COLLABORATIVE SCIENCE FOR ESTUARIES
WEBINAR SERIES

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Restoring Native Oysters on North America's West Coast

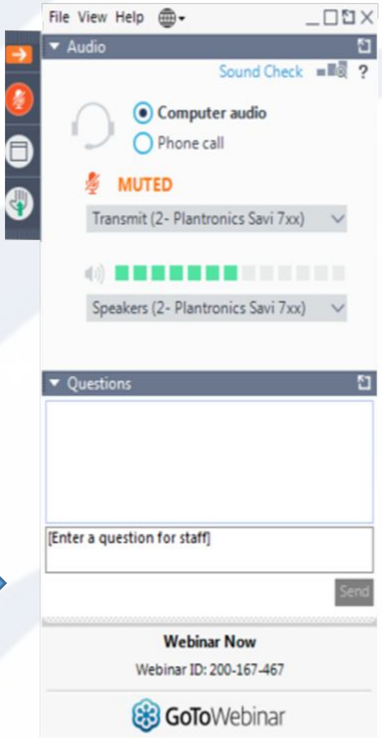
National Estuarine
Research Reserve System
Science Collaborative

Date: Tuesday, April 21, 2020
Time: 3.00 - 4.00 PM ET

National Estuarine Research Reserve System

Have a question?

Use the “Questions” function to pose questions throughout the webinar.



National Estuarine
Research Reserve System
Science Collaborative

Olympia oyster restoration science

OYSTER RESTORATION SCIENCE

- Introduction
- Coastwide network
- Restoration approaches
- Lessons learned and next steps

FOUNDATION SPECIES

build structured habitat

K Wasson

ESTUARIES

are typically dominated by soft sediments

FOUNDATION SPECIES

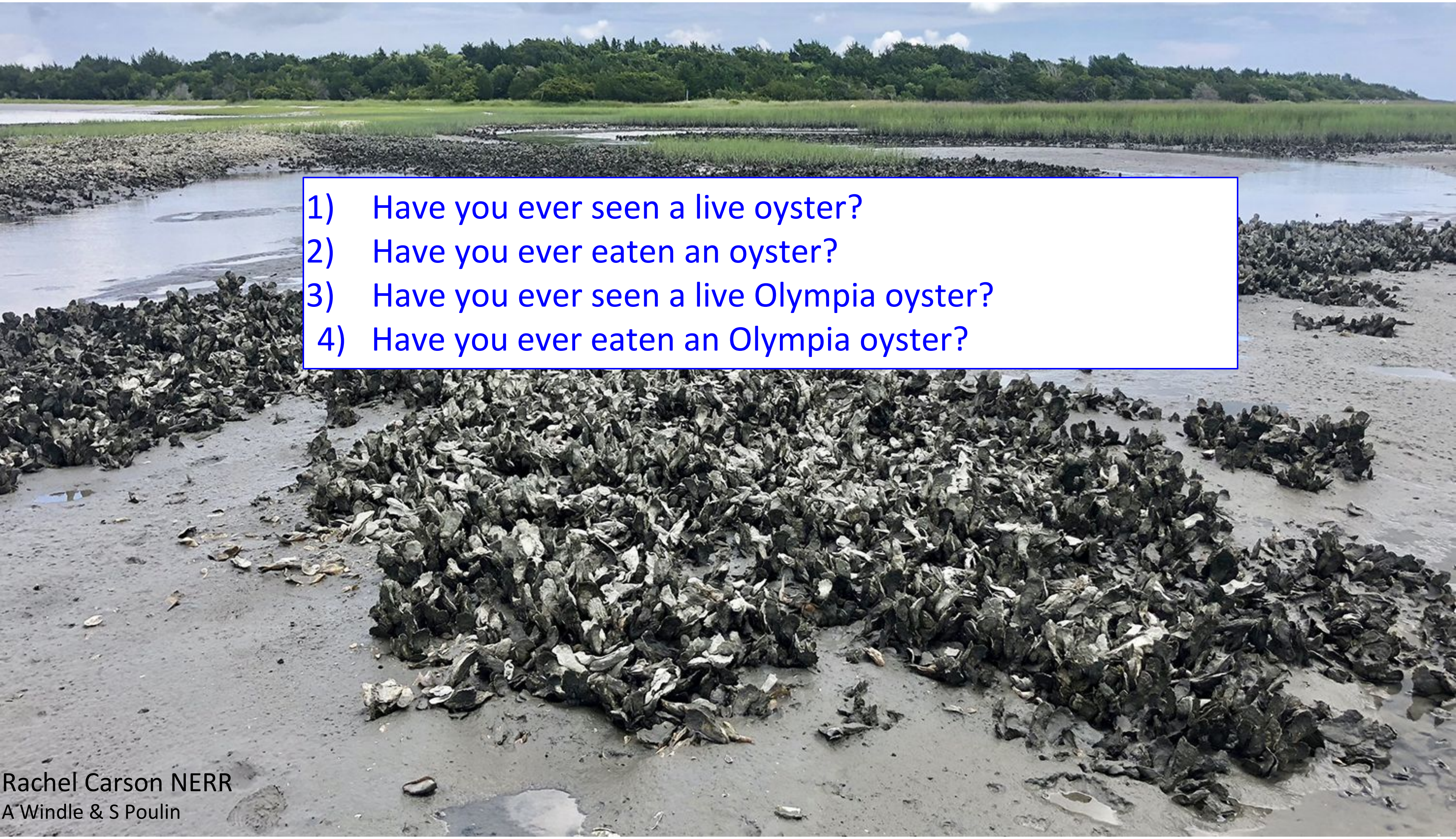
provide structure in estuaries

OYSTERS

are iconic foundation species in estuaries

POLLING QUESTIONS

1) Have you ever seen a live oyster?
2) Have you ever eaten an oyster?
3) Have you ever seen a live Olympia oyster?
4) Have you ever eaten an Olympia oyster?



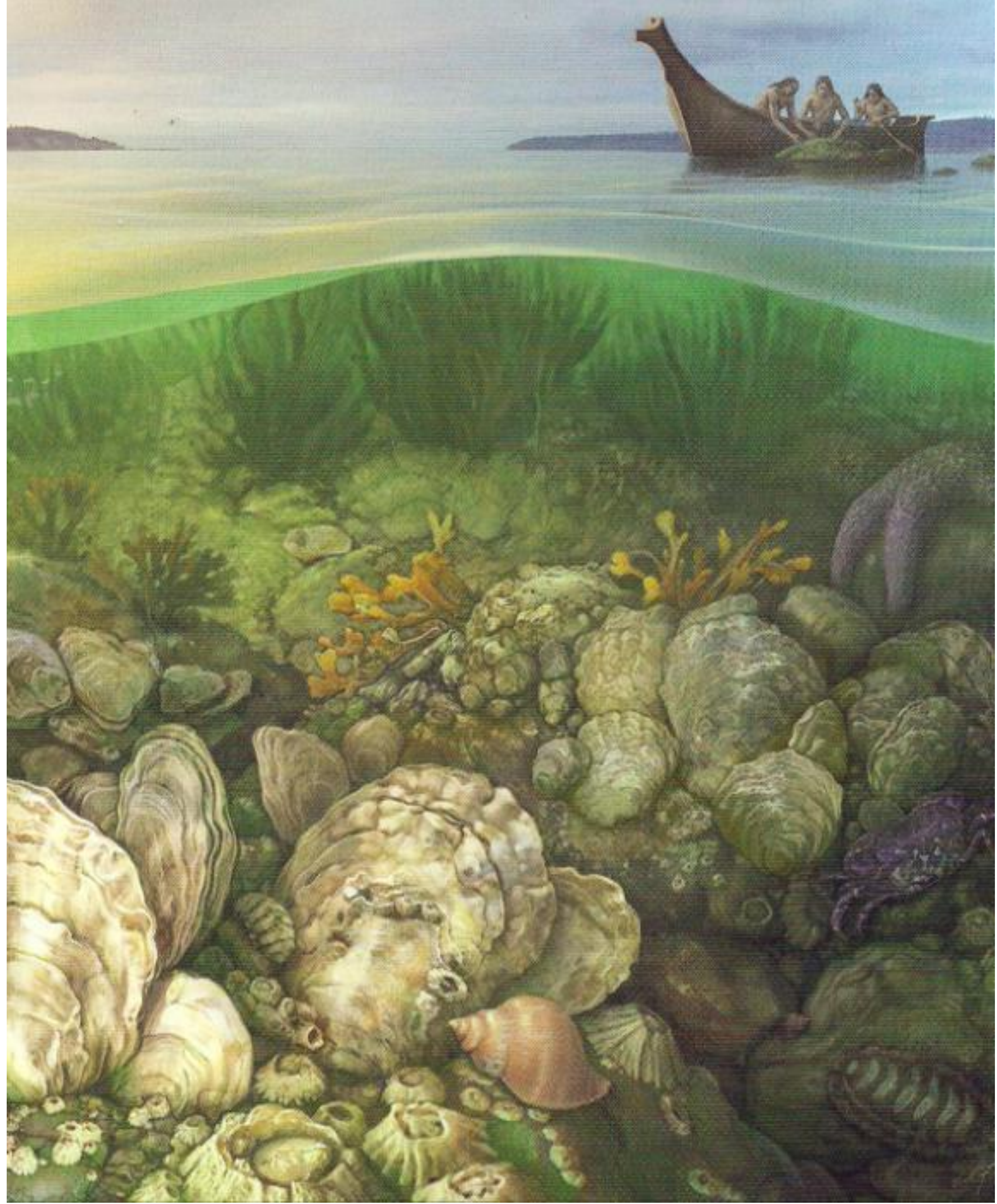
THE OLYMPIA OYSTER

Ostrea lurida

the only indigenous oyster from BC to BC

COASTAL LEGACY

Olys have been part of healthy Pacific bays and estuaries for thousands of years



Painting by Cory and Catska Ench, 2003
From Journal of Shellfish Research March 2009

OLYMPIA OYSTERS ARE TASTY!

Basis of first commercial aquaculture on West Coast

OLYS TYPICALLY FORM SMALL CLUSTERS

grow on each other, “biogenic” habitat

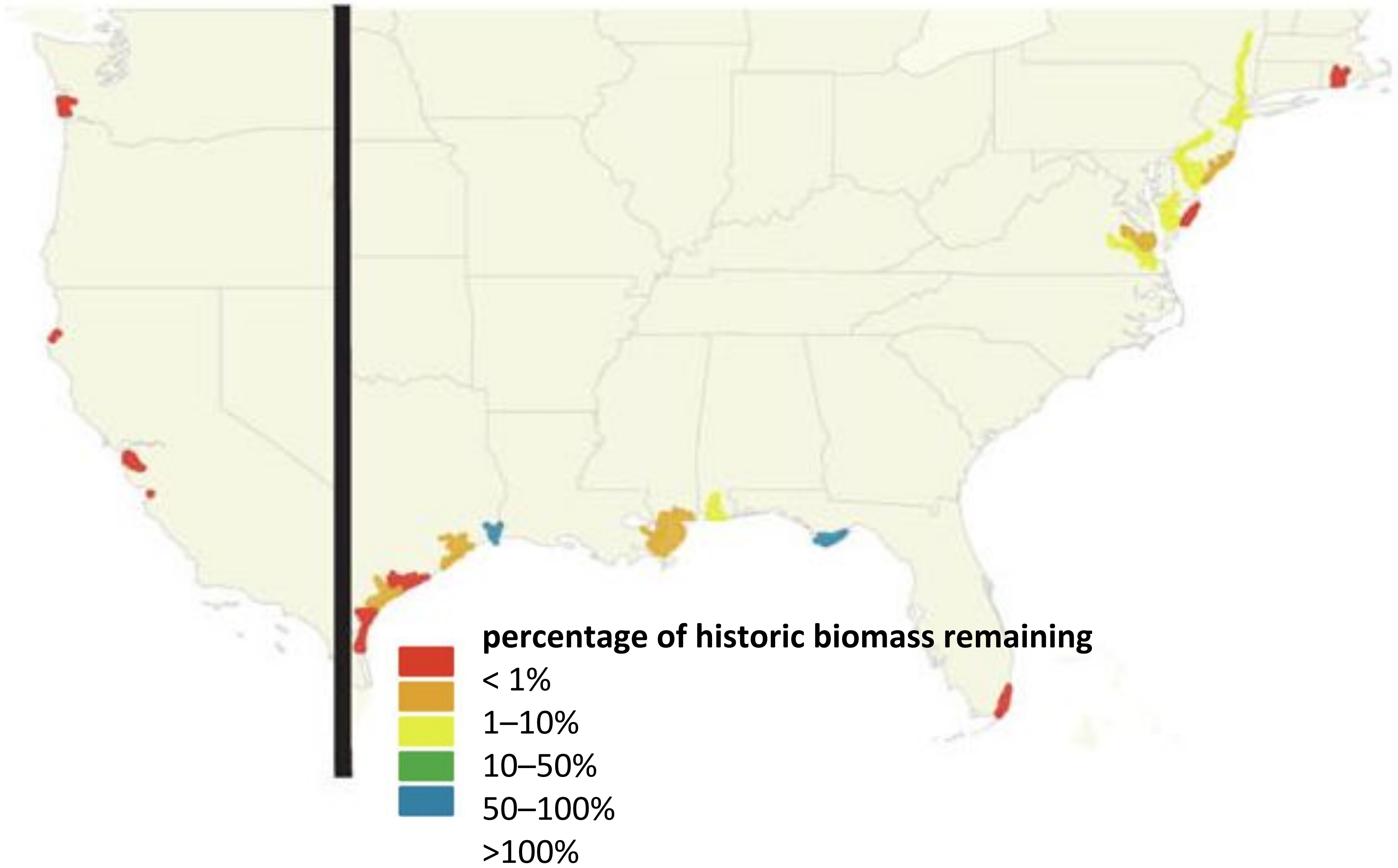

OLYS ARE FOUNDATION SPECIES
low relief beds
Puget Sound Restoration Fund

OLYS CAN BE ABUNDANT

extensive beds when conditions are right

OYSTERS HAVE DECLINED

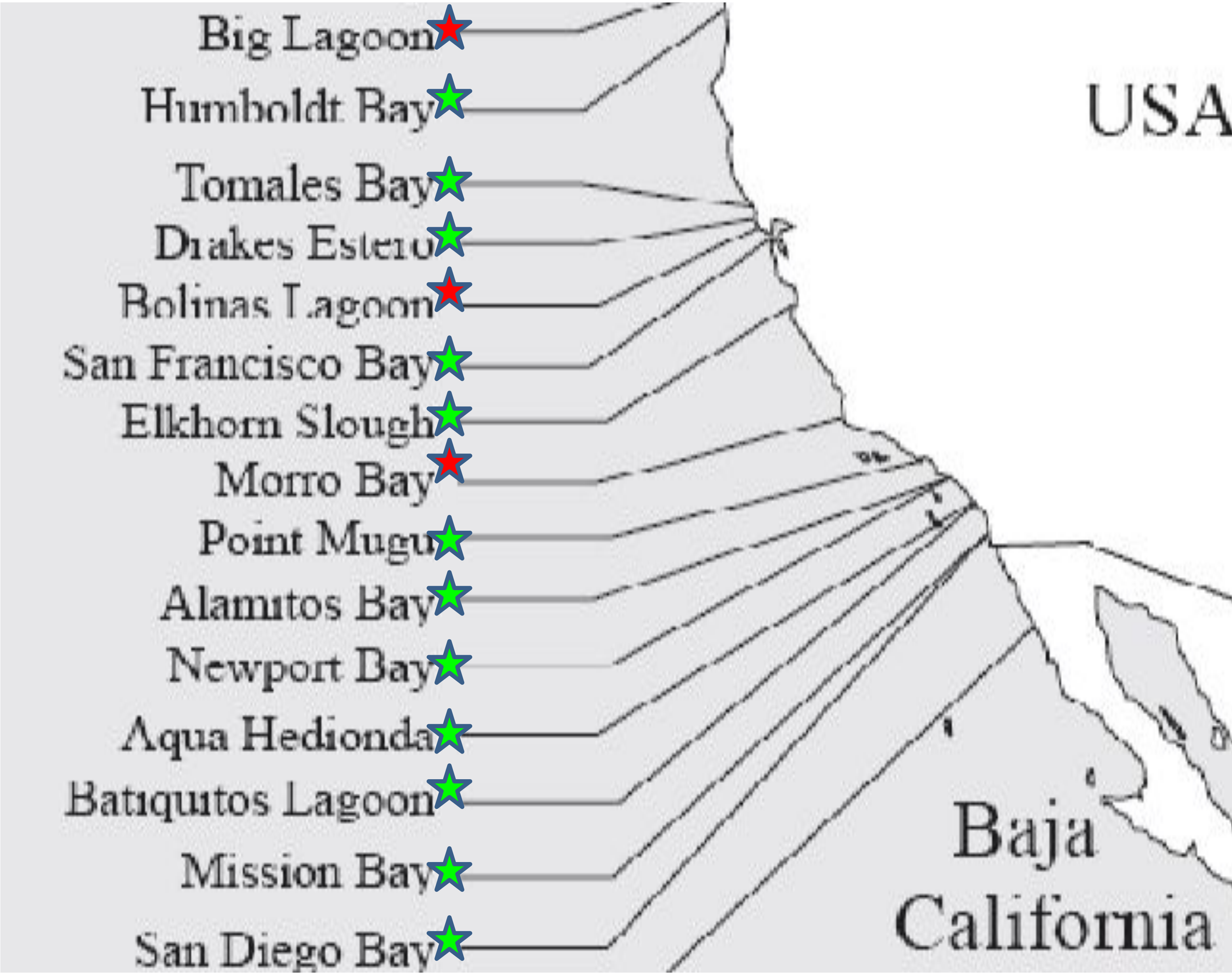
decrease in abundance



From Zu Ermgassen 2012

DECREASE IN DISTRIBUTION

Loss of oysters from some California bays



Sites with and without Olympia oysters

(Data and map from Polson et al. 2009)

ELKHORN SLOUGH

At risk of local extinction

Population size estimated at **5000** by Wasson 2010 *Wetlands*

CHALLENGES TO OYSTERS

(why don't they always look like this?)

GOOPY MUD

small clusters on shells easily buried

HUMAN INFLUENCES

activities that can increase sediment burial

erosion of sediments
from watershed

nutrient inputs
increase organic goop

so instead of oysters on natural shell bits…

…oysters on artificial hard substrates

WATER QUALITY

hypoxia can also limit oysters

Elkhorn Slough Foundation

HUMAN INFLUENCES

activities that can decrease water quality

water control
structures and diking

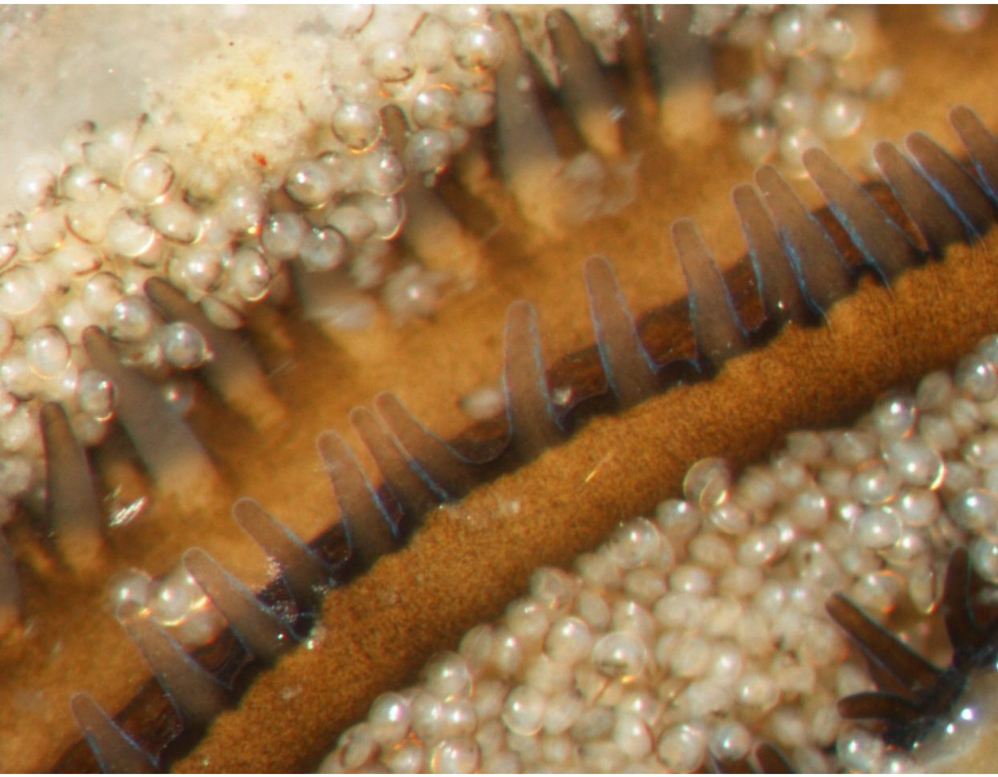
nutrient and
contaminant inputs

PREDATORS

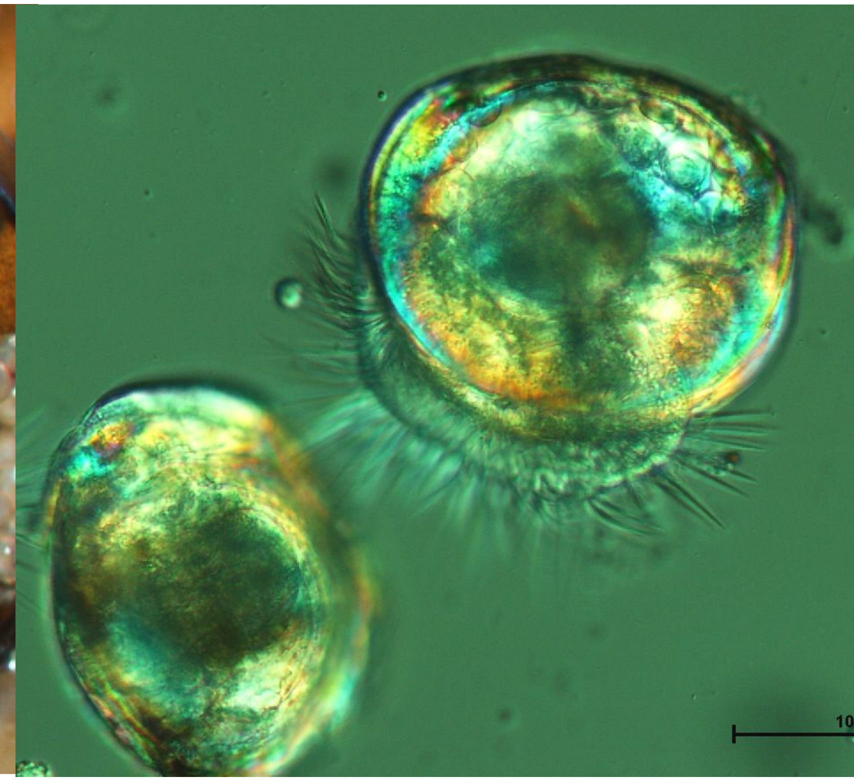
Non-native oyster drills that came along with non-native oyster culture

MAKING BABIES

successful reproduction is another challenge



oyster larvae being brooded



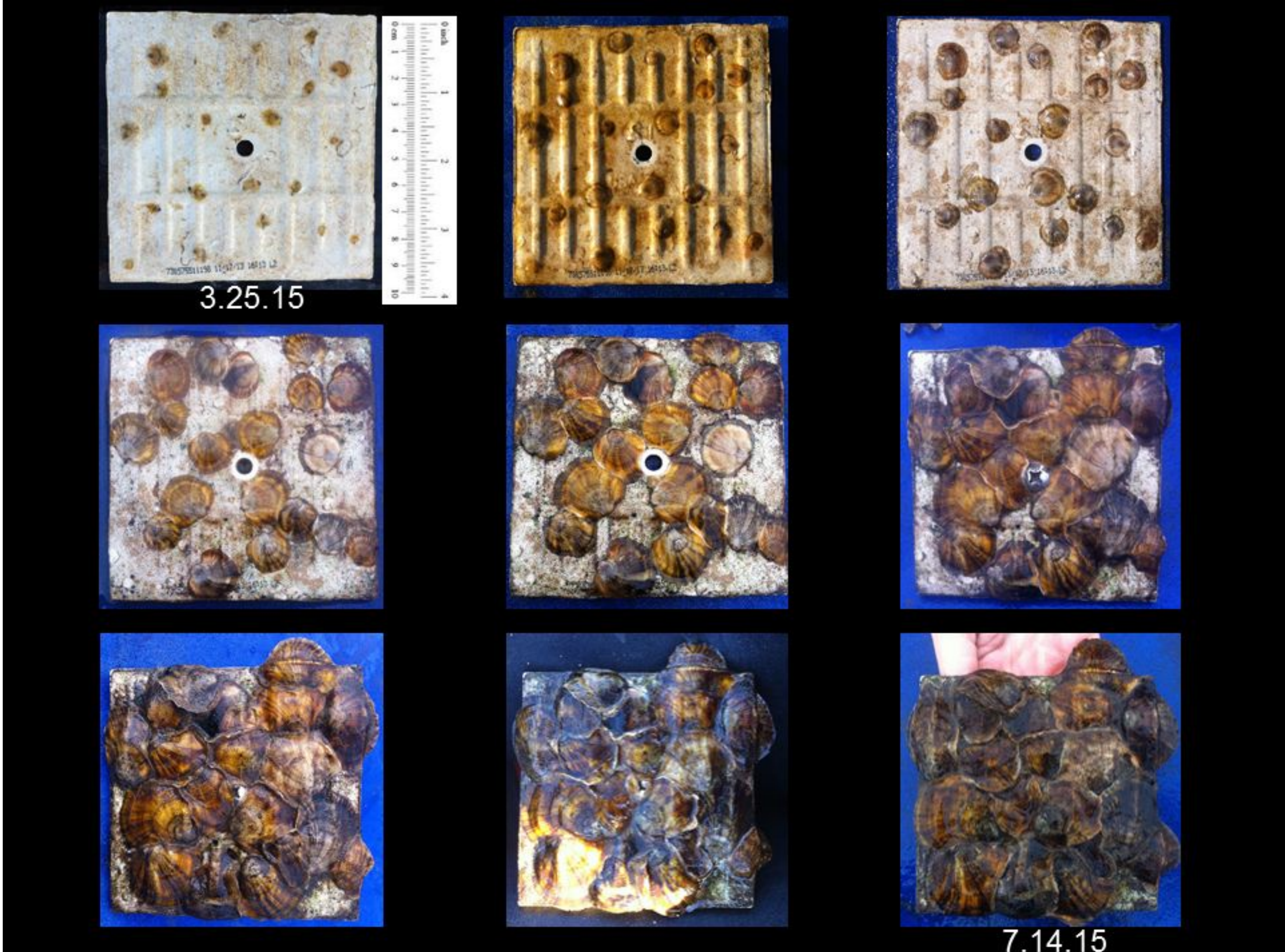
oyster larvae swimming in the water

Photos: J Moore

RECRUITMENT MONITORING

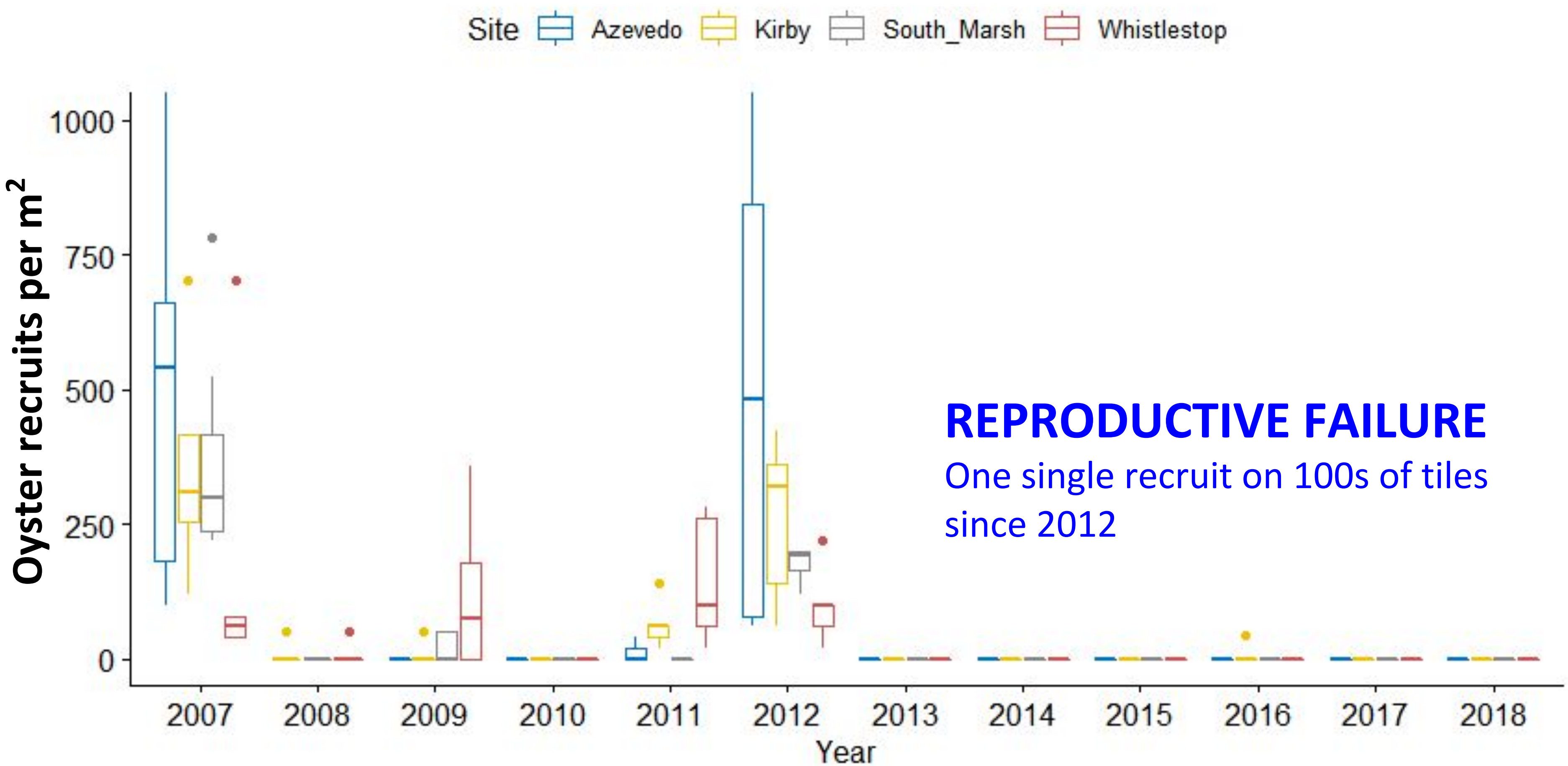
Check for juveniles on tiles

K Wasson



Photos: P N Wade

RECRUITMENT
at Elkhorn Slough

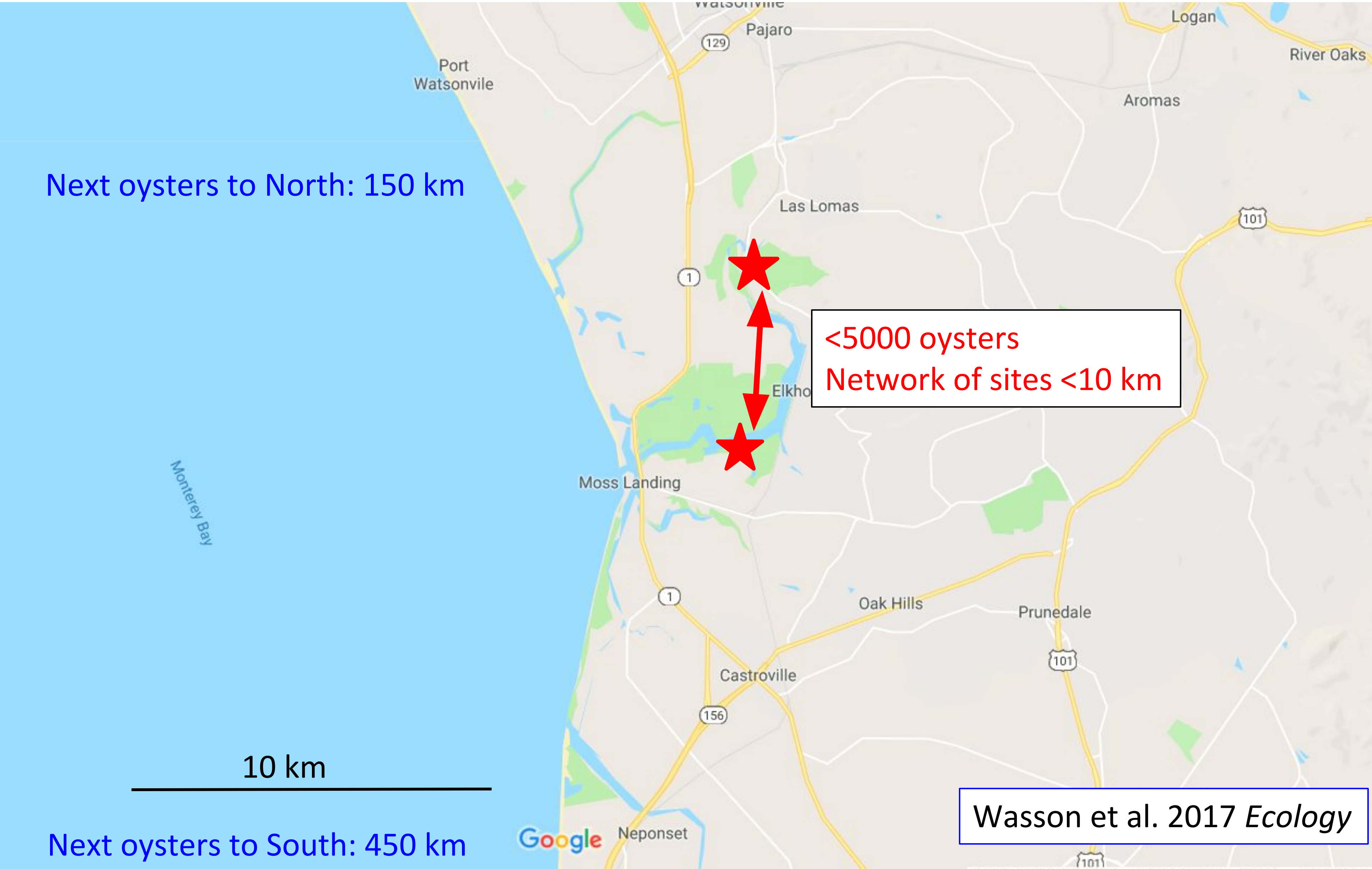


REPRODUCTIVE FAILURE

One single recruit on 100s of tiles since 2012

RECRUITMENT FAILURE

highest in small, isolated populations



REVERSING DECLINES

Olympia oyster restoration

Place-based conservation work is inherently local….
but networks allow you to scale up and learn from each other

OYSTER RESTORATION SCIENCE

- Introduction
- Coastwide network
- Restoration approaches
- Lessons learned and next steps

Past & Current Olympia Oyster Restoration Efforts

Elkhorn Slough, CA

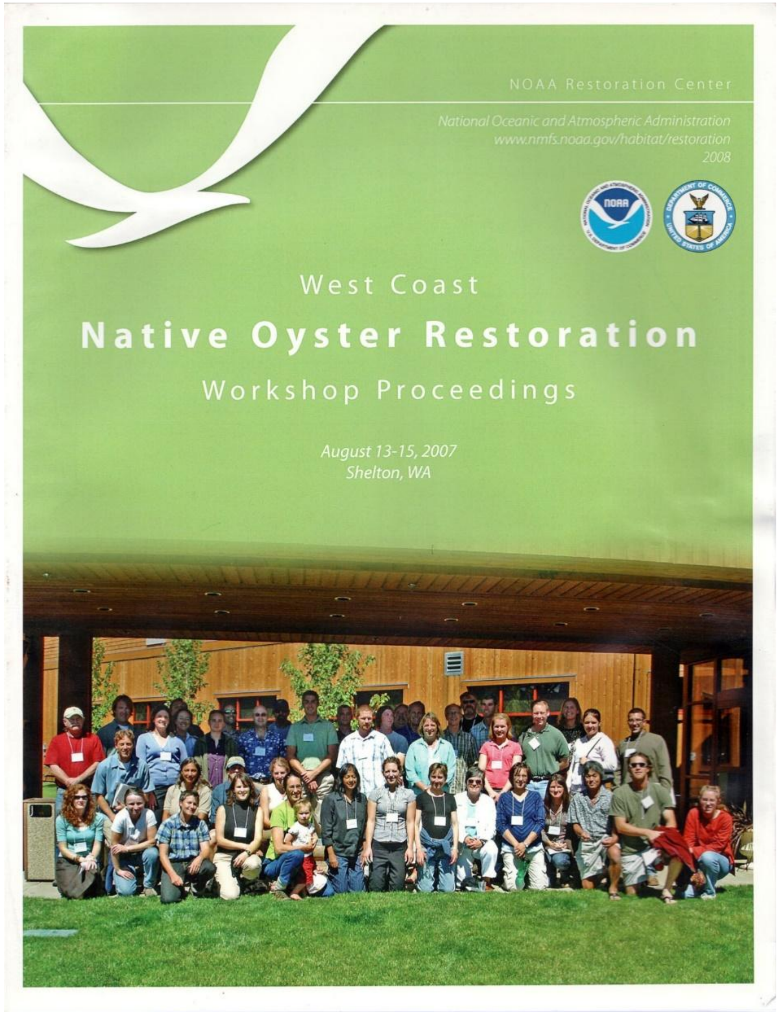
Netarts Bay, OR

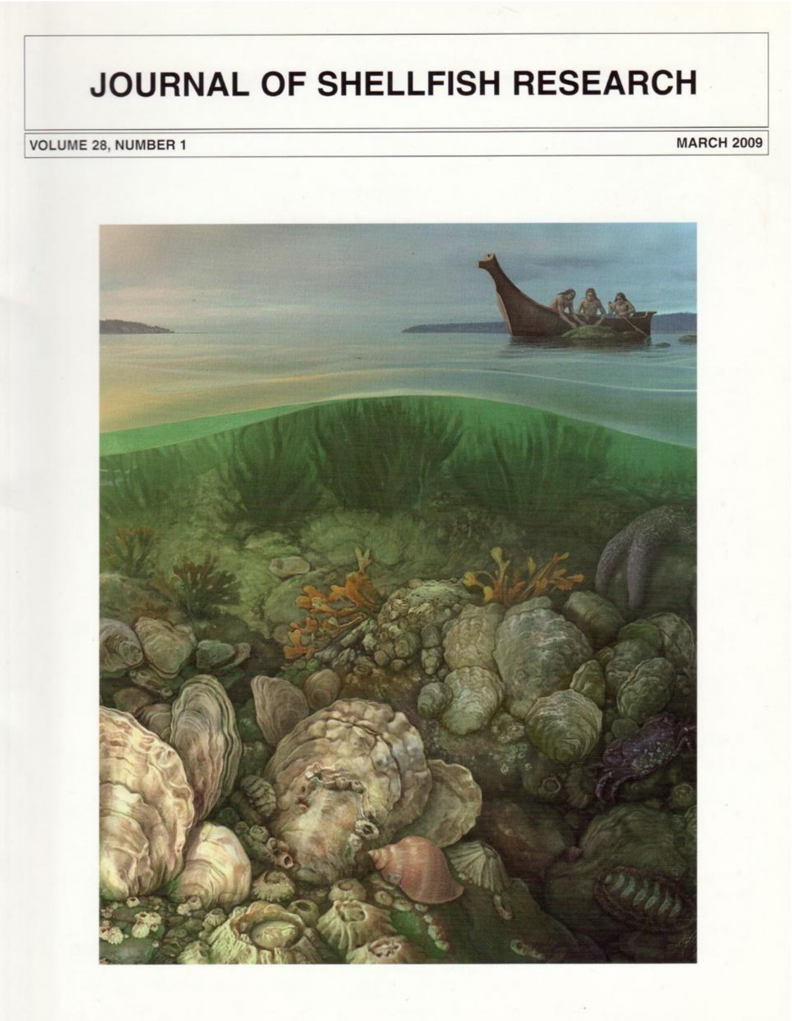
Puget Sound, WA

- Restoration projects initiated in about a dozen estuaries in the last 10 years, often with different goals/methods
- Sites are typically hundreds of miles apart, limiting communication or collaboration

Past Collaborations: Restoration Workshops

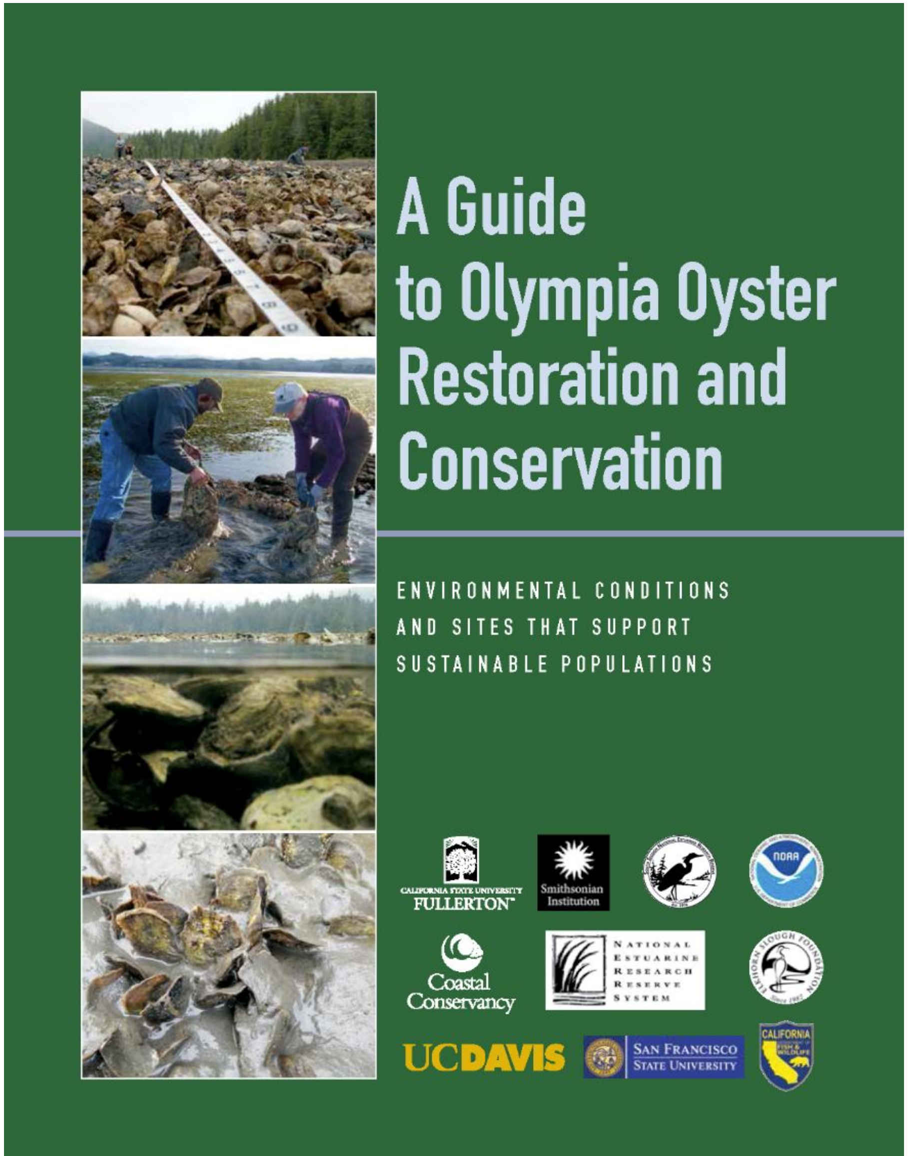
Exchange ideas and spark new collaborations

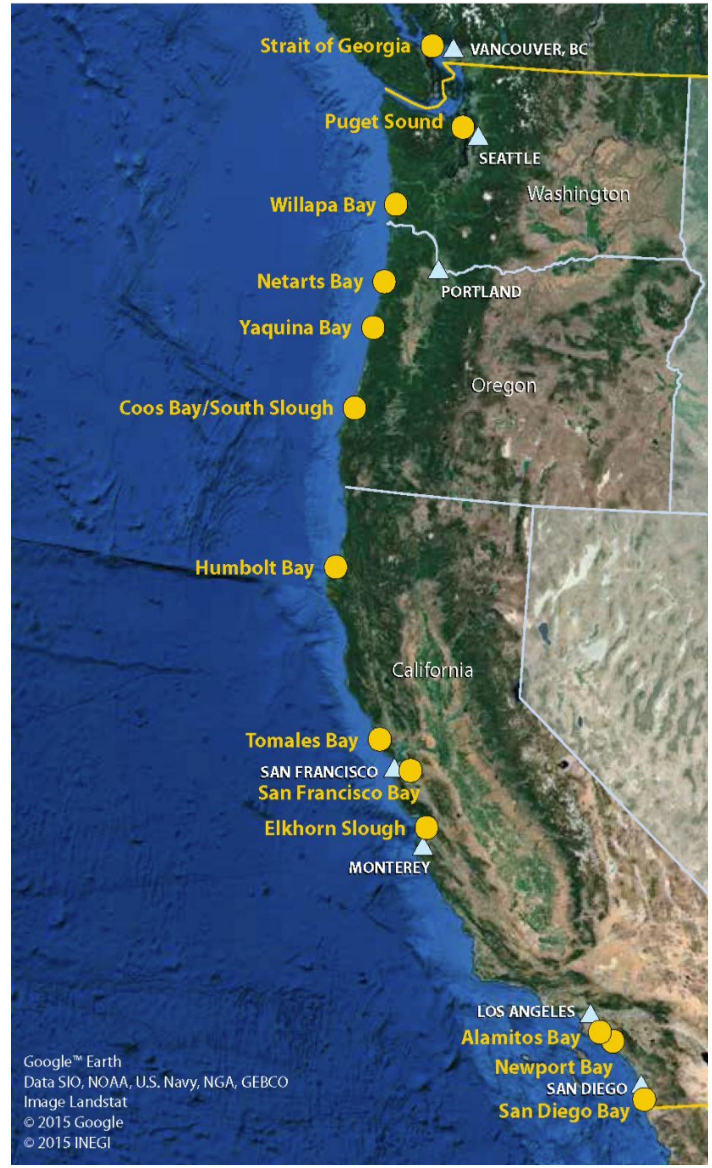




Past Collaborations: Restoration Guides

Collaboration on oyster status and threats (NSC project)





NOOC

Native Olympia Oyster Collaborative

Scientists, restoration practitioners, agencies, tribal communities, and growers ***across 2500 km of the West Coast from BC to BC***

- *35 Steering Committee members*
- *Over 140 members coast-wide*

Native Olympia Oyster Collaborative

Vision

Resilient native oyster populations in a network of bays and estuaries from British Columbia to Baja California, valued by people and forming an integral part of healthy coastal ecosystems

Overarching Goals

- *Community engagement*: raise public profile and build support for Olympia oyster conservation and restoration
- *Restoration/conservation*: learn from each other to improve the design and implementation of projects
- *Research:* exchange information to improve our understanding of factors that limit oyster populations
- *Aquaculture:* share approaches for using hatcheries to support recruitment-limited populations

Native Olympia Oyster Collaborative

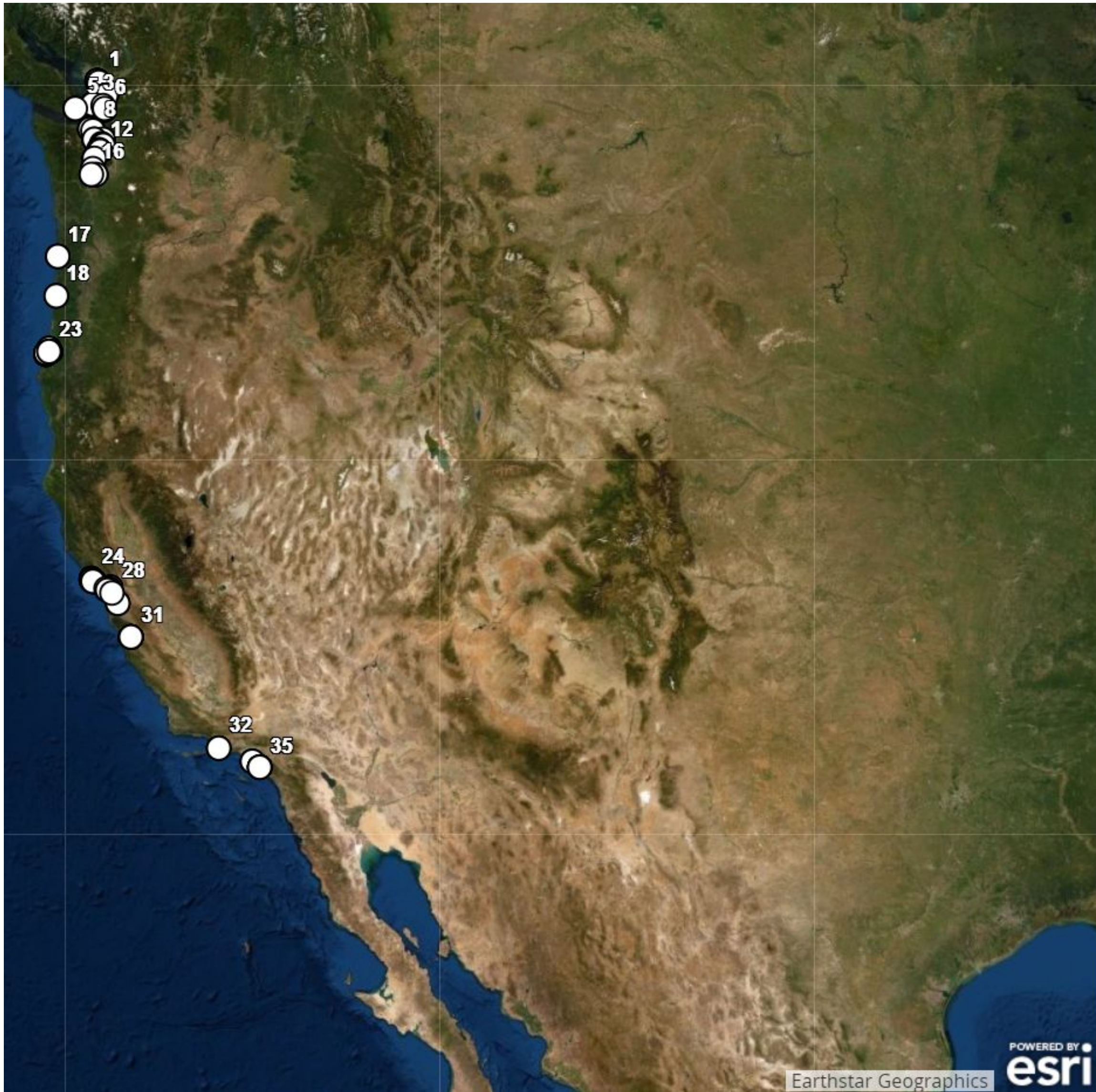
Website

- Archive & interactive map of all current & historic restoration projects on the West Coast
- Resources for educators and students
- Information about Olympia oysters to the public

https://oysternet.sf.ucdavis.edu/

Native Olympia Oyster Collaborative

Restoration Database & Story Map



A Story Map

NOOC - Native Olympia Oyster Collaborative

Projects Overview Map

(Click on project name to be directed to project page)

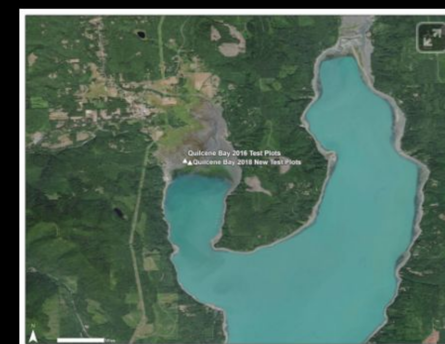
1. Drayton Harbor Olympia Oyster Project - Drayton Harbor, WA
2. Whatcom MRC Pilot Olympia Oyster Restoration Project - North Chuckanut Bay, WA
3. Fisherman Bay Living Shorelines - Fisherman Bay, WA
4. Fidalgo Bay Olympia Oyster Restoration - Fidalgo Bay, WA
5. Gorge Waterway Urban Oysters - Gorge waterway/Portage Inlet, BC
6. Swinomish Olympia Oyster Restoration - Skagit and Similk Bays, WA
7. MRC Clallam County Olympia Oyster Restoration - Sequim Bay, WA
8. Discovery Bay Olympia Oyster Project - Discovery Bay, WA
9. Port Gamble Olympia Oyster Restoration - Port Gamble Bay, WA
10. MRC Quilcene Bay Olympia Oyster

Site Profiles

A Story Map

NOOC - Native Olympia Oyster Collaborative

10. MRC Quilcene Bay Olympia Oyster Project - Quilcene Bay, WA



Quilcene Bay sites

<u>Project Goals</u>: To test feasibility of re-establishing Olympia oyster beds in Quilcene Bay under current site conditions, which have changed since historic expansive oyster beds were first documented there.

Site Profiles

Dogfish Bay (Liberty Bay) picture of the crew in 2009 sitting on top of the shell pile next to the U.S. Navy pier prior to spreading.

A Story Map

NOOC - Native Olympia Oyster Collaborative

Restoration Approach: Olympia oyster juveniles on Pacific oyster shell (grown by Taylor Shellfish and Lummi Nation) were added to the site

Average Tidal Elevation MLLW (m) :
Volume of Hard Substrate Added (m^3) : 3134
Area substrates were deployed (m^2) : 72900

Years Implemented: 2001-2011
Years Monitored: 2007-2017

Numbers of Olympia oysters on restoration substrates:

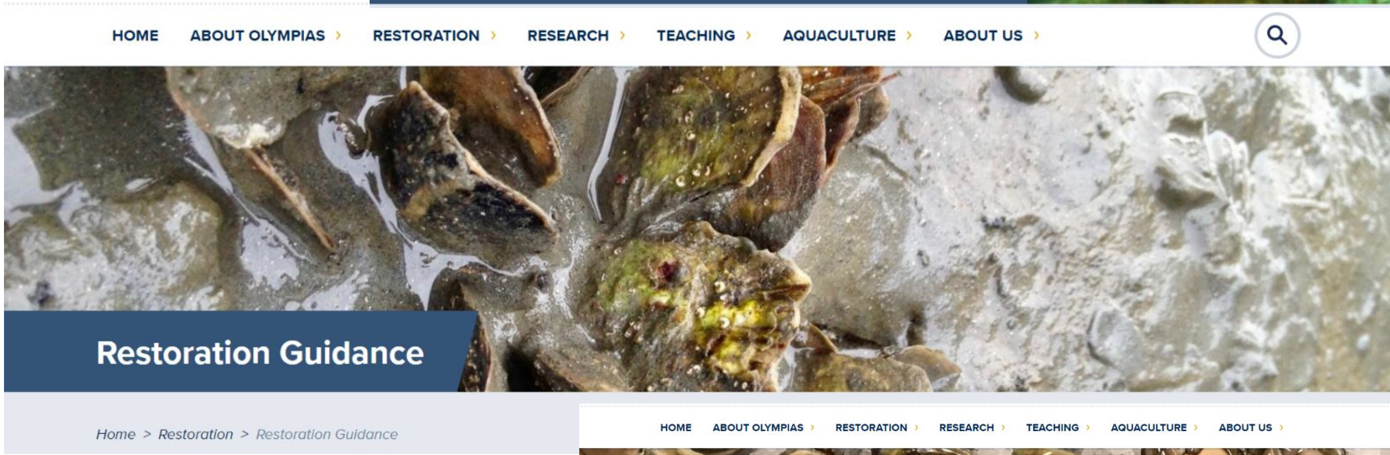
- 1 year after deployment: 0 - 1,000
- 5 years after deployment: > 1,000,000
- 10 years after deployment: > 1,000,000

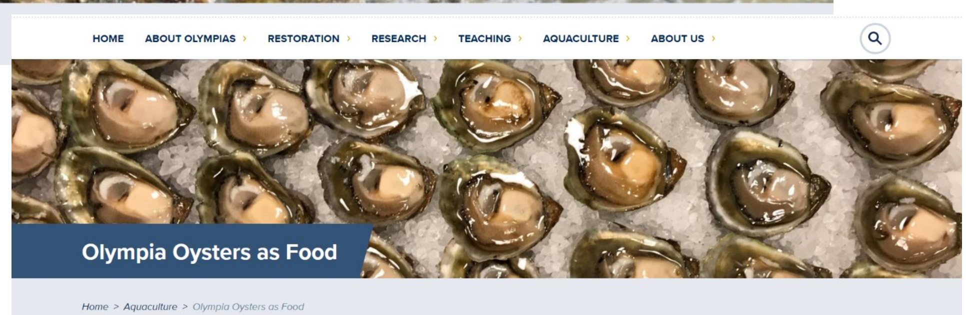
Major Challenges to Restoration Success: None

Lessons Learned: Long water residence time and gentle slopes make for ideal locations for restoration; working in a historic oyster reserve is too.

Native Olympia Oyster Collaborative

Website





Website

Native Olympia Oyster Collaborative

HOME ABOUT OLYMPIAS › RESTORATION › RESEARCH › TEACHING › AQUACULTURE › ABOUT US ›

Home > *Teaching*

Olympia oysters can serve as locally relevant anchor for studying biology, ecology, climate change, math, social studies, and engineering. The scientists within our network also know that to protect and restore native oysters, we need the support and help of local communities. Many of our scientists work alongside educators to help them bring cutting edge research to schools.

We have collected **lesson plans and ideas** and

- Classroom Material
- Lesson Plans

OYSTER RESTORATION SCIENCE

- Introduction
- Coastwide network
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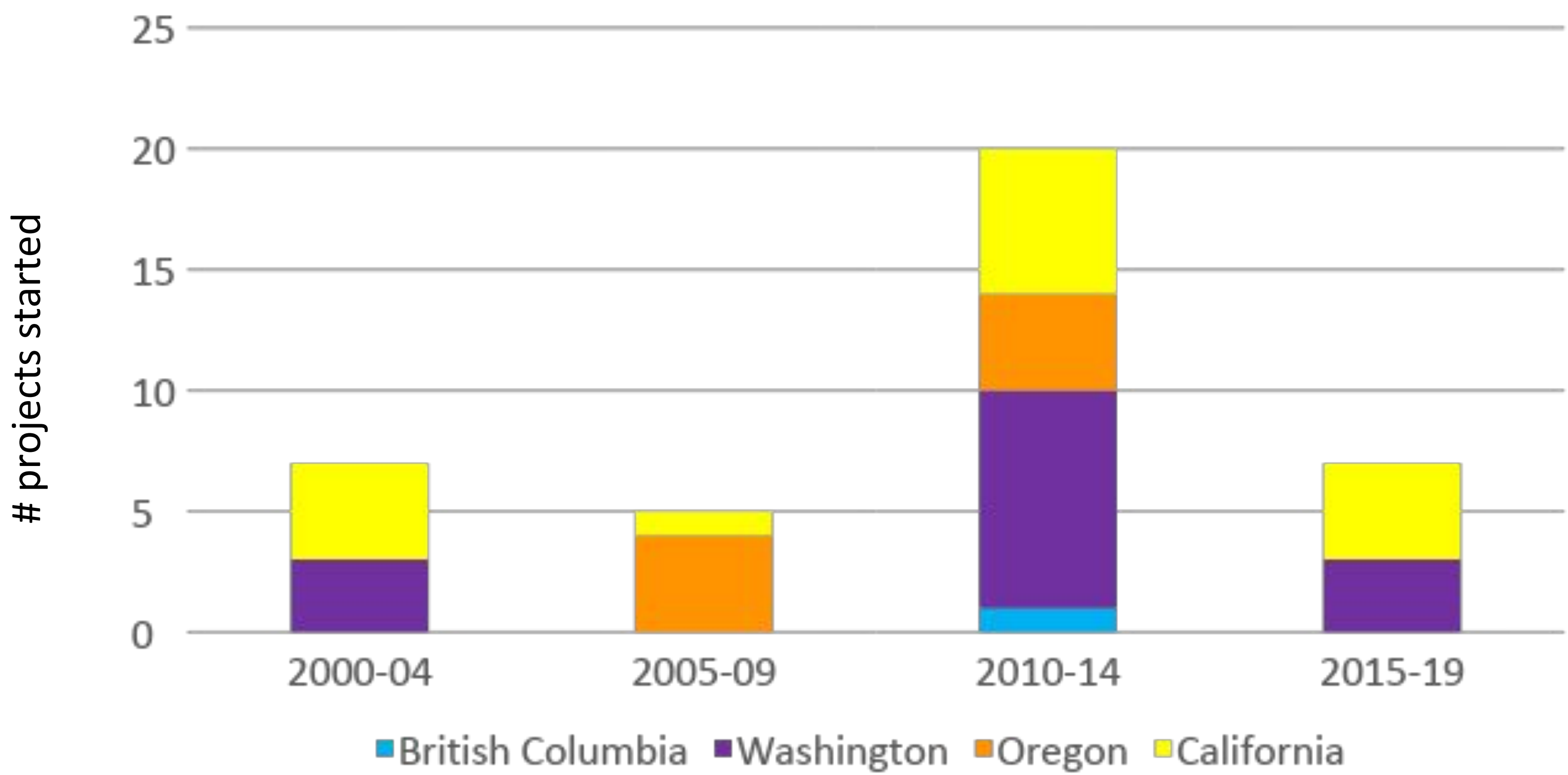
OVERVIEW OF TWO DECADES

39 oyster restoration projects, most in WA and CA



RELATIVE LITTLE $ SPENT ON OLYS

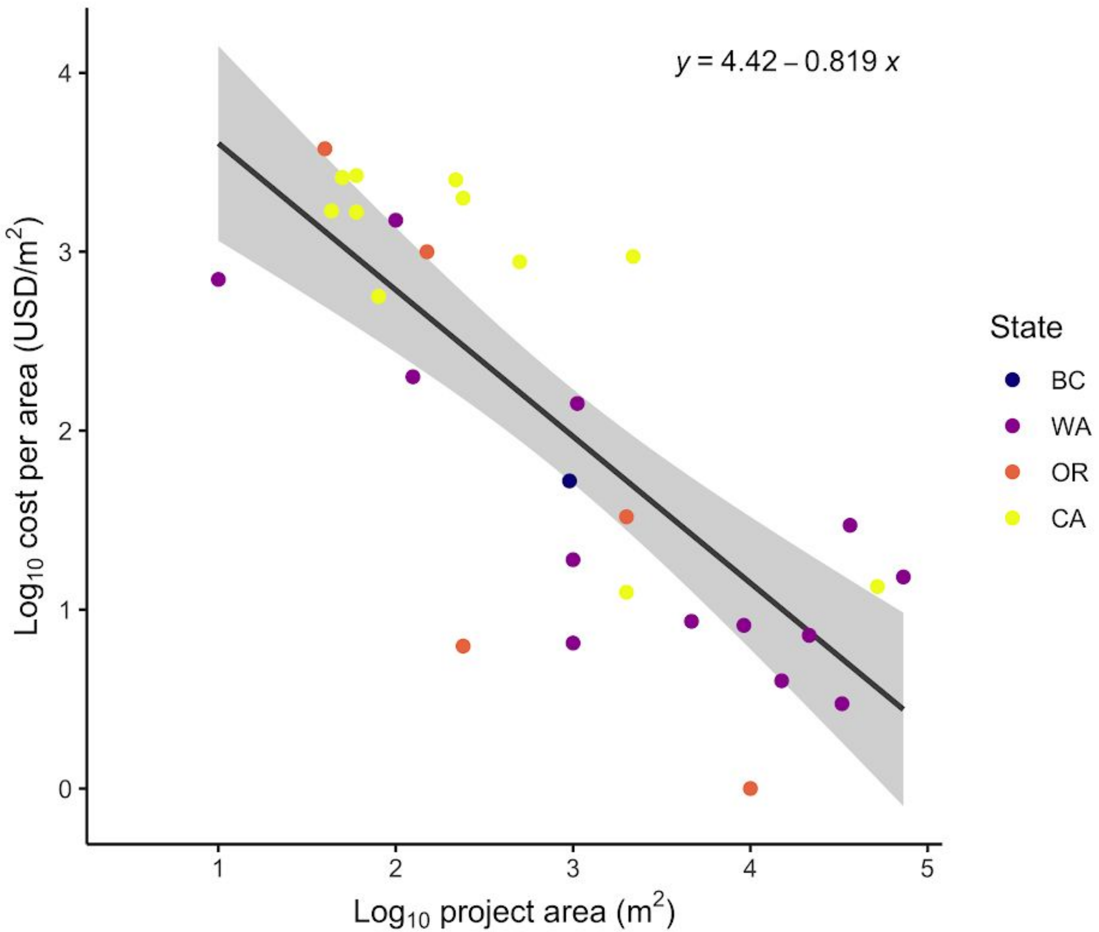
About $8 M for 32 projects reporting budgets

Average & standard deviation of restoration project cost

Washington	**$229** K	± $388 K
Oregon	**$75** K	± $ 72 K
California	**$371** K	± $555 K

LARGER IS BETTER

Cost per area restored decreases with size

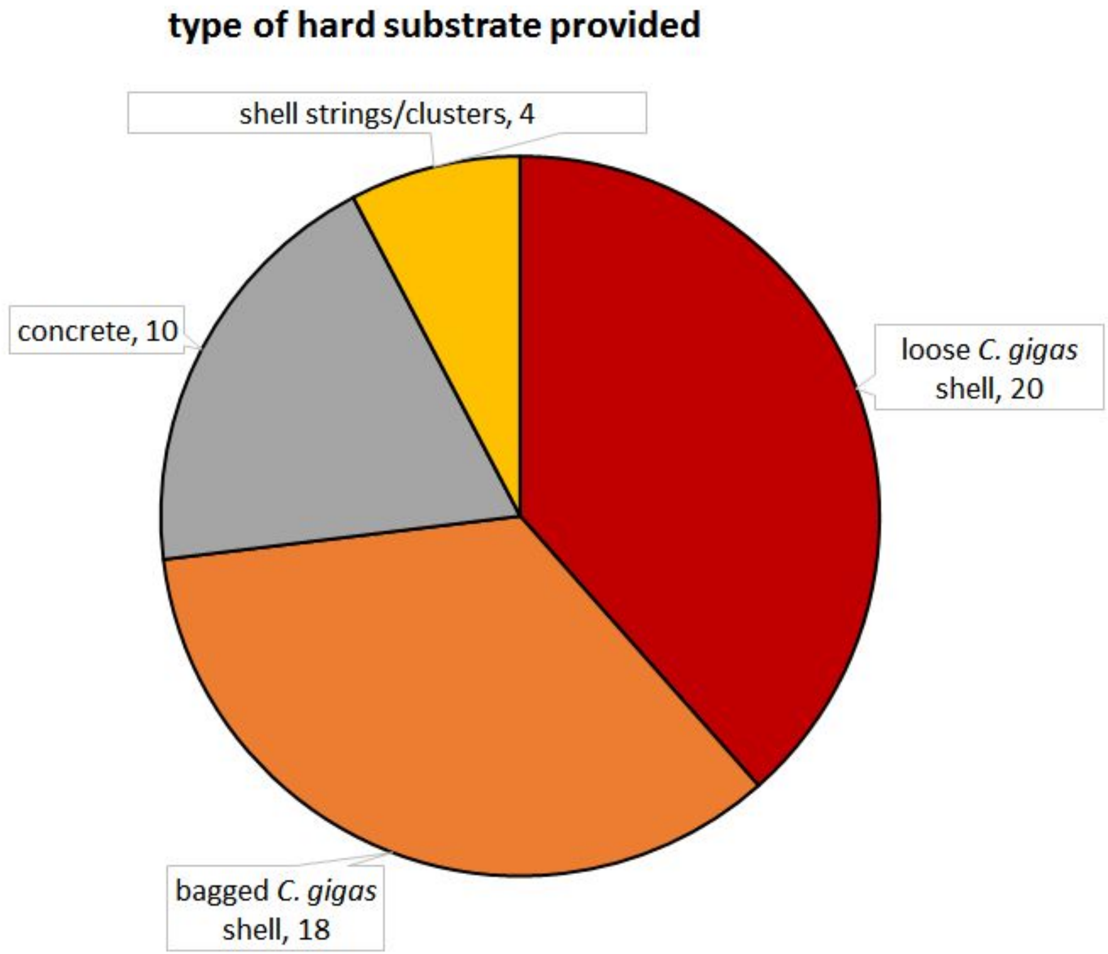


RESTORATION APPROACH

Almost every project involved adding hard substrates to mudflats

SUBSTRATE ADDED

By far most common: Pacific oyster shell



Loose Pacific oyster shell

Liberty Bay – WA10


Loose Pacific oyster shell
Port Gamble – WA8


Bagged Pacific oyster shell
Netarts Bay – OR1
TNC

Stacked bags of Pacific oyster shell

San Francisco Bay – CA6

Pacific oyster shell clusters

Gaper clam shell clusters

Concrete/shell reef balls

SUBSTRATE PROFILE

Varied by region

Low profile

2/3 of projects

WA: all
OR: most
CA: some

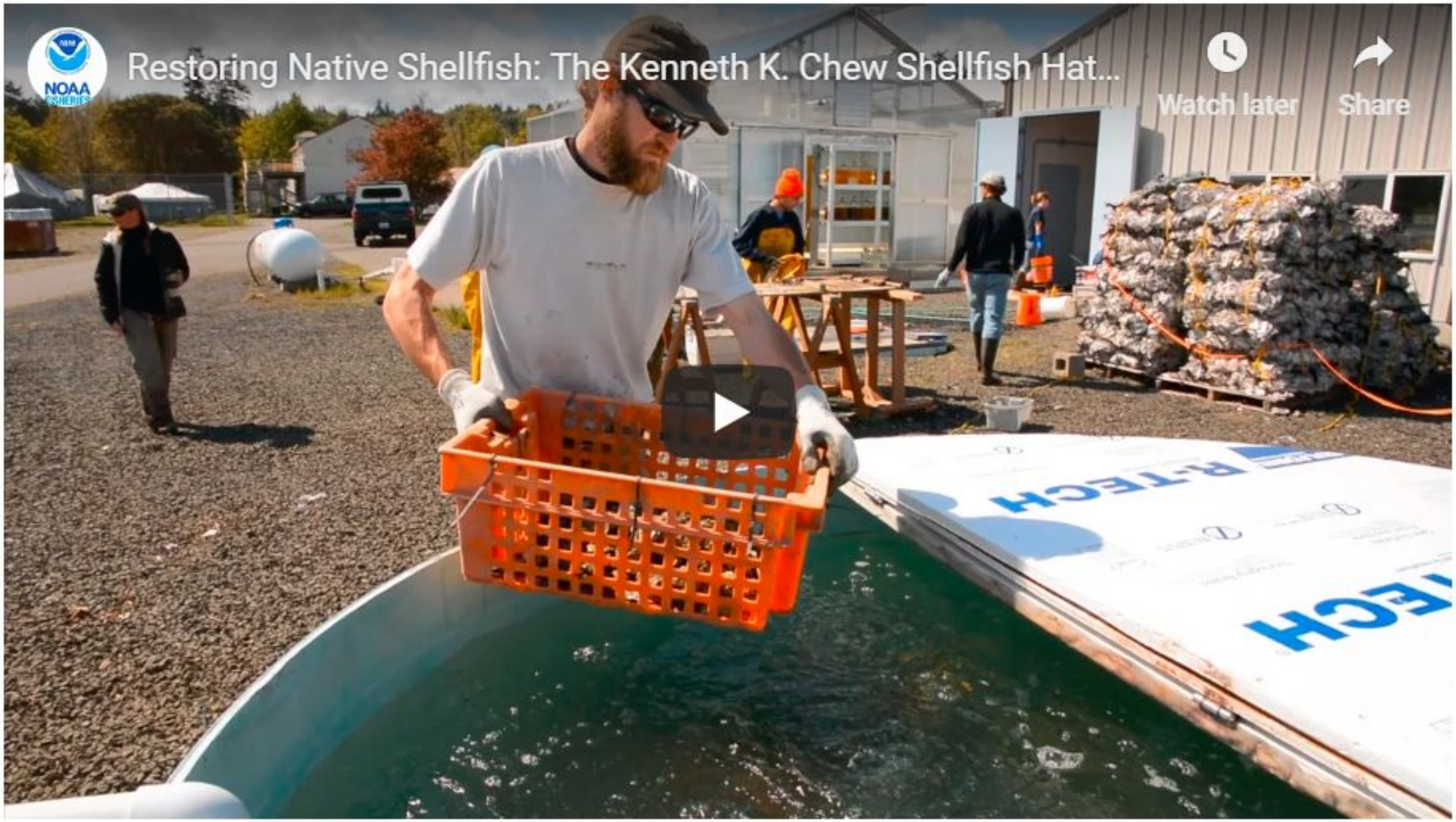
High profile

1/3 of projects

WA: none
OR: some
CA: many

BEYOND SUBSTRATE: ADDING OLYS

- 7 projects moved adults
- 8 projects moved wild-collected spat
- 16 projects added hatchery-raised juveniles



CONSERVATION AQUACULTURE

Critical for recruitment-limited populations

INCREASING ESTUARY POPULATION

First new recruits for Elkhorn Slough since 2012

QUESTIONS TO ASK BEFORE BEGINNING OYSTER RESTORATION

- Answer them with scientists and stakeholders in your region

- Answers differ by region and interests of community

WHERE DO OYSTERS MOST NEED OUR HELP?

Some places have abundant, increasing populations

Some places have rare, decreasing populations

We can help them the most in places where populations have declined the most

AT WHAT SCALE DO WE WANT TO MAKE A DIFFERENCE?

San Francisco Bay – CA-3

Provide representation of oyster habitat in a mudflat that didn't have any

site-scale

Significantly increase population in an area where it was reduced to near zero

estuary-scale

HOW CAN WE HELP OYSTERS THE MOST?

Water quality poor

Restore ecosystem health

Hard substrates limiting

Add substrates

Population size too small

Add oysters

WHERE CAN OYSTERS MOST HELP US?

Return of cultural legacy

Significant water quality improvement

Measurable increase in fisheries catch

Choose places where oyster restoration will lead to the biggest increase in desired services

IF THE FOCUS IS ON ECOSYSTEM SERVICES, SHOULD WE CARE ABOUT WHICH SPECIES ACHIEVES THEM?

- Both species taste good, filter water, provide fish habitat, protect shorelines

Ecosystem services framework may not provide rationale for conserving native biodiversity

WHAT SUBSTRATE ADDITION APPROACH SHOULD YOU USE?

Stakeholders want historic, biogenic habitat structure or want to minimize non-native fouling cover

Low profile

e.g. loose shells

Stakeholders want shoreline protection and can tolerate non-native cover, and/or site is very muddy

High profile

e.g. concrete

HOW MUCH OYSTER, EELGRASS, MUDFLAT AND MARSH HABITAT SHOULD YOU AIM FOR?

- Which habitat type has seen the most losses in this estuary?
- Which is likely most sustainable in the future?
- Which services are most critical for stakeholders in your area?

Set conservation goals for all habitats together

OYSTER RESTORATION SCIENCE

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Lessons Learned

Native Olympia Oyster Collaborative

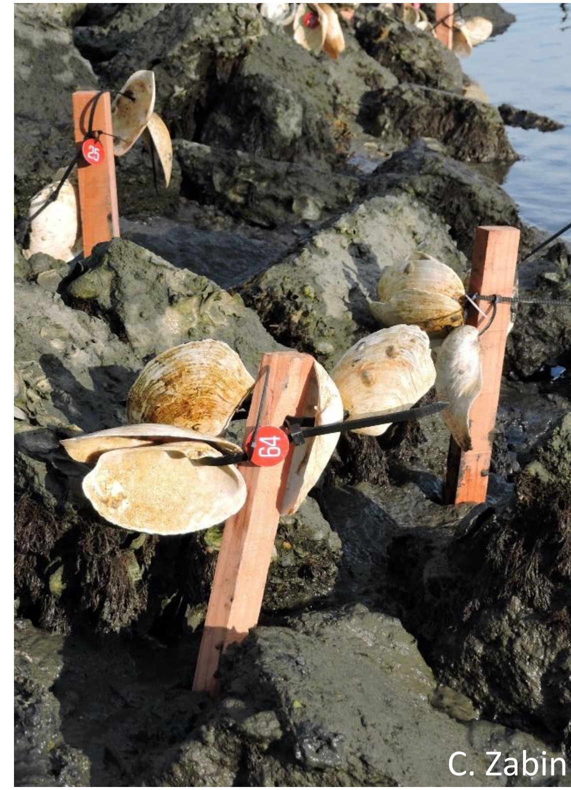
	Projects (out of 37)		Projects reporting success	
	Number	Percent	Number	Percent
NUMERIC OYSTER OBJECTIVES	**23**	**62%**		
on deployed restoration substrates				
numbers	5	14%	3	60%
densities	11	30%	8	73%
recruitment	10	27%	4	40%
in immediate vicinity (1 km of shoreline)				
numbers	3	8%	2	67%
densities	2	5%	1	50%
recruitment	5	14%	1	20%
in larger area (20 km of shoreline)				
numbers	0	0%	na	na
PEOPLE OBJECTIVES	**30**	**81%**		
community engagement	24	65%	22	92%
science / learning / testing methods	16	43%	14	88%
ECOSYSTEM SERVICES/FUNCTIONS	12	**32%**		
increase in desired animal species	9	24%	3	33%
shoreline protection	4	11%	0	0%
improved water quality	2	5%	1	50%

Community engagement, testing methods, and learning were fundamental, as important as focal species

NOC

Native Olympia Oyster Collaborative

Lessons Learned



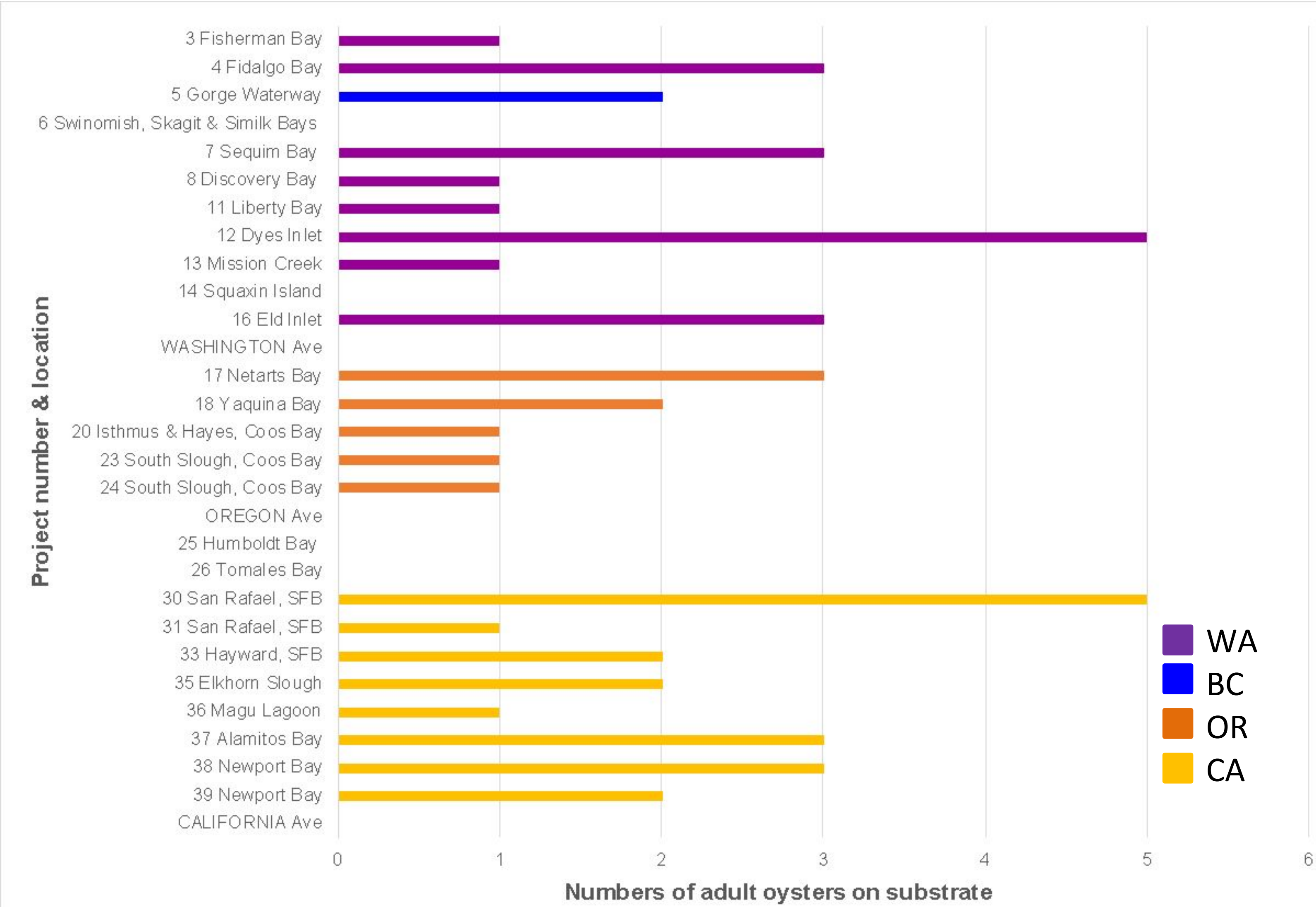
Community Engagement Benefits

- *Volunteer workforce*
- *Educational value*
- *Test new methods on a small scale*
- *Public support for management/policies*

Lessons Learned

Native Olympia Oyster Collaborative

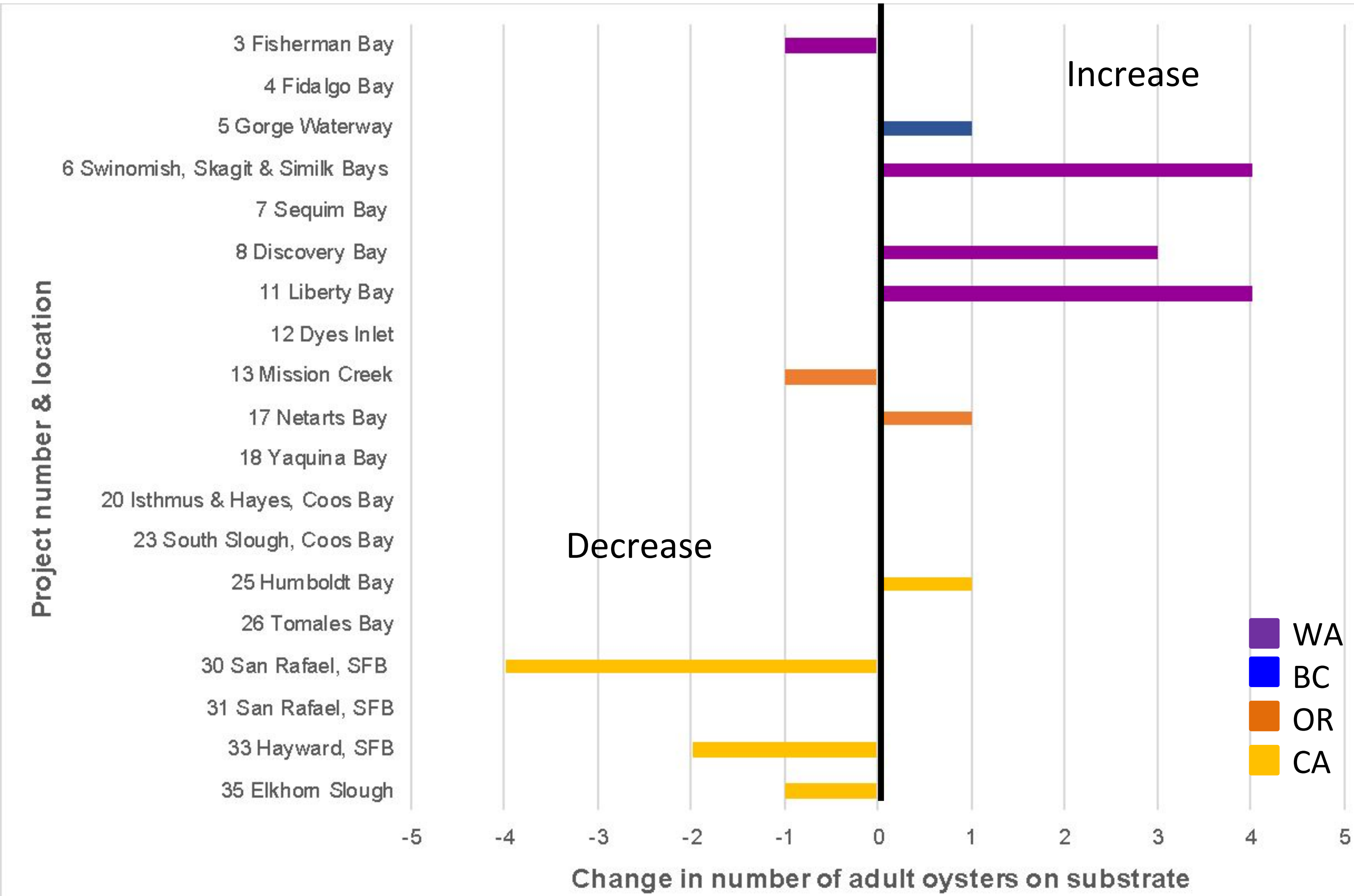
Number of Oysters on the Restoration Substrate After 1 year



Lessons Learned

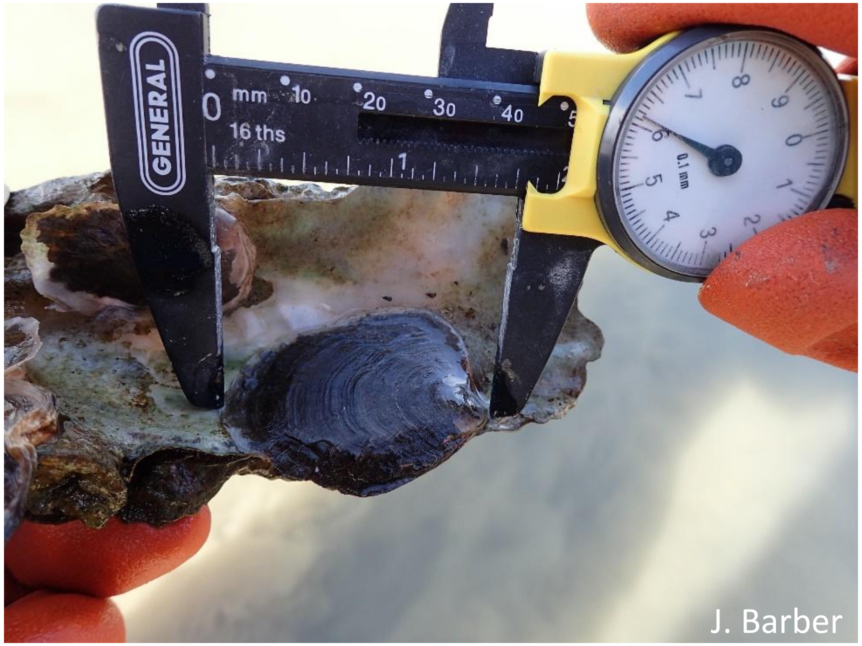
Native Olympia Oyster Collaborative

Change in Number of Oysters on the Restoration Substrate 1-5 years



NOOC
Native Olympia Oyster Collaborative

Lessons Learned

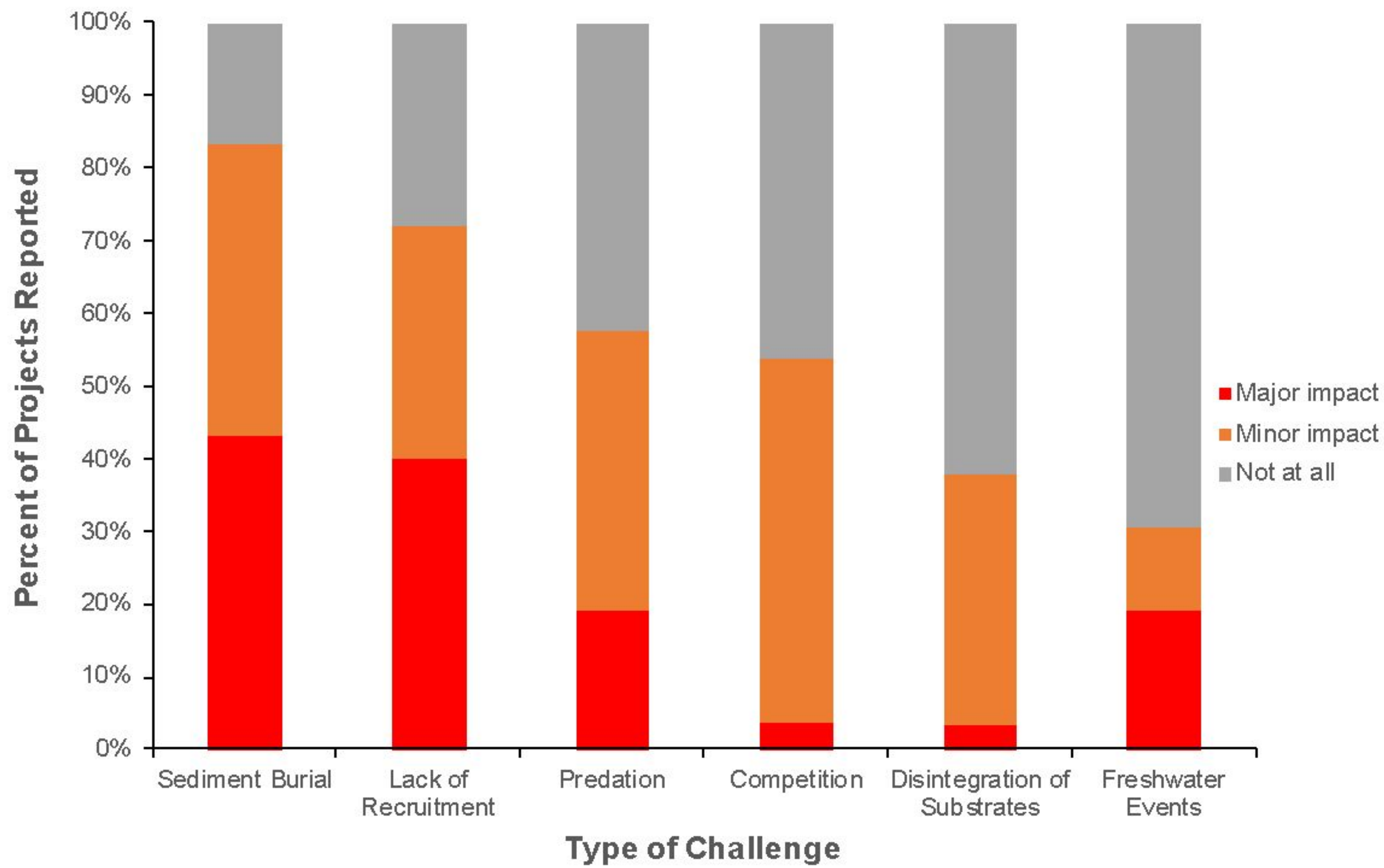


Monitoring

- *All projects tracked oyster measurements (#, size, recruitment) on the substrates / in immediate area of restoration: larger scale is needed*
- *Average length of monitoring is 4.5 years: longer-term monitoring is needed*
- *Monitoring effort varies: CA monitored the widest array of parameters (33), WA = 30, OR= 15, BC= 11*

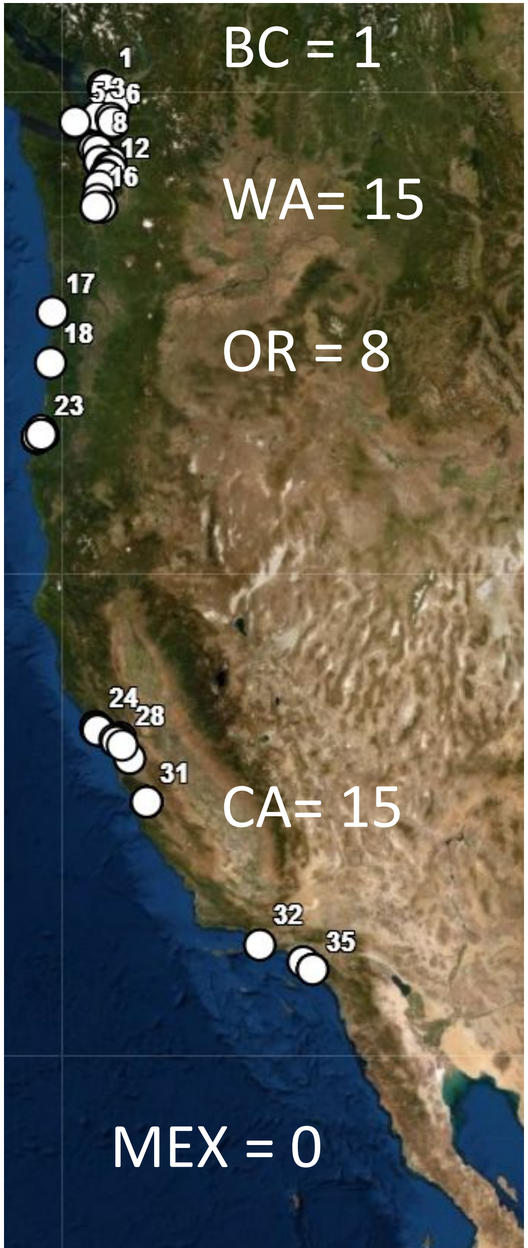
Lessons Learned

Top Challenges to Oyster Restoration



Ecosystem-level management would address common challenges to restoration

Lessons Learned



Regional strategies and coast-wide planning are needed to improve restoration/conservation of this species

Native Olympia Oyster Collaborative

SNAPP
Science for Nature and People PARTNERSHIP

Conservation Aquaculture of Marine Foundation Species


https://snappartnership.net/teams/conservation-aquaculture/

NOOC
Native Olympia Oyster Collaborative

SNAPP
Science for Nature and People PARTNERSHIP

What are the social and ecological trade-offs of using aquaculture as a conservation tool for marine foundation species, and what are the responsible methods for using this approach?

Conservation Aquaculture Products

- Global synthesis evaluating aquaculture as a conservation tool for marine foundation species, particularly in the face of a changing climate.

- Index of Suitability and guidance document for the use of aquaculture to support Olympia oyster conservation.

- Community Engagement Toolbox customizable strategies for engaging community members in conservation aquaculture of Olympia oysters.

A. Ridlon

International Olympia Oyster Network: Collaborative Research and Assessment of Management Goals in Baja California, Mexico

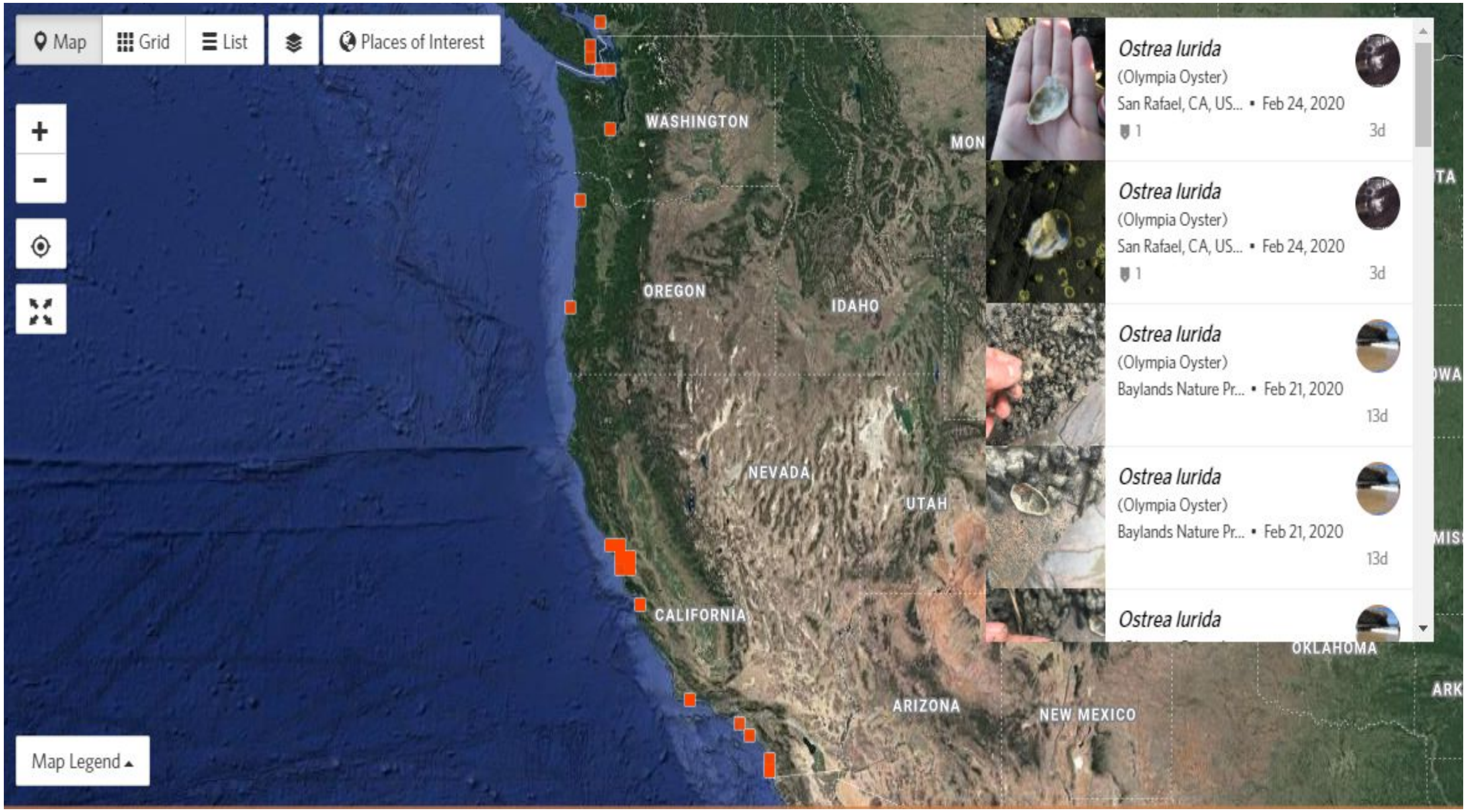
Native Olympia Oyster Collaborative

UC MEXUS ESTABLISHED 1980

Collaborative Research Goals

- Determine the distribution and population status of the native and introduced (Pacific) oyster, compare current with historical data
- Increase capacity for restoration of the native oyster in Mexico
- Establish local, long-term monitoring of the native and introduced oyster species

Mapping Olympia oyster distributions throughout the species' range



Please contact Kerstin if you have data to contribute!

Native Olympia Oyster Collaborative

Future Project

Coast-wide Coordinated Restoration Experiment

Make use of latitudinal variation to examine climate-related responses

OYSTER RESTORATION SCIENCE

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Olympia oyster restoration science
NOOC
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National Estuarine Research Reserve System

Q&A

Use the “Questions” function in the GoToWebinar console

Kerstin Wasson
Research Coordinator
Elkhorn Slough NERR, CA

April Ridlon
Collaborative Lead
Native Olympia Oyster Collaborative

Q&A

Q: Do Pacific oysters present a problem for Olympia oyster recruitment?

- **A:** Neither of us works directly in a place that has both species; our colleagues in Southern California and Puget Sound would probably know better. In places where Crassostrea is harvested, if Olympias have settled there you're going to lose those. There have been some studies from Willapa Bay that show negative interactions between the two species, but it may be site specific.

Q: Are there any projects using native oyster restoration as a living shoreline function to protect shorelines?

- **A:** San Francisco Bay has done a lot of work to monitor the ecosystem services provided by their living shoreline project there. To be clear, in those cases, a lot of the shoreline protection benefits are due to the substrate that's added, not the Olympias themselves. Olympias have a lower profile and grow lower in the intertidal zone, so their contributions as living shoreline substrates may be more modest.

Q: What data are available to measure the effects of oyster restoration for ecosystem health?

- **A:** We collected data from all 39 projects having ever been conducted on the West Coast. Some of those projects also directly measured ecosystem services, especially San Francisco Bay. We're happy to make those available via our website. There are a variety of graduate student theses focusing on specific services oysters provide. What's harder to do for the ecosystem health question is scale that up to the scale of an estuary.

Q: Can you give an example of how climate change impacts factor into restoration decisions?

- **A:** Climate change right now doesn't look to be the biggest threat of the coming decade in terms of explaining the extreme declines of oysters; it's still things like sediment burial and hypoxia. The Olympia oysters actually did better at higher temperatures in some experiments we ran, and are a bit more resilient to acidification than other species. Certainly increased storm frequency can have a negative impact on places that have a lot of freshwater input. Overall, compared to salt marshes, which are all doomed within decades in the face of sea level rise, we don't see that kind of vulnerability in Olympias.

Q: Can olympia oysters grow on vertical surfaces like seawalls? What about rock riprap?

- **A:** Definitely. They do this very well in urban estuarine places where Olympias may have naturally congregated but have been altered. They can grow up the side of pilings, and they're often on the sides of seawalls. Many sites in Southern California show this as well. They just need hard substrate and a chance to not be out-competed by other species.

Q: How far North does the Olympia oyster range extend?

- **A:** British Columbia.
  Polson, M.P. and Zacherl, D.C., 2009. Geographic distribution and intertidal population status for the Olympia oyster, Ostrea lurida Carpenter 1864, from Alaska to Baja. Journal of Shellfish Research, 28(1), pp.69-77.

Q&A

Q: Can you address the benefits of Olympia oysters to salmon? Is there related research? Publications?

- **A:** In San Francisco Bay, a living shoreline project is quantifying abundance of juvenile salmon near the oyster restoration site versus adjacent areas. On Swinomish tribal lands in Washington, researchers have examined invertebrate communities in oyster restoration areas. Those are the only examples I can think of, and I believe neither is published.

Q: Why haven't there been more low-profile restoration projects attempted in California?

- **A:** Many sites are so muddy that low profile projects would be buried. You would have to make it a priority to find a site that is firm and has a gentle slope - and those are not necessarily in ideal geographic sites for access, willing landowners, etc.

Q: How long should oyster shell be cured before being used for restoration projects? On the East Coast, shell is considered 'cured' after 6 months but on the West Coast, we have heard 1-3 years. Is this mandate from the Health Department?

- **A:** The issue is that the shell being used here is from a different, non-native species, so extreme caution is warranted to avoid transfer of non-native pathogens from other regions. Not clear how long is needed, but good to err on the side of caution.

Q: Do you have an idea how far Olympia larvae travel before settling?

- **A:** It varies. They sometimes stay in the water column for weeks, and go far if they catch the right currents, but sometimes settle almost immediately, close by. We don't really know what average distance is and how that varies among sites.
  Carson, H. S. (2010). Population connectivity of the Olympia oyster in southern California. Limnology and Oceanography, 55(1), 134-148.

Q: Have you tested the water in Elkhorn Slough for abundance or absence of micro-algae available for the oysters to eat?

- **A:** No. We monitor chlorophyll-a concentrations, and they seem fine, but nothing more sophisticated than that.

Q: What are the most critical physical and chemical environmental variables which impact growth rate and numbers?

- **A:** Temperature and food availability.

Q: Does NOOC engage with commercial aquaculture?

- **A:** Yes, we are currently collaborating with growers to explore the potential for aquaculture with Olympia oysters in West Coast estuaries.

Q: Did you exclusively use Gaper clam substrate at Elkhorn Slough, or did you compare it to sets on Pacific or concrete? What types of clam shells seemed to work best?

- **A:** We have used concrete and wood as well as gaper shells. Gaper shells seem best, but mostly they are a good fit for a nature reserve, where we don't want to use artificial substrates.

Q&A

Q: Is there any evidence of latitudinal variability in adaptational advantage to stressors like hypoxia or warming temperatures? Are there any populations projected to do better than others?

- **A:** Yes, timing of breeding, for instance, differs by latitude, due to local adaptation. Overall, our research suggests that warming water temperatures will not be a major threat to Olympias, as they actually grow faster and reproduce more in warmer water. Hot air temperatures during low tide exposure could become more of a problem though. It is unclear whether there's any particular population that seems more resilient to stressors overall. Given that oysters have to face multiple stressors (freshwater events, hot summer days, hypoxia, etc.) it seems a bit dangerous to select for one particular trait, without knowing how it might affect the rest.

Q: To what extent do living Pacific oysters serve as a source or sink for the production of Olympia oyster larvae?

- **A**: Where Pacific oysters are harvested, there have been reported issues with Olys settling on them, and thus being lost from the population. In general, Pacific oysters grow higher in the intertidal than Olys, so the species don't compete as much as you might think.

Q: Do juvenile Olympia oysters respond differently to stressors than larger adult Olympia oysters?

- **A:** Juvenile Olympias, like other species, are more sensitive to stressors, such as desiccation and thermal stress on a hot summer, low-tide day, or a freezing winter night. They are also more vulnerable to predation - easier to get into.

Q: Do European green crabs present any challenges to Olympia oyster restoration?

- **A:** Potentially. They do co-occur, but there haven't been many reported problems with restoration projects.

Q: Can we benefit by co-occurence of Olympia oyster enhancement/restoration efforts, coupled with efforts (such as eelgrass and salt marsh recovery) to reduce the loads of suspended sediments?

A: It's certainly worth exploring, but the needs of eelgrass, marsh and oysters are all quite different, and the main stressor limiting each on this coast is different, so it's not clear that there are synergies to co-locating restoration projects. But we should look!

Q: One of your pictures showed Olympia oyster cluster substrate being placed in between eelgrass. What is the interaction between native eelgrass and Olympia oysters? Did they co-exist, could they co-exist?

- **A:** There have been some studies of this recently, and the answers are complicated. It's not clear they benefit each other - but it's worth exploring further.

Lowe, A.T., Kobelt, J., Horwith, M. and Ruesink, J., 2019. Ability of eelgrass to alter oyster growth and physiology is spatially limited and offset by increasing predation risk. Estuaries and Coasts, 42(3), pp.743-754.

Valdez, S.R., Peabody, B., Allen, B., Blake, B. and Ruesink, J.L., 2017. Experimental test of oyster restoration within eelgrass. Aquatic Conservation: Marine and Freshwater Ecosystems, 27(3), pp.578-587.

Q&A

Q: What information do we have on genetics for conservation breeding, and how do we figure out numbers needed to become self-sustaining?

- **A:** Some restoration projects (Fidalgo Bay WA, Netarts Bay, OR) were able to start with virtually no oysters and have populations become self-sustaining with around a million oysters. So maybe the threshold is something like that? I wish we knew. There have been some genetic studies.

  Silliman, K., 2019. Population structure, genetic connectivity, and adaptation in the Olympia oyster (Ostrea lurida) along the west coast of North America. Evolutionary applications, 12(5), pp.923-939.