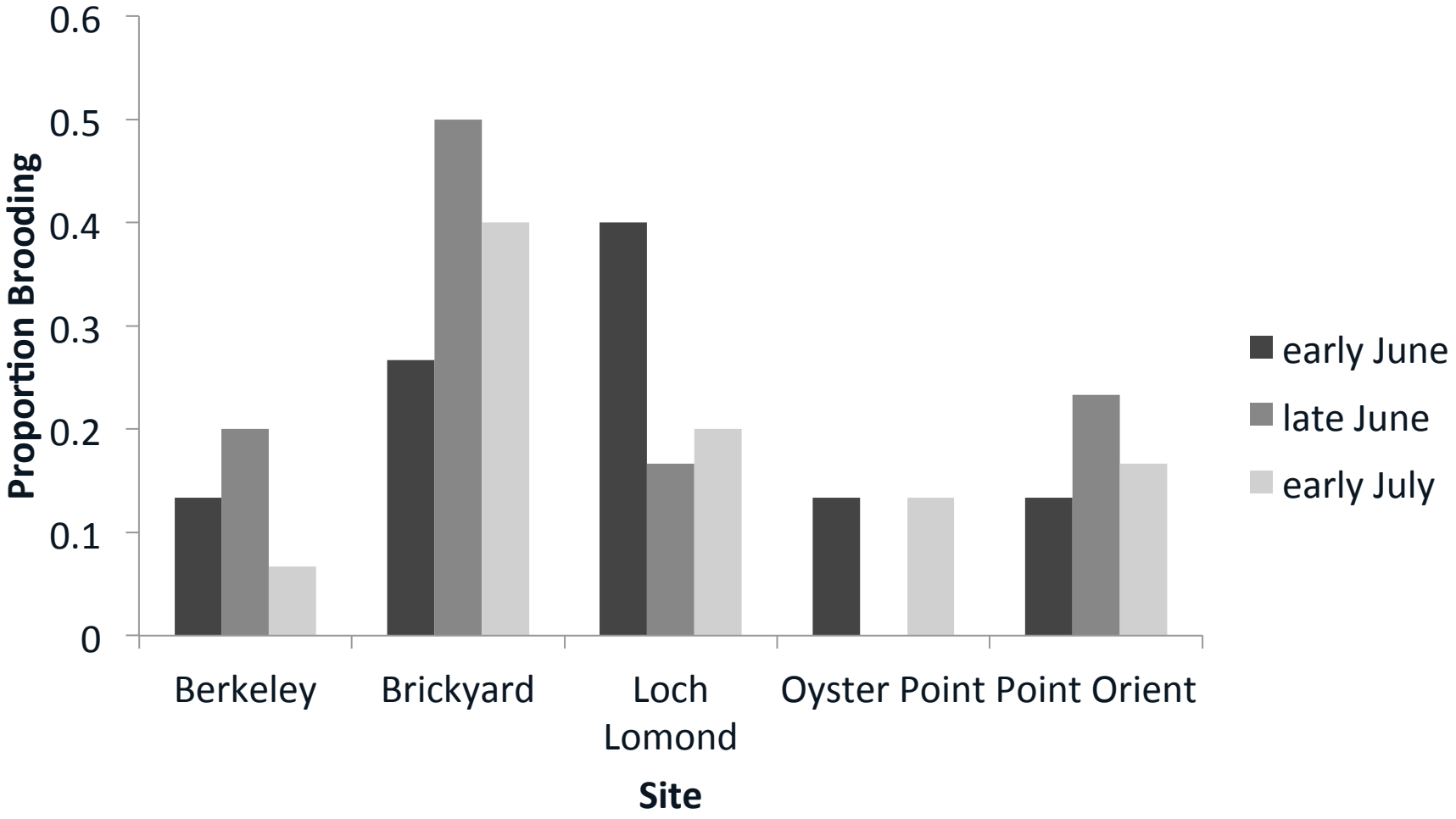
Reproduction

- 5 sites in SFB
- Biweekly sampling, summer
- 30 oysters

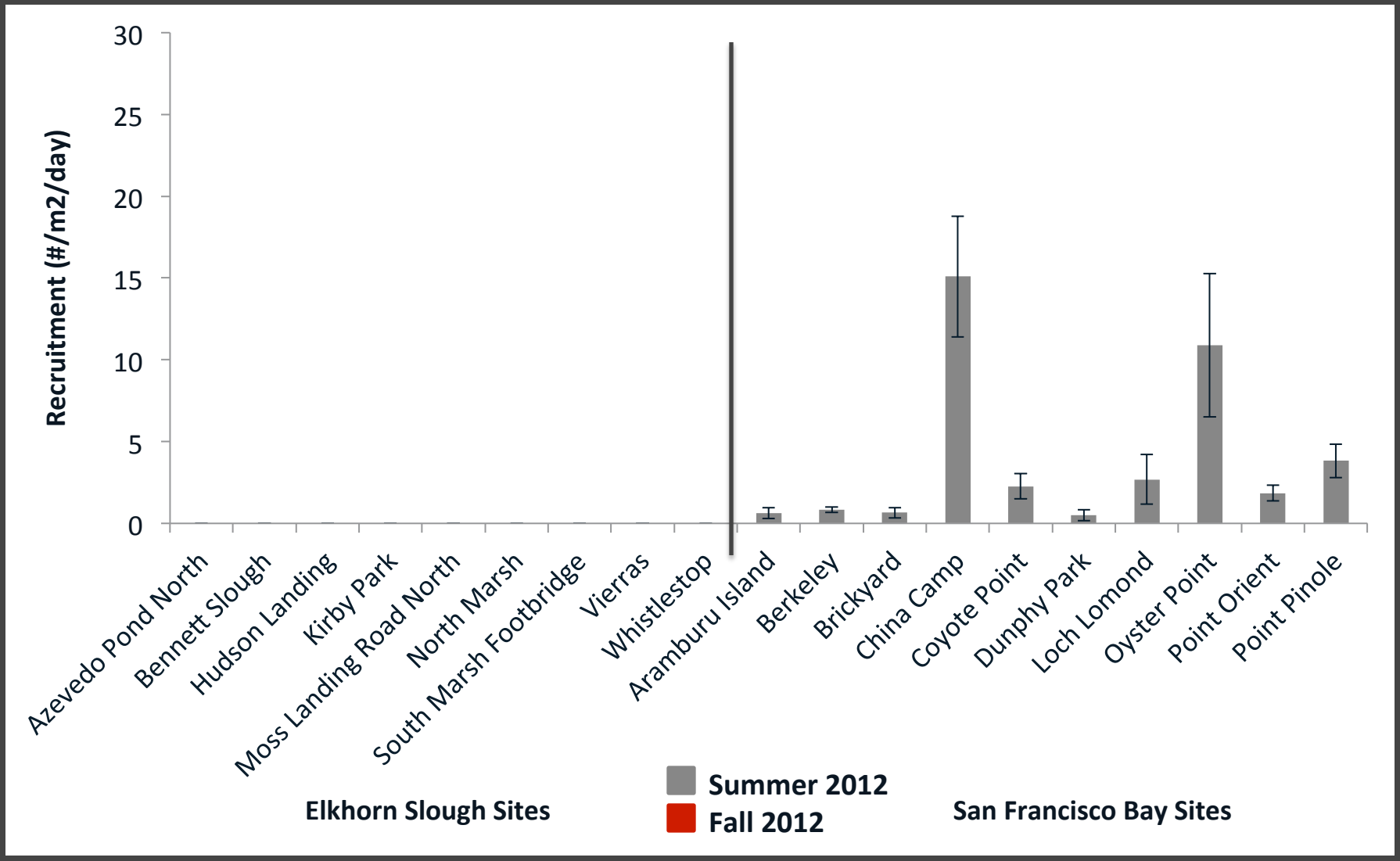
Recruitment

- 9 sites ES, 11 sites SFB , quarterly
- 8 sites in SF biweekly, summer
- 6 tiles
- Counted all recruits

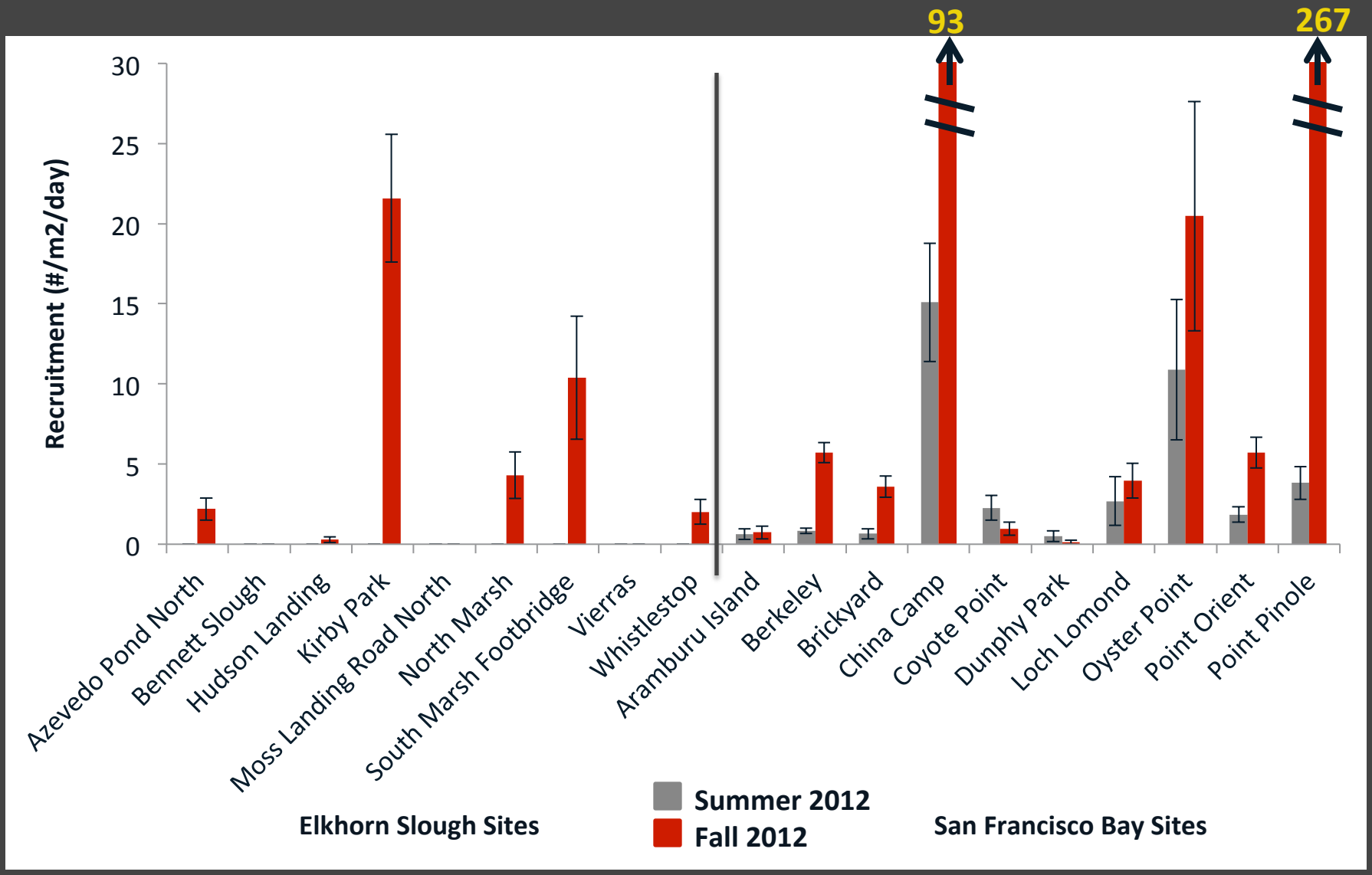
Oysters brooding larvae, SFB 2012



Recruitment: Summer 2012



Recruitment: Fall 2012

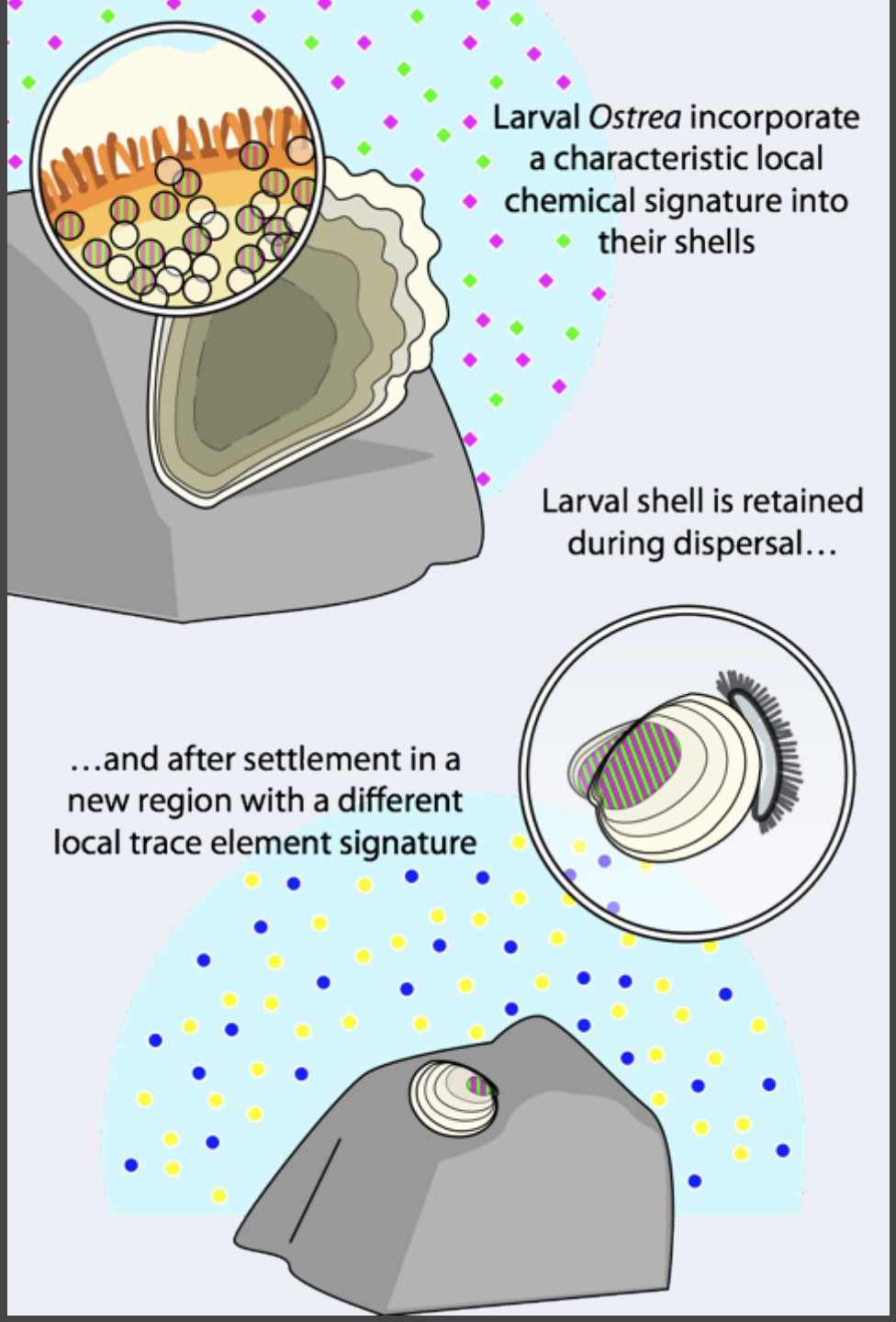


Recruitment and site connectivity

Open populations

- Larvae that recruit to one of our study sites may have originated elsewhere
- Some sites might be sources and others might be sinks
- Important to know this for conservation; need to protect source populations

We may be able to assess this by analyzing oyster shell chemistry


Larval *Ostrea* incorporate a characteristic local chemical signature into their shells
Larval shell is retained during dispersal…
…and after settlement in a new region with a different local trace element signature

Recruitment and site connectivity

- Shell chemistry of larvae
- Compared with recruits sampled biweekly

Preliminary findings: field data

- Environmental factors
  - Max air temp
  - Max water temp

- Oyster performance
  - Recruitment
  - Density

Preliminary findings: field data

- Environmental factors
- Dissolved oxygen

- Oyster performance
- Juvenile oyster size

Preliminary findings: field data

- Environmental factors
- Turbidity

- Oyster performance
- Recruitment

Preliminary findings: field data

- Environmental factors
- Mussel cover

- Oyster performance
- Adult oyster size

"Big soup" Analysis

- Environmental factors
  - Water and air temperature
  - Salinity
  - Dissolved oxygen
  - Turbidity
  - Chl A
  - Sedimentation
  - Substrate (amount and size)
  - Presence and abundance of sessile organisms

+ 1

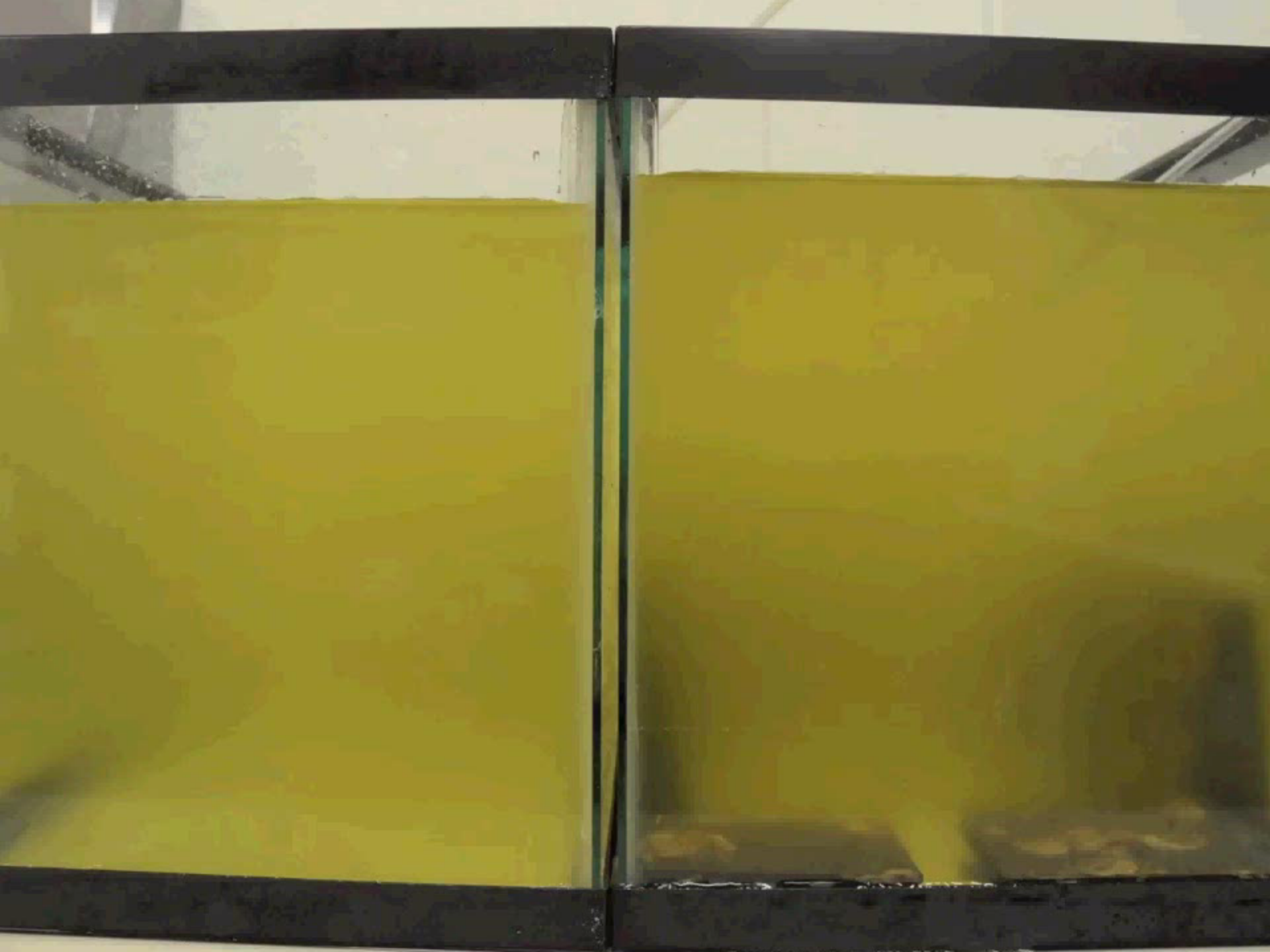
+ 3

- 5

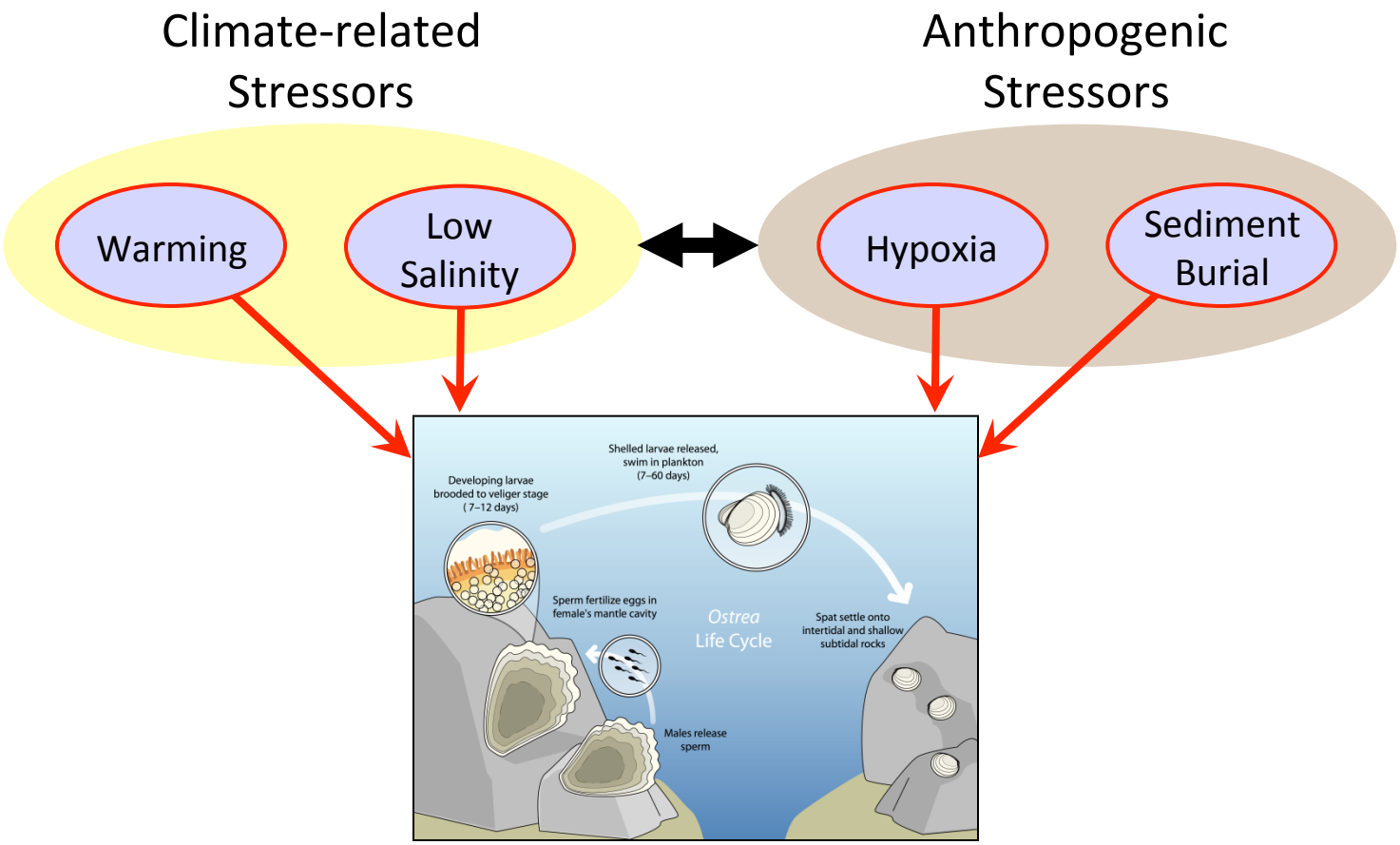
- Oyster performance
  - Reproduction (brooding)
  - Recruitment
    - *larvae arrive
    - *larvae survive
  - - Connectivity between sites
  - Growth
  - Survivorship
  - Density
  - Sizes

Lab Experiment Update: Effects of Stressors on Olympia Oysters

Brian Cheng
Bodega Marine Laboratory
University of California, Davis
Email: bscheng@ucdavis.edu



Simplified conceptual model

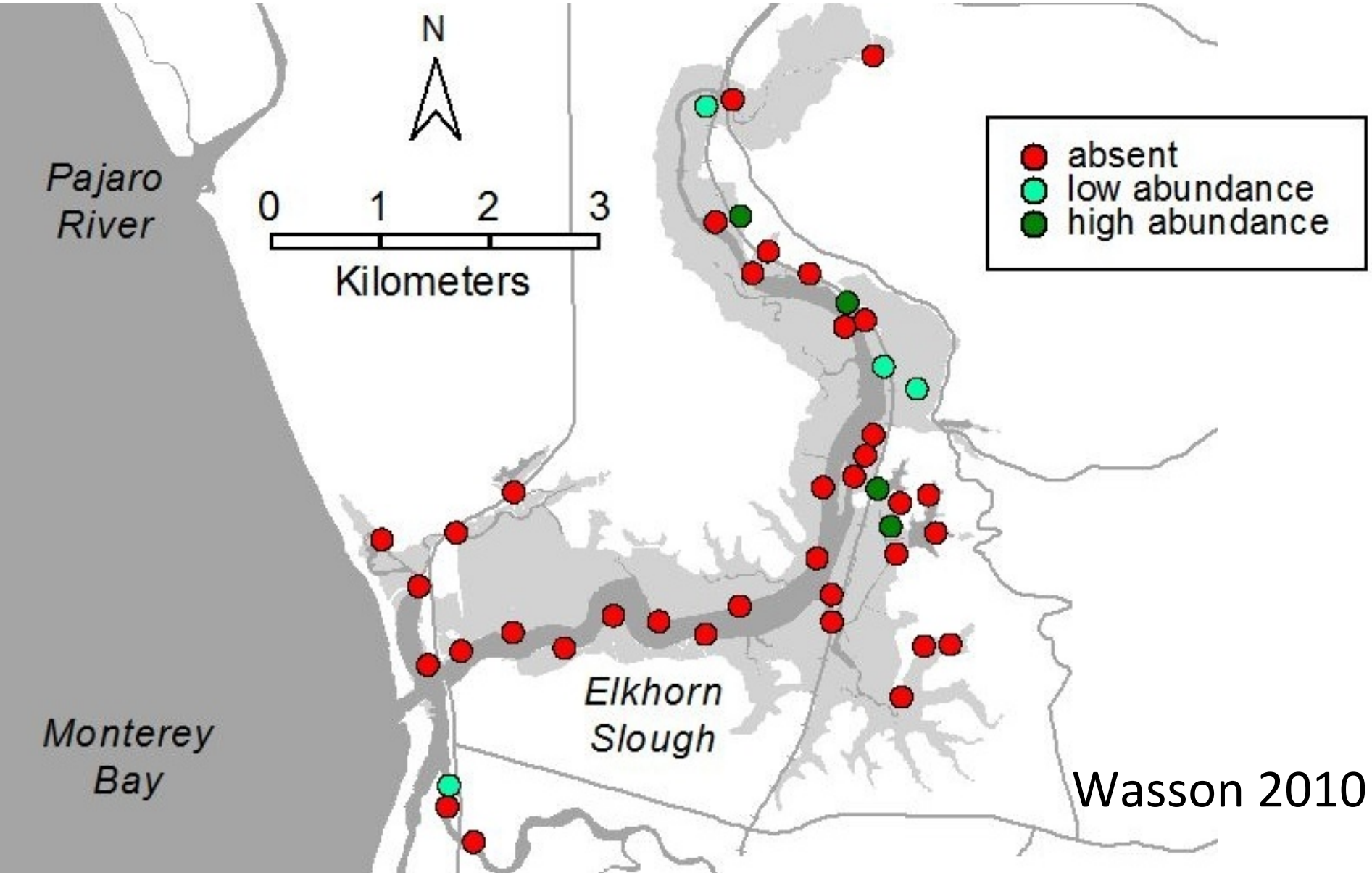


Elkhorn Slough

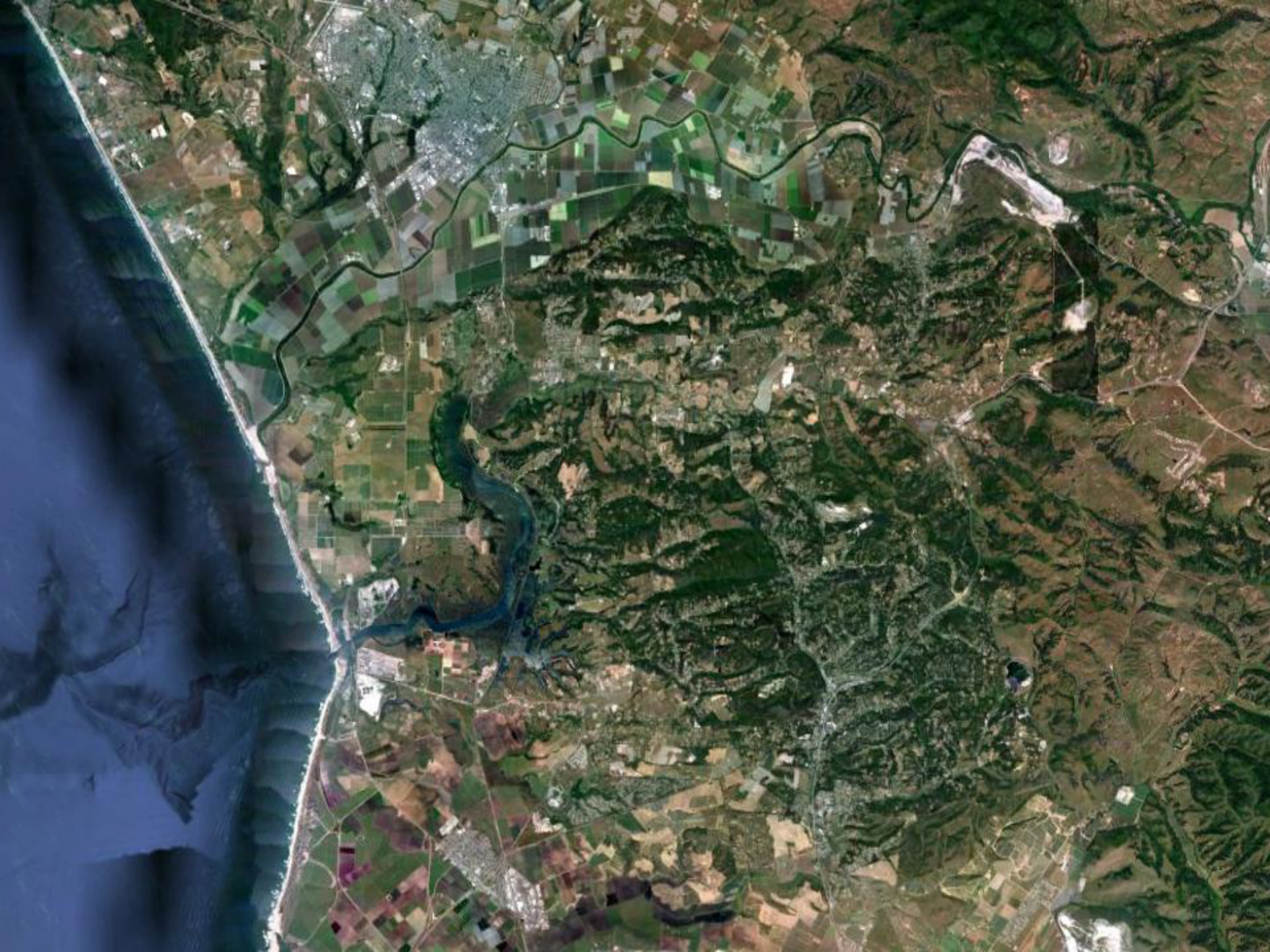
You are here

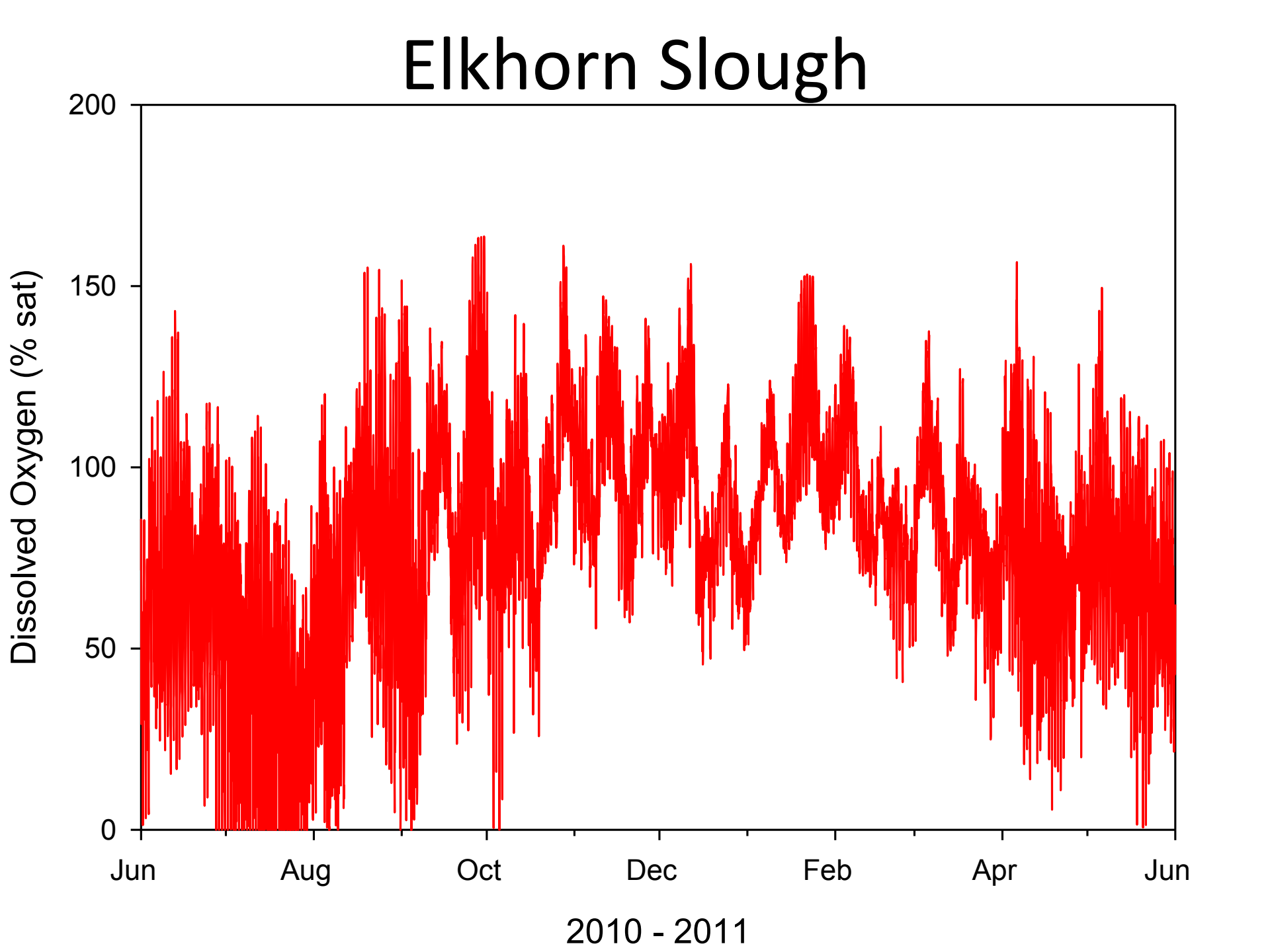
Oyster population estimate ~ 5,000

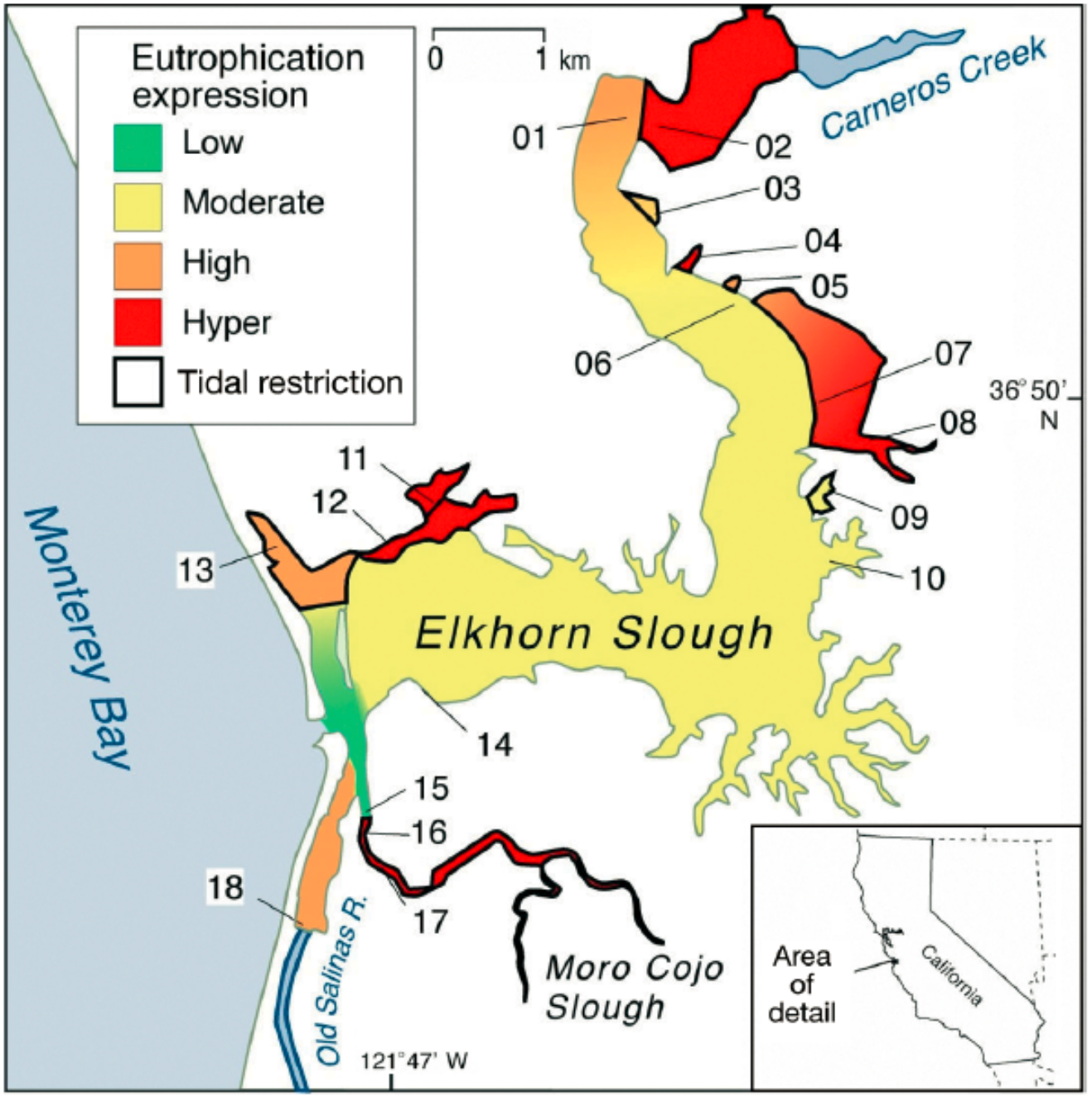
Oysters absent from most of estuary



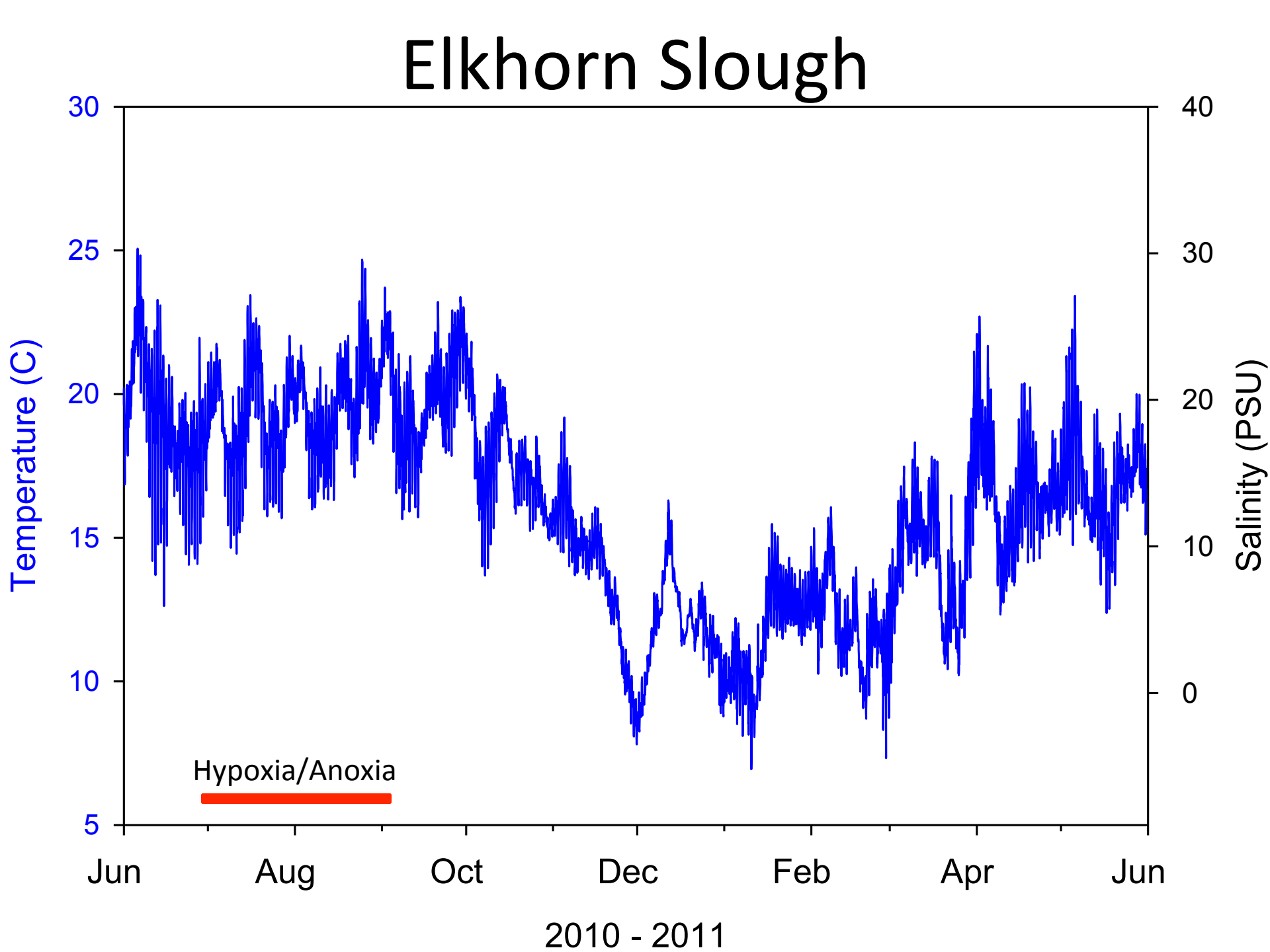
Wasson 2010

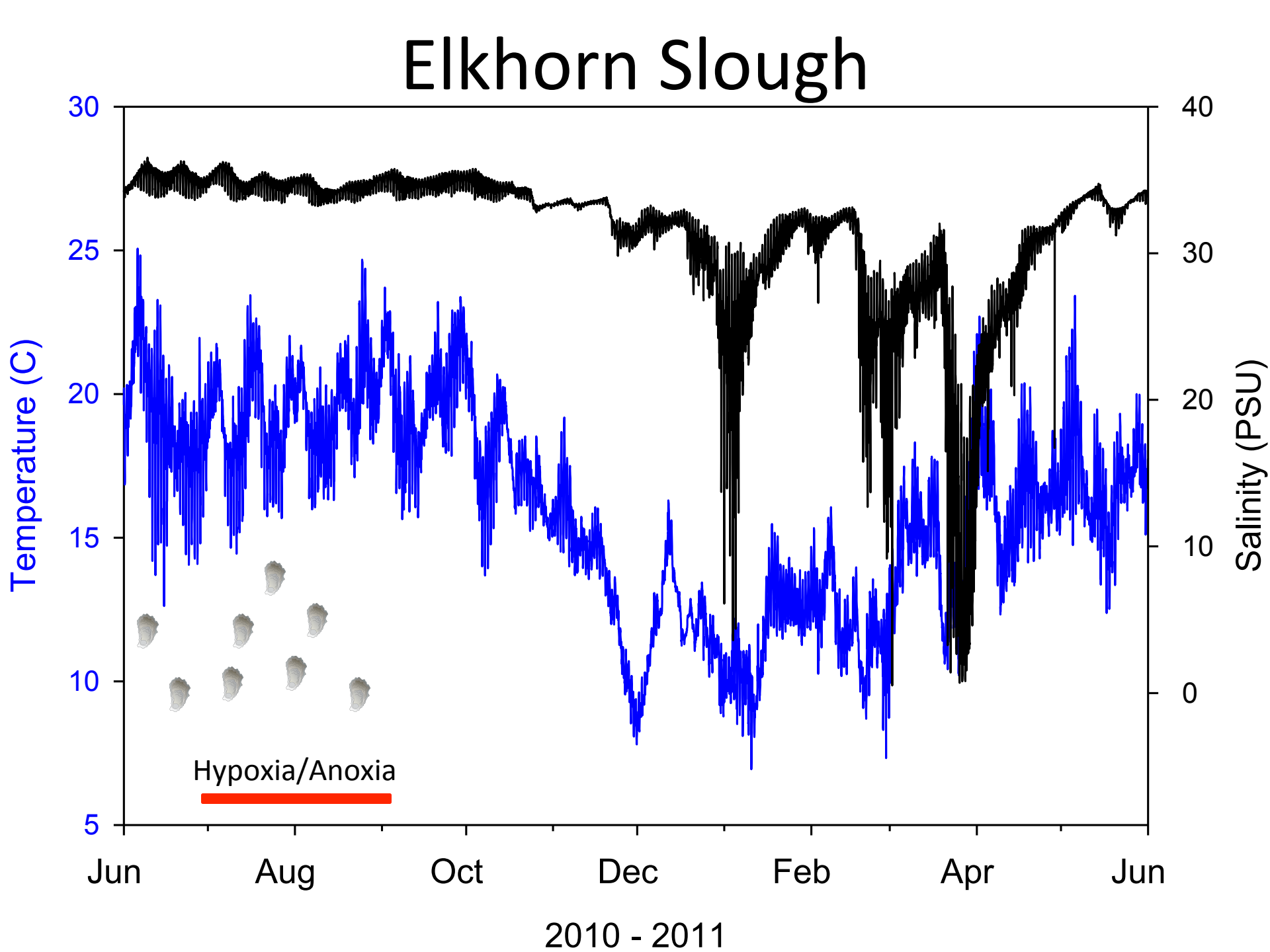



Elkhorn Slough
Dissolved Oxygen (% sat)
200
150
100
50
0
Jun
Aug
Oct
Dec
Feb
Apr
Jun
2010 - 2011



Hughes et al. 2011


Elkhorn Slough
30
25
20
15
10
5
Temperature (C)
40
30
20
10
0
Salinity (PSU)
Hypoxia/Anoxia
Jun
Aug
Oct
Dec
Feb
Apr
Jun
2010 - 2011


Elkhorn Slough
30
25
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Temperature (C)
40
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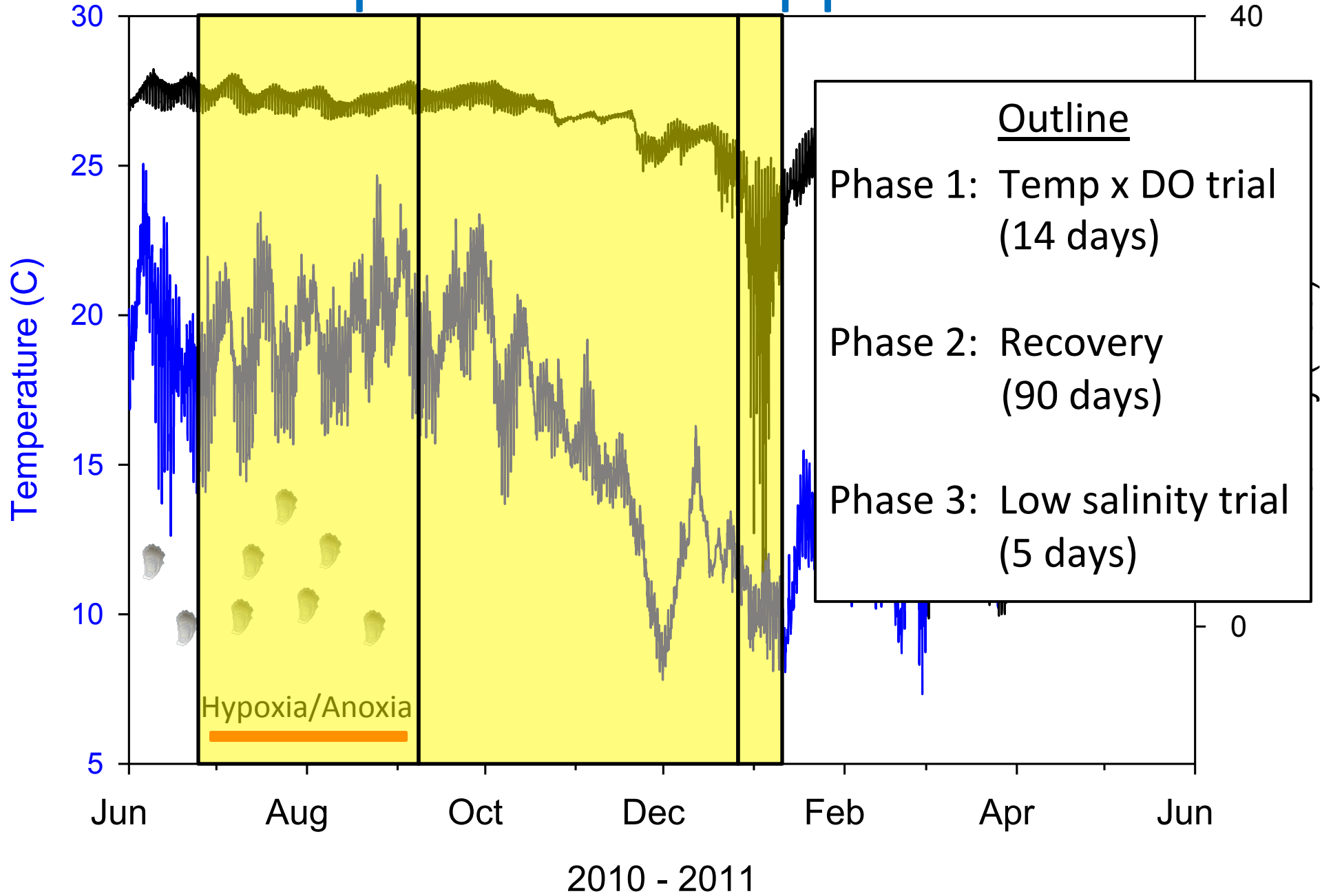
20
10
0
Salinity (PSU)
Hypoxia/Anoxia
Jun
Aug
Oct
Dec
Feb
Apr
Jun
2010 - 2011

Experimental Approach

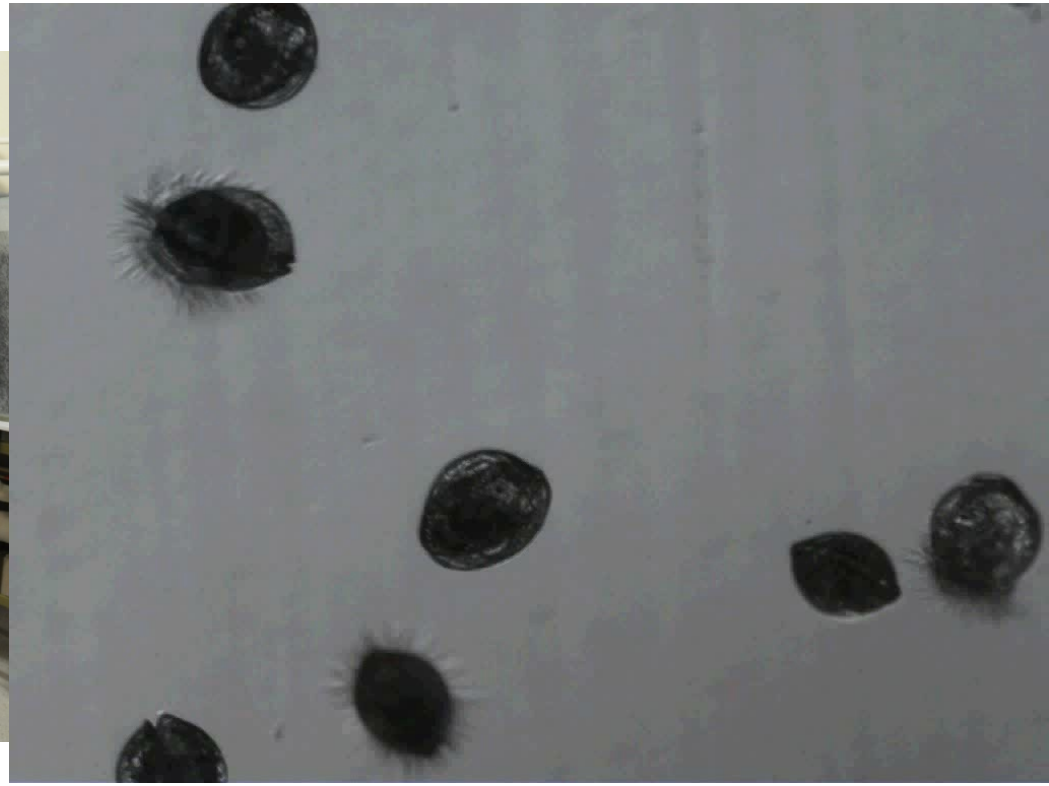


Questions

1. How do multiple simultaneous stressors affect oysters? (temp x DO)
2. Are oysters capable of recovering from these stressors over time?
3. Does early stress affect performance at later stages in response to low salinity? (latent effect?)

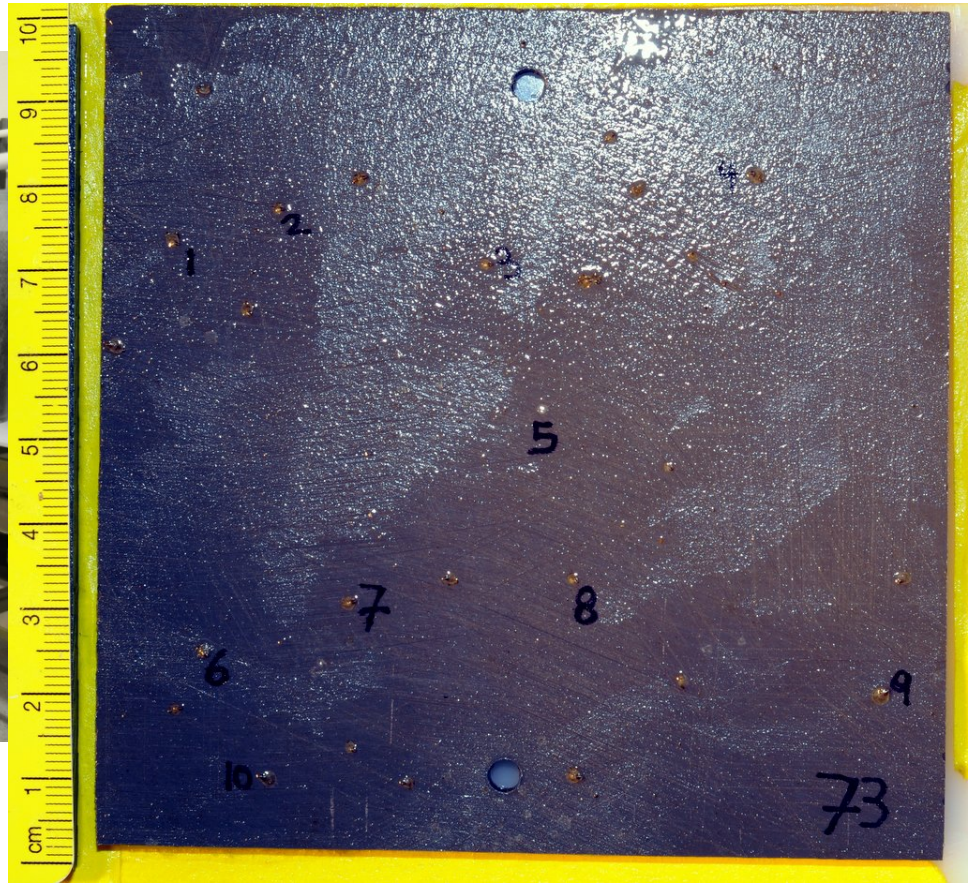
Methods

- Spawned oysters from San Francisco Bay adults (6 collection sites)



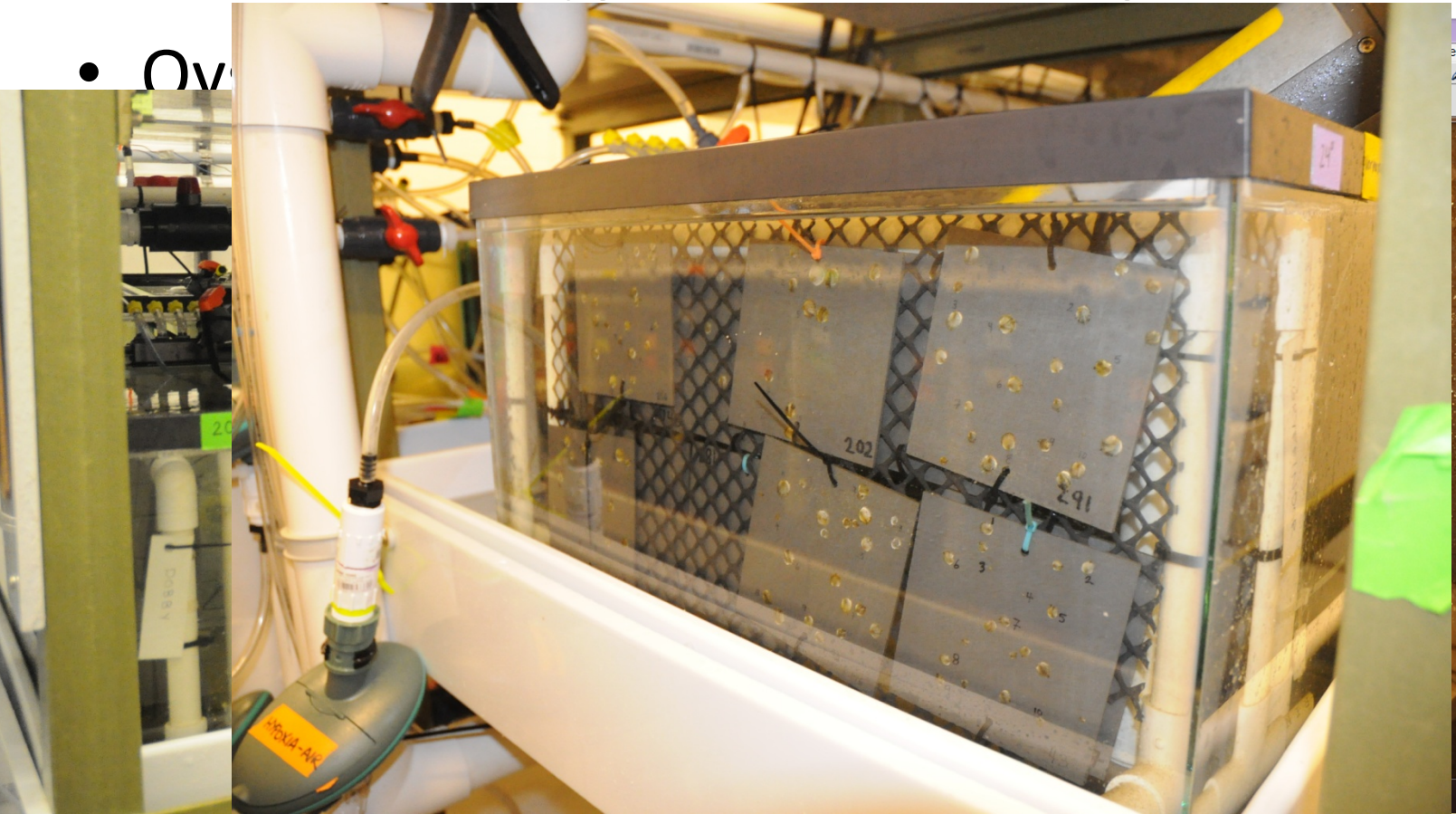
Methods

- Spawned oysters from San Francisco Bay (6 collection sites)

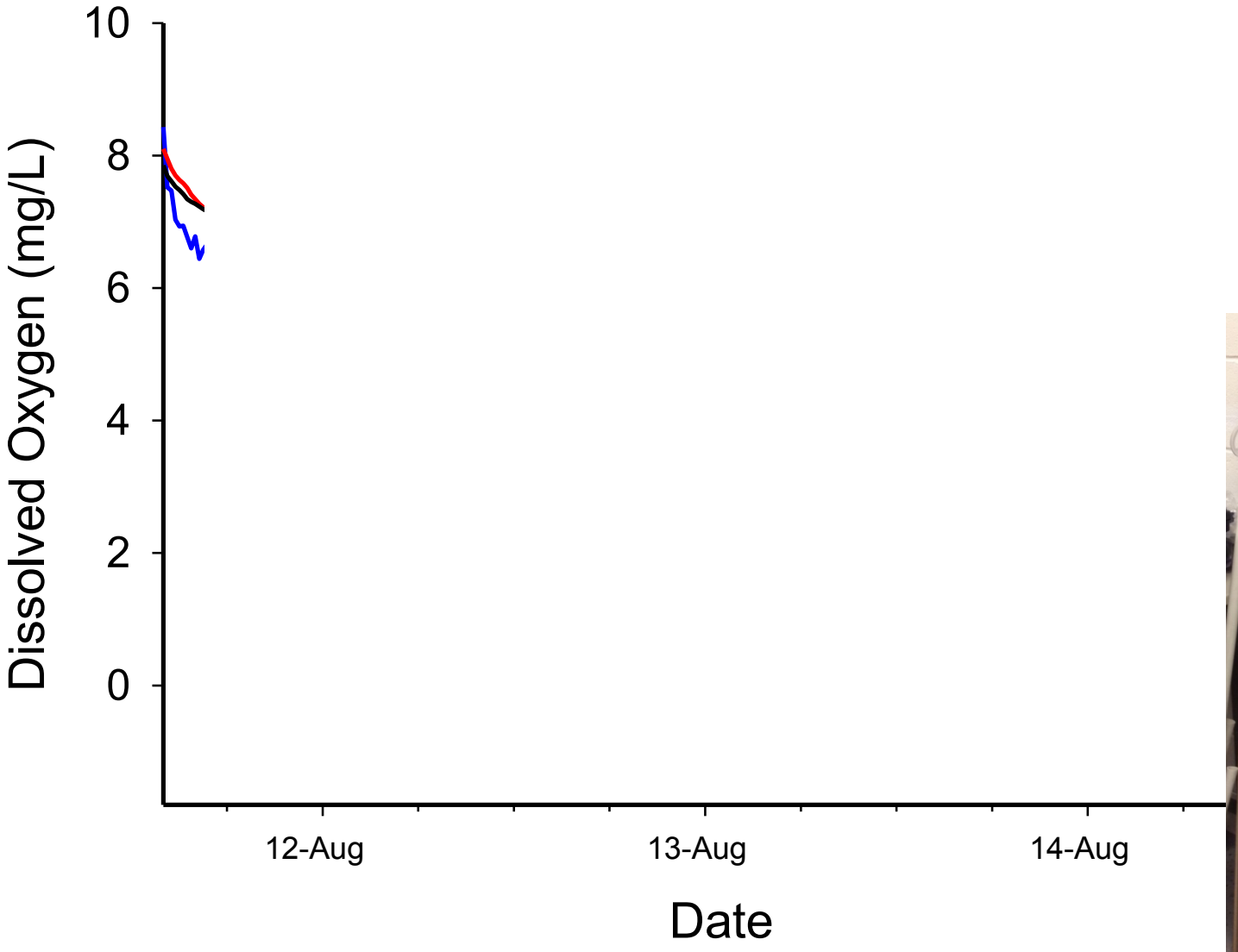


Methods – Phase 1

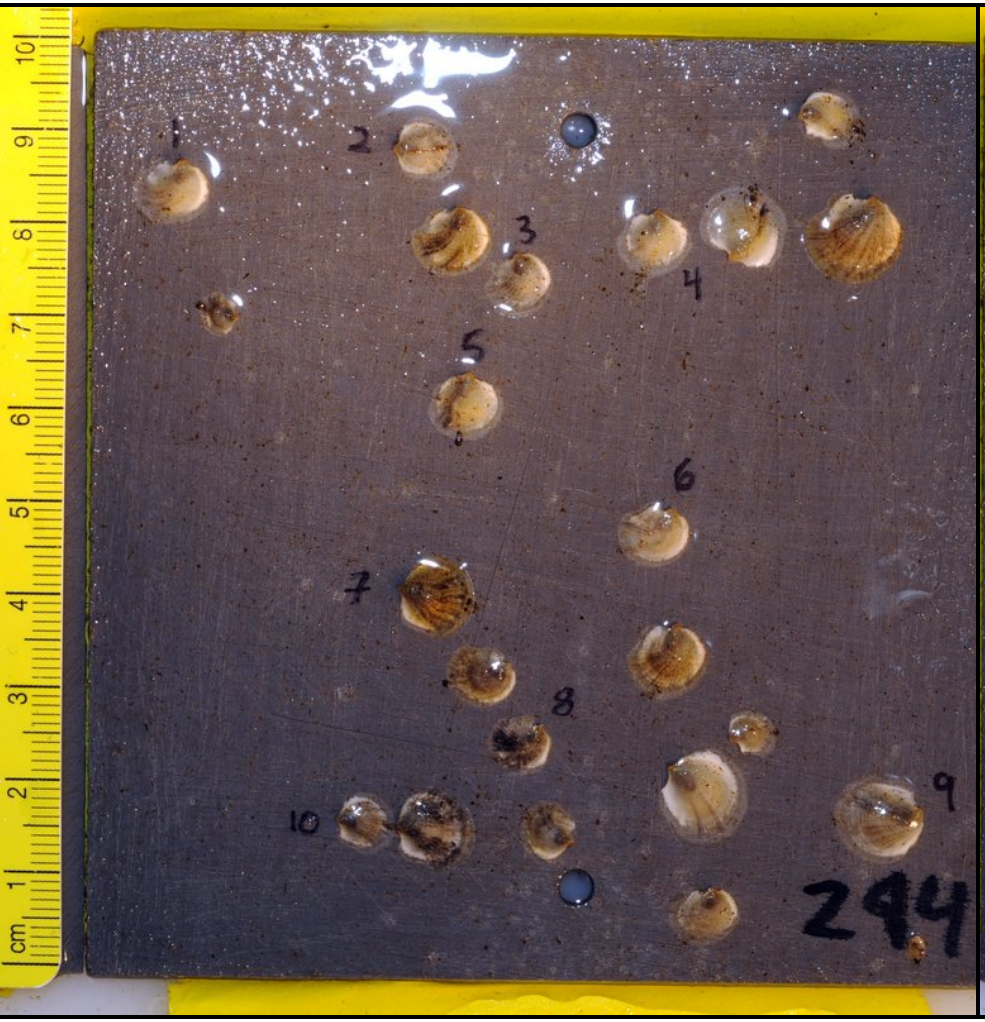
- Subjected newly settled oysters to
  - Temperatures: 20/24° C
  - Dissolved oxygen: 0.6, 2.0, 6.5 mg/L
- Oy



Trial conditions

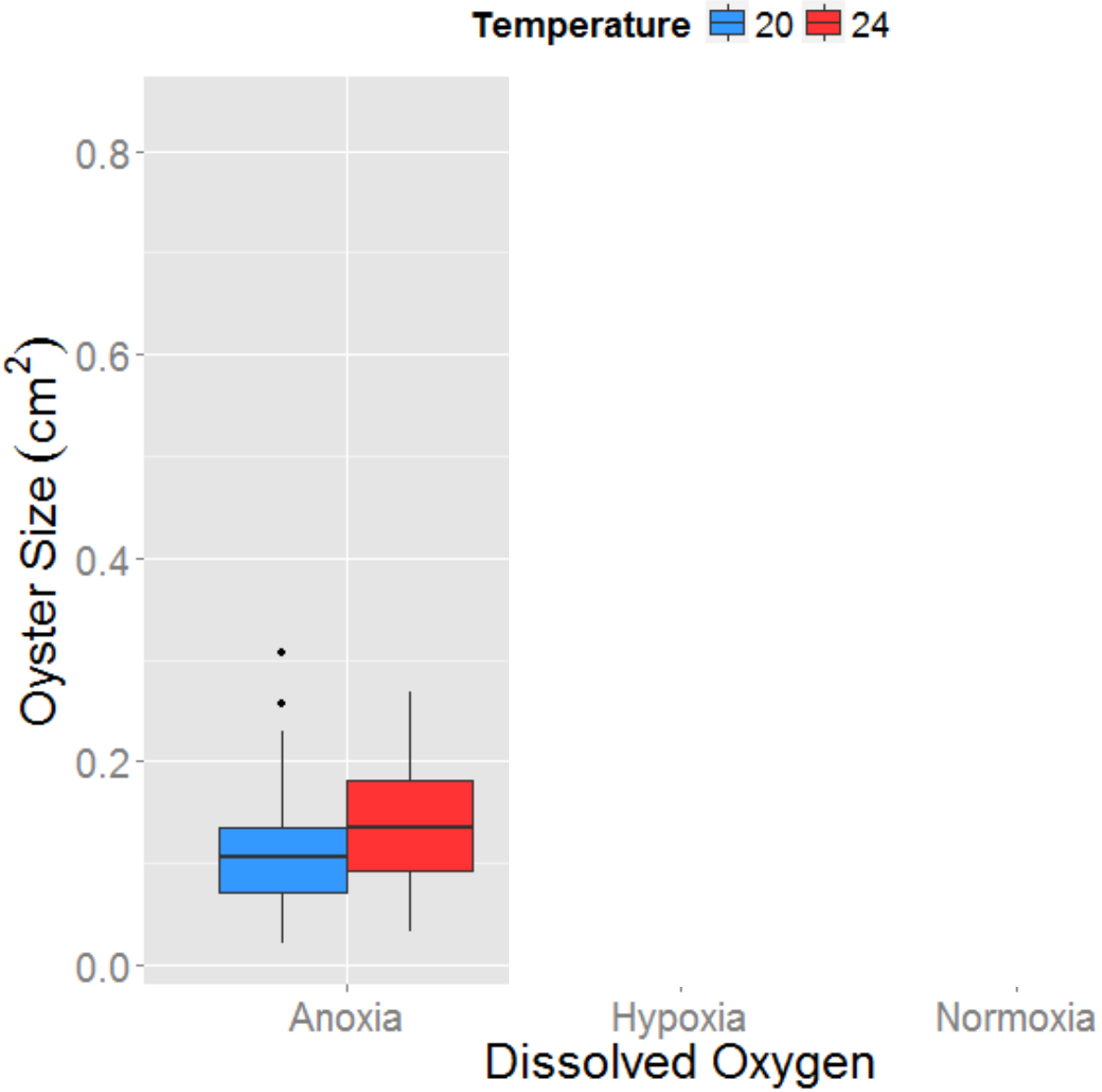


24° C Normoxia



24° C Anoxia

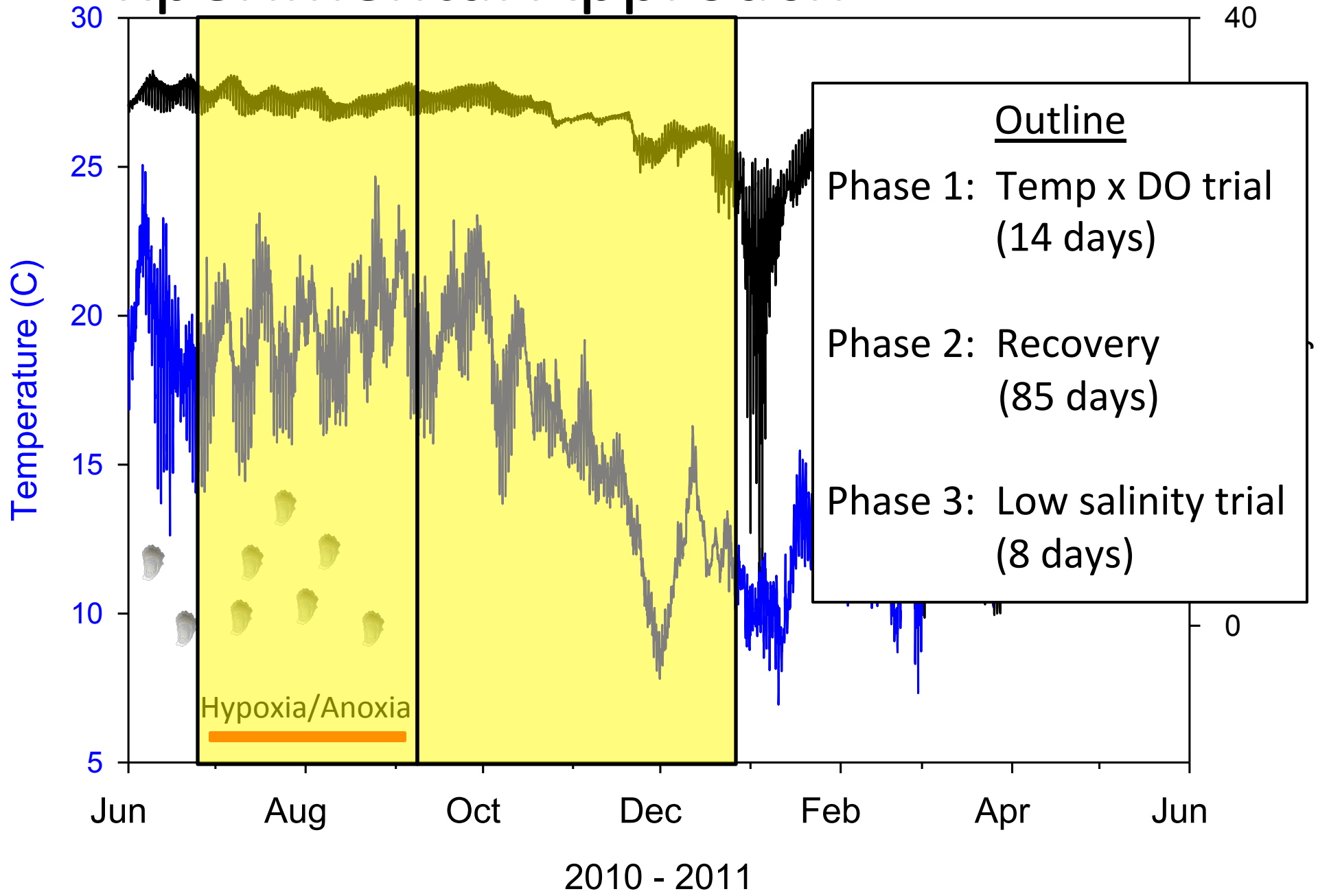
Phase 1: Oyster Growth at 2 weeks



Both DO and Temp have an effect on growth (insert effect size here)

DO has larger effects

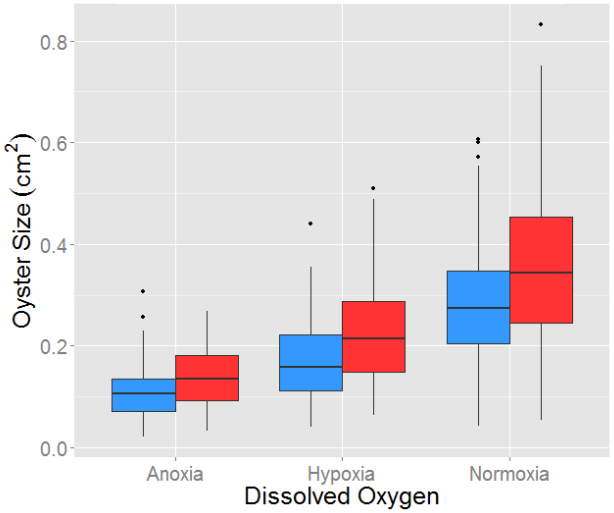
Experimental Approach

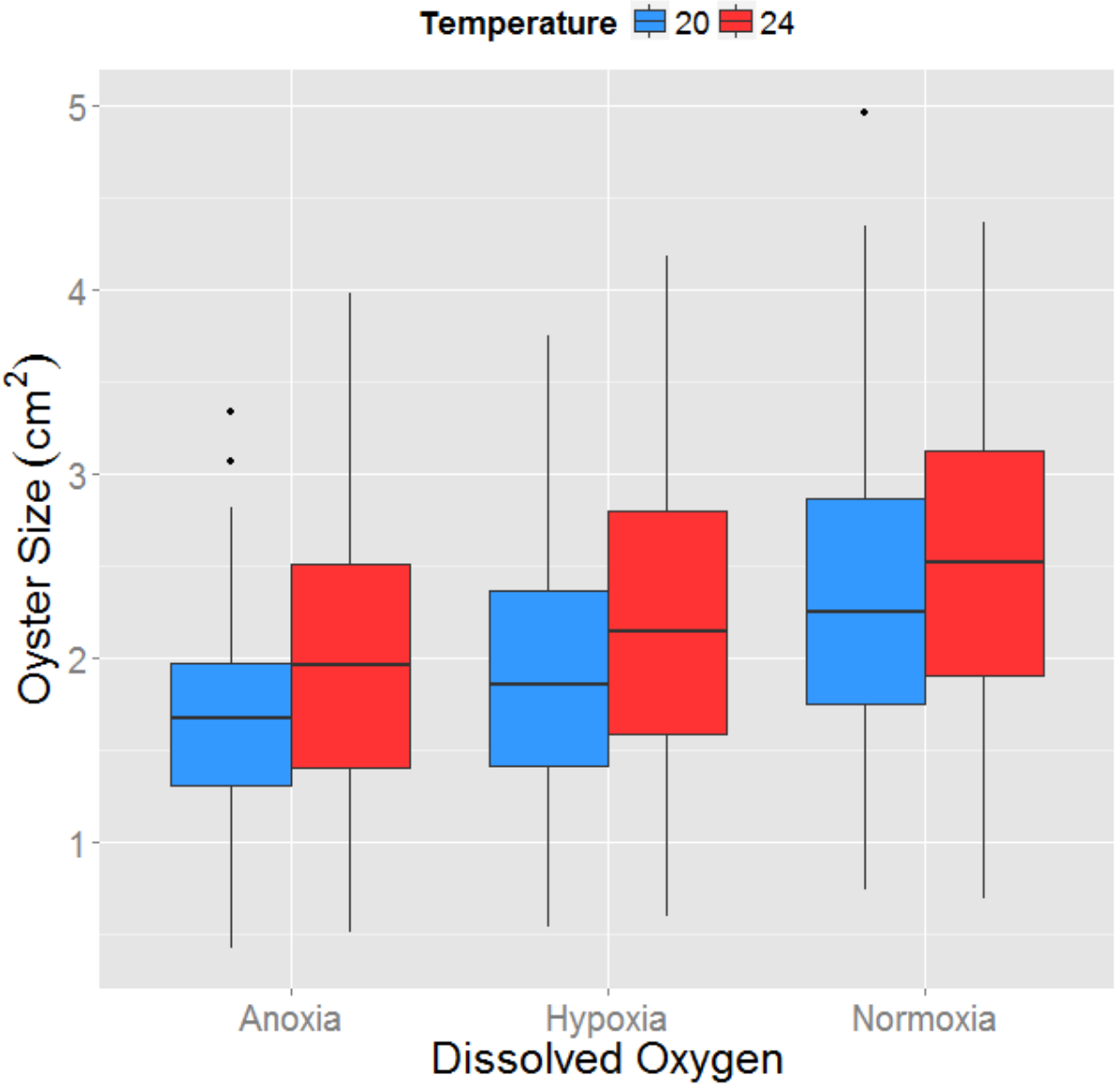


Phase 2: Oyster Growth at 14 weeks

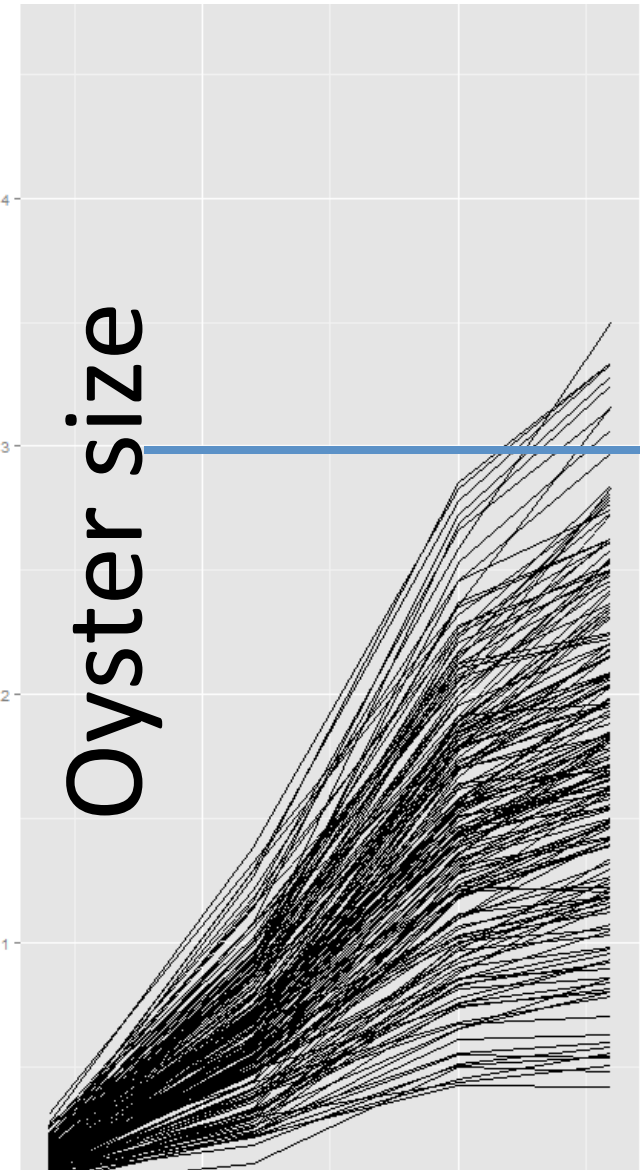
Brian will insert text on changes in effect size

Growth at 2 weeks



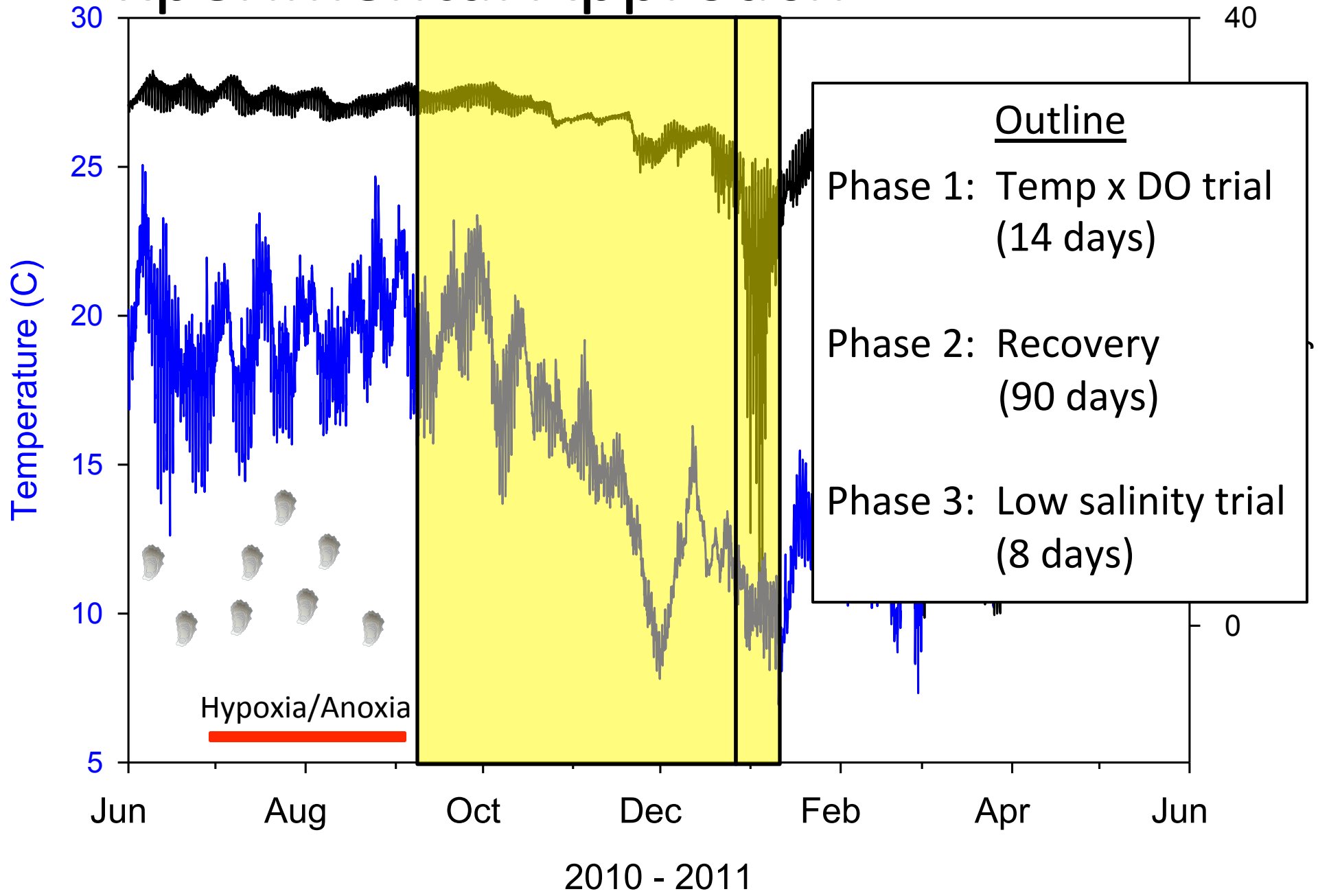


Anoxia



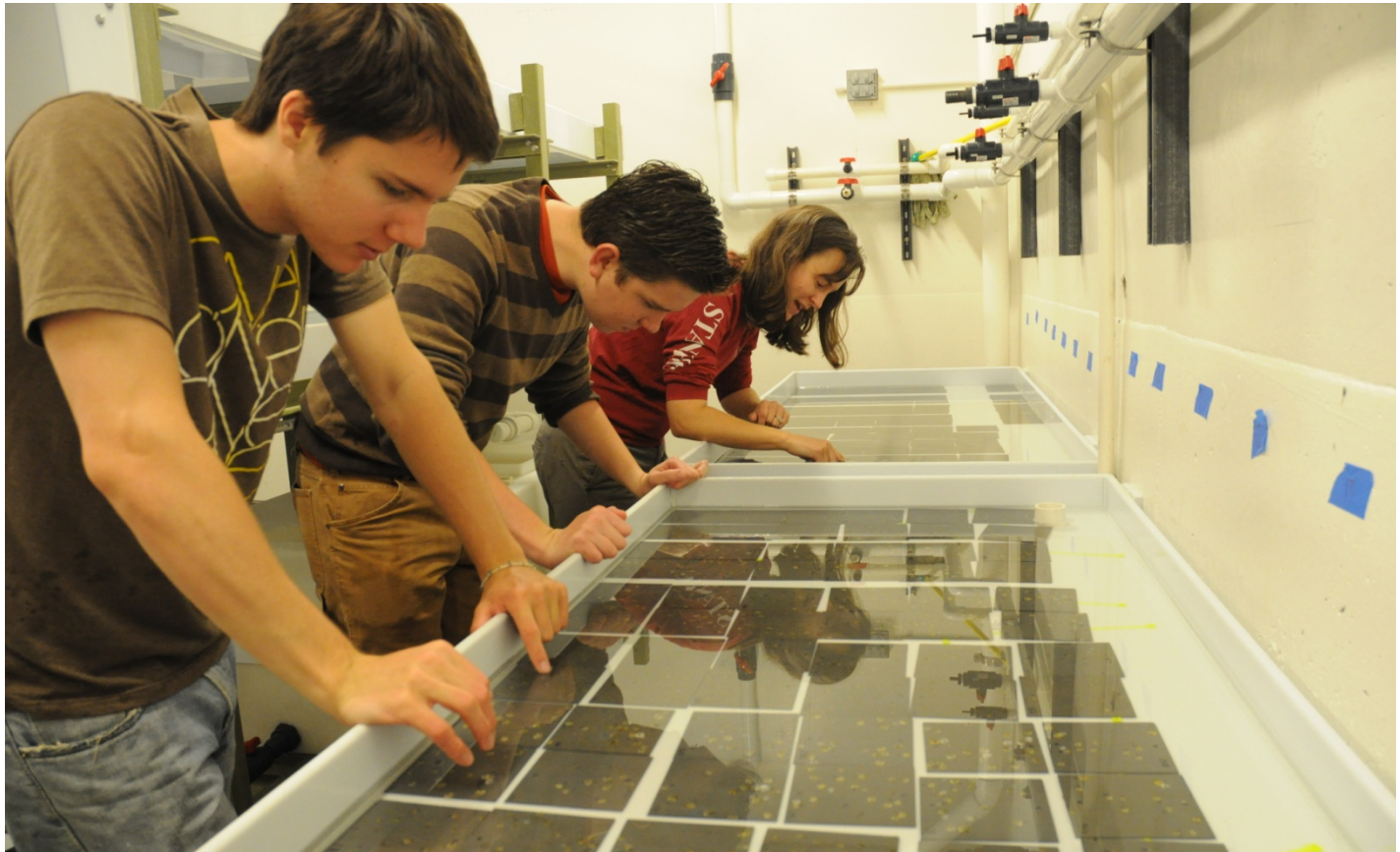
Time

Experimental Approach

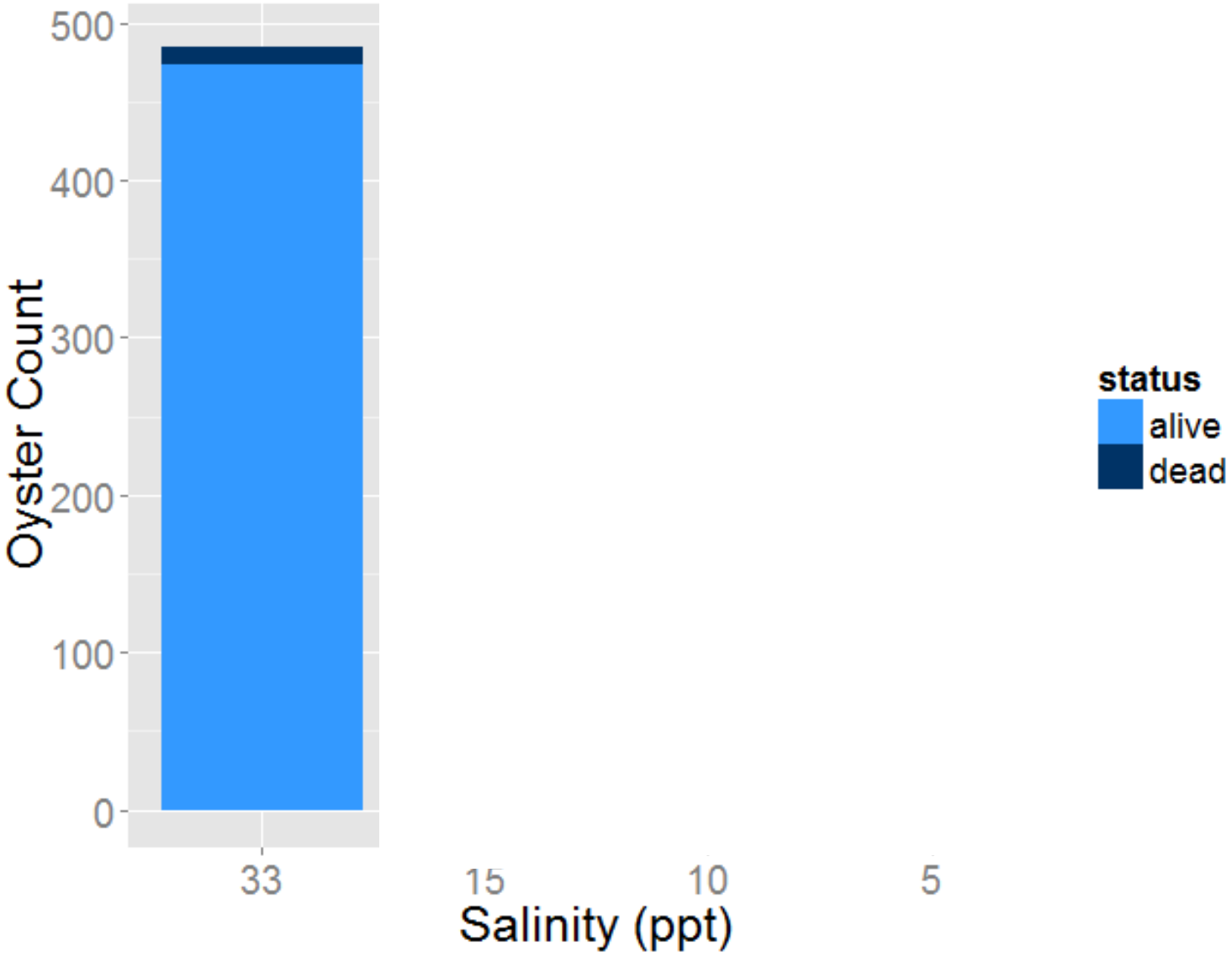


Methods – Salinity Tolerance

- At end of experiment:
  salinity decreased 5 ppt/day
- Target salinity for 8 days: 33, 15, 10, 5 ppt



Phase 3: Salinity Tolerance



Questions

1. How do multiple simultaneous stressors affect oysters?

   Additive effects – DO larger impacts

2. Are oysters capable of recovering from these stressors over time?

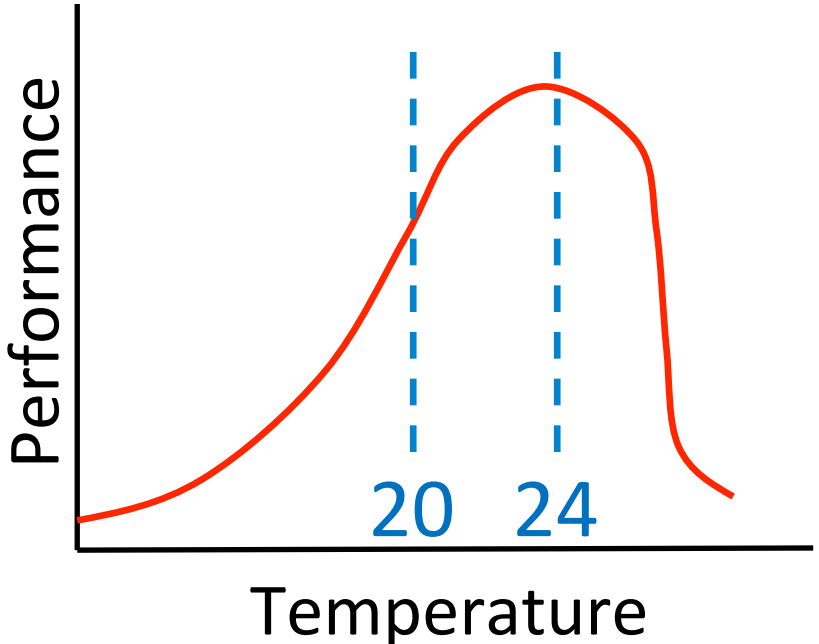
   Partial recovery possible

3. Does early stress affect performance at later stages in response to low salinity?

   No link between early life DO stress and salinity tolerance

Summary

- Multiple stressors are common and timing of stressors with life stage is important
- Low DO results in lower oyster growth (sub-lethal effect)
- Low salinity has lethal impacts
- Warming may be beneficial up to a point



Implications

- Restoration success depends on understanding relevant stressors (know your site!)
- Restoration success is likely estuary dependent
  - Elkhorn Slough: DO
  - SFB: salinity
- Other stressors can have large impacts

Future Experiments

Current/Planned Experiments:

- How do adult oysters respond to low salinity events?
- How do juvenile oysters respond to low salinity and high air temperature?

Proposed Experiments:

- How will oysters tolerate burial by sediment?

Acknowledgements

Technicians

Charlie Norton

Chris Knight

Emily Seubert

BML

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END-USER PRODUCTS

How best to package new information to inform management

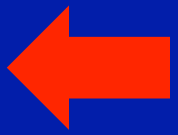
We'd like to know….

- What are the most important analyses to do with our new data? What questions do you need answered?

CONTENT

- How can we make our data easy for you to use? In what format do you prefer to receive the new information?

PACKAGING



What roles do you play with regard to Olympia oysters? Select ONE

25%	1. “on-the-ground” Oly restoration
0%	2. oyster farming (any species)
0%	3. planning/policy for oysters
38%	4. planning/policy for estuarine habitats
6%	5. funding of oyster restoration projects
6%	6. permitting / regulation related to oysters
0%	7. monitoring of oysters
13%	8. research projects on oysters
6%	9. education / outreach about oysters
6%	10. other / none

END-USER PRODUCTS

- Guidelines
- Conceptual models
- Decision trees
- Site evaluations
- Regional maps
- Site selection tools

(will review each and then have you score its usefulness to your management decisions)

Guidelines

Description of end-product:

--summary and interpretation of management implications of our new data
--brief written recommendations supplemented by figures/tables

Guidelines

Which questions would this product apply to?

ALL SEVEN QUESTIONS

Where: recommendations about best sites

When: recommendations about timing

How: recommendations about stressor reduction

Guidelines

Based on your past experience with similar products or your anticipated future needs…

How valuable would this type of product be for applying new science to your needs ?

END-USER PRODUCTS

Guidelines

Conceptual models

Decision trees

Site evaluations

Regional maps

Site selection tools

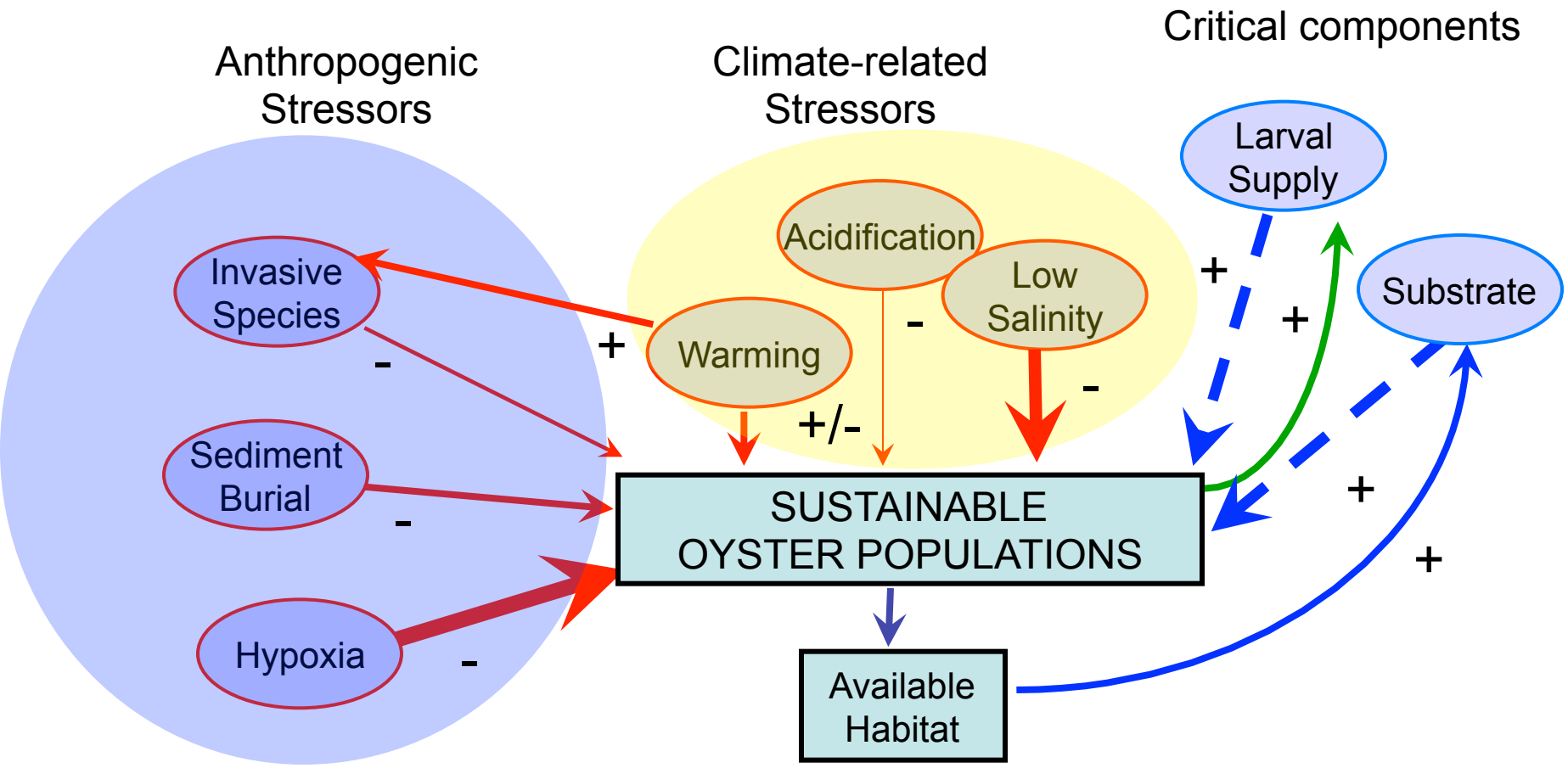
Conceptual models

Description of end-product:

-- diagram showing which oyster parameters are affected by different factors

--could be one single model, or variants developed to guide the different questions

Conceptual model



Conceptual models

Which questions would this product apply to?

Where: model useful for site selection by showing which factors matter

How: model applied to developing strategies for enhancing resilience through stressor reduction

Conceptual models

Based on your past experience with similar products or your anticipated future needs…

How valuable would this type of product be for applying new science to your needs ?

END-USER PRODUCTS

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Decision trees

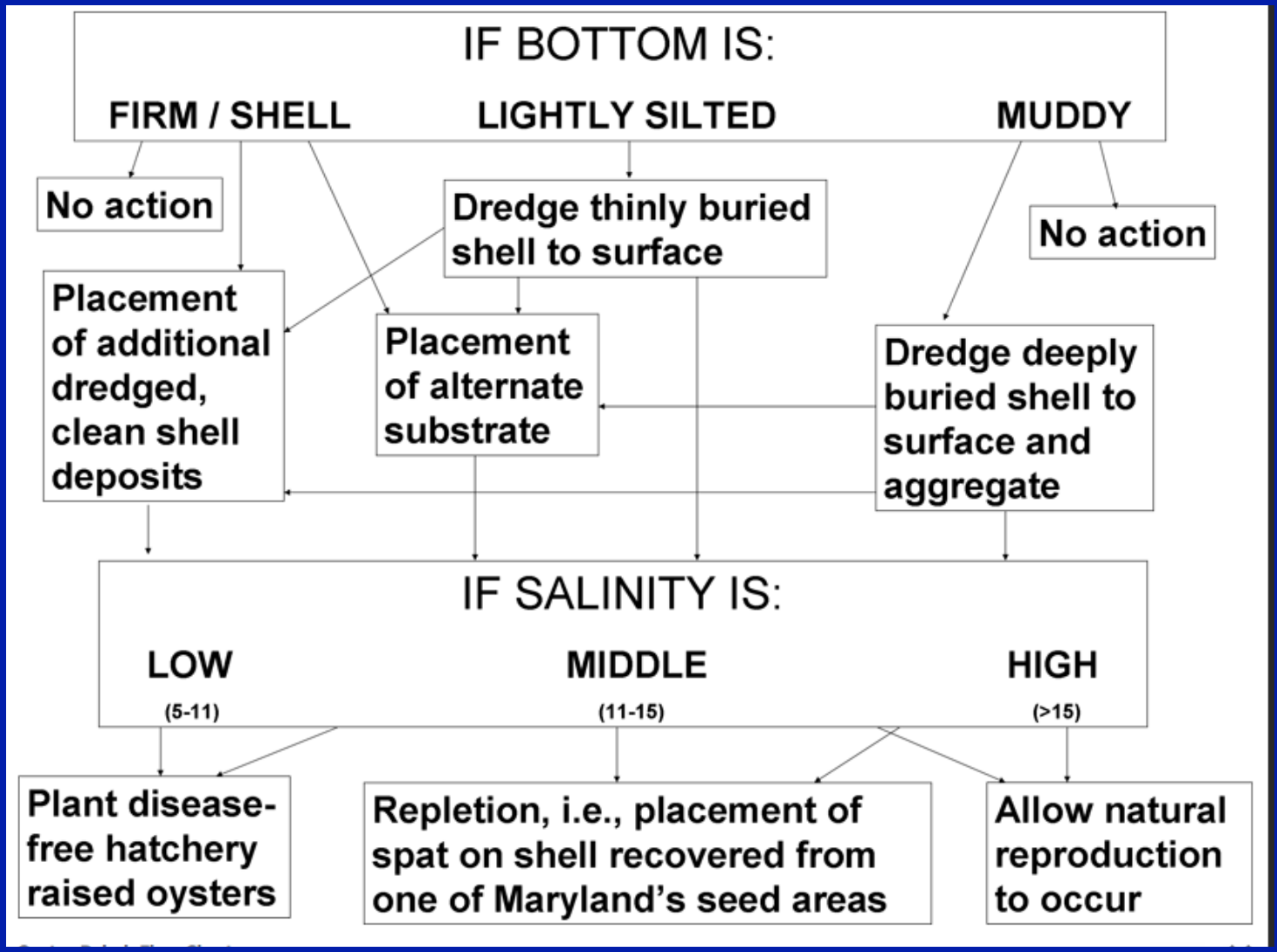
Description of end-product:

-- provides guidance about which stressors to focus on at sites with differing conditions

--dichotomous key or flow chart

Decision trees

Example:



-Maryland Department of Natural Resources

Decision trees

Which questions would this product apply to?

How: helps managers identify critical stressors to focus on at a given site

Decision trees

Based on your past experience with similar products or your anticipated future needs…

How valuable would this type of product be for applying new science to your needs ?

0% 1. **NOT** valuable

29% 2. **SOMEWHAT** valuable

18% 3. **MODERATELY** valuable

18% 4. **VERY** valuable

35% 5. **EXTREMELY** valuable

END-USER PRODUCTS

Guidelines

Conceptual models

Decision trees

Site evaluations

Regional maps

Site selection tools

Site evaluations

Description of end-product:

-- table summarizing info on the 18+ monitored sites

Site evaluations

Example:

SITE	OYSTER RESTORATION SUITABILITY SCORE
China Camp	High
Port Orient	Low
Loch Lomond	Medium
Port Pinole	Medium
Brickyard Cove	Low
Sausalito	High
Berkeley	High
Arambaru Island	Medium
Oyster Point	Medium
Coyote Point	Low
Eden Landing	High

Site evaluations

Example:

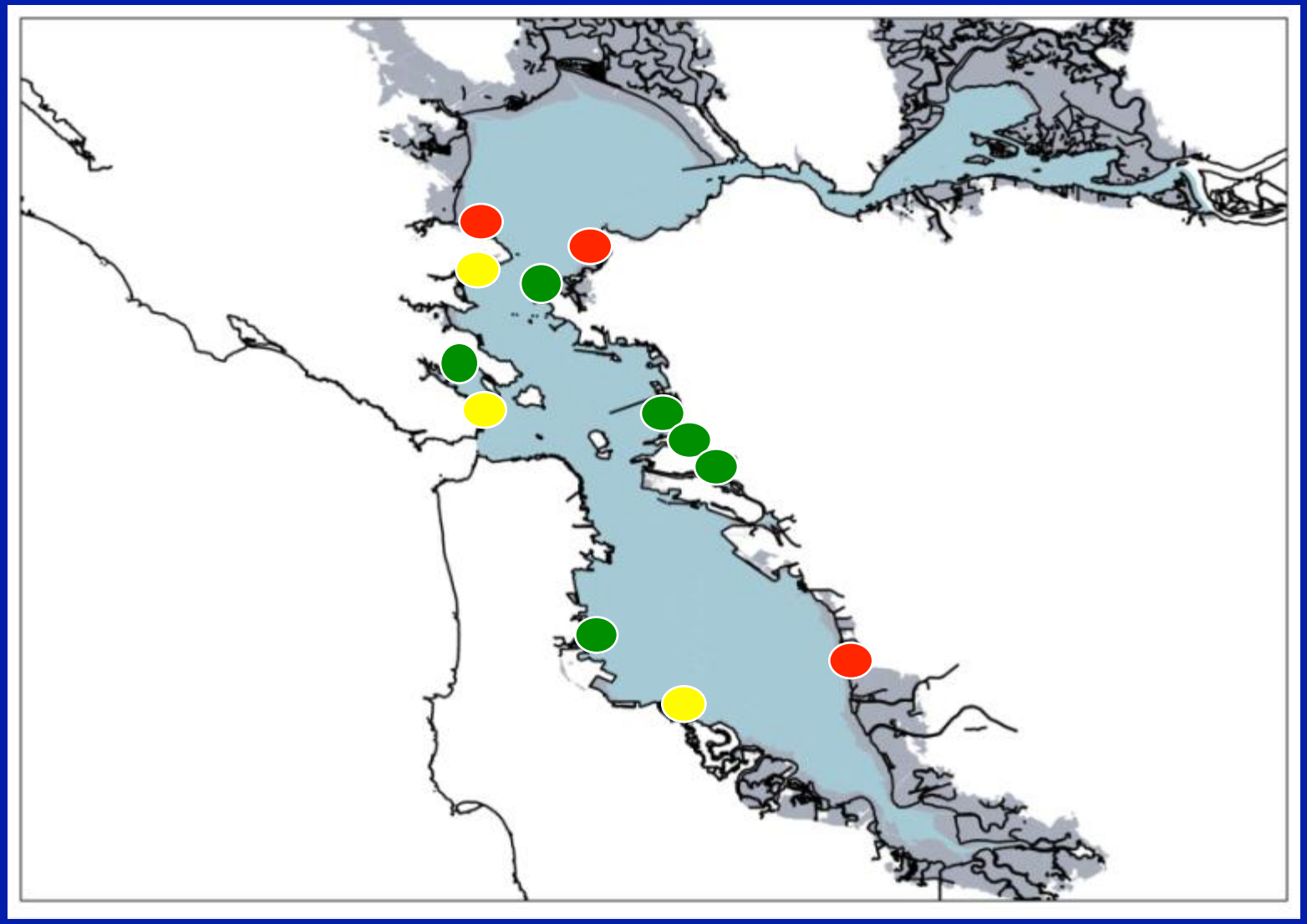
SITE	OYSTER RESTORATION SUITABILITY SCORE	OYSTER ATTRIBUTES		STRESSORS			
		Adult density nearby	Recruitment rate	Freshwater exposure	Hypoxia frequency	Sedimentation	Invasive cover
China Camp	High	High	High	Medium	Low	Low	Medium
Port Orient	Low	Low	Low	High	Medium	High	High
Loch Lomond	Medium	Low	Medium	High	Medium	Low	Low
Port Pinole	Medium	Medium	Low	Medium	Low	Medium	Low
Brickyard Cove	Low	Low	Low	High	High	High	High
Sausalito	High	Medium	High	Low	Low	Medium	Low
Berkeley	High	High	Medium	Low	Low	Low	Medium
Arambaru Island	Medium	Medium	Medium	Medium	High	Medium	Low
Oyster Point	Medium	Low	High	Medium	Medium	Medium	Medium
Coyote Point	Low	Low	Low	High	Medium	High	High
Eden Landing	High	High	Medium	Low	Low	Medium	Low

Site evaluations

Description of end-product:

-- or could summarize site assessment on map

Site evaluations



Site evaluations

Which questions would this product apply to?

Where: summaries show which of the 18 siteshave most critical existing populations OR best restoration potential

Site evaluations

Based on your past experience with similar products or your anticipated future needs…

How valuable would this type of product be for applying new science to your needs ?

END-USER PRODUCTS

Guidelines

Conceptual models

Decision trees

Site evaluations

Regional maps

Site selection tools

Regional maps

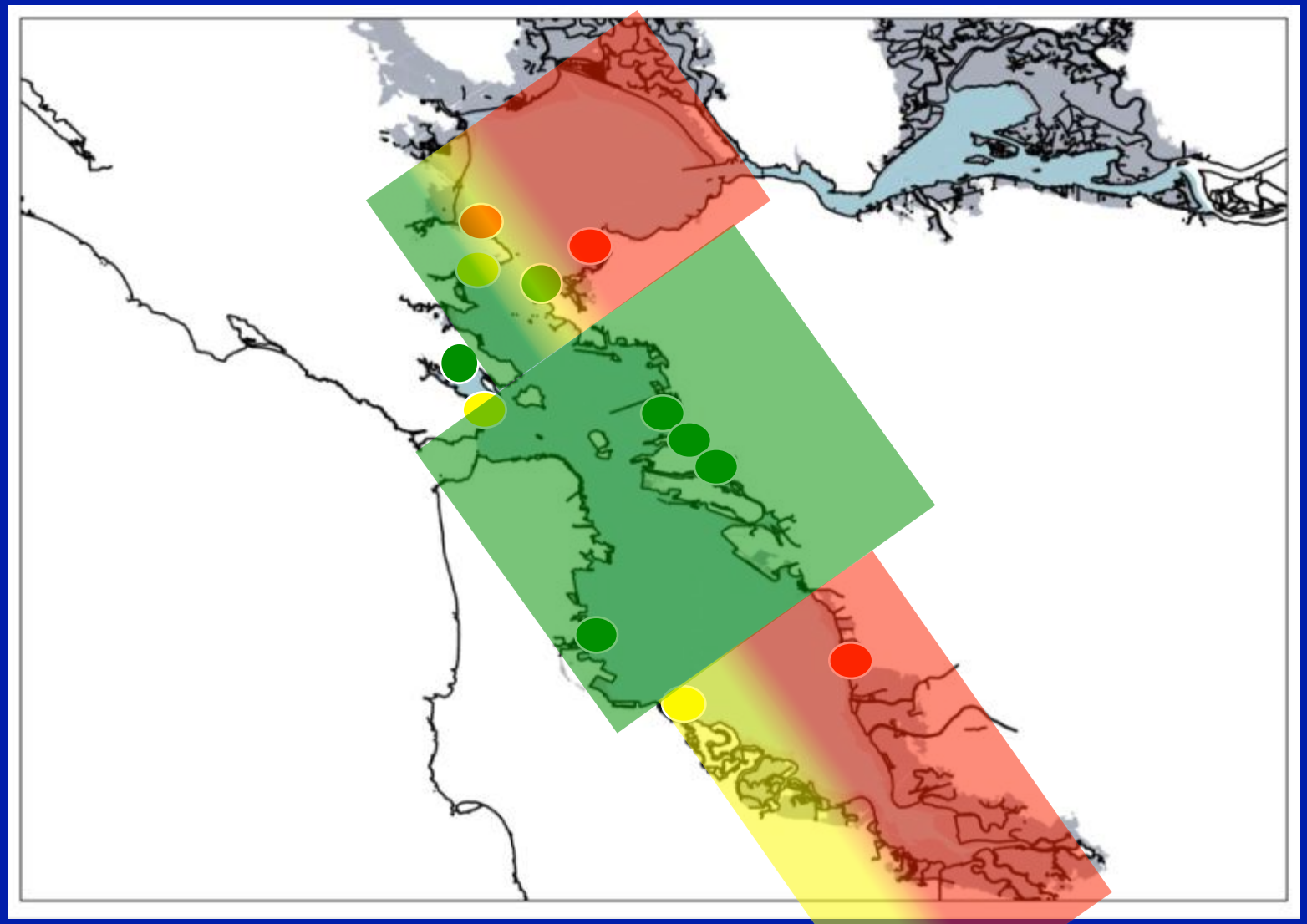
Description of end-product:

--maps of San Francisco Bay and Elkhorn Slough

--GIS used to interpolate between our 18+ sampled stations: moderate uncertainty

--assessment of suitability of regions based only on factors that vary as a continuous gradient

Regional maps



Regional maps

Which questions would this product apply to?

Where: maps show which regions have most critical existing populations OR best restoration potential

Regional maps

Based on your past experience with similar products or your anticipated future needs…

How valuable would this type of product be for applying new science to your needs ?

END-USER PRODUCTS

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Site selection tools

Site selection tools

Description of end-product:

-- formal “decision-support tools,” employing software to create tailored products

--allows assessment of sites other than the 18+ we studied

--end-user inputs data and obtains assessment of whether this is appropriate restoration site

Site selection tools

Example: Interactive site "report card"

You enter information about your site….

SITE	OYSTER ATTRIBUTES		STRESSORS			
	Adult density nearby	Recruit-ment rate	Fresh-water exposure	Hypoxia frequency	Sedimentation	Invasive cover
Site X	High	High	Medium	Low	Low	Medium
Site Y	Low	Low	High	Medium	High	High
Site Z	Low	Medium	High	Medium	Low	Low

Site selection tools

…and the tool calculates a restoration score

SITE	OYSTER RESTORATION SUITABILITY SCORE	OYSTER ATTRIBUTES		STRESSORS			
		Adult density nearby	Recruit-ment rate	Fresh-water exposure	Hypoxia frequency	Sedimentation	Invasive cover
Site X	High	High	High	Medium	Low	Low	Medium
Site Y	Low	Low	Low	High	Medium	High	High
Site Z	Medium	Low	Medium	High	Medium	Low	Low

Site selection tools

Which questions would this product apply to?

Where: interactive tools help managers evaluate sites for conservation/restoration

Site selection tools

Based on your past experience with similar products or your anticipated future needs…

How valuable would this type of product be for applying new science to your needs ?

DISCUSSION OF END-USER PRODUCTS

--Are there any other end-user products we missed?

--Reflections about how you use products?

Working together, we will apply the new science towards conserving and restoring Olympia oysters!

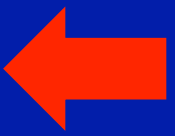
Using new science to improve MANAGEMENT DECISIONS ABOUT OLYMPIA OYSTERS

Major goals of our project

- **Do research that can improve management decisions for Olympia oysters**
- **Analyze and communicate results in ways that will be useful to you in your decision-making**

We'd like to know….

- What are the most important analyses to do with our new data? What questions do you need answered?

CONTENT 

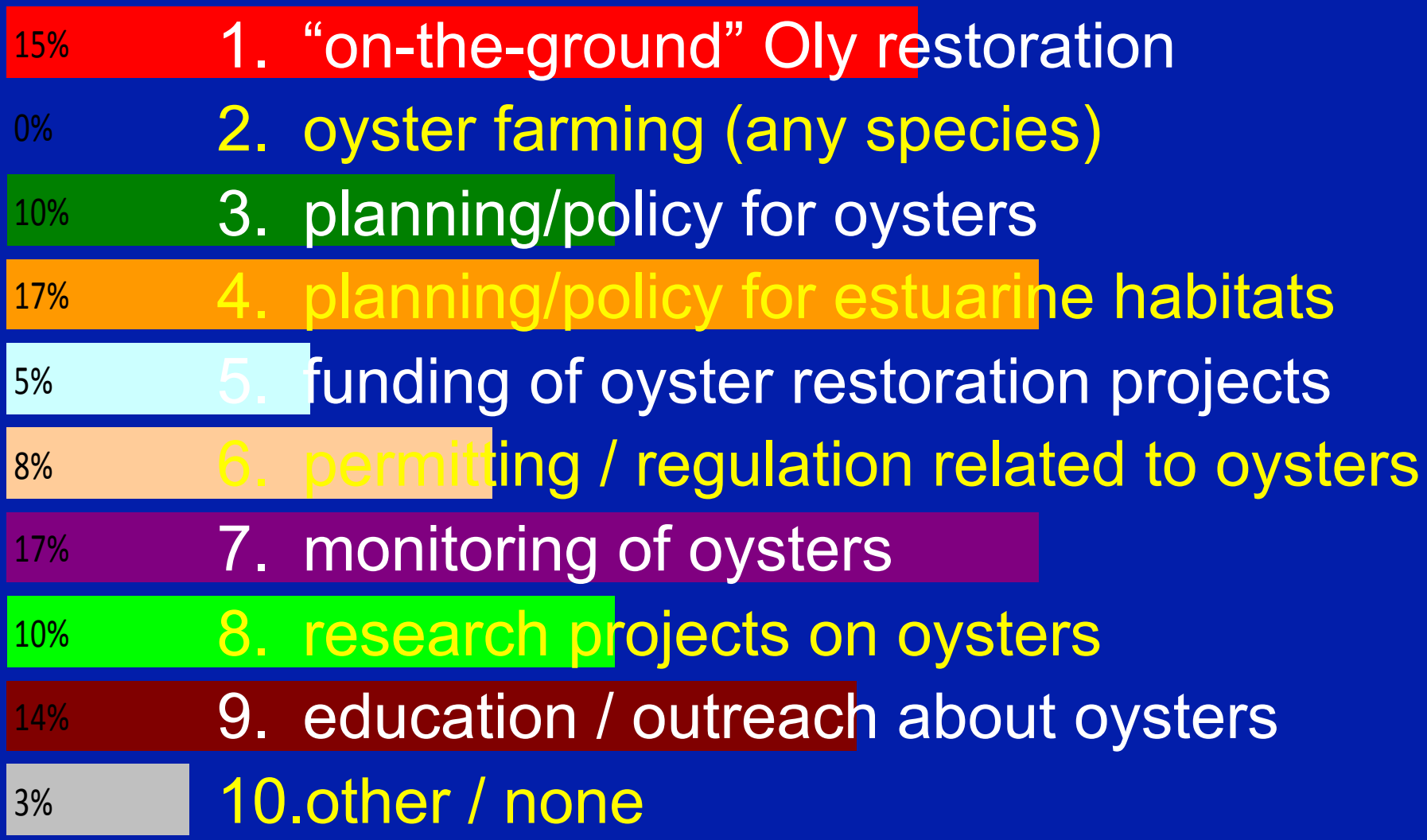
- How can we make our data easy for you to use? In what format do you prefer to receive the new information?

PACKAGING (after Rozum / tools)


Collaboration between science & management
Vote early and often!

What do YOU do with oysters?

What roles do you play with regard to Olympia oysters? Select ALL that apply



What roles do you play with regard to Oly oysters? Select ONE

16% 1. "on-the-ground" Oly restoration

0% 2. oyster farming (any species)

5% 3. planning/policy for oysters

37% 4. planning/policy for estuarine habitats

11% 5. funding of oyster restoration projects

5% 6. permitting / regulation related to oysters

0% 7. monitoring of oysters

11% 8. research projects on oysters

11% 9. education / outreach about oysters

5% 10. other / none

MANAGEMENT DECISIONS

7 questions explained & prioritized

We will explain how our new science will answer them

You will tell us:

How important is this question for improving Oly conservation/restoration?

How often do you make this decision?

MANAGEMENT DECISIONS

WHERE to conserve/restore (Q1,Q2, Q3a)

WHETHER to restore at a particular site (Q3b)

WHEN to restore (Q4)

HOW to restore (Q5, Q6, Q7)

For all of the above, our science sheds light on what is best for oysters, not on human dimensions of restoration.

Our data also do not help with WHY questions.

1) Which sites support the most sustainable existing Oly populations?

Answers from new science:

--field data show where oyster densities are high, where stressors are low

--lab data shed light on importance of different stressors

1) Which sites support the most sustainable existing Oly populations?

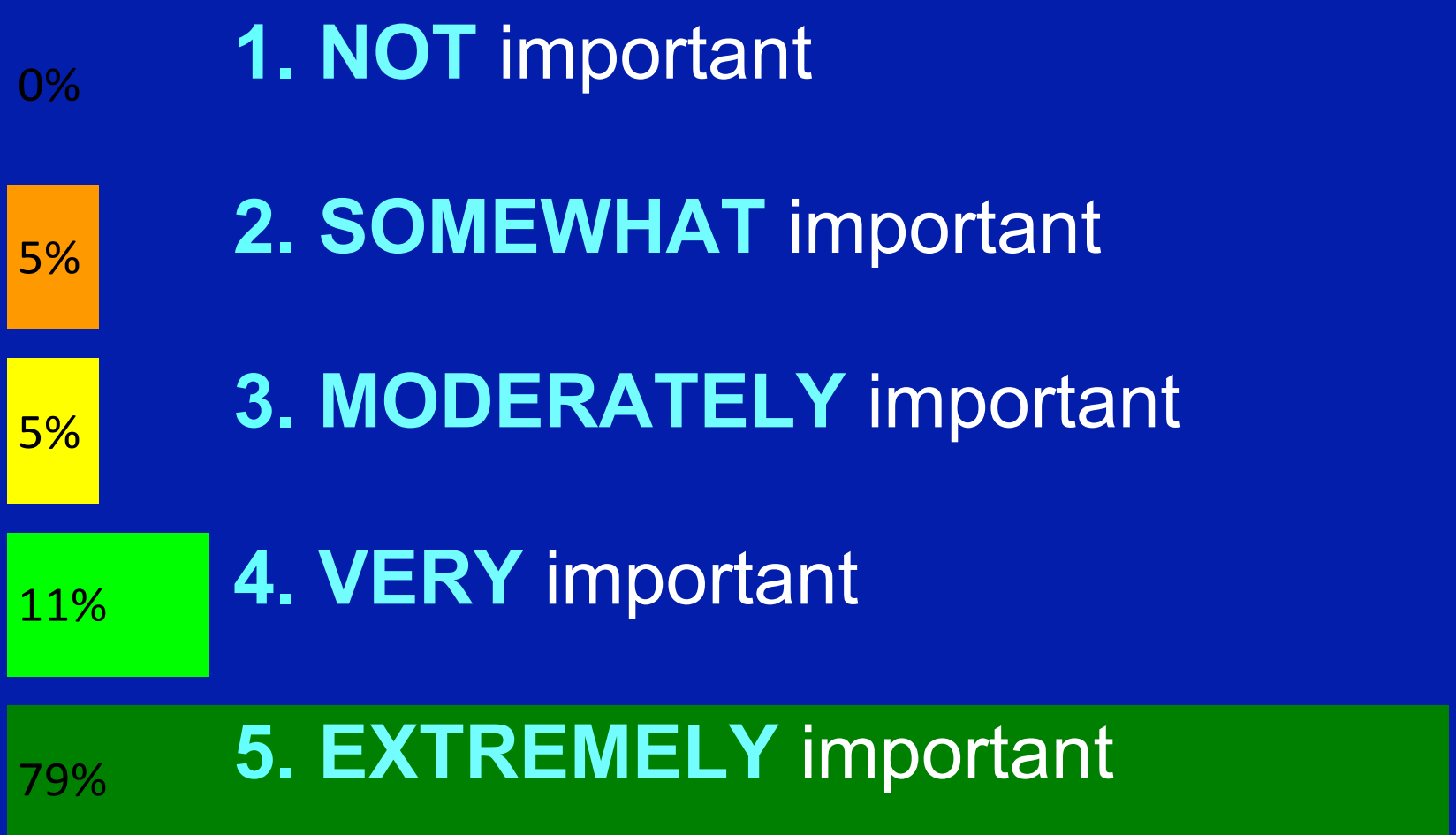
Examples of management applications:

--resource agency permitting of development project avoids disturbance to important existing areas

--regulatory agency designates special conservation area

1) *Which sites support the most sustainable existing Oly populations?*

How important is answering this question for conserving/restoring Oly oysters in this region?



1) *Which sites support the most sustainable existing Oly populations?*

How often do you make decisions related to the above question?

2) Which sites are particularly important sources of larvae for the estuary?

Answers from new science:

--data showing source of recruits will reveal which regions supply disproportionate amounts of larvae

2) Which sites are particularly important sources of larvae for the estuary?

Examples of management applications:

SAME AS FOR QUESTION 1

--resource agency permitting of development project avoids disturbance to important existing areas

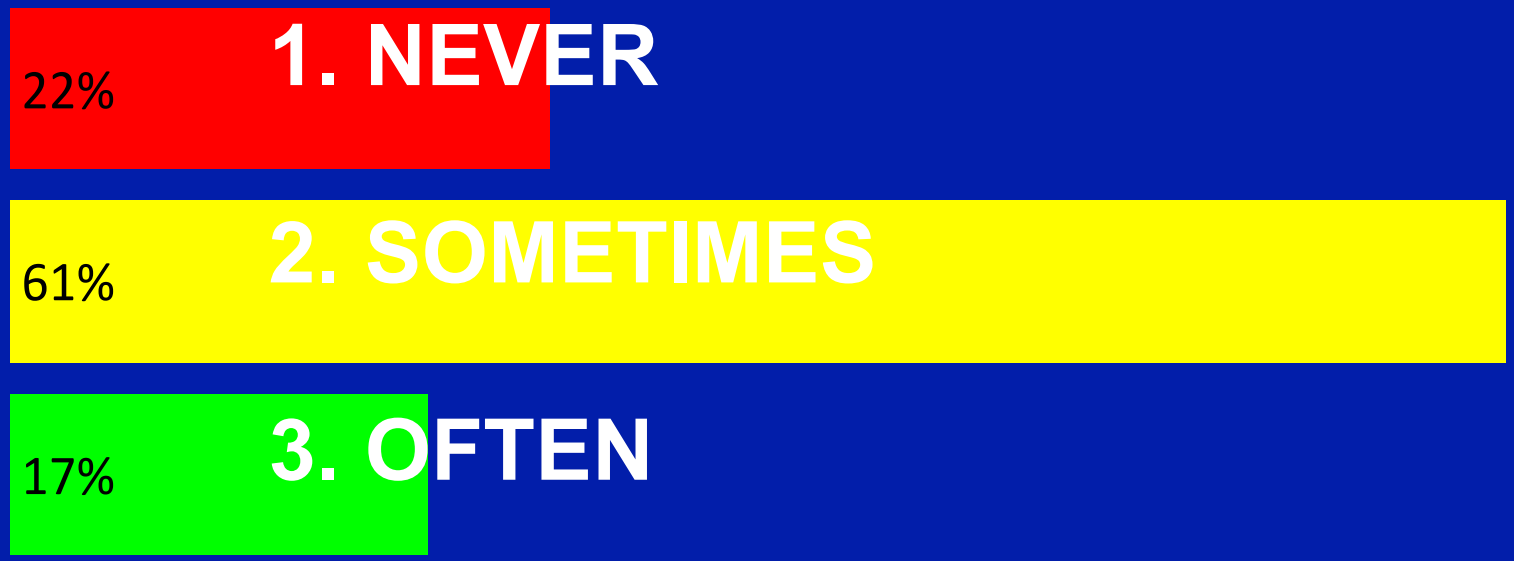
--regulatory agency designates special conservation area

2) *Which sites are particularly important sources of larvae for the estuary?*

How important is answering this question for conserving/restoring Oly oysters in this region?

2) *Which sites are particularly important sources of larvae for the estuary?*

How often do you make decisions related to the above question?



3a) Which sites are best for sustainable Oly restoration projects?

(note shift from focus on CONSERVATION of existing populations to RESTORATION of new populations)

Answers from new science:

--field data show where conditions are suitable

--lab data shed light on importance of different stressors

3a) Which sites are best for sustainable Oly restoration projects?

Examples of management applications:

--funder picks the restoration proposal with greatest likelihood of long-term success

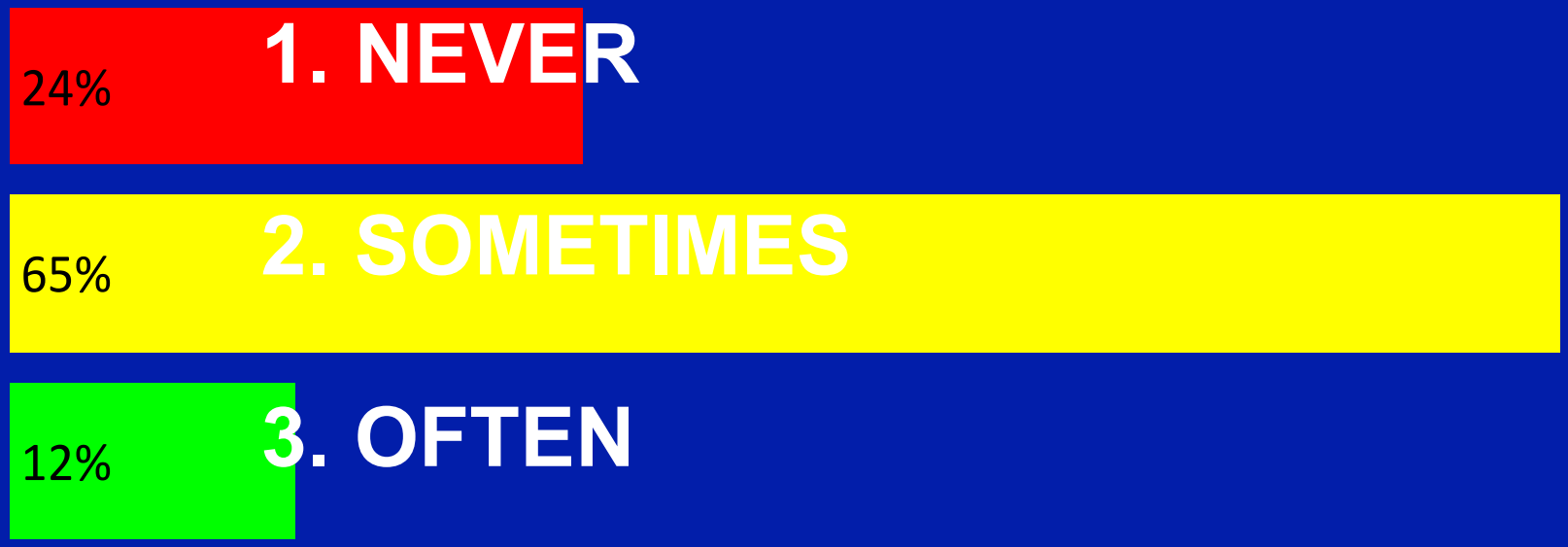
--grass-roots restoration group decides which site to propose for next restoration project

3a) Which sites are best for sustainable Oly restoration projects?

How important is answering this question for conserving/restoring Oly oysters in this region?

3a) Which sites are best for sustainable Oly restoration projects?

How often do you make decisions related to the above question?



MANAGEMENT DECISIONS

WHERE to conserve/restore (Q1,Q2, Q3a)

WHETHER to restore at a particular site (Q3b)

WHEN to restore (Q4)

HOW to restore (Q5, Q6, Q7)

3b) Is an oyster restoration project likely to be successful at site X?

Very similar to 3a, but evaluating a single site, not prioritizing among multiple sites

Answers from new science: (same as 3a)

--field data show where conditions are suitable

--lab data shed light on importance of different stressors

3b) Is an oyster restoration project likely to be successful at site X?

Examples of management applications:

--conservation landowner decides whether to invest in oyster restoration at a property they own

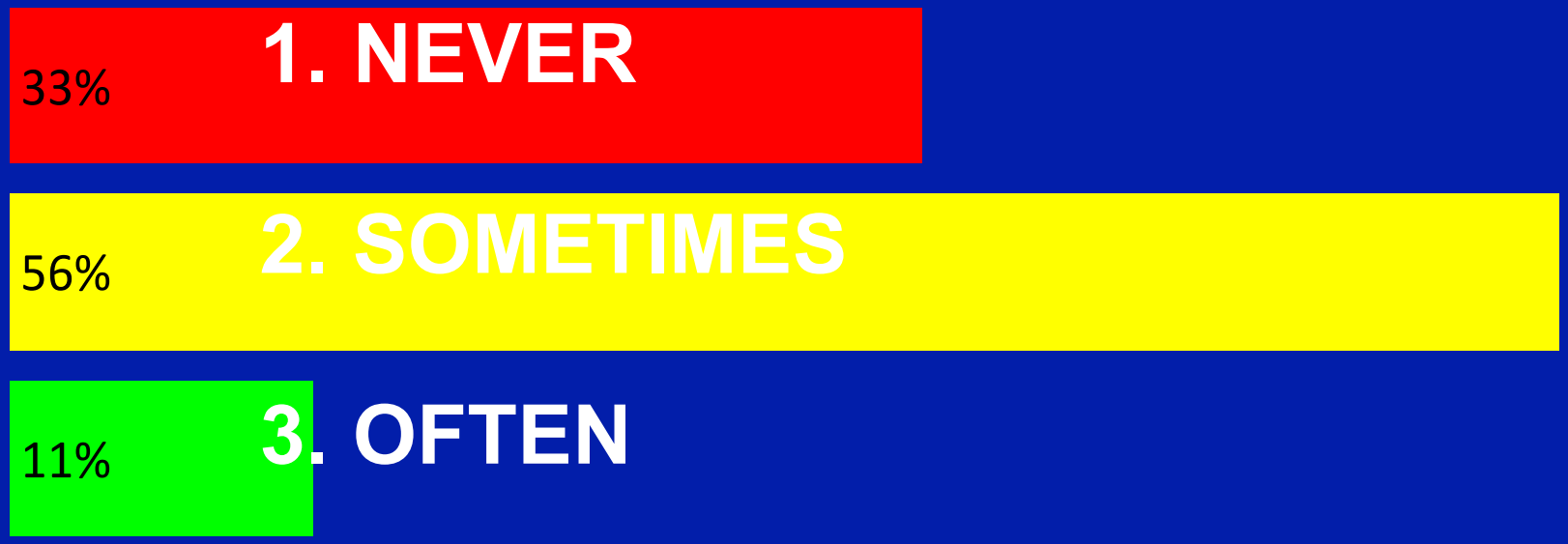
--restoration group decides whether to invest in restoration at a particular site

3b) Is an oyster restoration project likely to be successful at site X?

How important is answering this question for conserving/restoring Oly oysters in this region?

3b) Is an oyster restoration project likely to be successful at site X?

How often do you make decisions related to the above question?



MANAGEMENT DECISIONS

WHERE to conserve/restore (Q1,Q2, Q3a)

WHETHER to restore at a particular site (Q3b)

WHEN to restore (Q4)

HOW to restore (Q5, Q6, Q7)

4) When should oyster restoration reefs be deployed?

Answers from new science:

--field data show best times of year to maximize oyster recruitment and minimize stressors

--data can also suggest which types of years to avoid (e.g. El Niño)

4) When should oyster restoration reefs be deployed?

Examples of management applications:

--resource practitioners decide whether to deploy new reefs in May vs. July to maximize oyster success

4) *When should oyster restoration reefs be deployed?*

How important is answering this question for conserving/restoring Oly oysters in this region?

4) *When should oyster restoration reefs be deployed?*

How often do you make decisions related to the above question?

MANAGEMENT DECISIONS

WHERE to conserve/restore (Q1,Q2, Q3a)

WHETHER to restore at a particular site (Q3b)

WHEN to restore (Q4)

HOW to restore (Q5, Q6, Q7)

5) How do effects of climate-related stressors compare to those of other existing stressors?

Answers from new science:

--lab experiments compare effects of climate-related and other stressors

--field data provide opportunity to correlate oyster success to stressors across sites

5) How do effects of climate-related stressors compare to those of other existing stressors?

Examples of management applications:

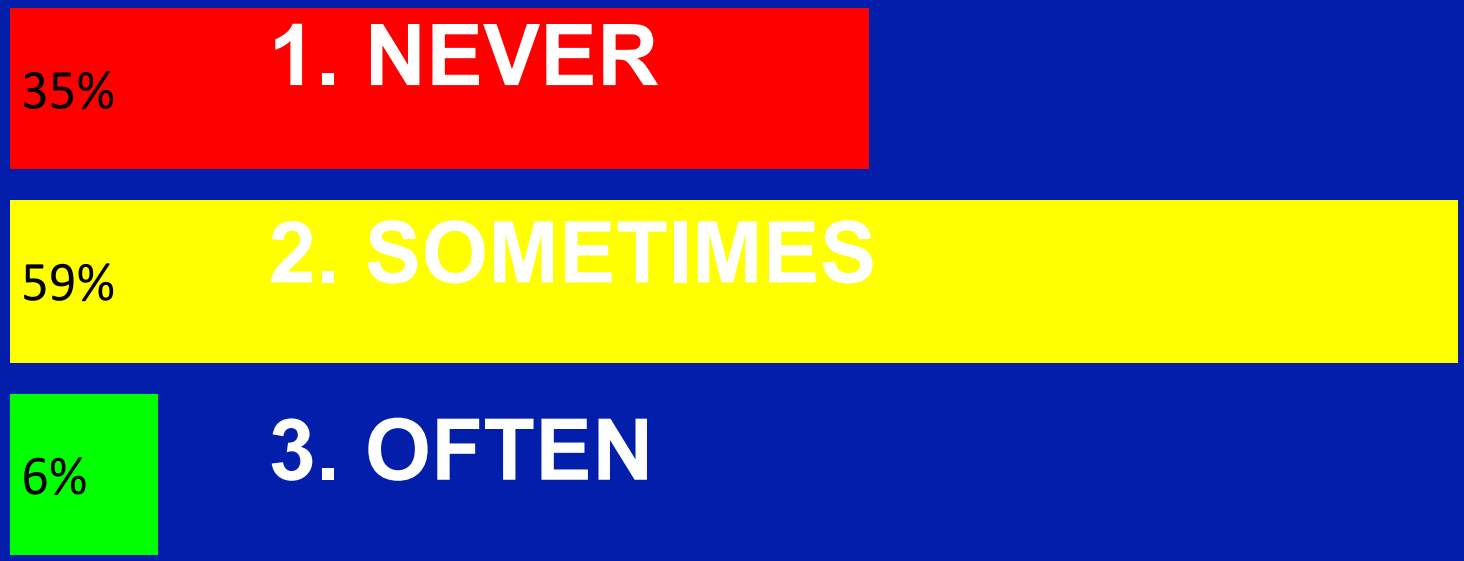
--strategic plan for estuary identifies critical stressors to focus on addressing in coming decade

5) How do effects of climate-related stressors compare to those of other existing stressors?

How important is answering this question for conserving/restoring Oly oysters in this region?

5) How do effects of climate-related stressors compare to those of other existing stressors?

How often do you make decisions related to the above question?



6) Can resilience of oysters to climate change be enhanced by decreasing other stressors?

Answers from new science:

--lab experiments examine interactions between climate-related and other stressors

--field data provide opportunity to identify such interactions through multivariate analyses

6) Can resilience of oysters to climate change be enhanced by decreasing other stressors?

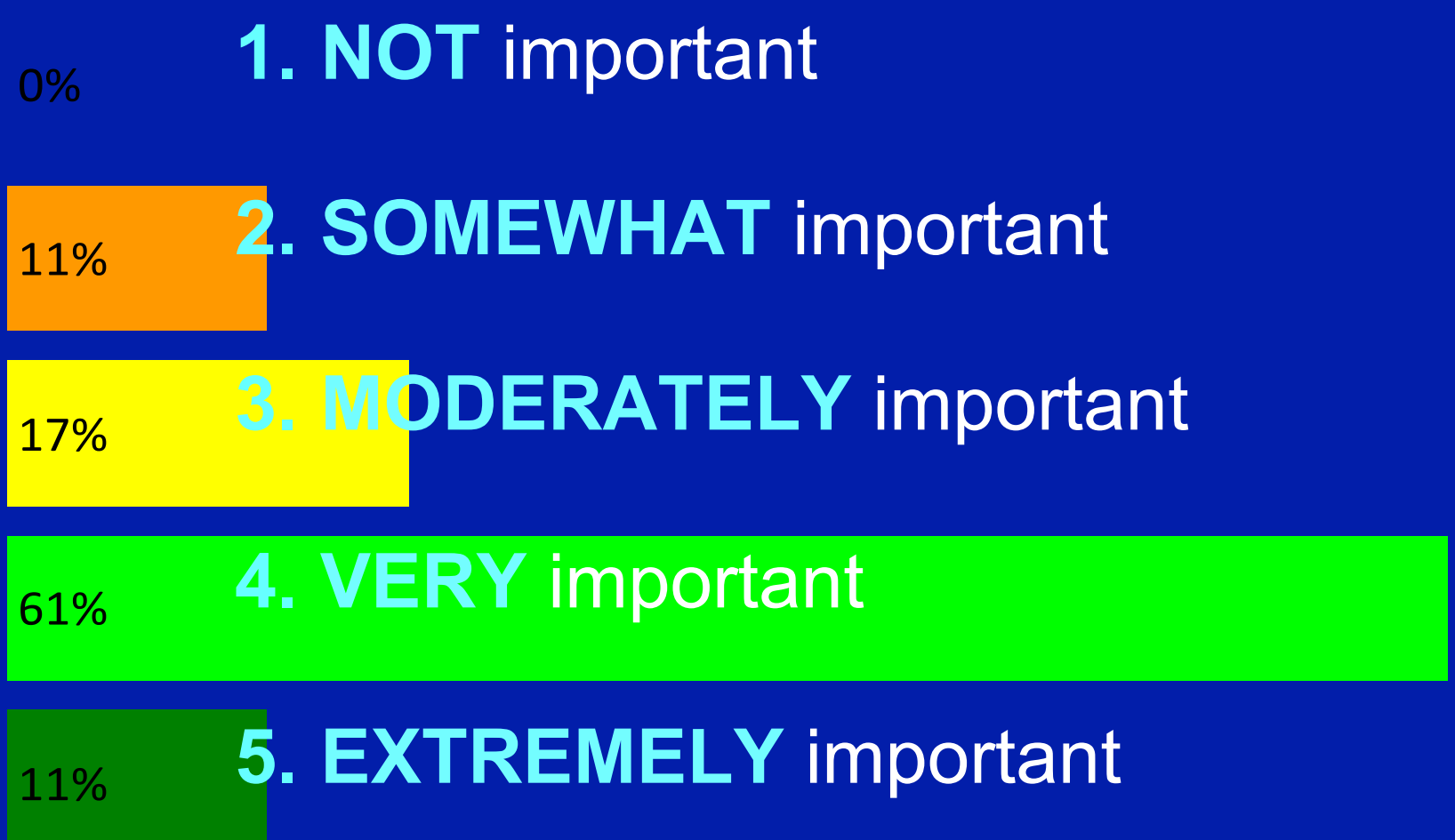
Examples of management applications:

--regulatory agencies implement stronger policy to reduce existing stressors if doing so enhances climate change resilience

--conservation landowners identify critical stressors to reduce to provide more capacity for resilience

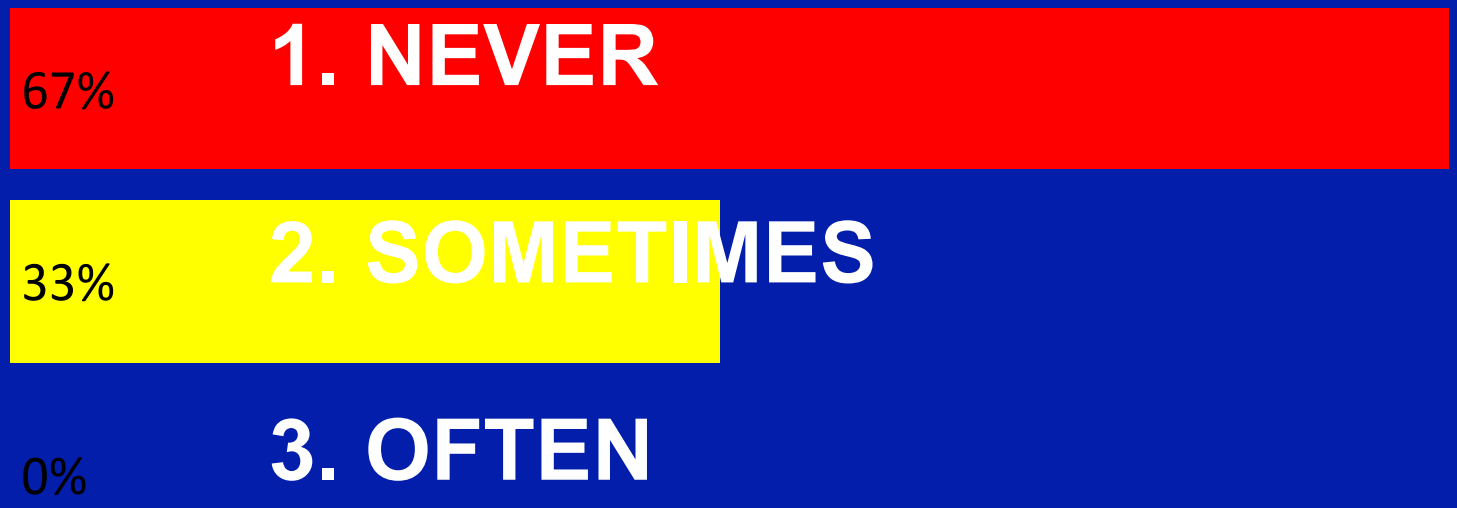
6) Can resilience of oysters to climate change be enhanced by decreasing other stressors?

How important is answering this question for conserving/restoring Oly oysters in this region?



6) Can resilience of oysters to climate change be enhanced by decreasing other stressors?

How often do you make decisions related to the above question?



7) Do oyster reefs need to be "seeded" with oysters prior to deployment?

Answers from new science:

--field data will identify which sites have good conditions for oysters but low recruitment

7) Do oyster reefs need to be "seeded" with oysters prior to deployment?

Examples of management applications:

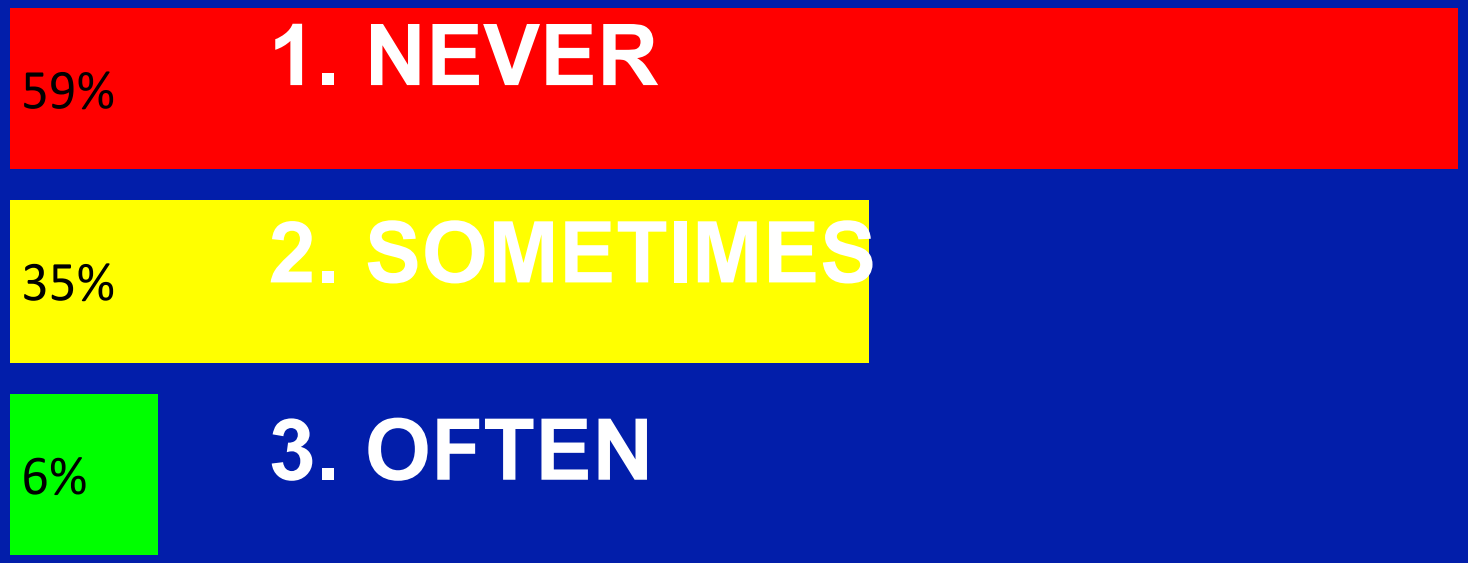
--restoration practitioners determine whether "seeding" of reefs is needed for particular sites

7) *Do oyster reefs need to be "seeded" with oysters prior to deployment?*

How important is answering this question for conserving/restoring Oly oysters in this region?

7) *Do oyster reefs need to be "seeded" with oysters prior to deployment?*

How often do you make decisions related to the above question?



DISCUSSION OF MANAGEMENT DECISIONS

--Are there any other management decisions we missed?

--Reflections about how management decisions can be improved by science that came up during the prioritization?