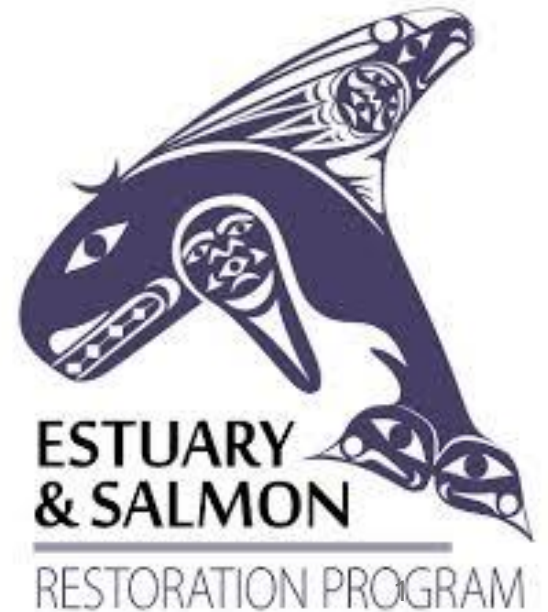


Impacts of overwater structures to salmon and kelp

ESRP Learning Grant (22-1702)

Project end Webinar 21 Nov 2025



Dock Study Team

Small overwater structures: a review of effects on Puget Sound habitat and salmon

Max R. Lambert*, Reed Ojala-Barbour, Robert Vadas Jr., Aimee P. McIntyre, & Timothy Quinn

Science Division, Habitat Program, Washington Department of Fish & Wildlife

*Corresponding Author: Max.Lambert@dfw.wa.gov



REVIEW

<https://doi.org/10.1071/PC22037>

PACIFIC CONSERVATION BIOLOGY



Do small overwater structures impact marine habitats and biota?

Max R. Lambert^{A*} , Reed Ojala-Barbour^A, Robert Vadas Jr.^A, Aimee McIntyre^A and Timothy Quinn^A



Washington Department of
FISH & WILDLIFE

Wendel Raymond
Brian Ulaski
William Dezan
Keith Douville
Max Lambert



PUGET SOUND
RESTORATION FUND

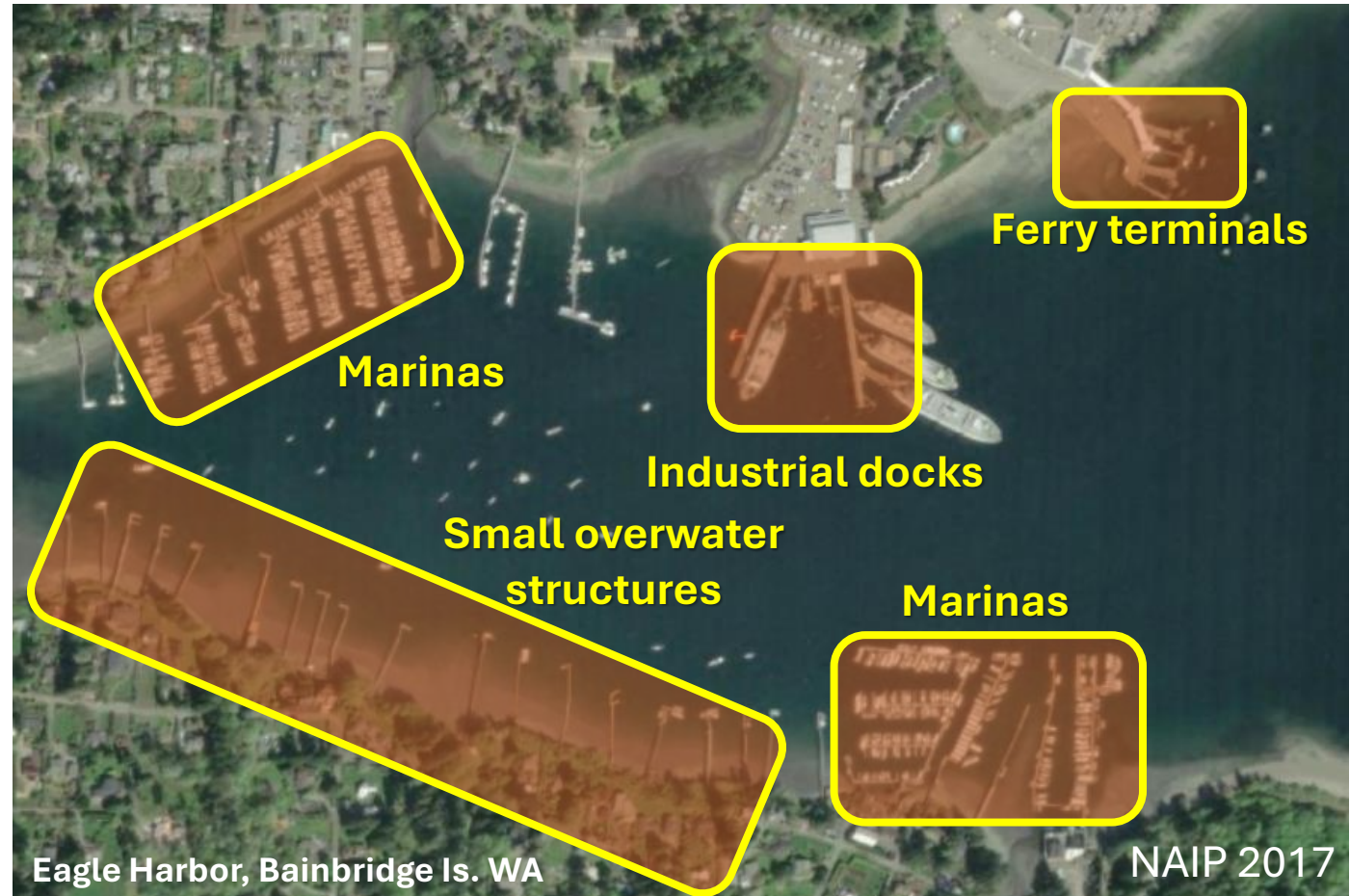
Jodie Toft
Hilary Hayford
Kari Inch
Habitat Team



Jason Toft
Kerry Accola
WET Lab

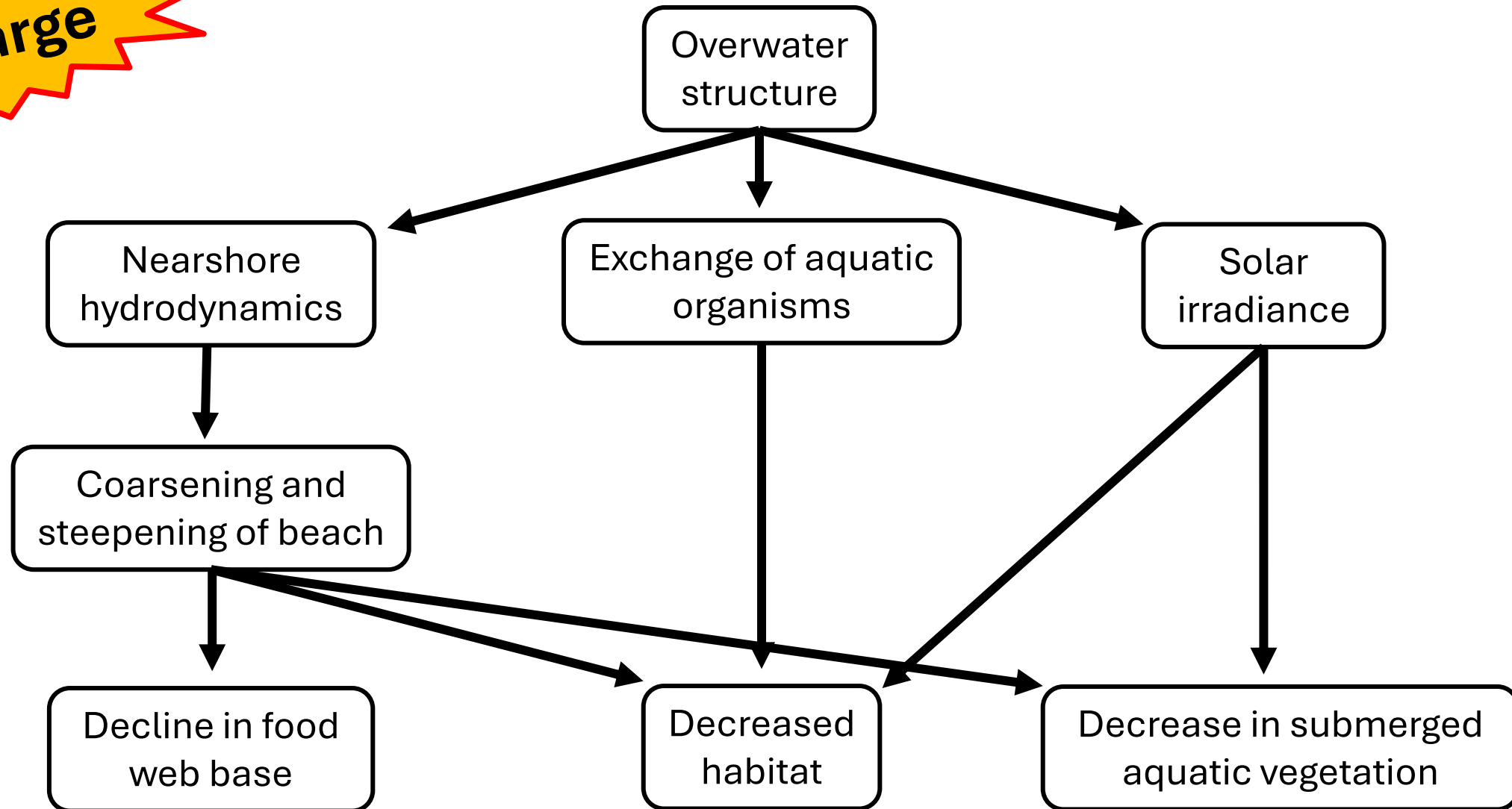
Overwater structures in Puget Sound

- **Ubiquitous feature of Puget Sound**
 - 8316 OWS total
 - 9km² of intertidal habitat (~1000 football fields)
 - Multiple types
 - Strong evidence that large structures
 - ✓ Reduce light and therefore vegetation
 - ✓ Salmonids avoid



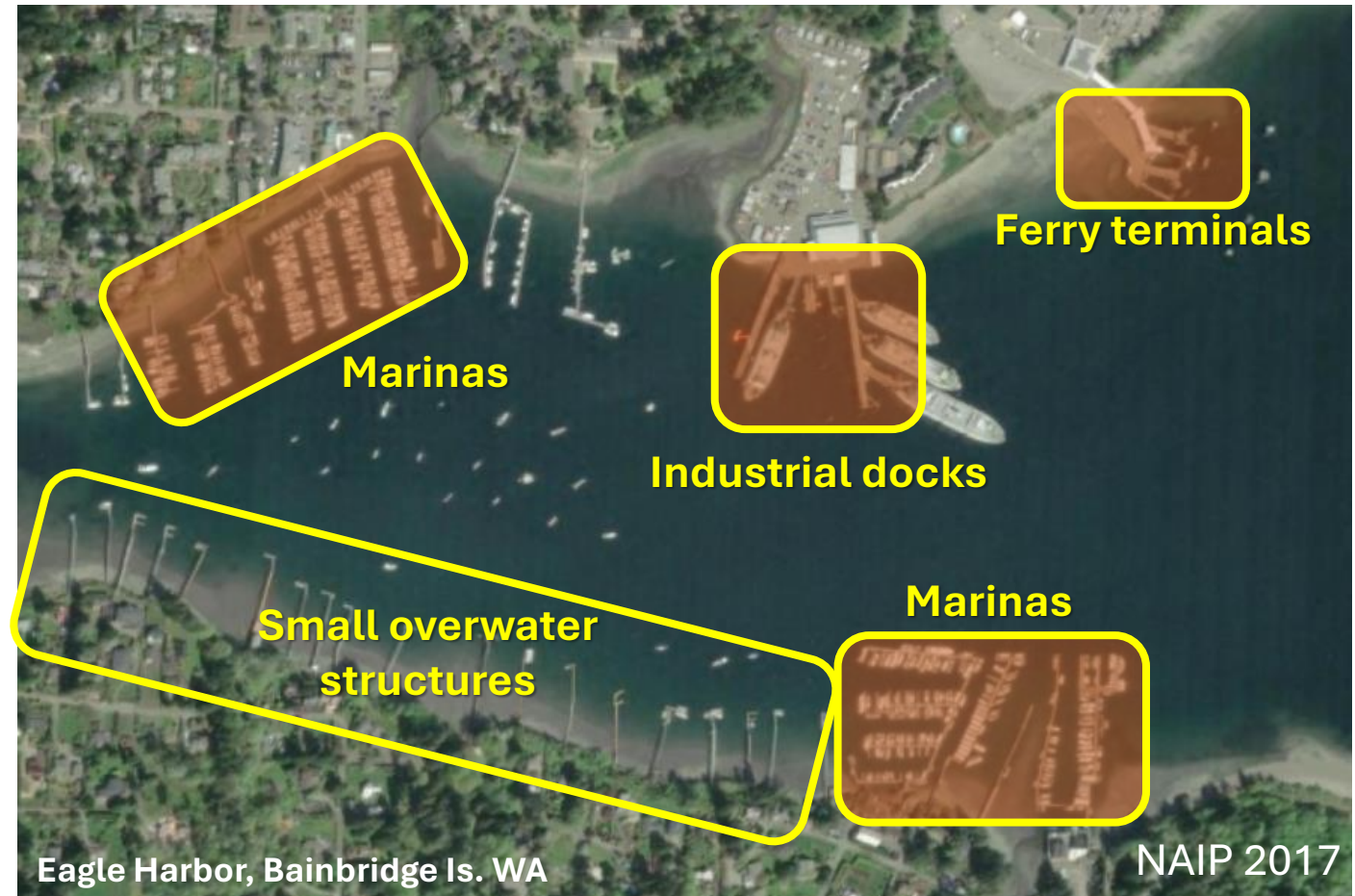
Overwater structures in Puget Sound

Large



Overwater structures in Puget Sound

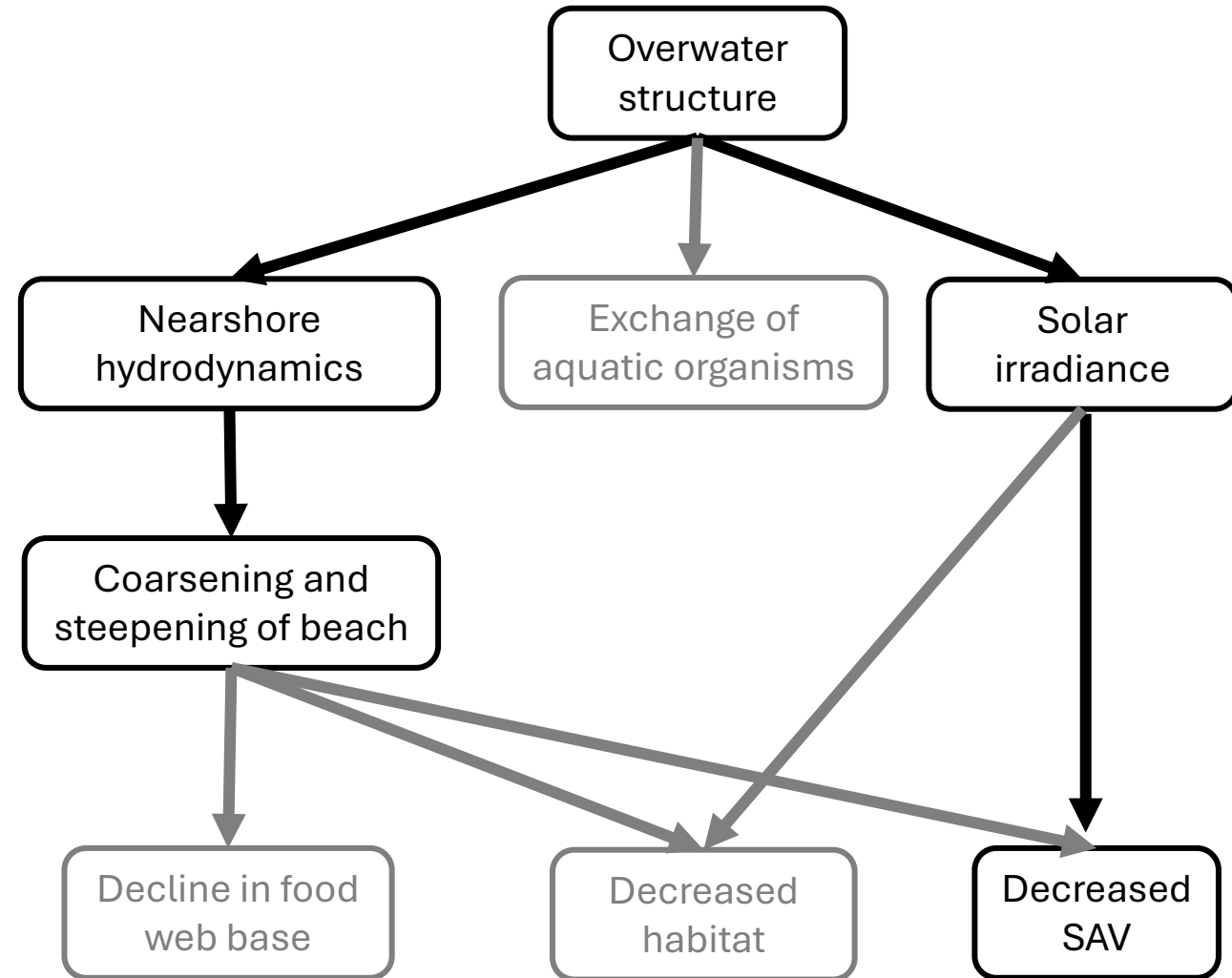
- **Ubiquitous feature of Puget Sound**
 - 8316 OWS total
 - 9km² of intertidal habitat (~1000 football fields)
 - Multiple types
- Small overwater structures
 - 6064 SOWS
 - < 560m² (~6000ft²)
 - Typically, ≤18m (60ft) long and ≤ 2.4m (8ft) wide
 - Do effects seen with large OWS transfer to SOWS?



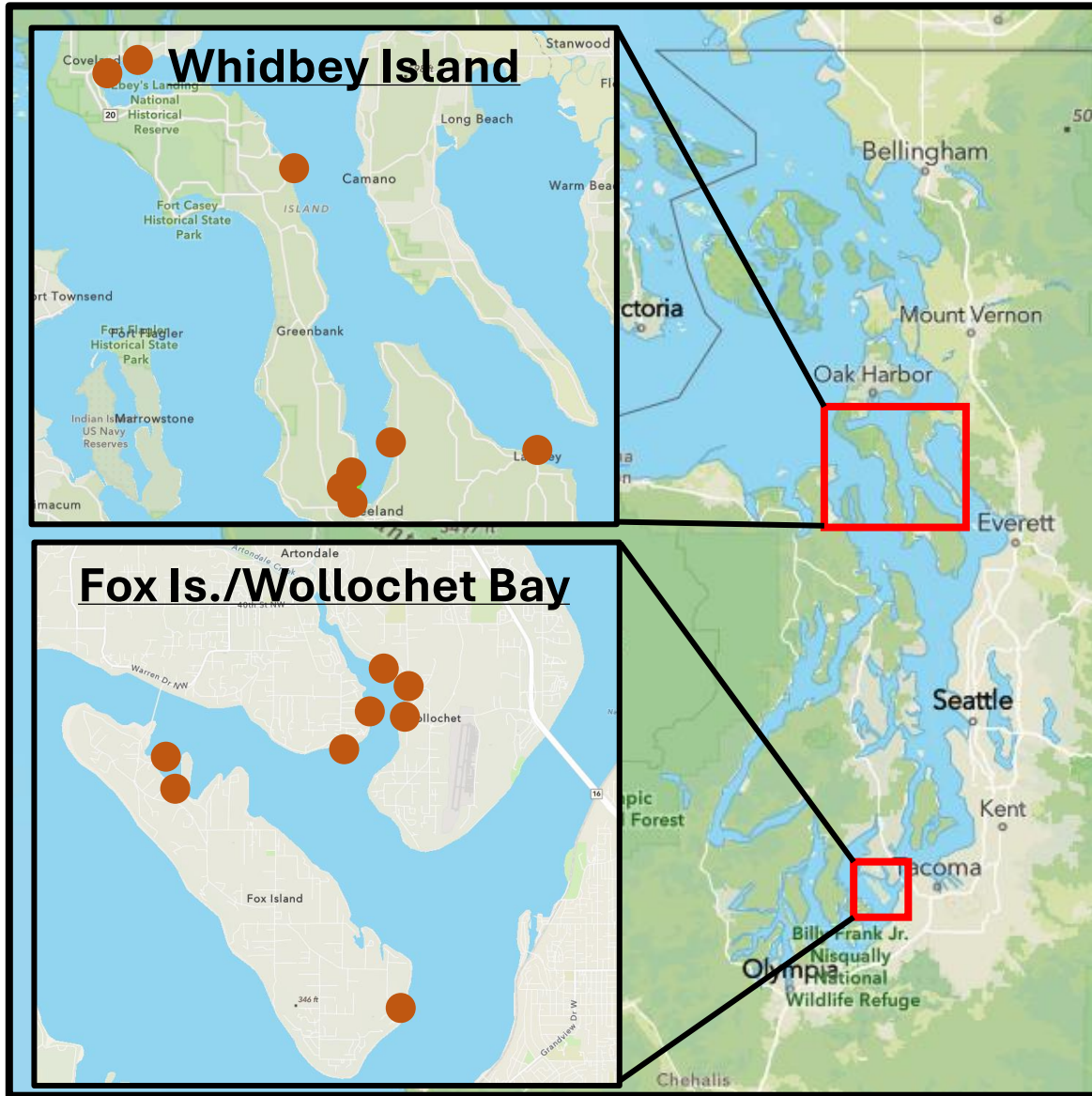
Questions

What is the effect of small overwater structures?

- Reduced light will affect salmon behavior and kelp diversity and cover.
- Physical structure will affect nearshore hydrology and sediment transport.
- Abundance and diversity of species associated with SOWS?



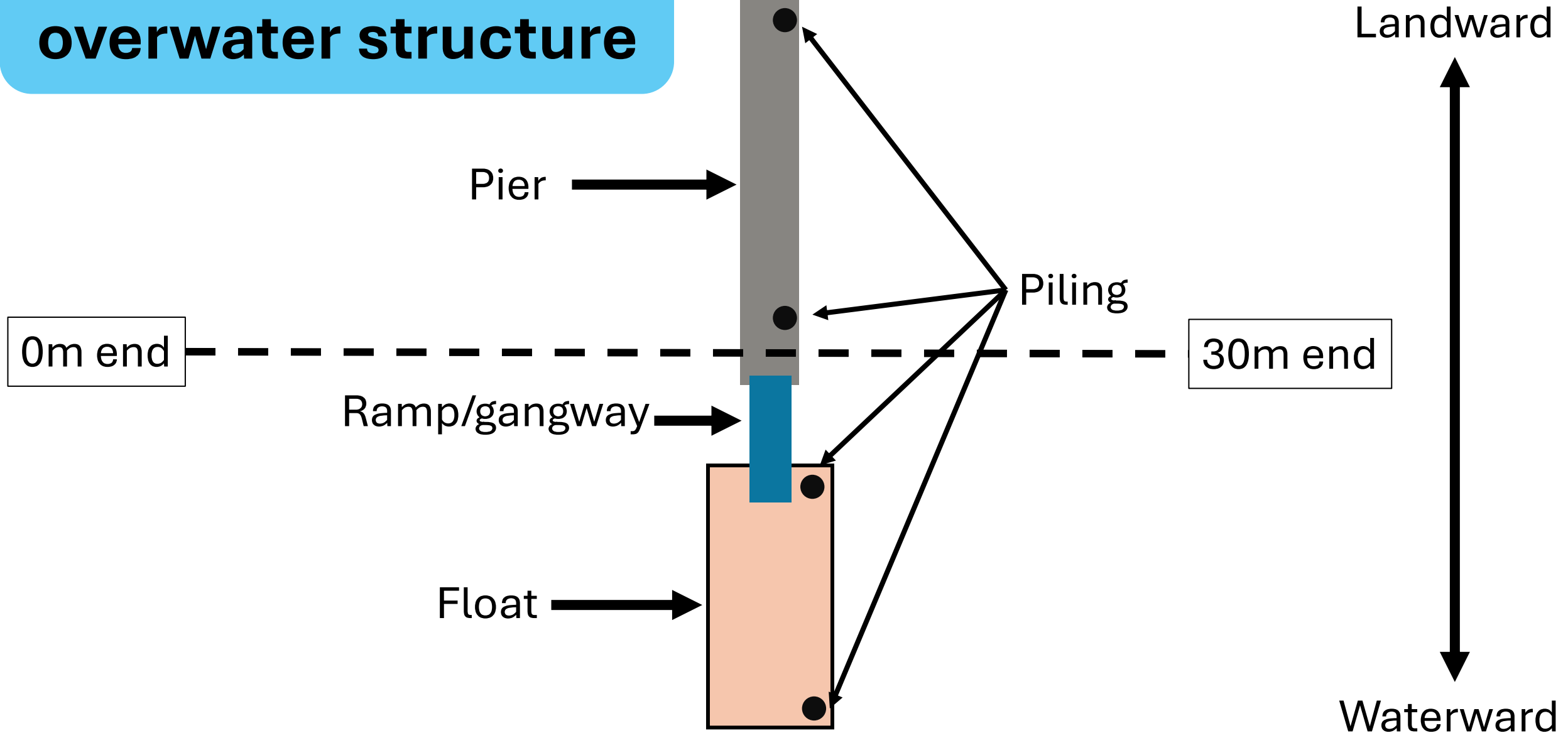
Study area and sites



Two regions with high densities of SOWS

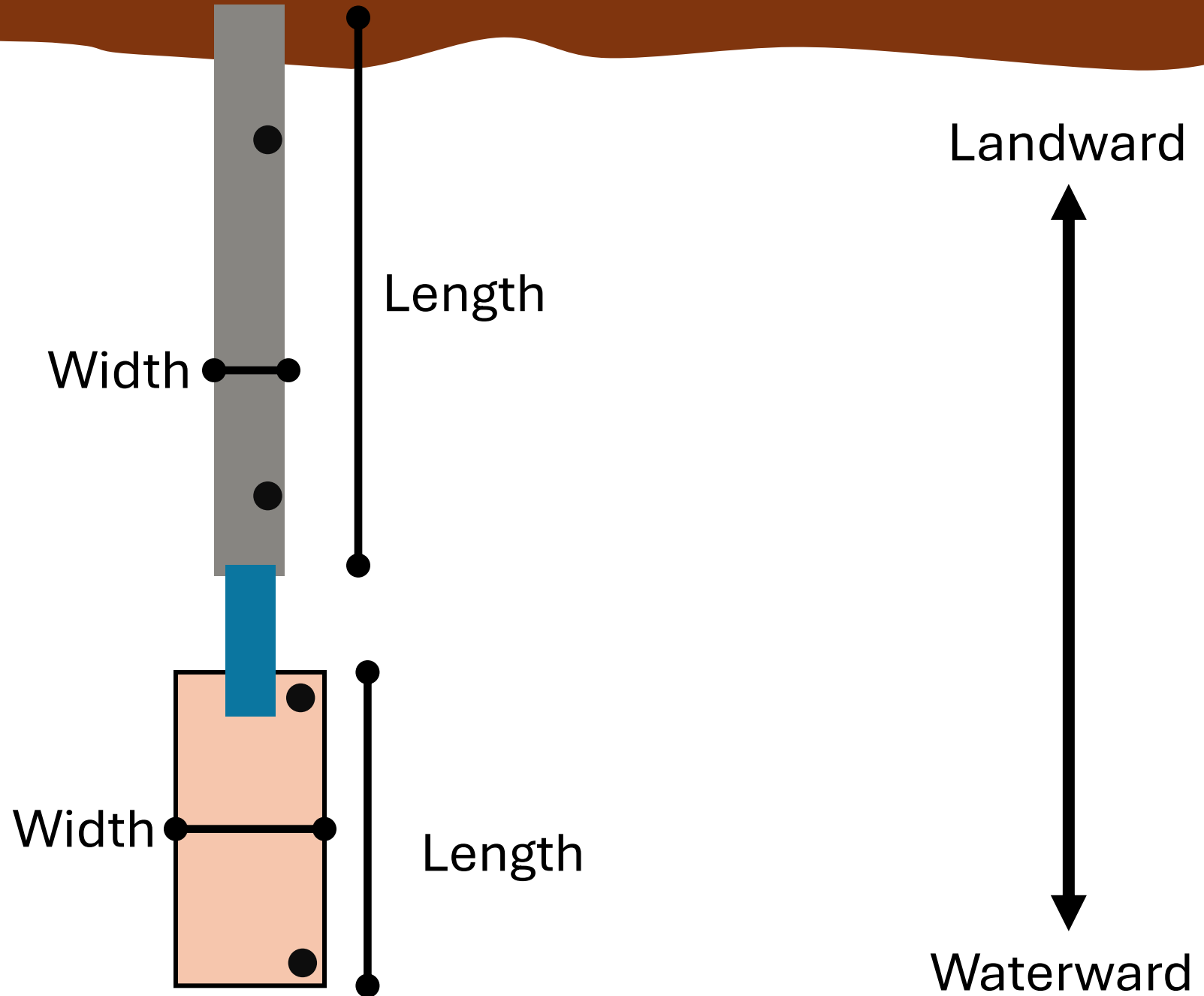
- 16 total sites. 8 per region.
- Candidate sites identified $< 560\text{m}^2$. $\geq 30\text{m}$ from other OWS.
- Fieldwork Feb – Oct 2024
 - Structural features and dimensions
 - Light
 - Sediment and elevation
 - Snorkel survey – fish
 - Dive survey – kelp and inverts (10 sites)

Generalized overwater structure



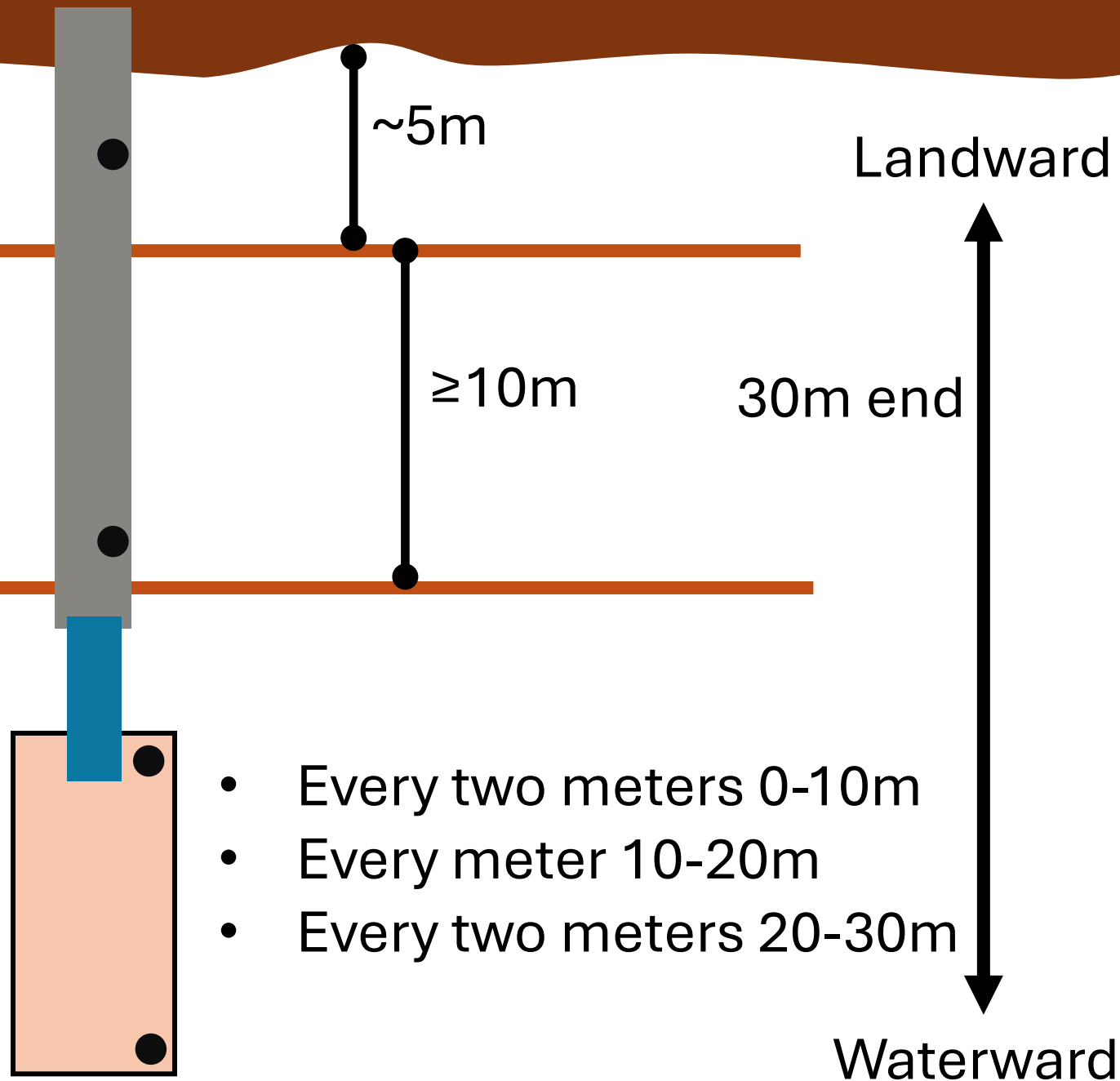
Structure survey

- Dimensions
- Height above MLWW
- Piling material
- Deck material
- Grating



Sediment and elevation survey

0m end



Snorkel surveys

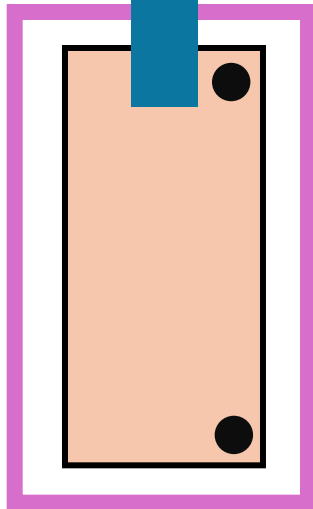
PAR measured in/out shade



Landward



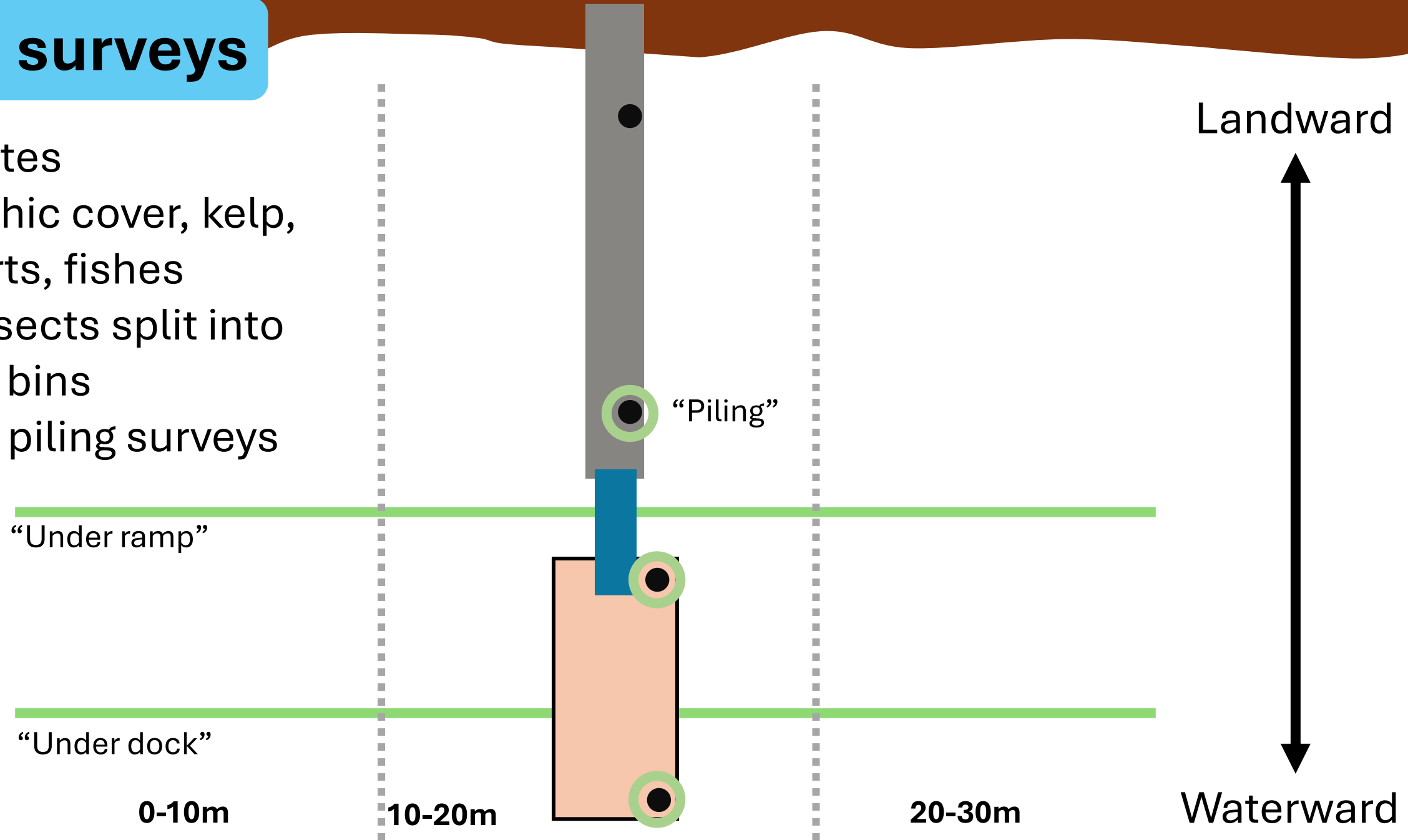
Waterward



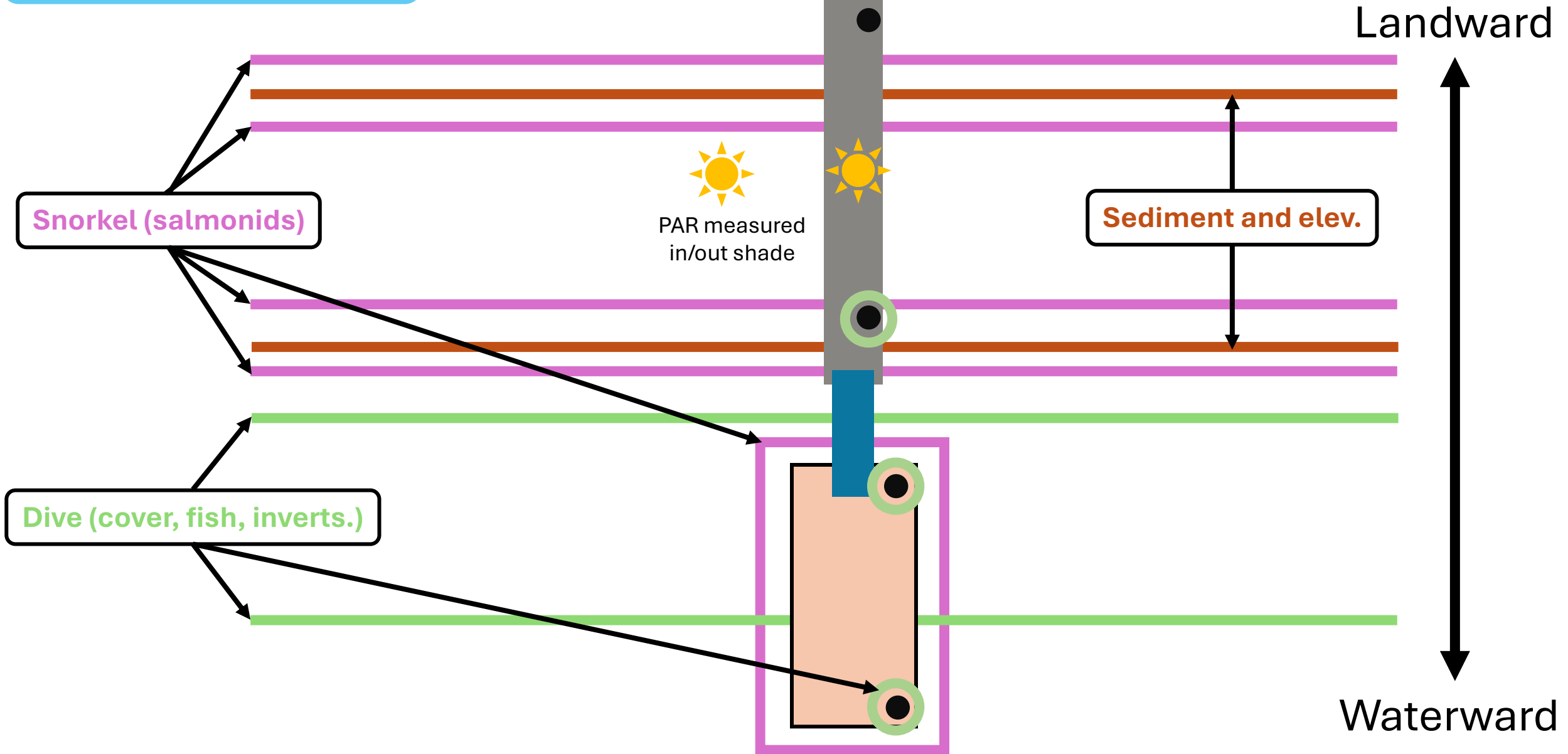
- Surveyed twice
- ≥ 4 30m transects
- Obs. grouped as under, adjacent, or away from SOWS

Dive surveys

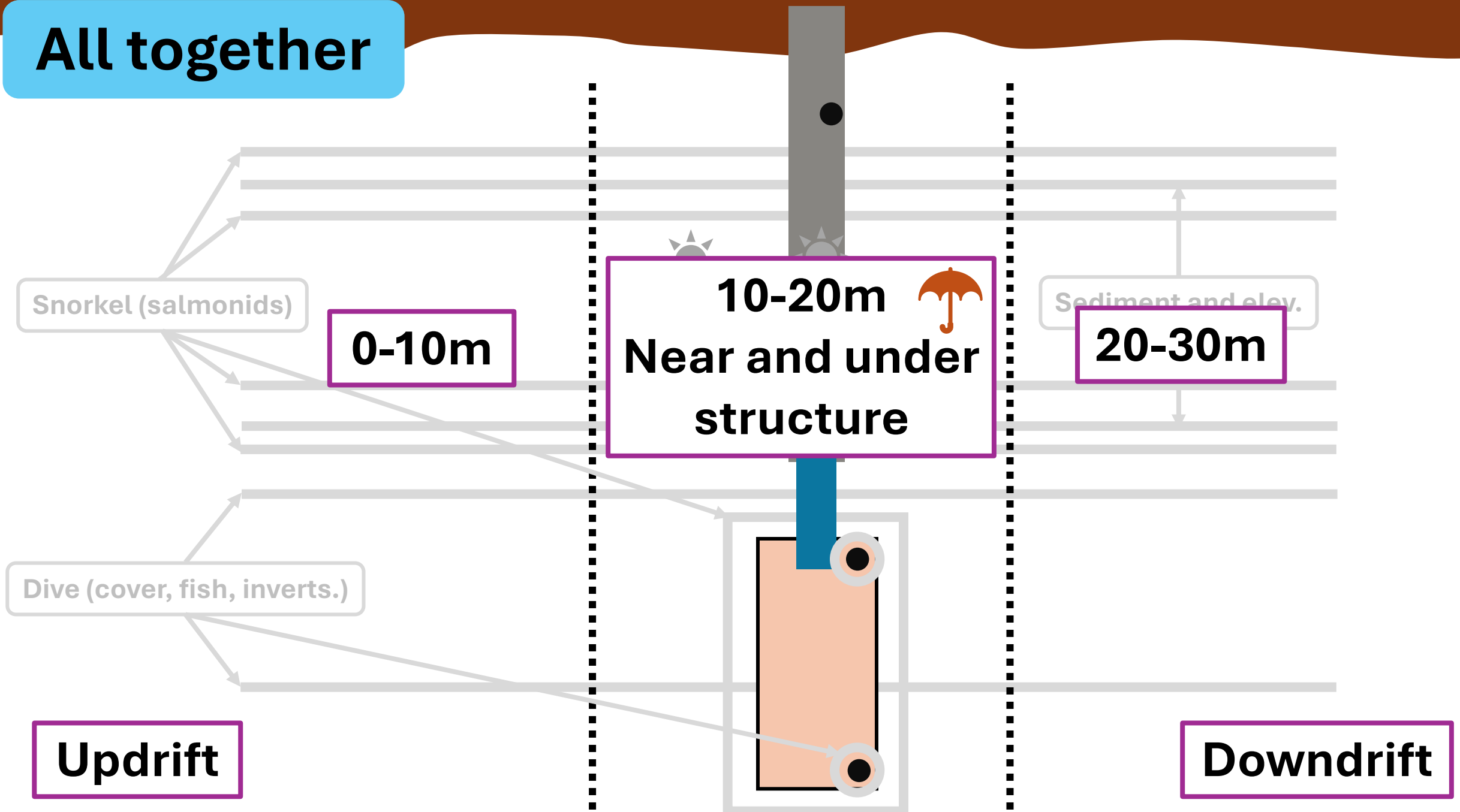
- 10 sites
- Benthic cover, kelp, inverts, fishes
- Transects split into 10m bins
- Pilot piling surveys



All together



All together



Results: Structural metrics

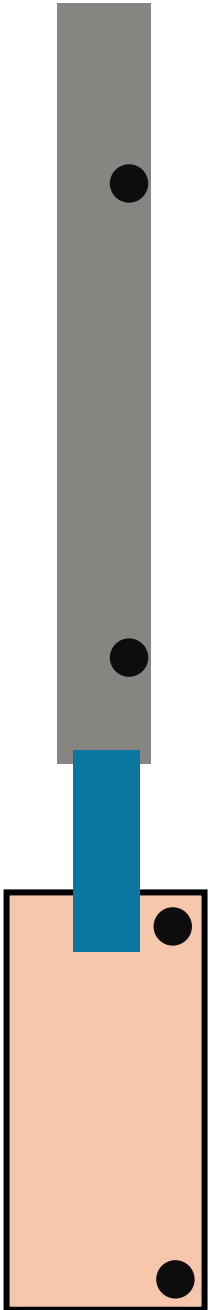
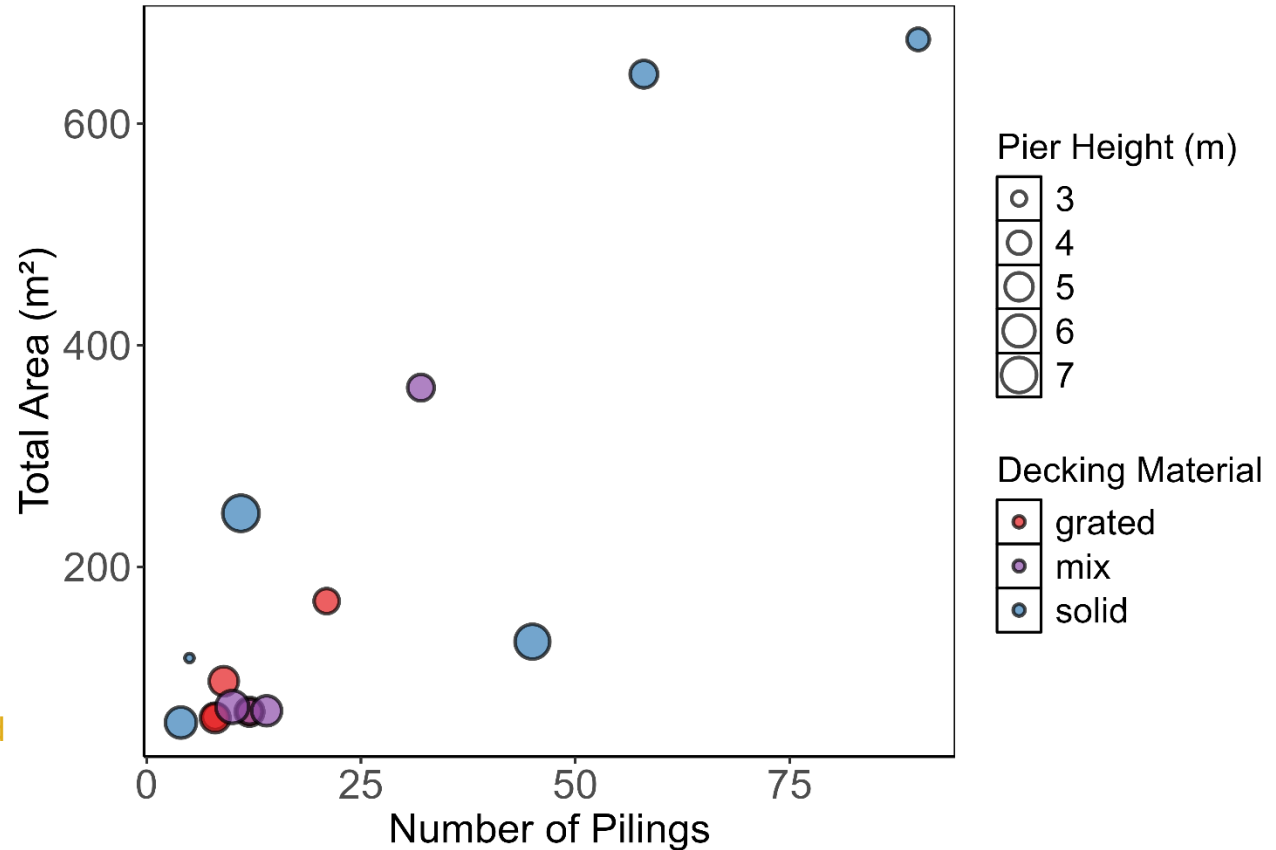


Results: Structural metrics

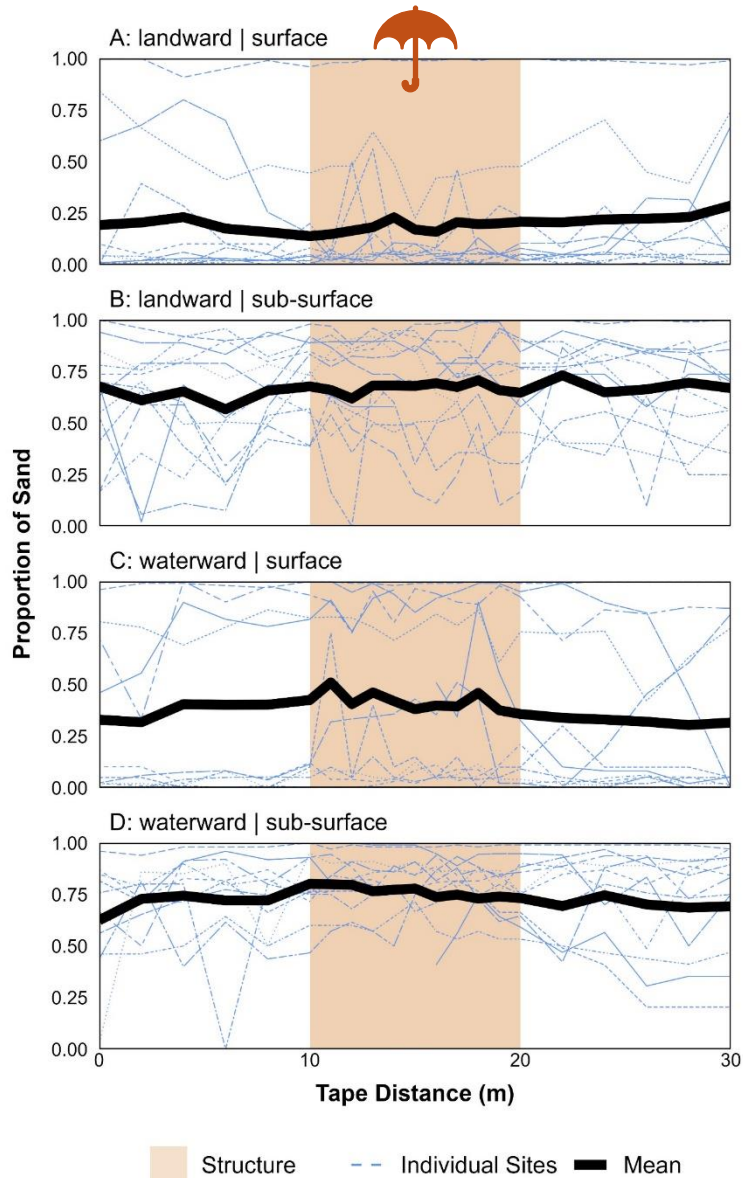


- Total area (m²): 59.5 – 676.2
- Piling count: 4 – 90
- Pier height (m) MLLW: 2.8 – 7.4
- Decking: grated, solid, mixed
- All armored, except three
- All in drift cell, except one
- **Most meet current WAC permitting standards, lots of variability and some outliers**

correlated



Results: Sediment and elevation



Do SOWS alter sediment transport and influence sediment composition?

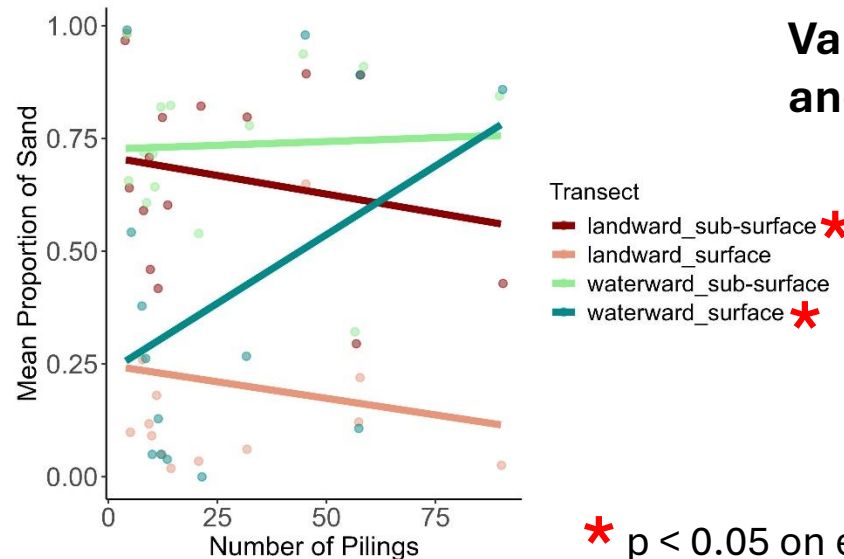
Sand represents light fraction material

- **No change across transect bins**
- Similar patterns with mud, shell

Piling effect

- Landward = negative correlation
- Waterward = positive correlation

Variable effects of SOWS features and sediment composition



aligning with the expectation of fixed structures

* $p < 0.05$ on effect of transect bin

 Under/near SOWS

Results: Sediment and elevation



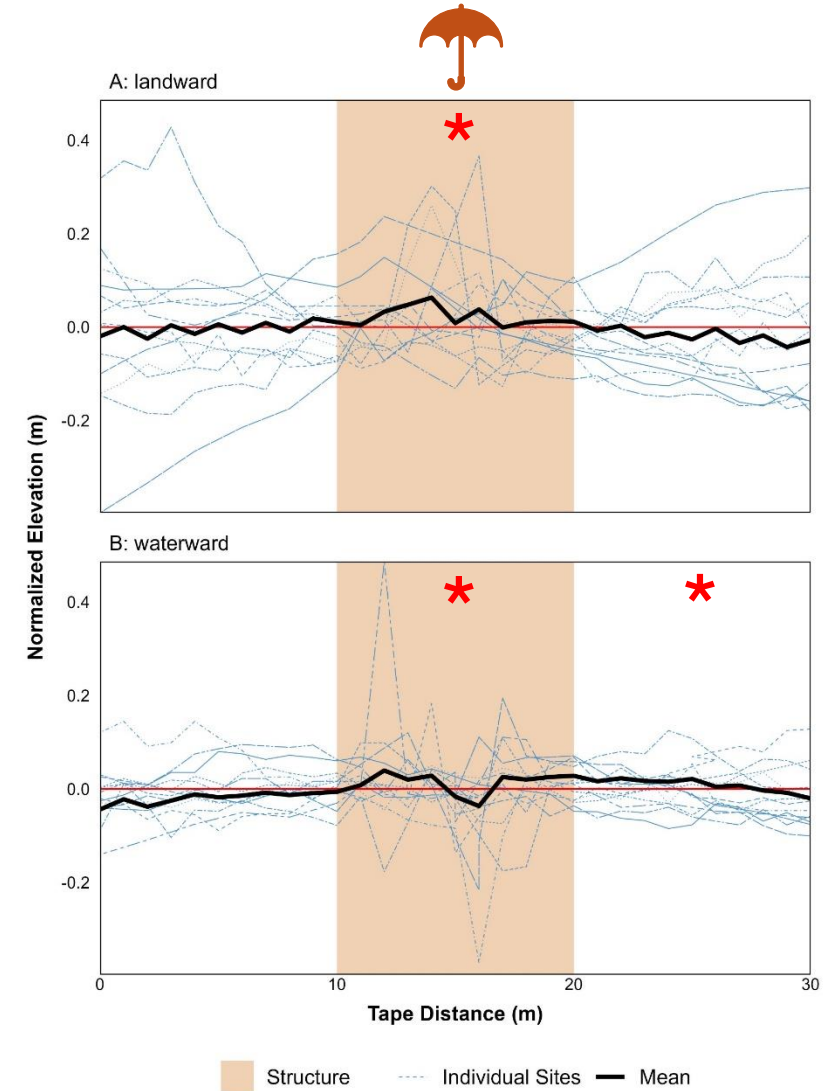
Do SOWS alter sediment transport and influence accretion?

Elevation increases under and downdrift of SOWS

Measurement error much smaller than observed variability

Changes in elevation suggest SOWS may be altering sediment dynamics across the shoreline in some capacity

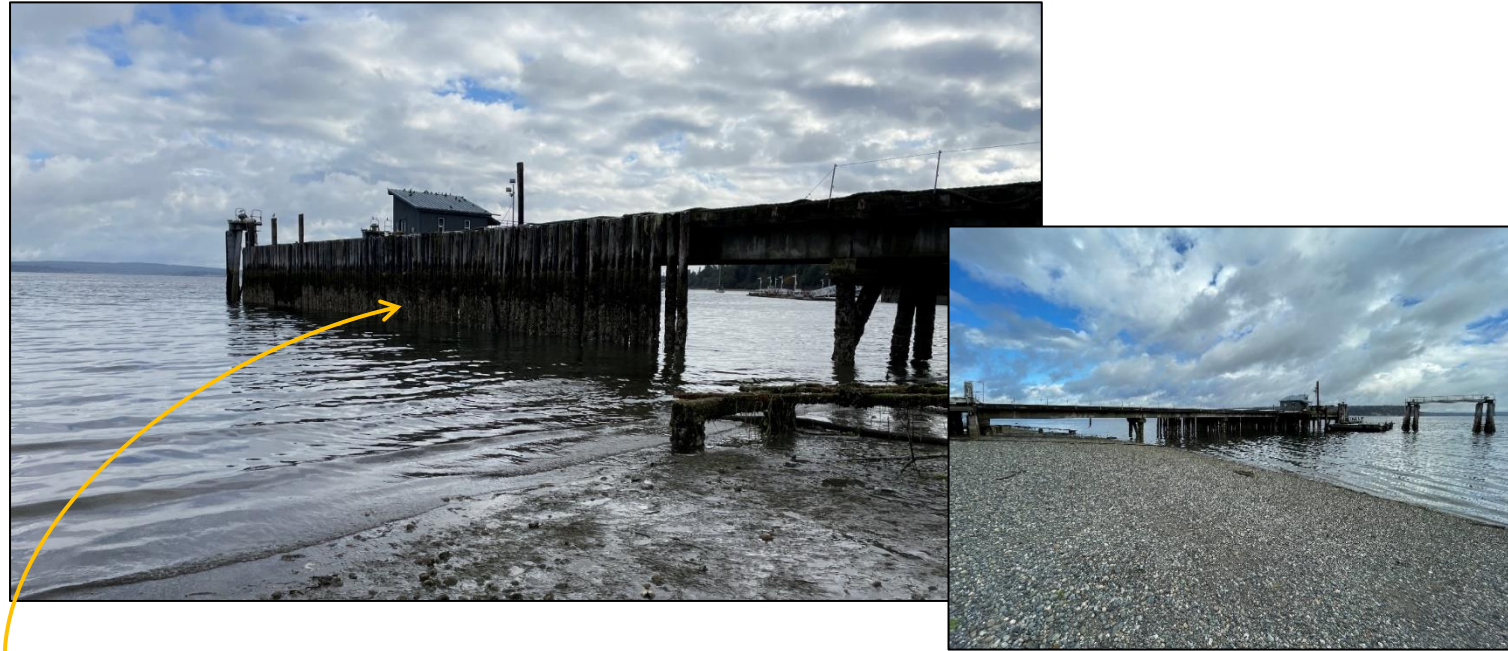
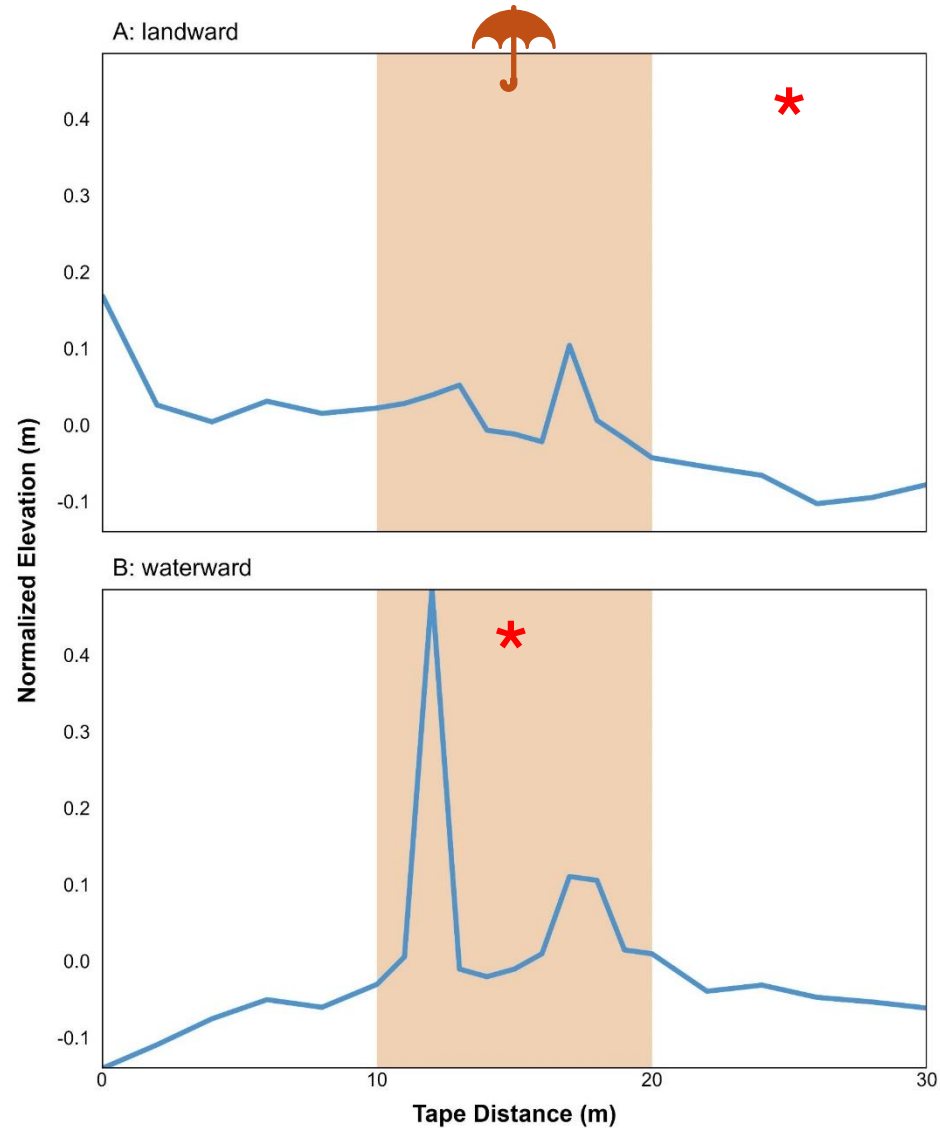
No change with number of pilings



* $p < 0.05$ on effect of transect bin

 Under/near SOWS

Results: Sediment and elevation



If SOWS are built in certain ways, this looks to affect physical environment

SOWS can influence elevation patterns at parcel scale, which may be masked by pooling of data

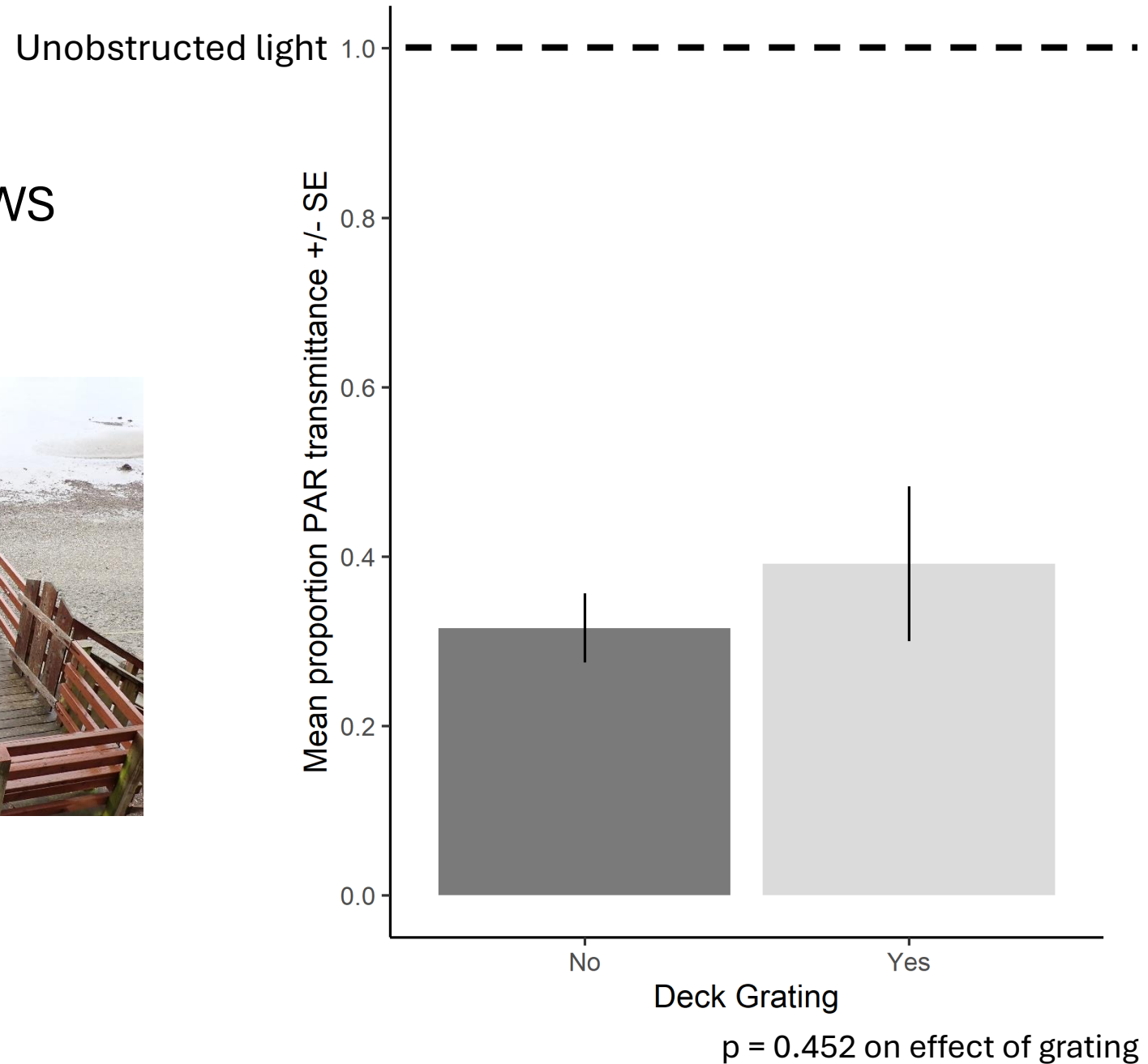
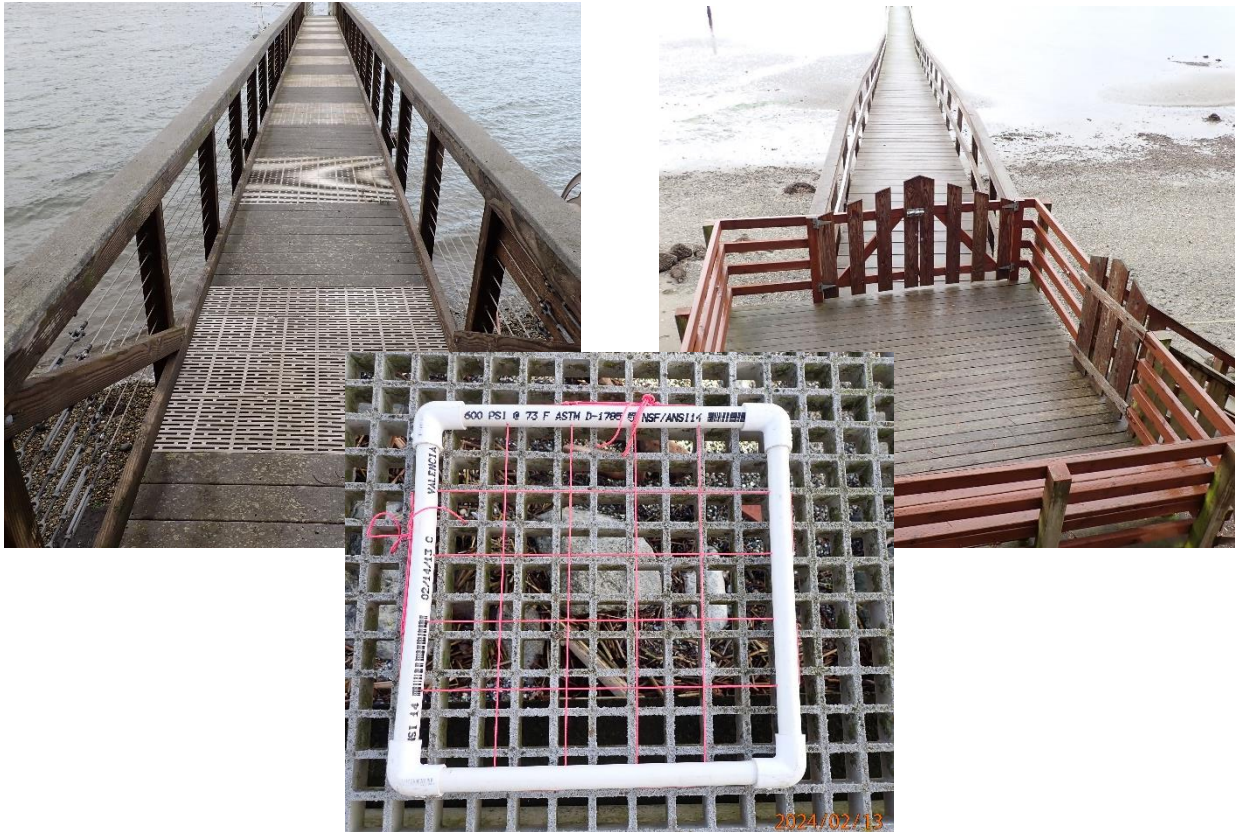
* $p < 0.05$ on effect of transect bin

 Under/near SOWS

Results: light

Photosynthetic active radiation

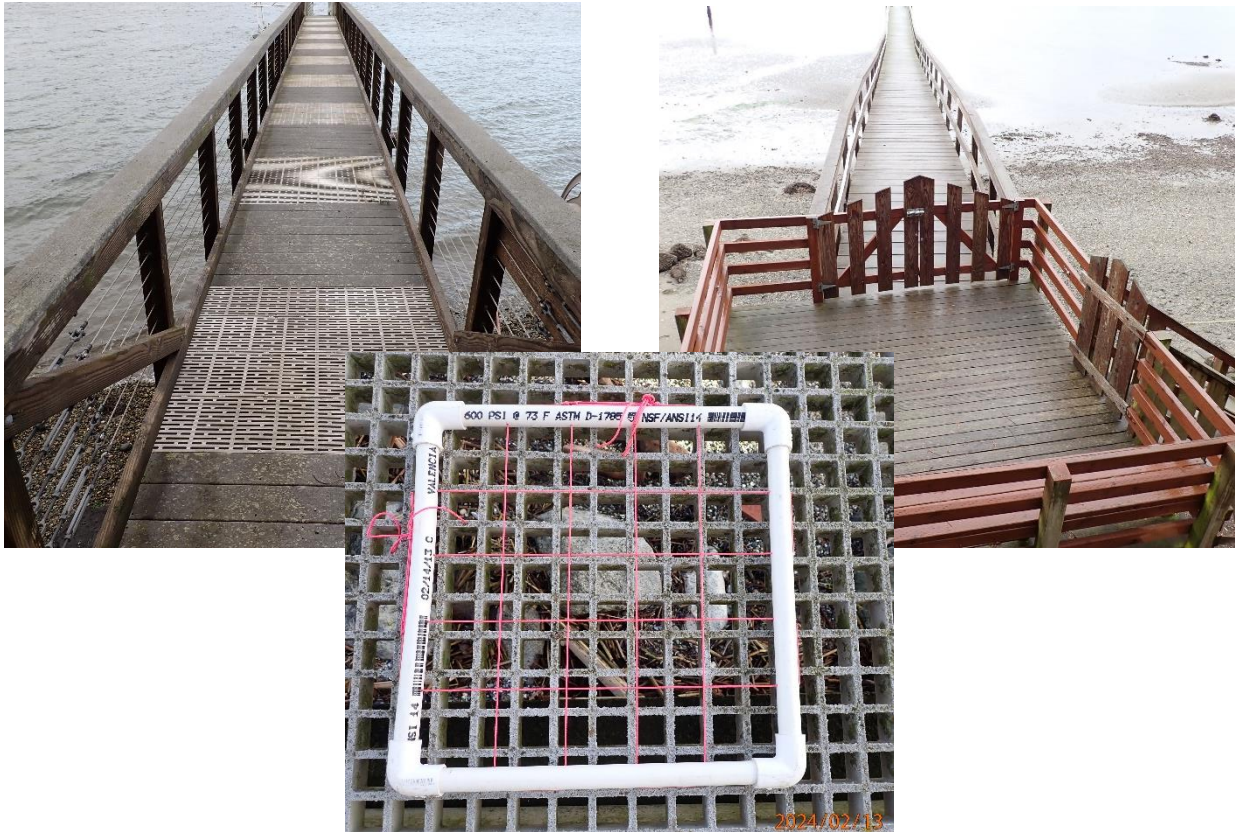
- ~ 65% reduction of light under SOWS
- No effect of grating



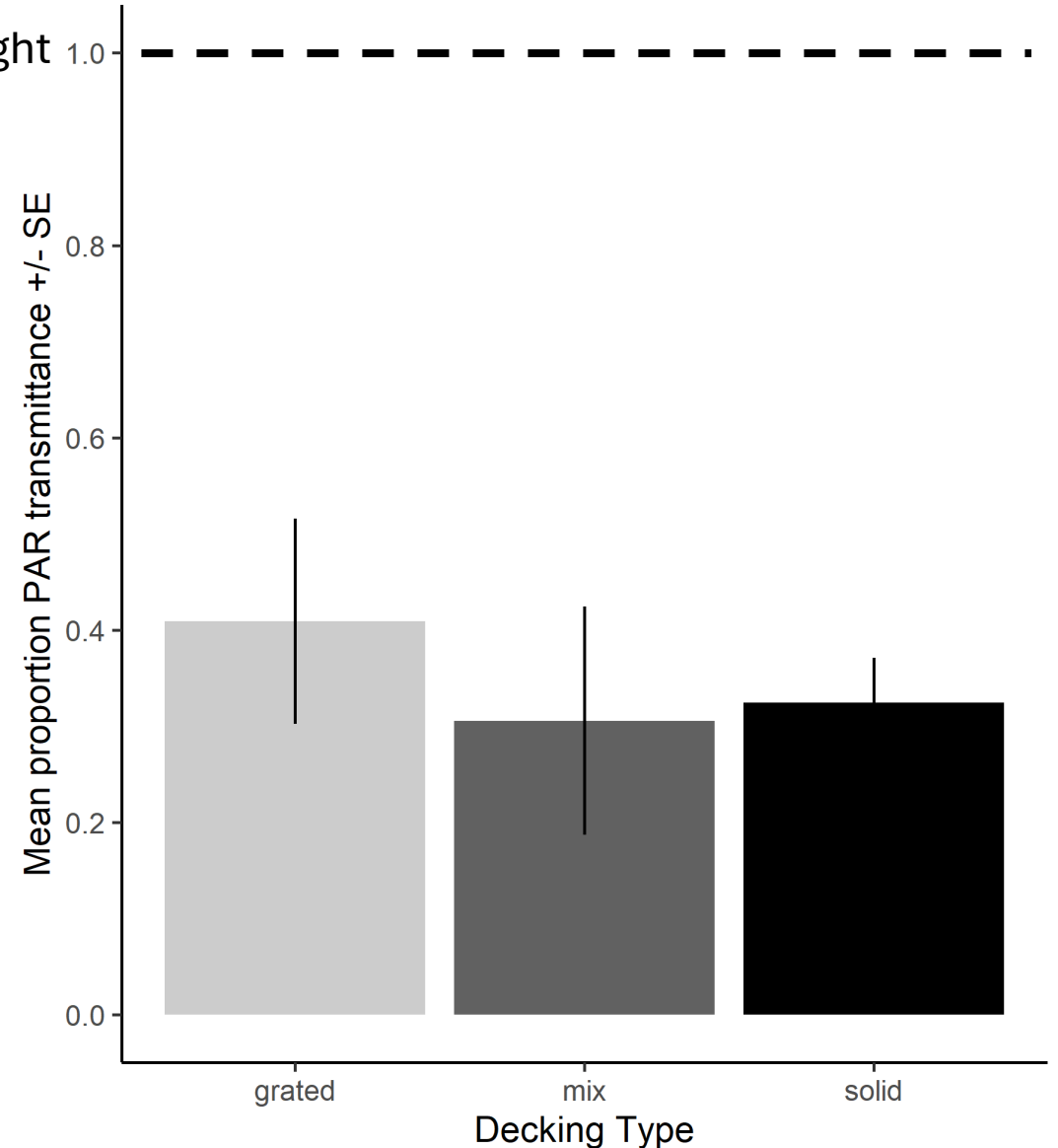
Results: light

Photosynthetic active radiation

- No effect of decking material when further broken down



Unobstructed light



ANOVA on effect of group $p = 0.665$

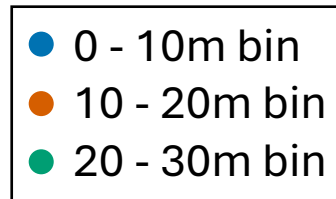
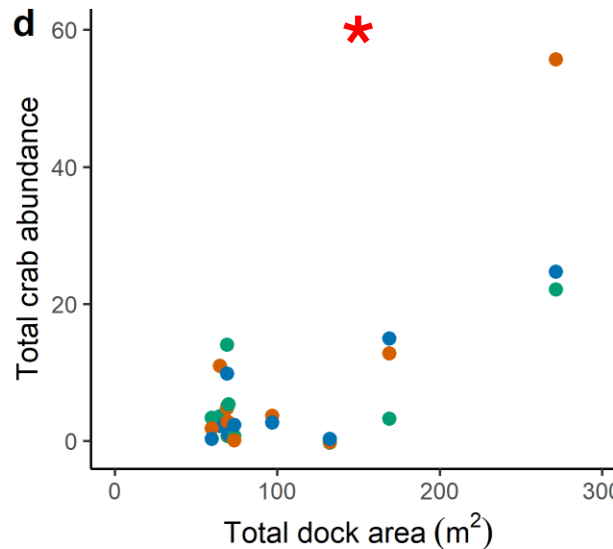
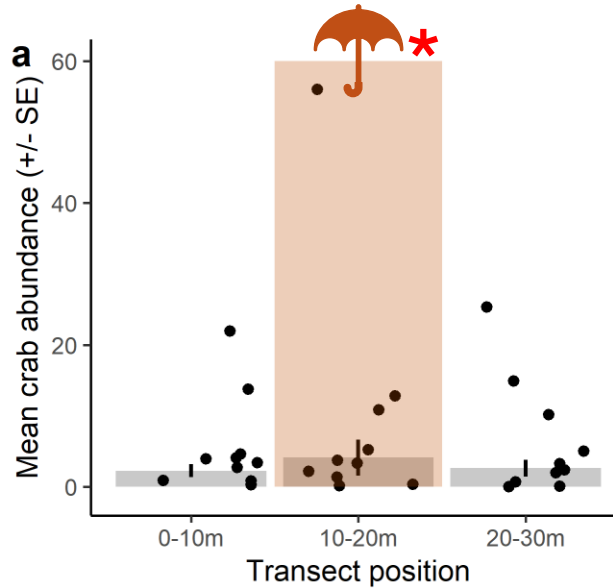
Results: benthic flora and fauna



Results: benthic flora and fauna

Crab abundance

- Greater near SOWS
- Increases with area
- Dominated by
 - Graceful crabs
 - Red rock crabs

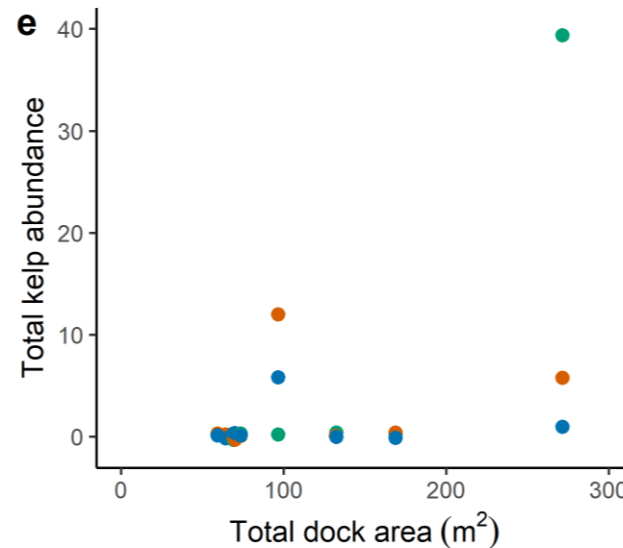
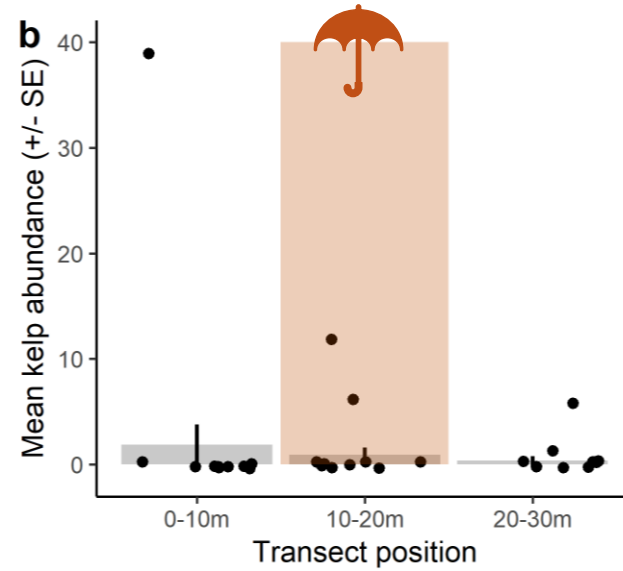


* $p < 0.05$ ANOVA on effect of transect bin and total area

Results: benthic flora and fauna

Kelp abundance

- Absent at most sites
- Weak associations with transect bin and total area
- Dominated by sugar kelp when present

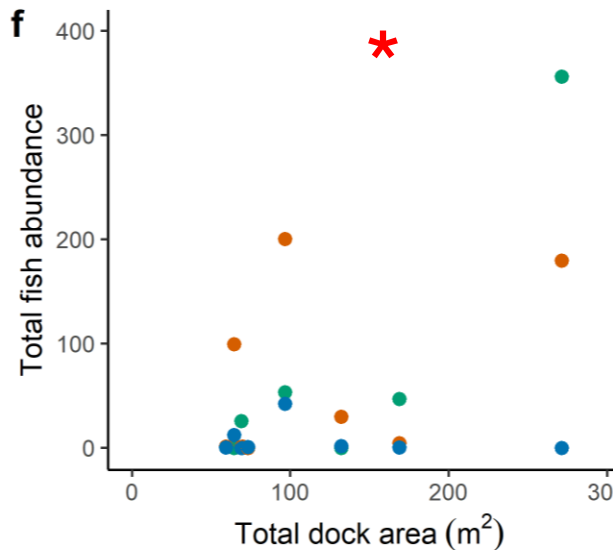
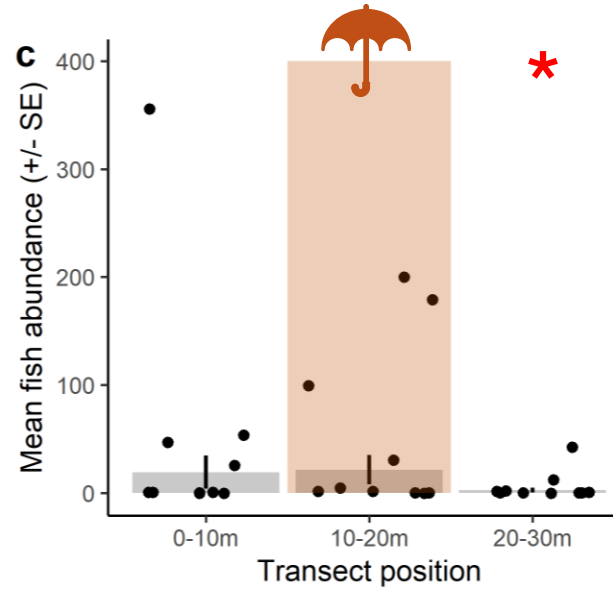


* $p < 0.05$ ANOVA on effect of transect bin and total area

Results: benthic flora and fauna

Fish abundance

- Lower in 20-30m bin
- Increases with area
- Dominated by
 - Shiner perch
 - Flatfish



* $p < 0.05$ ANOVA on effect of transect bin and total area

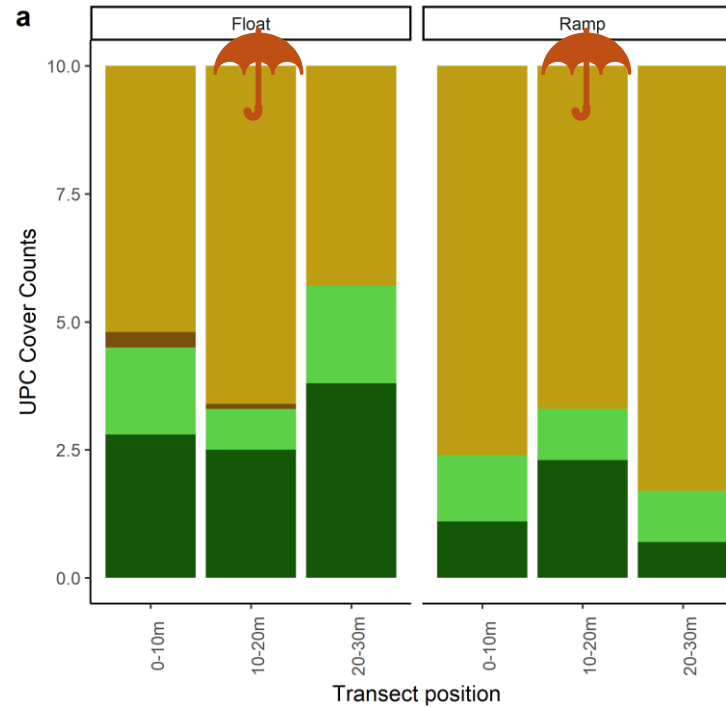
Results: benthic flora and fauna

Benthic cover

- Dominated by bare substrate
- Slight reduction in vegetation under SOWS
- No effect of bin or transect



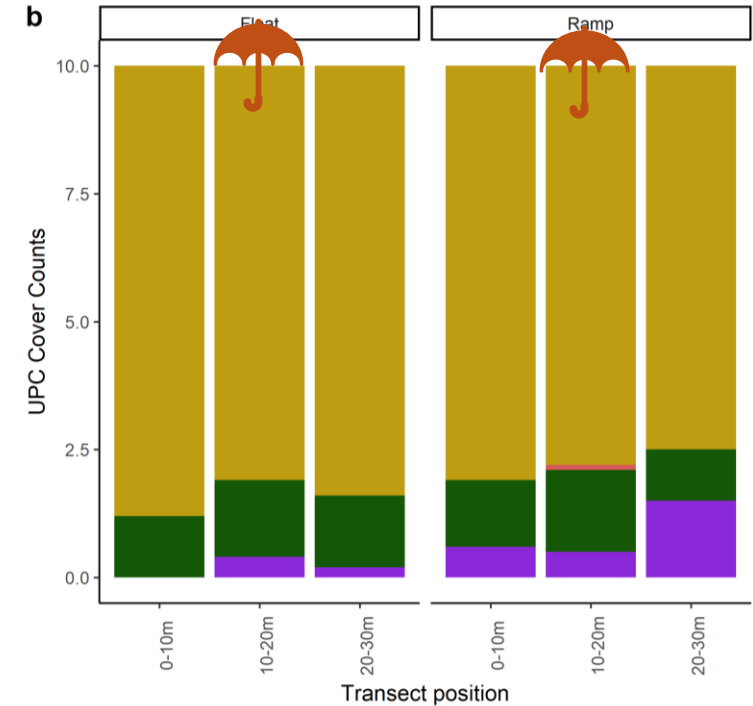
Superlayer - “understory”



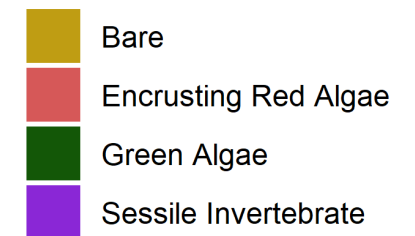
Cover



Cover - “on the bottom”



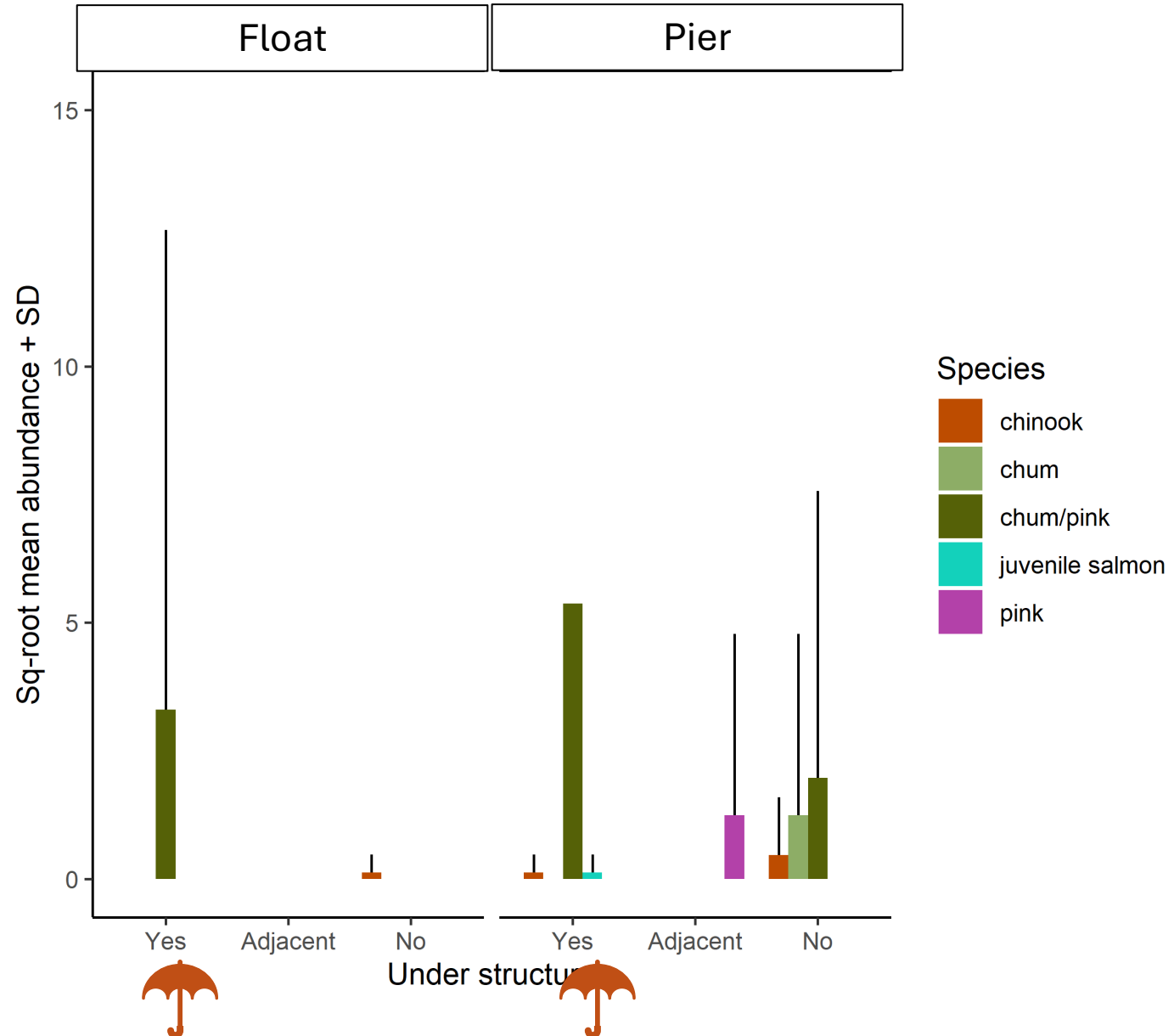
Cover



Results: salmonid abundance

Salmonid abundance

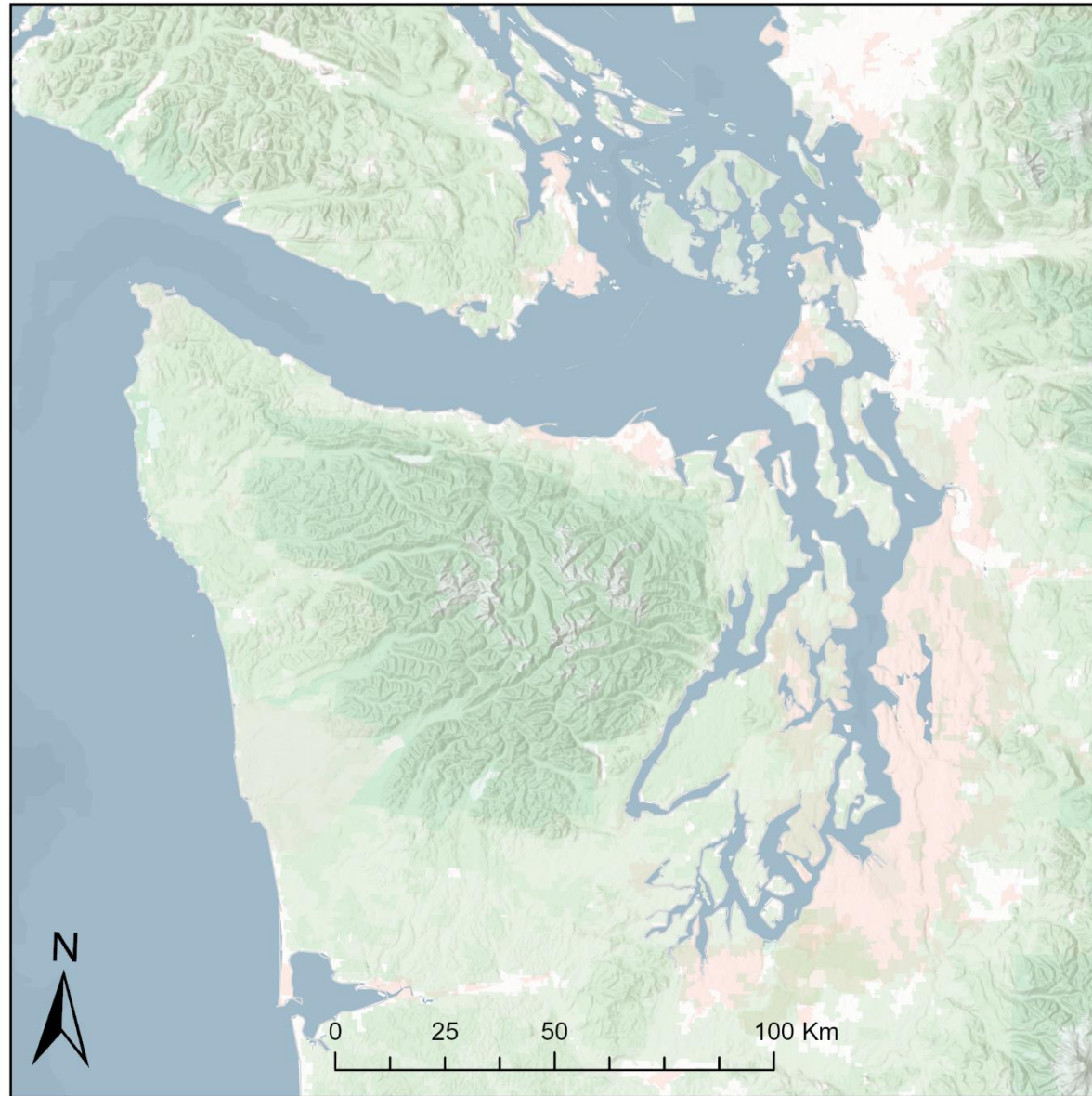
- Highly variable
- Low encounter rate (9/16)
- Pink/Chum common
- Chinook rare
- No pattern with SOWS adjacency
- Pink/Chum often observed in shallow, landward transect
- Chinook observed further offshore



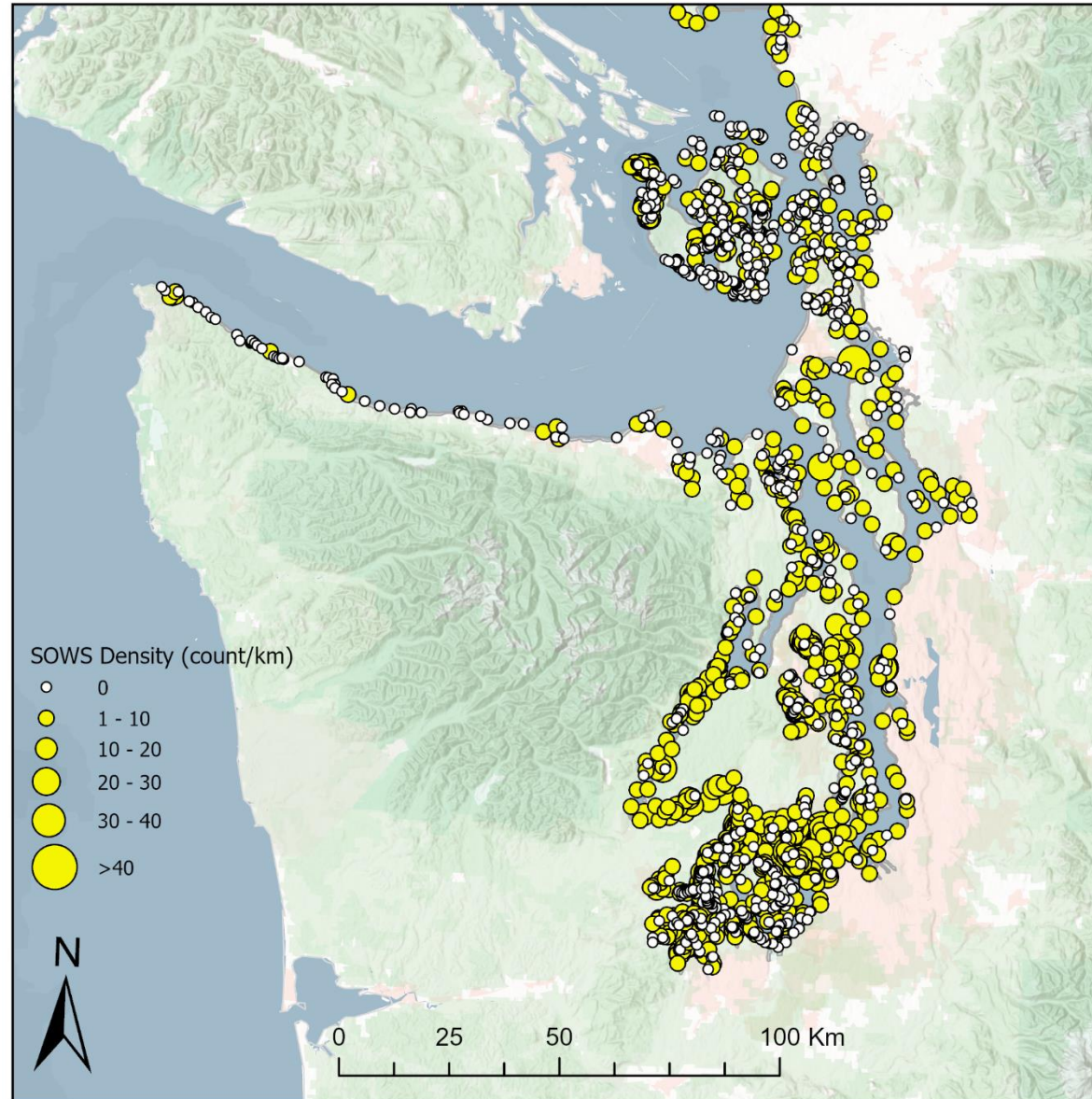
Results: salmonid abundance



Results: spatial analysis

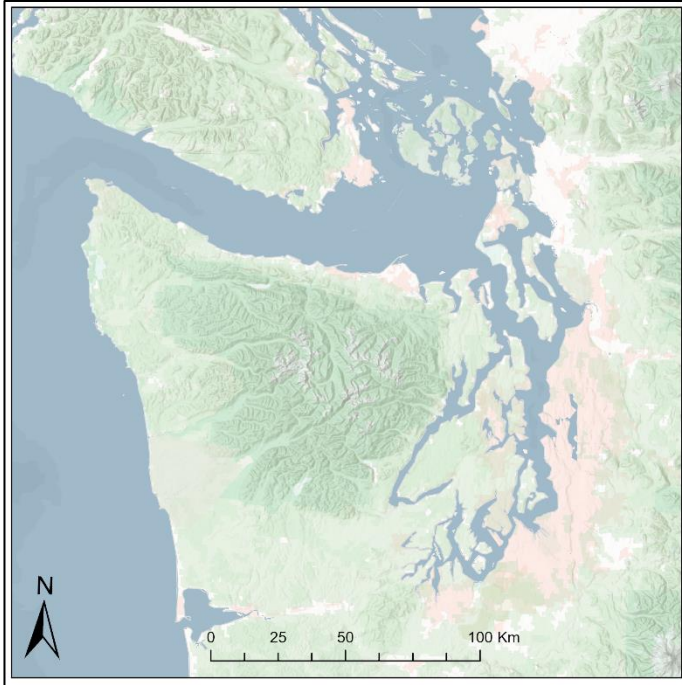


Results: spatial analysis



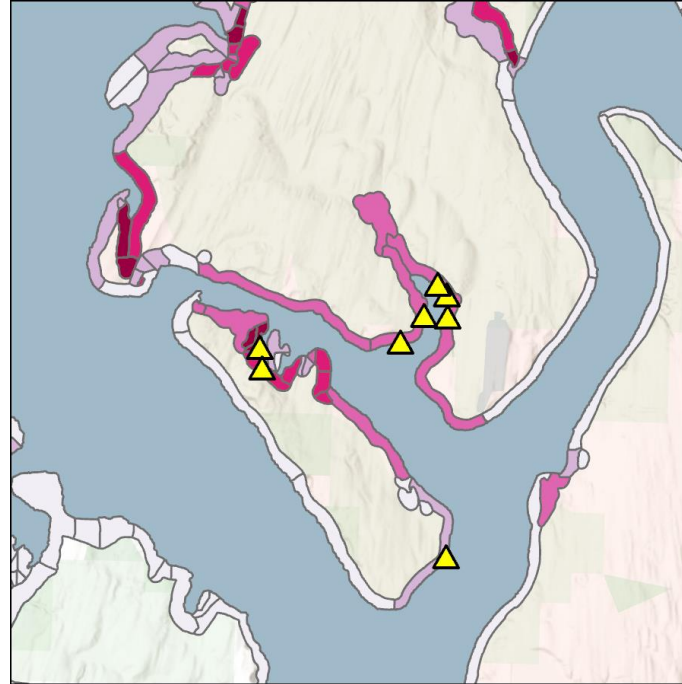
Results: spatial analysis by drift cell

Puget Sound



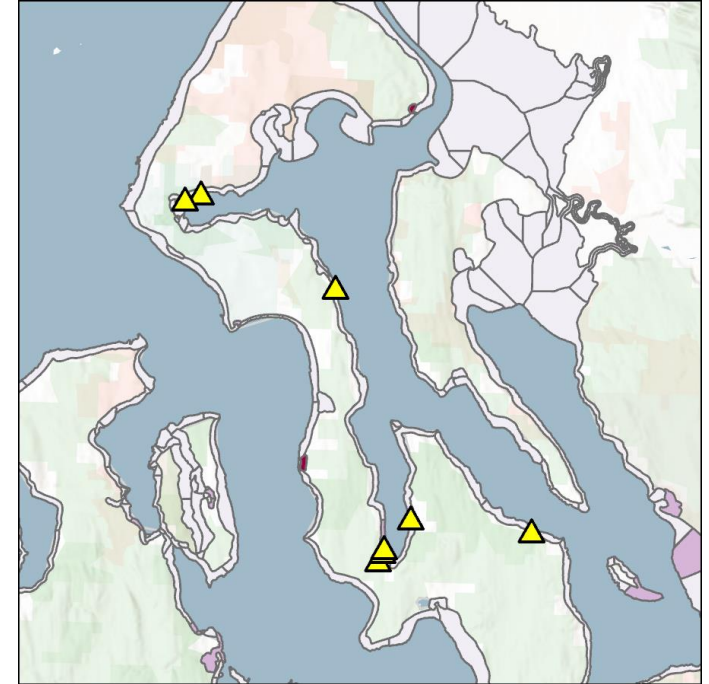
SOWS per km: 2.5 +/- 5.0

Wollochet/Fox Is.

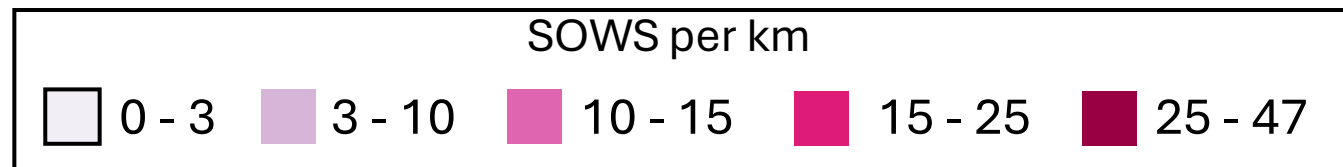


15.0 +/- 6.9

Whidbey Is.



1.4 +/- 2.1



Results: recap

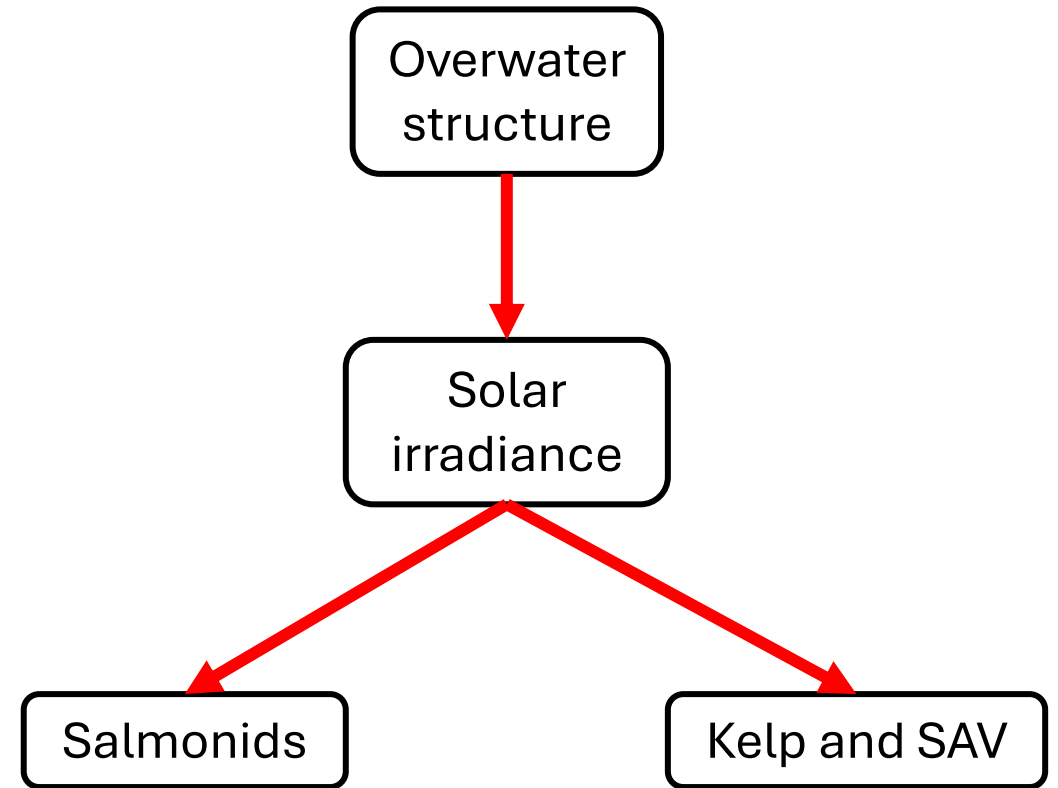
Metric	Effect of small overwater structures	
Sediment character		No up/down drift effect. Pilings affect small grain sizes.
Beach elevation		Increase elevation and variability near SOWS.
Light		SOWS reduce light. Grating has no effect.
Crab abundance		Positive effect of structure and SOWS size.
Kelp abundance		Limited data. Kelp are rare.
Benthic fishes		Positive effect of structure.
Benthic cover		Limited data. Dominated by bare substrate.
Salmonids		Variable, low encounter rate.
Spatial context		Study areas span areas of high and low SOWS density.

Questions revisited

What is the effect of small overwater structures?

- Reduced light will affect salmon behavior and kelp diversity and cover.

Conceptual model

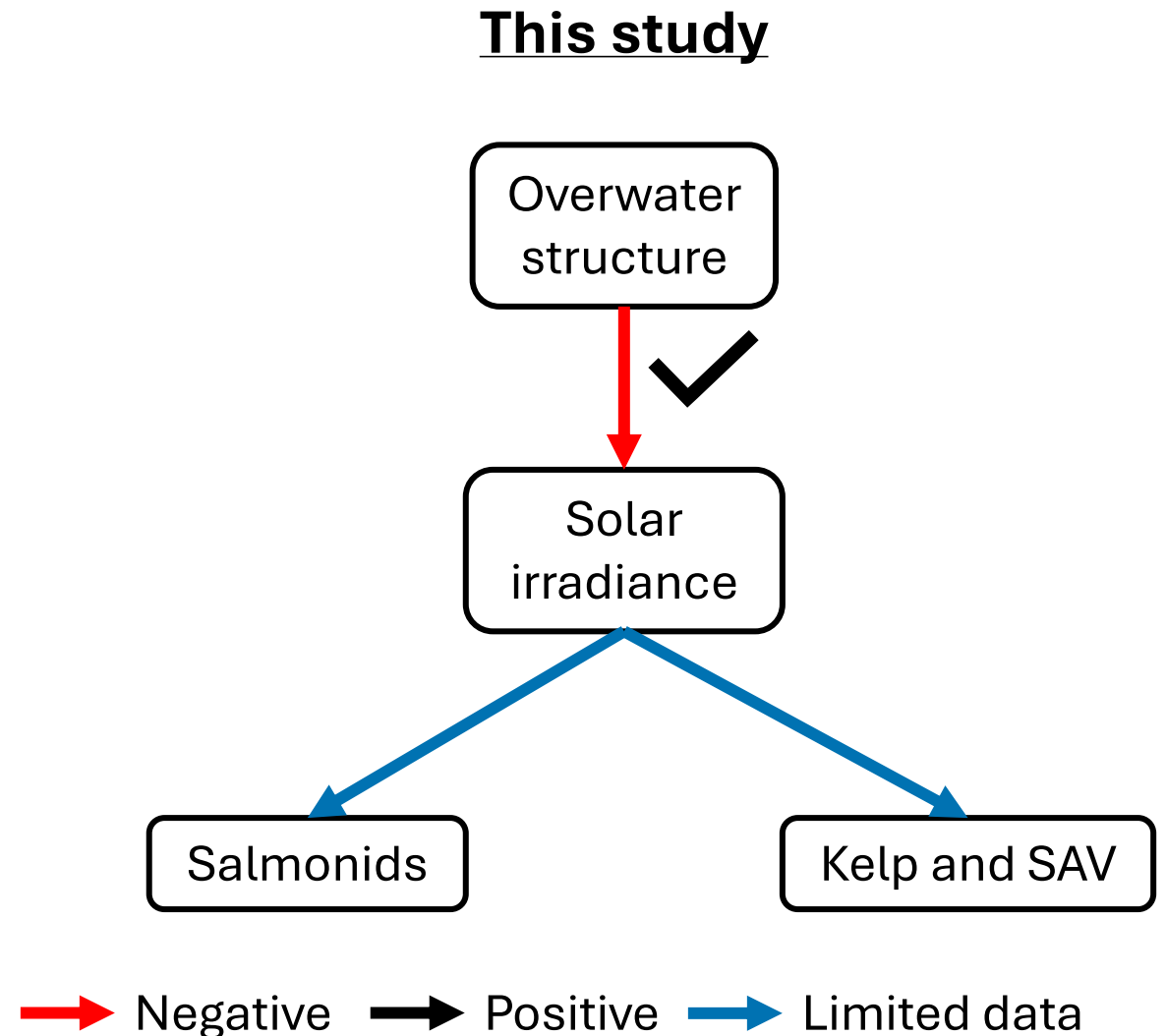


→ Negative → Positive → Limited data

Questions revisited

What is the effect of small overwater structures?

- Reduced light will affect salmon behavior and kelp diversity and cover.
 - ❖ SOWS reduce light and appear to limit SAV
 - ❖ Kelps were rarely observed
 - ❖ Variable salmon abundance and behavior

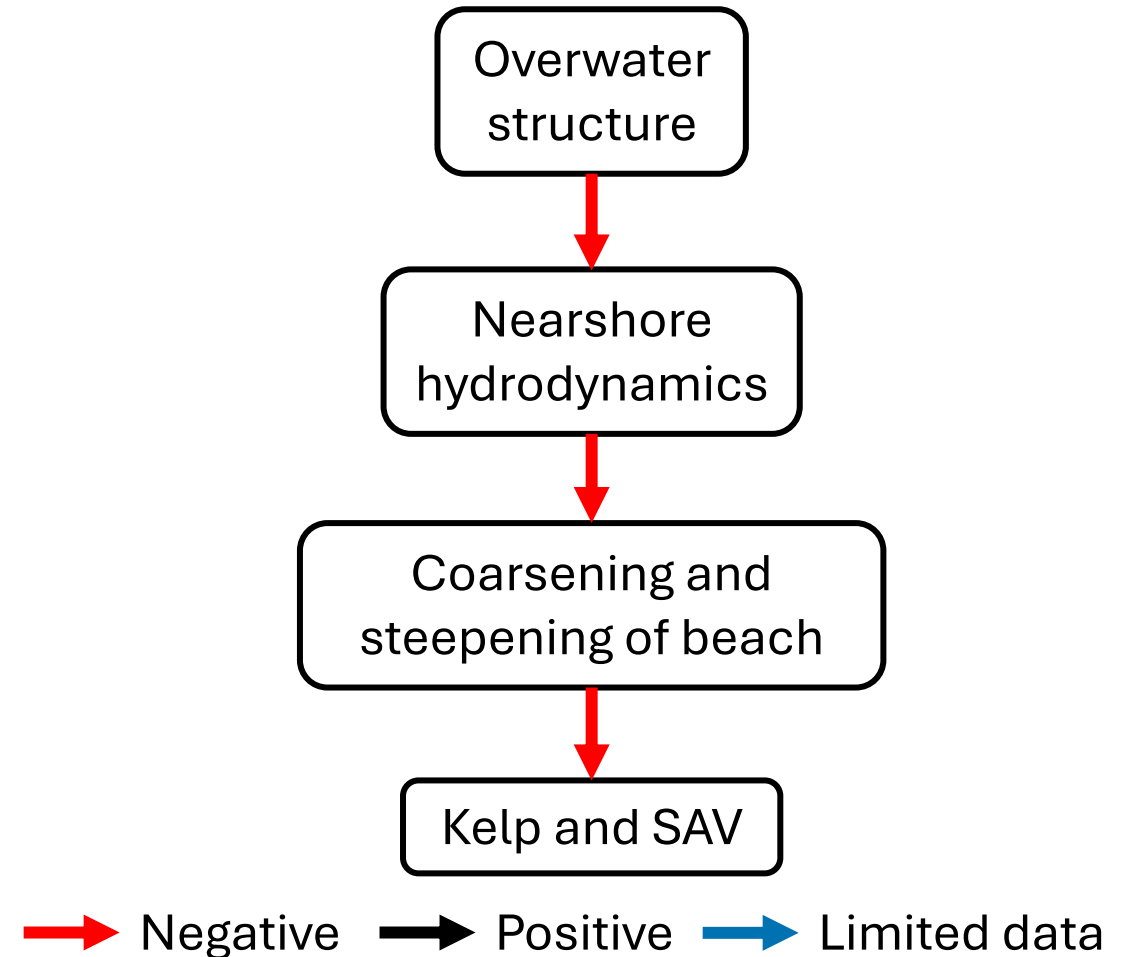


Questions

What is the effect of small overwater structures?

- Physical structure will affect nearshore hydrology and sediment transport

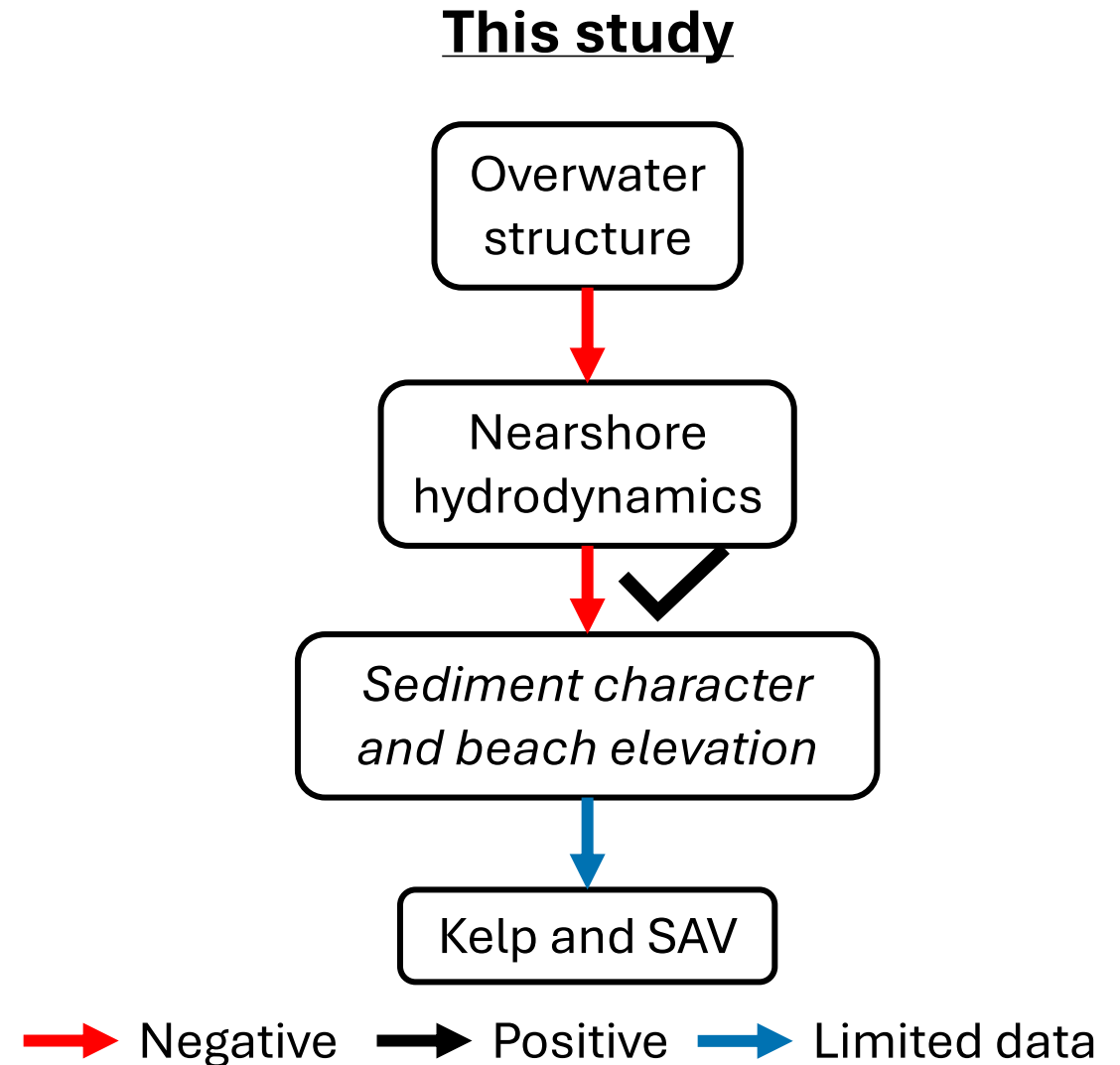
Conceptual model



Questions

What is the effect of small overwater structures?

- Physical structure will affect nearshore hydrology and sediment transport
 - ❖ Pilings affect sediment
 - ❖ Elevation increase near SOWS
 - ❖ Trickle-down effects of kelp and SAV unclear

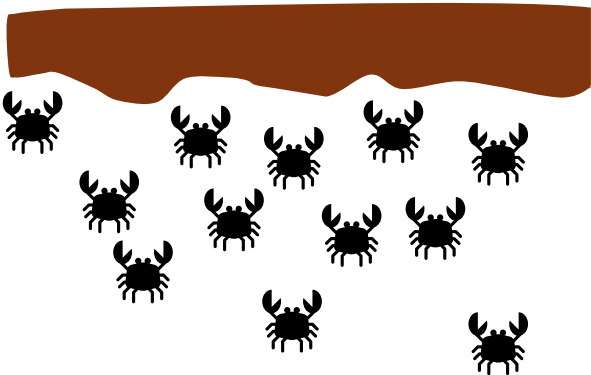


Positive effects

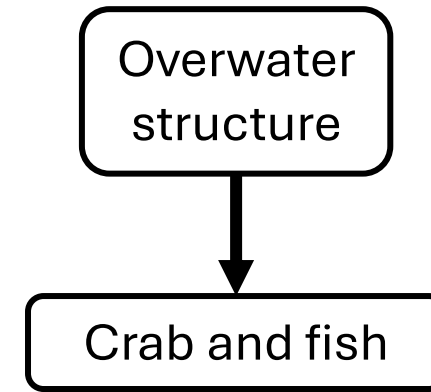
More crabs and benthic fish near structure

- Aggregation effect vs. absolute increase

No SOWS n = 12



Conceptual model



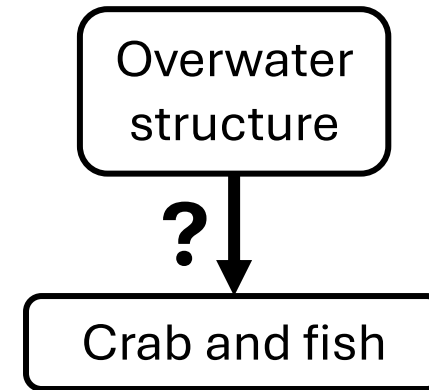
→ Negative → Positive → Limited data

Positive effects

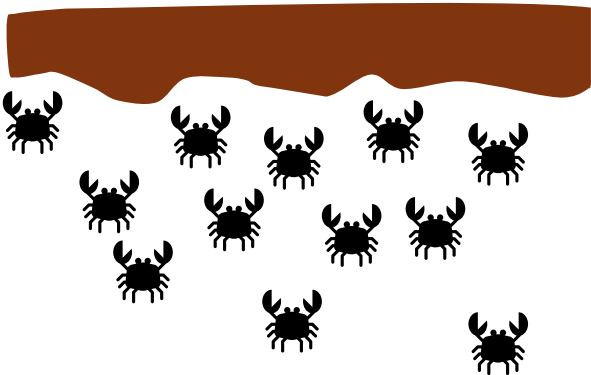
More crabs and benthic fish near structure

- Aggregation effect vs. absolute increase
- Red rock and Graceful crabs

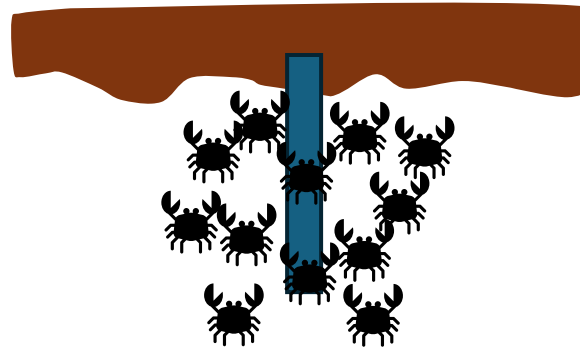
This study



No SOWS n = 12



SOWS n = 12



→ Negative → Positive → Limited data



So, these SOWS don't seem to be that big of deal, right?

Well, not exactly. We are still learning and there are some important things to consider

Key Points

‘No effect’ does not mean no effect

- *Statistically* different results are not everything. Site-specific effects can be pronounced.
- Zeros are data too!
- Species of interest inhabit these places.
- # pilings and structure area seems to matter. Size threshold?



Key Points

SOWS shorelines are armored shorelines

- 13 or 16 study sites were armored



Key Points

The problem of pattern and scale

- Space and time are hard to control
- SOWS affects likely operate at multiple scales and interact with other forces.
- Context matters

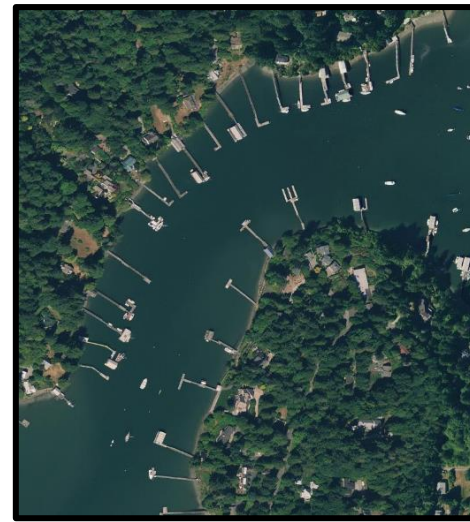
1 meter



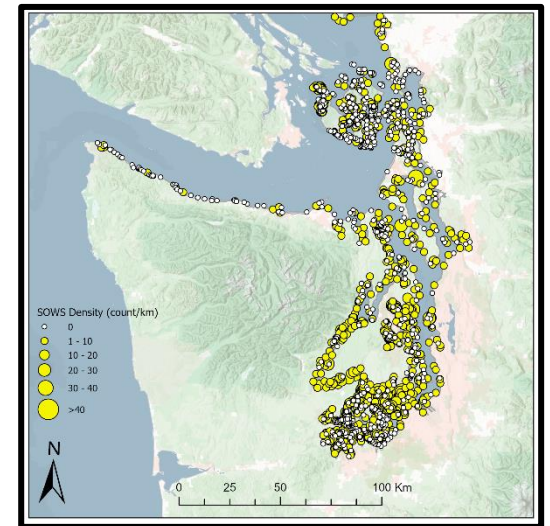
10s meters

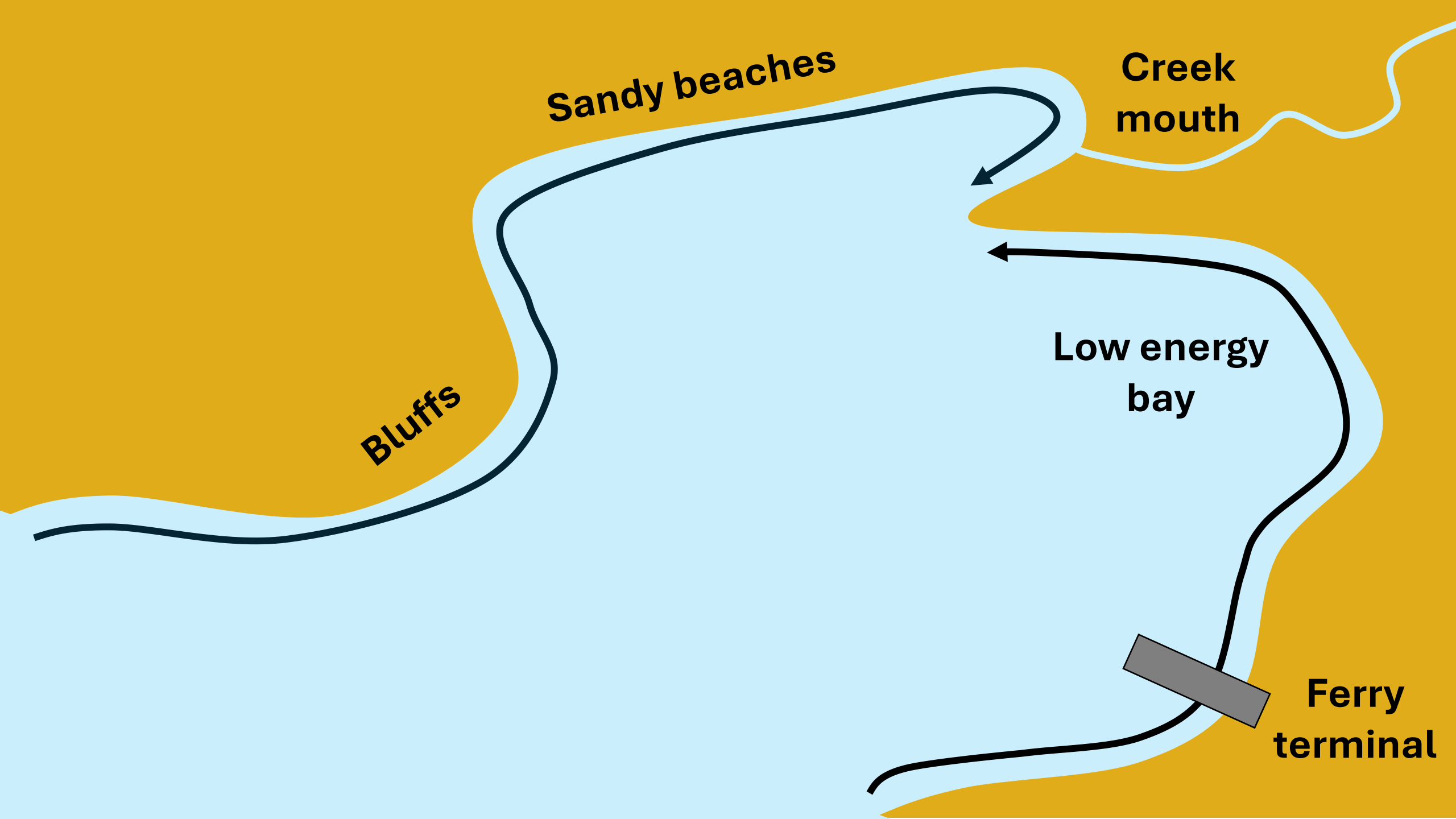


100s meters



1000s meters





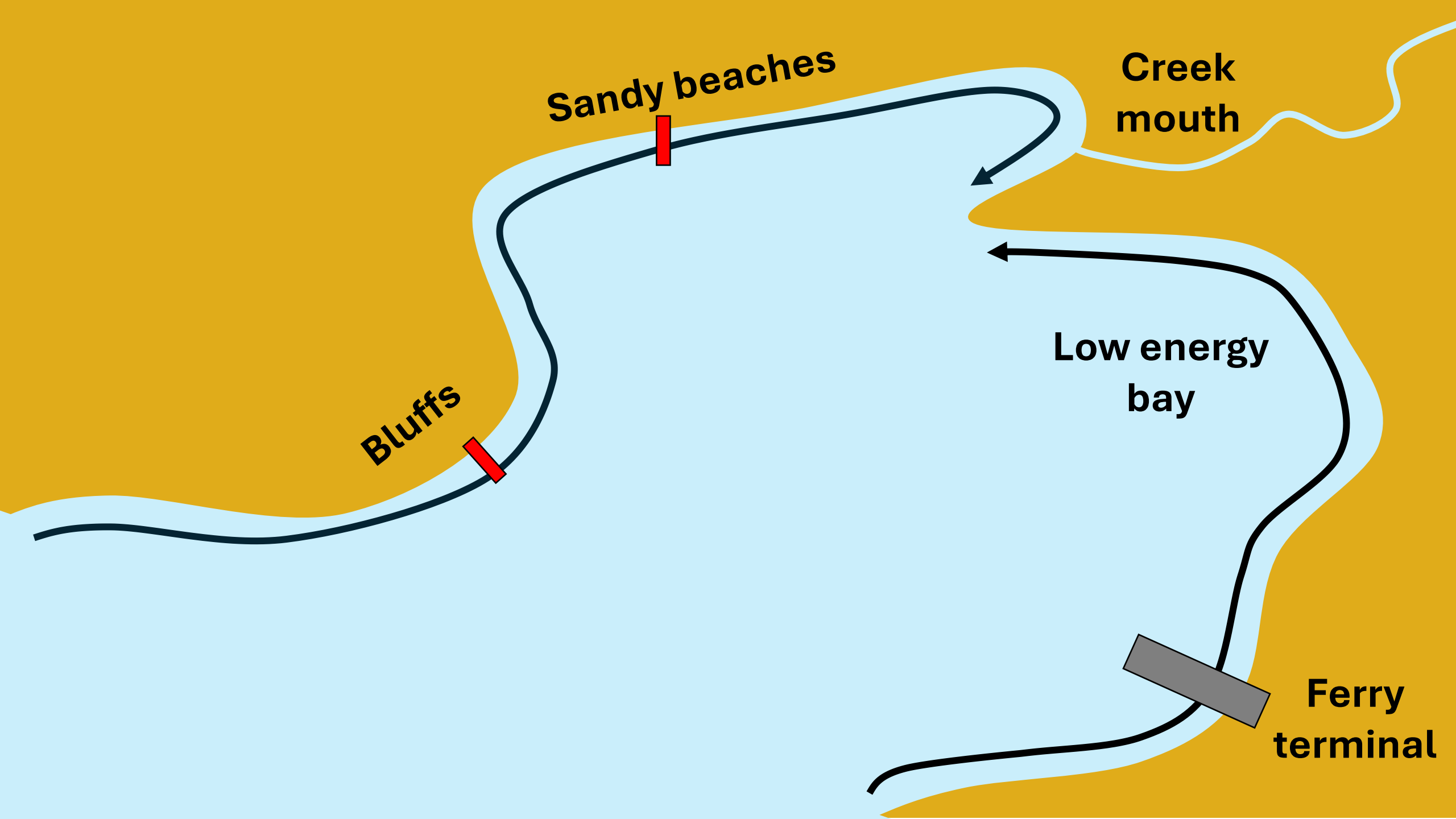
Sandy beaches

**Creek
mouth**

**Low energy
bay**

Bluffs

**Ferry
terminal**



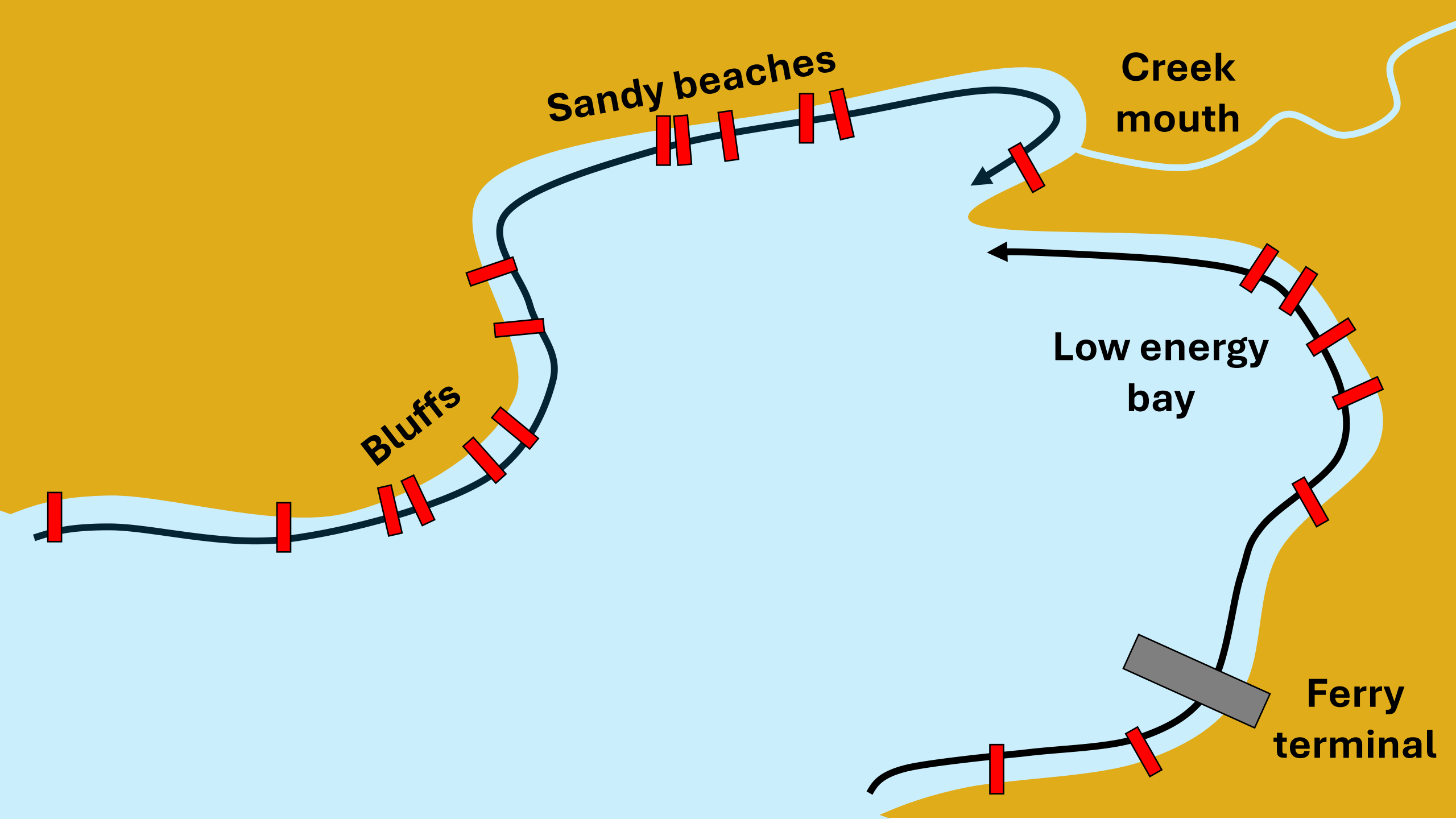
Sandy beaches

**Creek
mouth**

**Low energy
bay**

Bluffs

**Ferry
terminal**



Sandy beaches

**Creek
mouth**

Bluffs

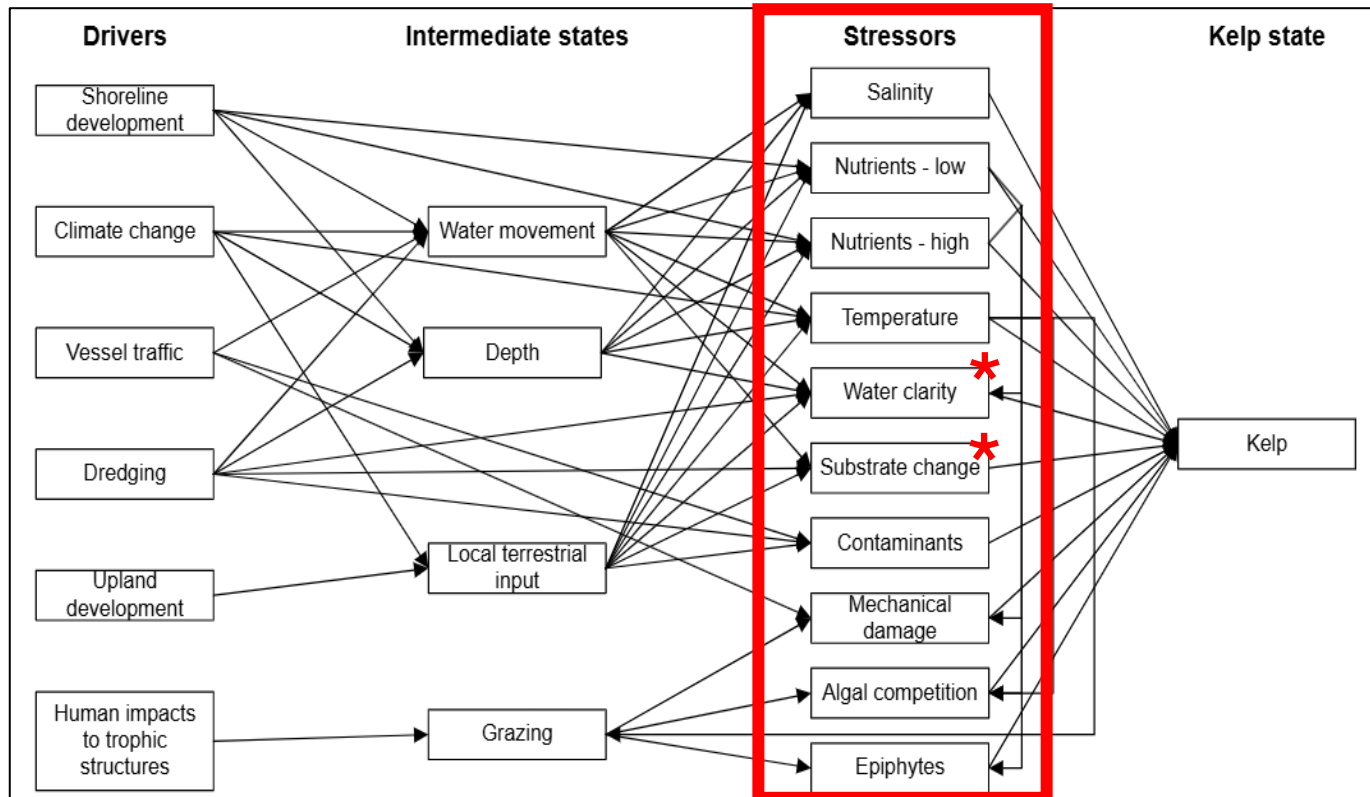
**Low energy
bay**

**Ferry
terminal**

Death by a thousand cuts

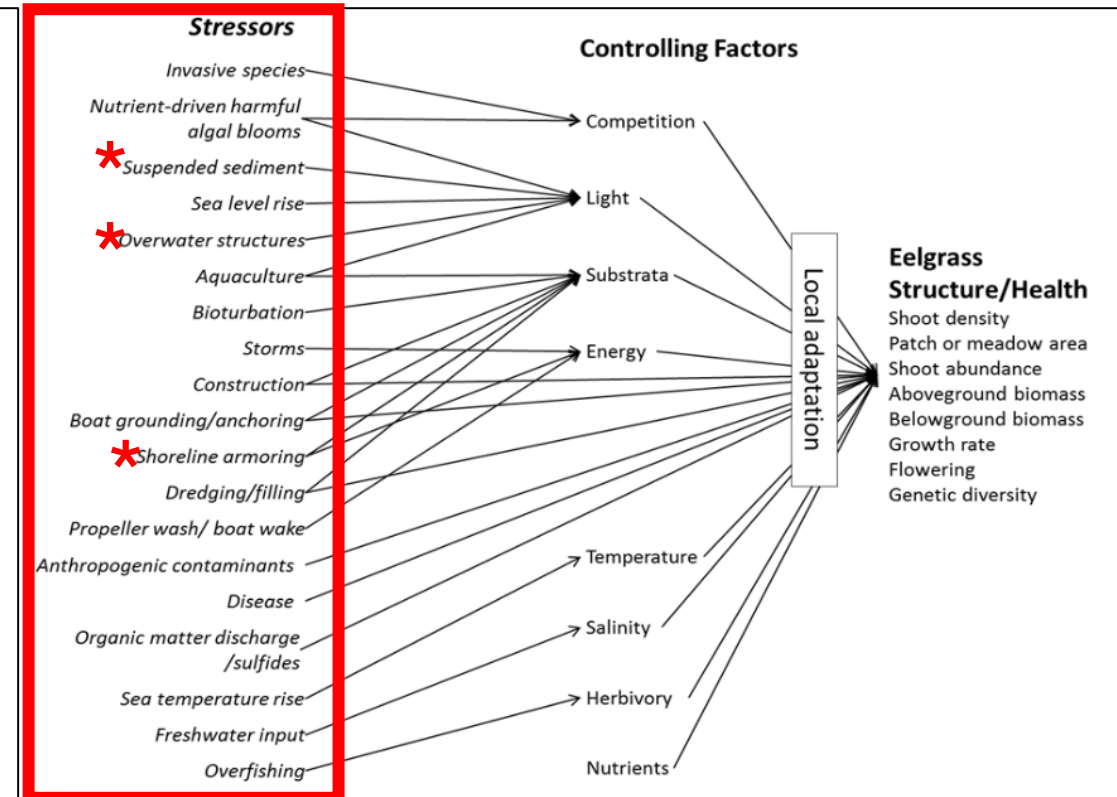
Kelp, eelgrass, and salmonids (and what they eat) are under threat on multiple fronts.

Kelp



Raymond et al. *in prep*, Hollarsmith et al. 2022

Eelgrass



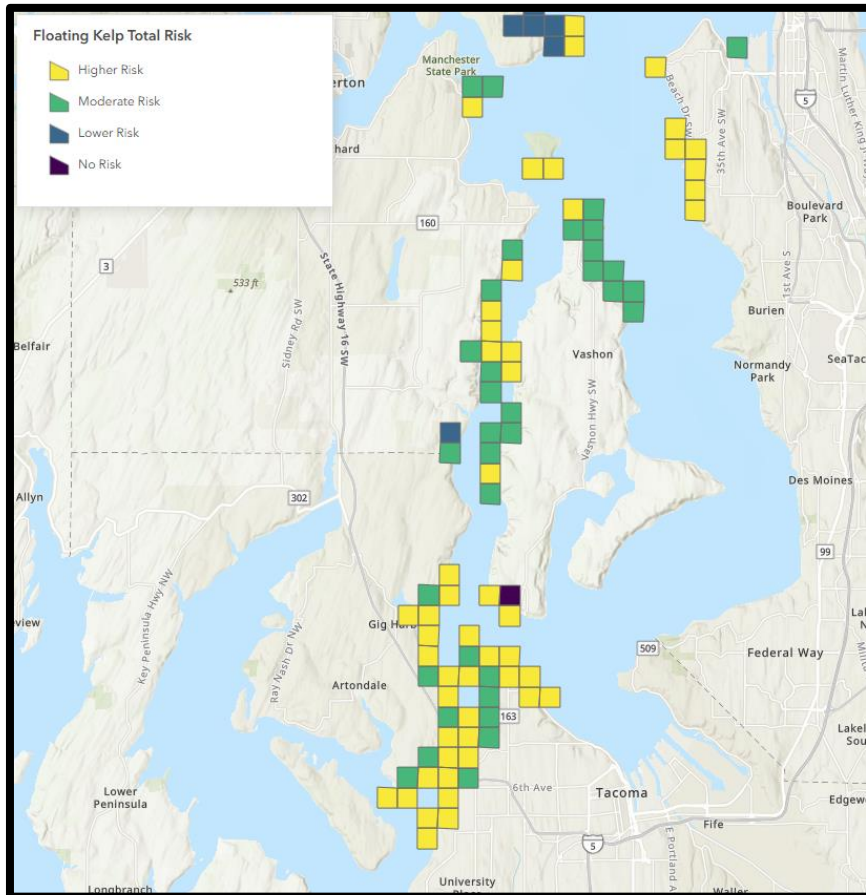
Thom et al. 2011

Death by a thousand cuts

Tools to assess cumulative risk and restoration priority

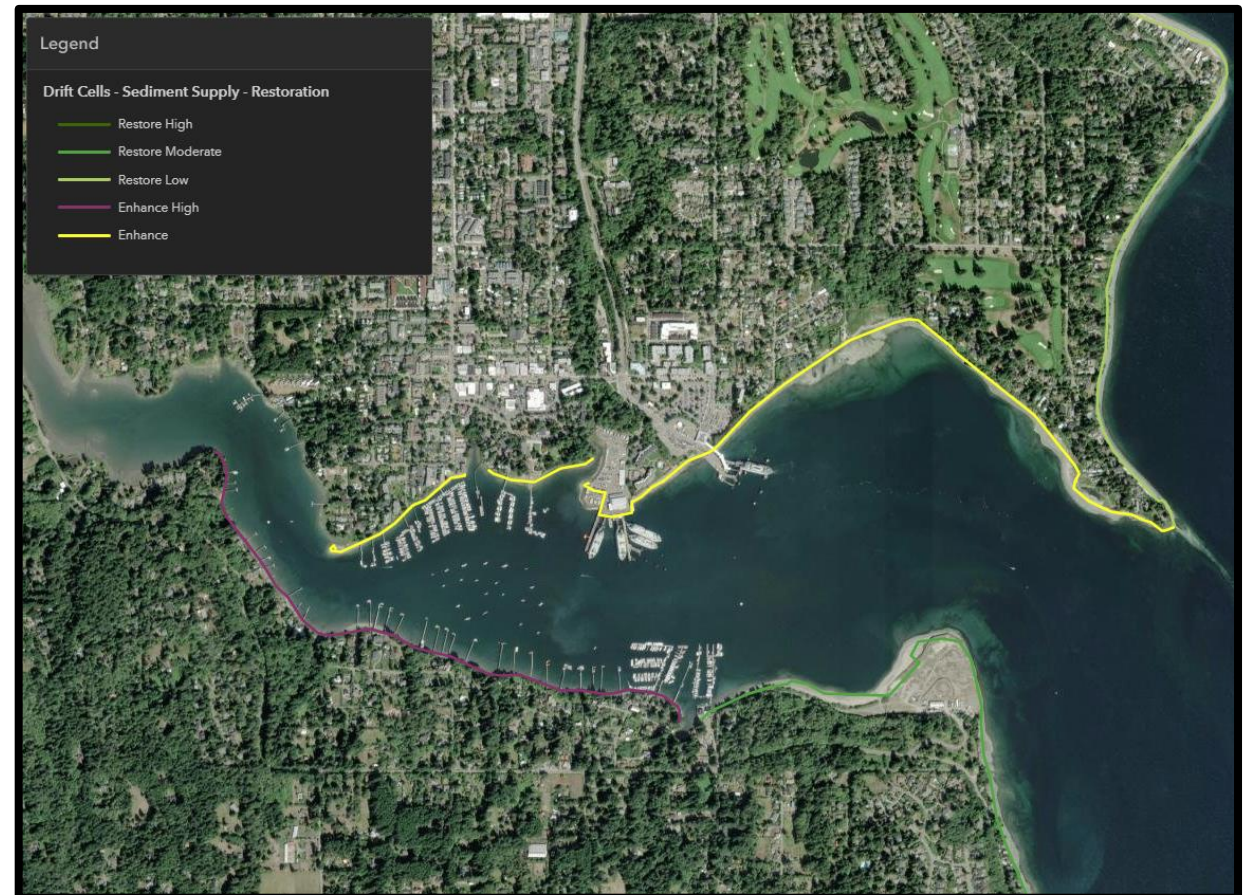
Kelp and eelgrass risk assessment

UW - Tacoma



Beach strategies

WDFW



Restoration perspective

Our picture of SOWS effects is still developing but there are clear implication for restoration

- **SOWS shorelines are armored shorelines**
 - Effect sediment transport
 - Steepen and coarsen beaches
- **Old SOWS use outdated materials**
 - Solid decking limiting light penetration
 - Creosote pilings and other material introduce pollutants



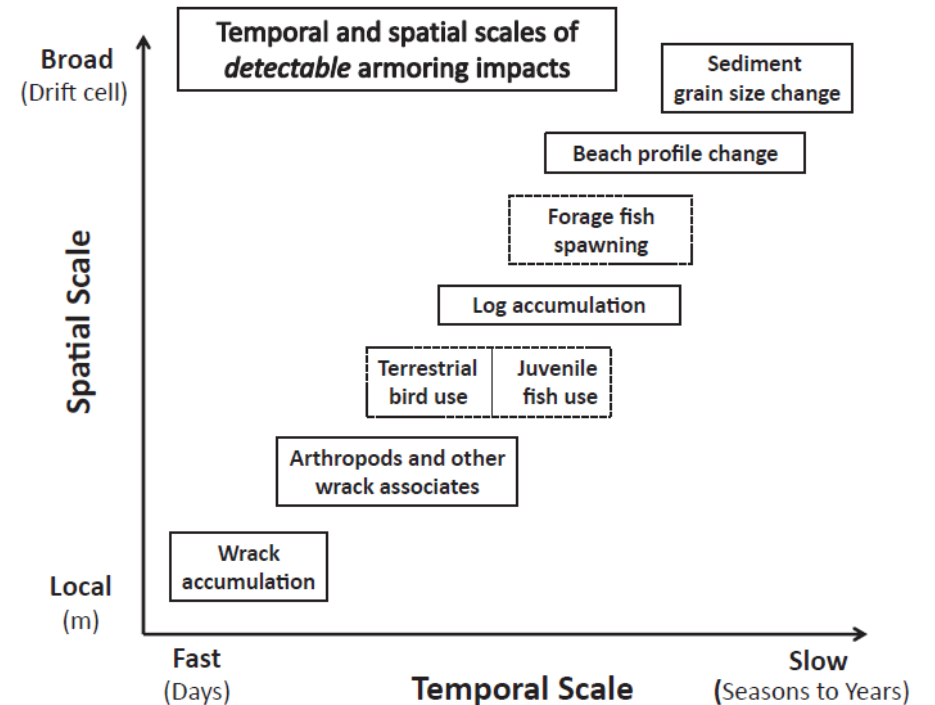
Food for thought and next steps

Armor vs. SOWS effects

Cumulative vs. local effects

Full controls

- Distance from SOWS is useful but limited
- Un-SOWSed shorelines
- Pre and post construction (building or removal)
- Nested large-scale analyses



Dethier et al. 2016 ECSS

A photograph of a long pier extending from a dark, forested shoreline into a calm body of water. The pier is made of concrete and has a wet, reflective surface. A small, blue, single-story building with a corrugated metal roof is situated on the pier. The sky is filled with heavy, grey clouds, and the water reflects the overcast light. The text "Thank you" is overlaid in the center of the image.

Thank you