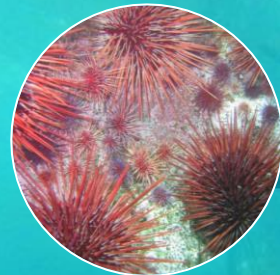
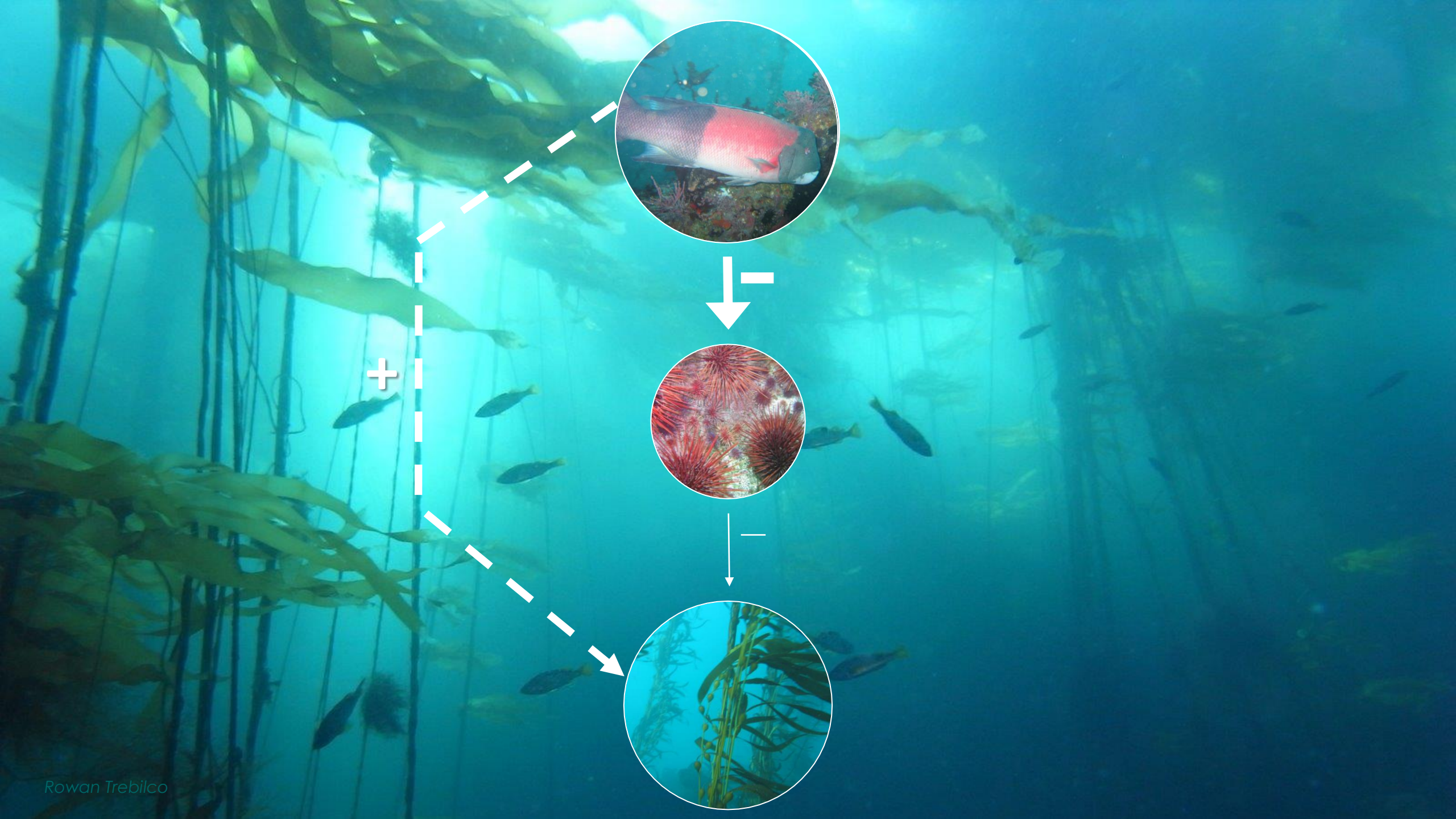




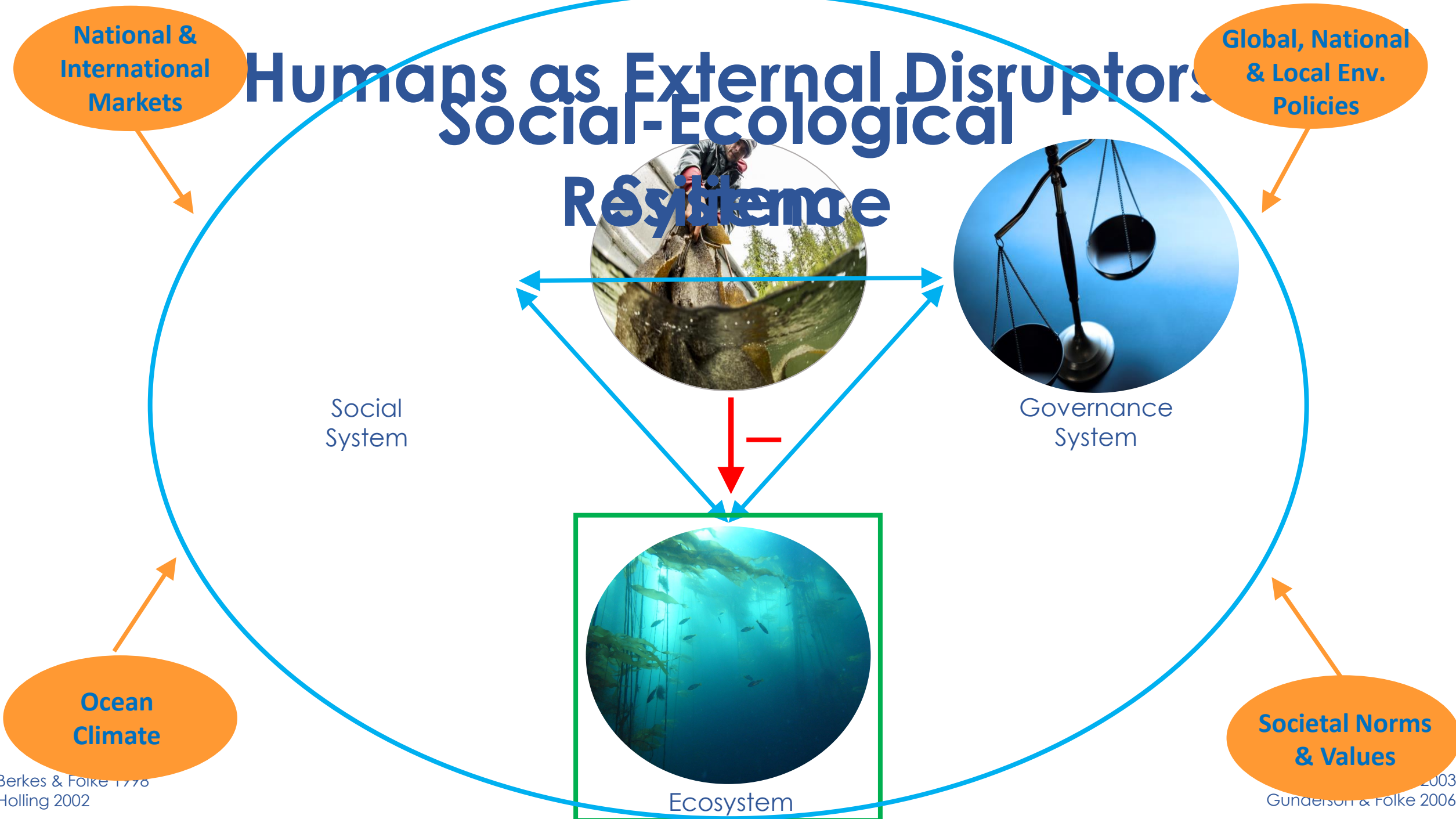
# Why Future Progress in Marine Science & Policy Needs to Look to the Past and People

Anne K. Solomon



# Humans as External Disruptors

## Social-Ecological Resilience



Berkes & Folke 1998  
Holling 2002

Gunderson & Folke 2003  
Gunderson & Folke 2006

# Social-Ecological Resilience



History & Prehistory of Kelp Forest Regime Shifts



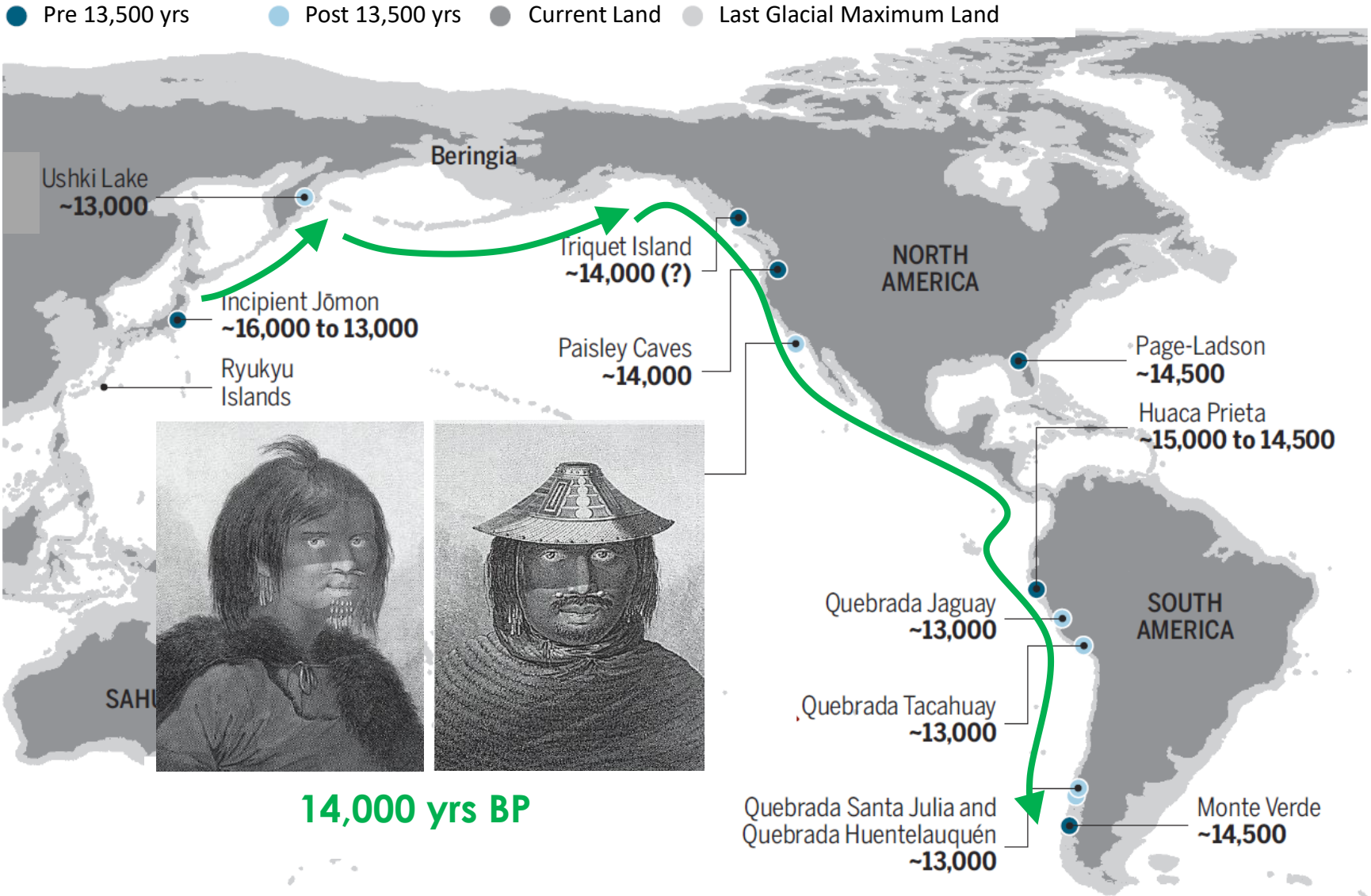
Resilience of Indigenous Intertidal Kelp Harvest



# Archaeological Evidence



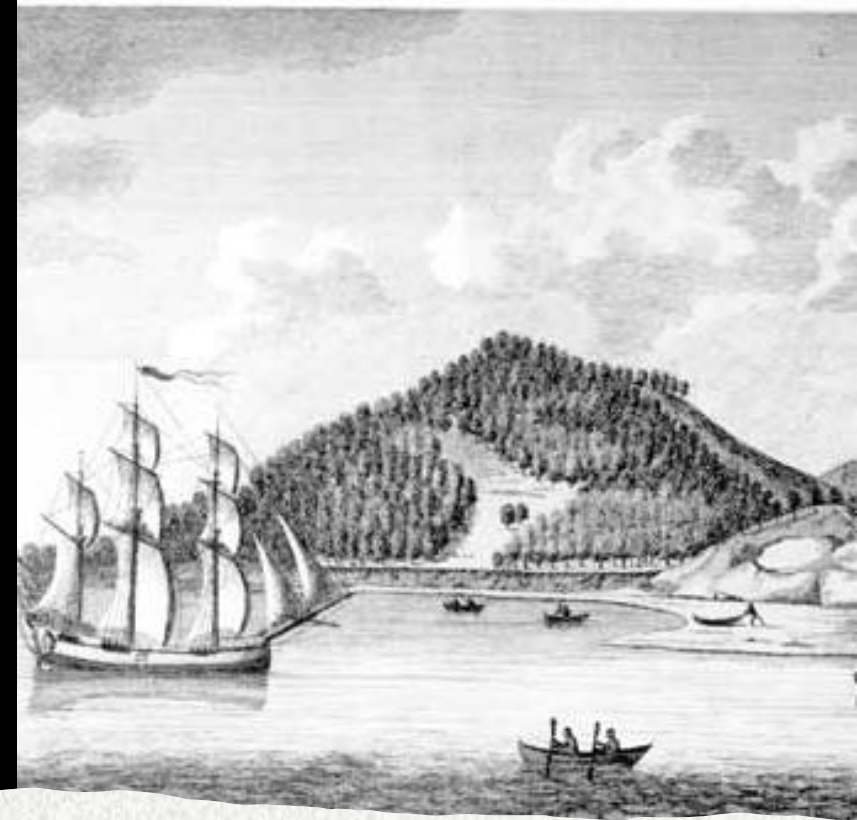
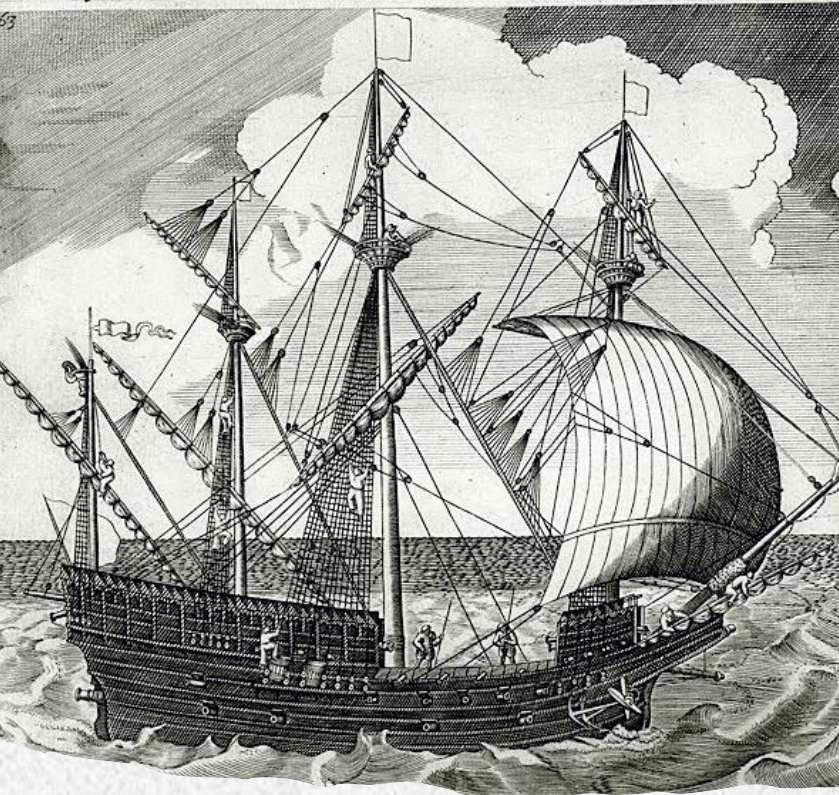
# Kelp Highway Hypothesis



Erlandson et al. 2006

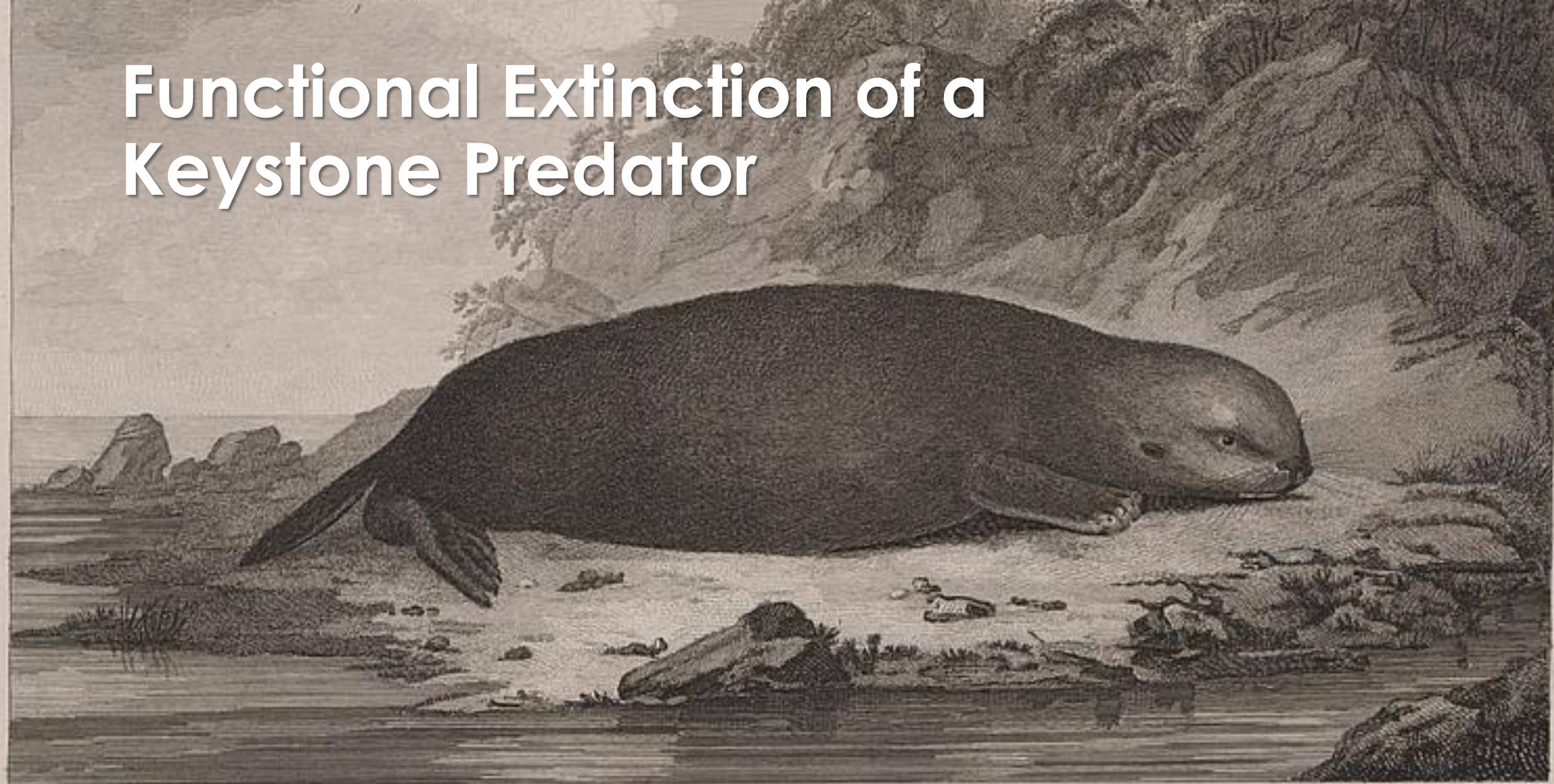
Braje et al. 2017





# Social-Ecological Transformation

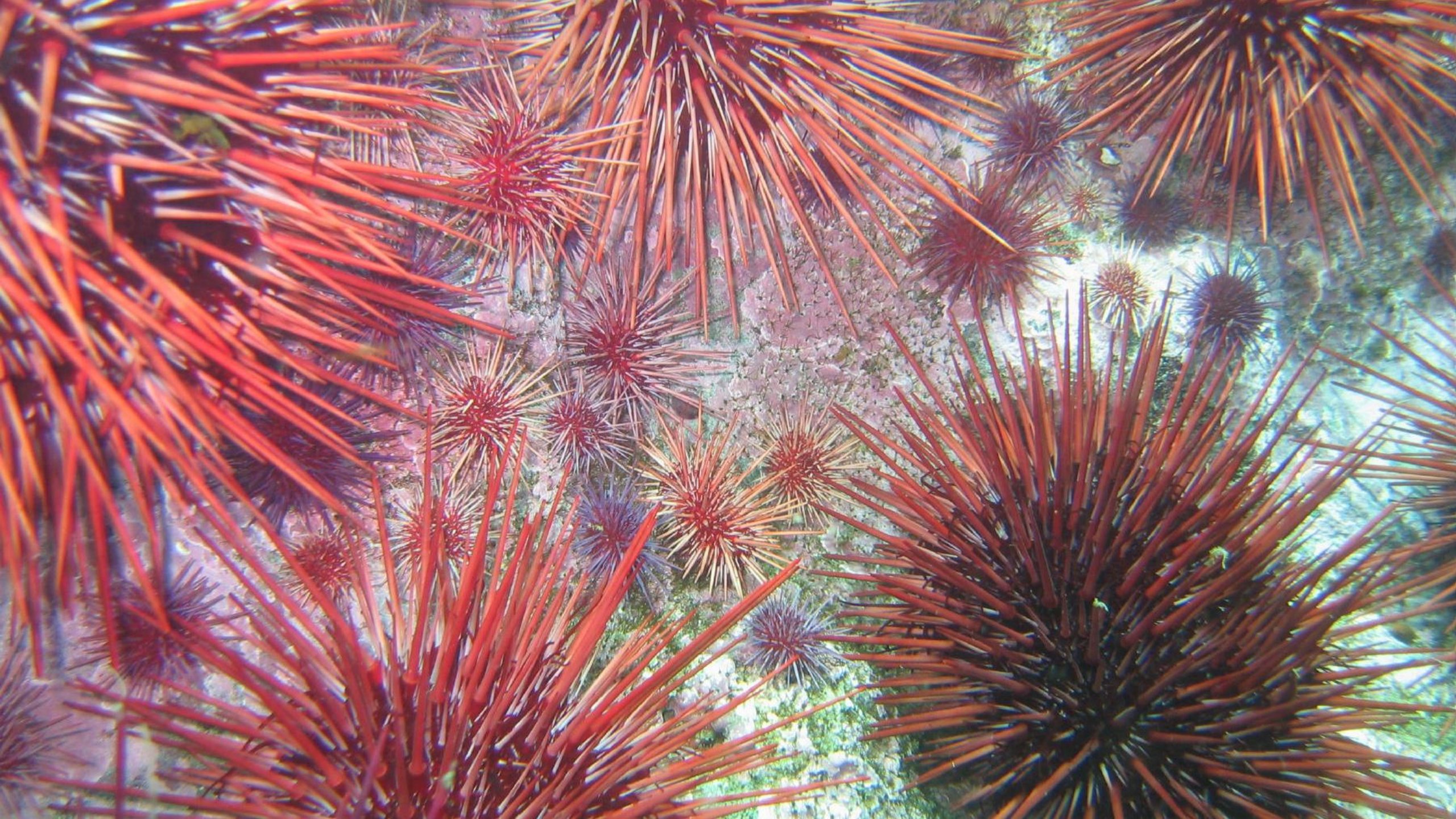
# Functional Extinction of a Keystone Predator



*J. Webber del.*

*Maxell sculp.*

*A SEA OTTER.*



# Colonial Dispossession of Indigenous Governance & Economies



- Stewardship Practices
- Marine Tenure Systems
- Trade Networks

# A Modern ~~Coastal~~ Facility's Success Story



# The Challenge: Differential Benefits of Alternative States



Social-Ecological Benefits and Costs  
Depend on Your Values & Objectives

# The Challenge: Equity & Justice



“We both have the right to food.”

Kii'iljuus Barbara Wilson, Haida Matriarch 2013

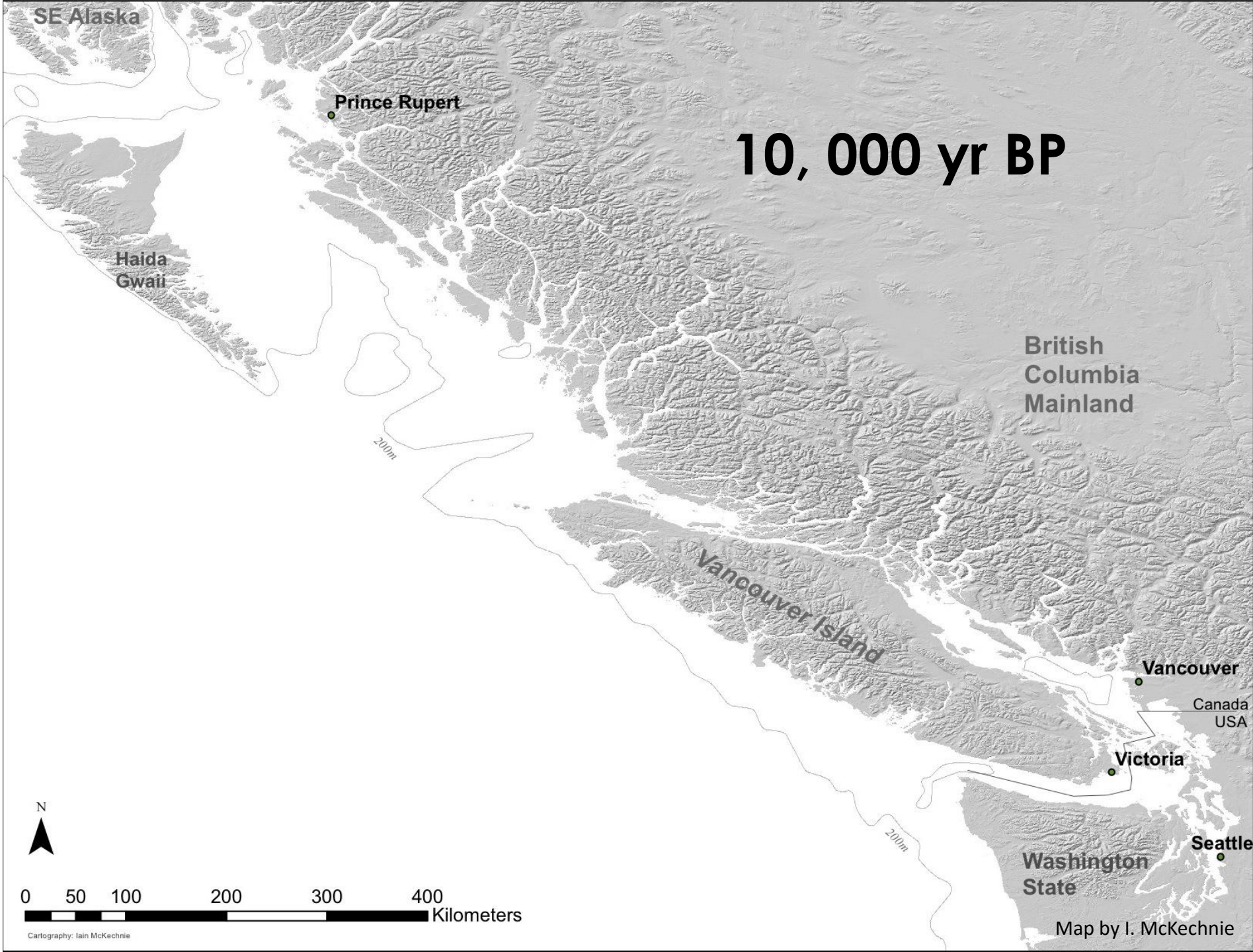
# Mental Model of Pre-Historic Kelp Forests

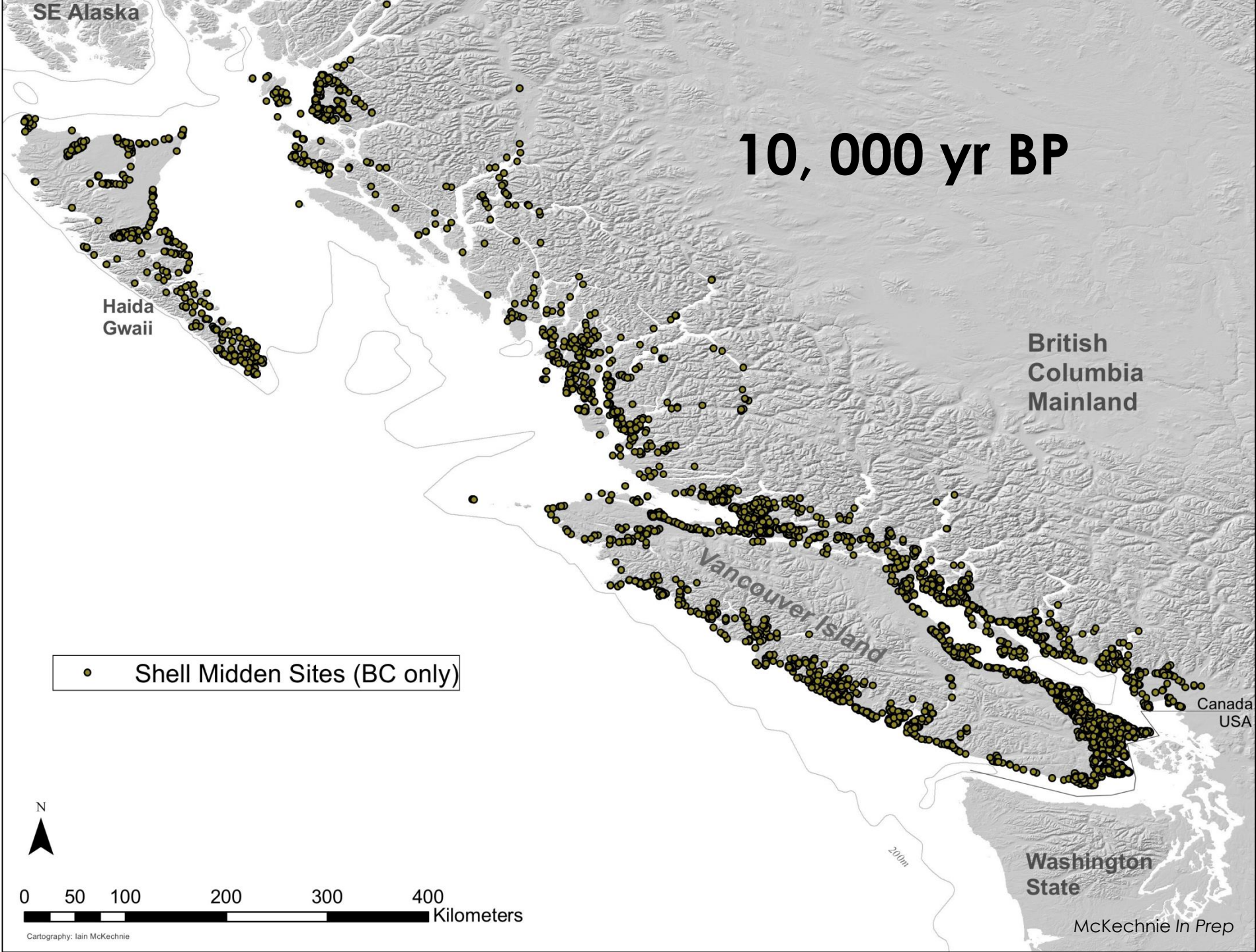


+

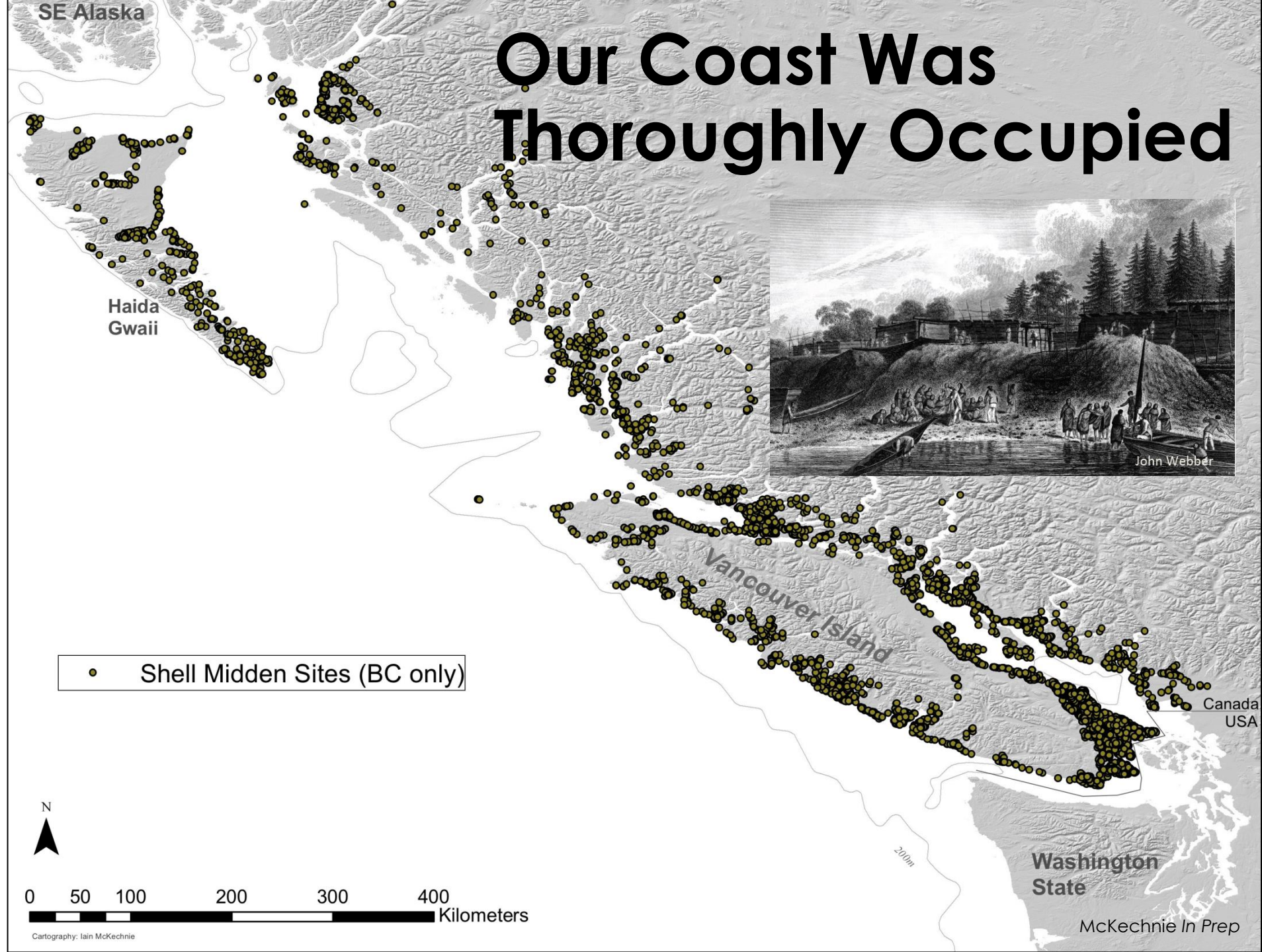
## Implicit Assumptions

1. Sea Otters at Carrying Capacity Everywhere
2. Kelp Forests Were Everywhere

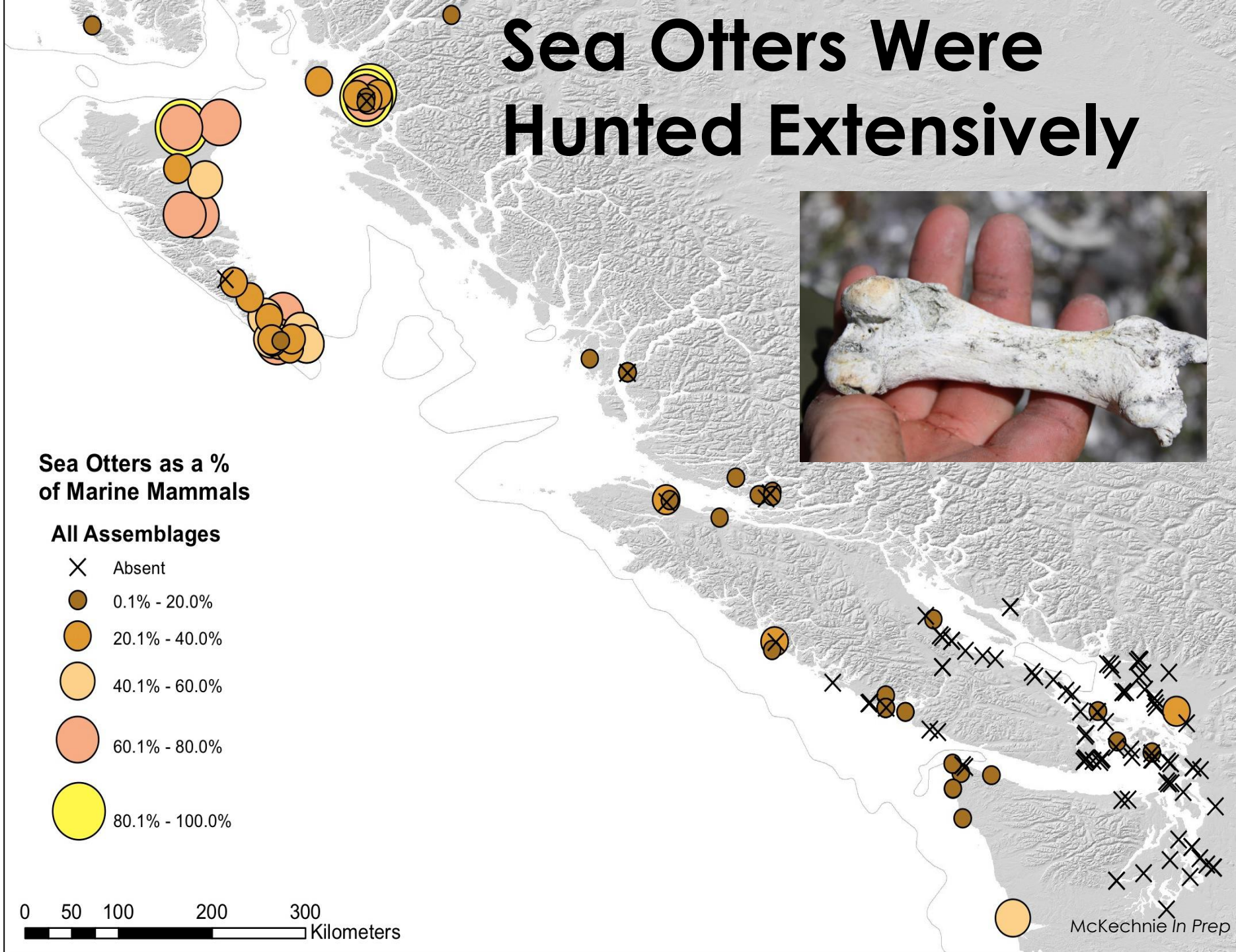




# Our Coast Was Thoroughly Occupied



# Sea Otters Were Hunted Extensively



# What did Coupled Human-Kelp Forest Systems Look Like in Deep Time?



**6000 yrs BP**



Erin Slade



Iain McKechnie

# What did Coupled Human-Kelp Forest Systems Look Like in Deep Time?

## Modern Mussel Sizes



# What did Coupled Human-Kelp Forest Systems Look Like in Deep Time?

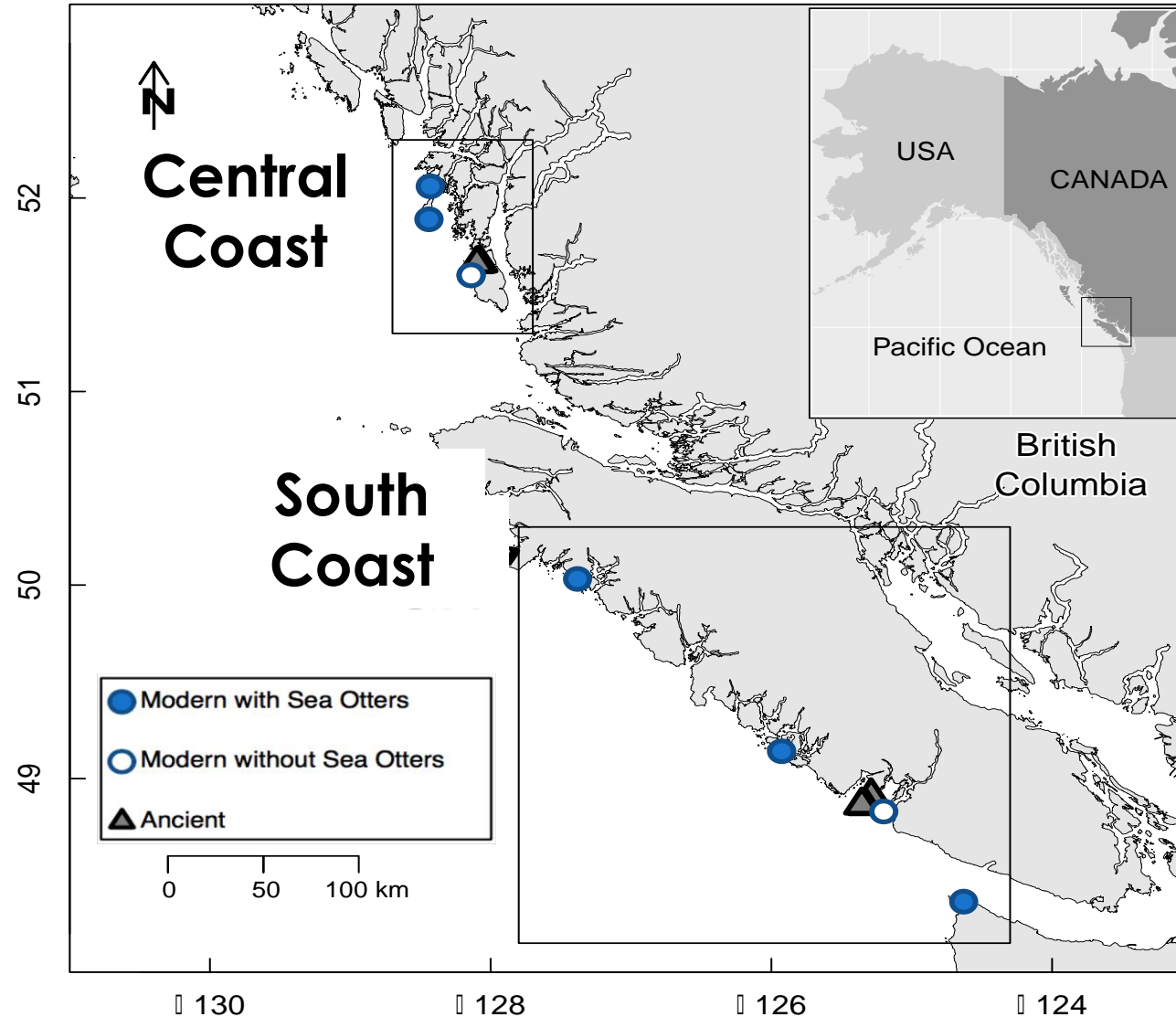
## Modern Mussel Sizes



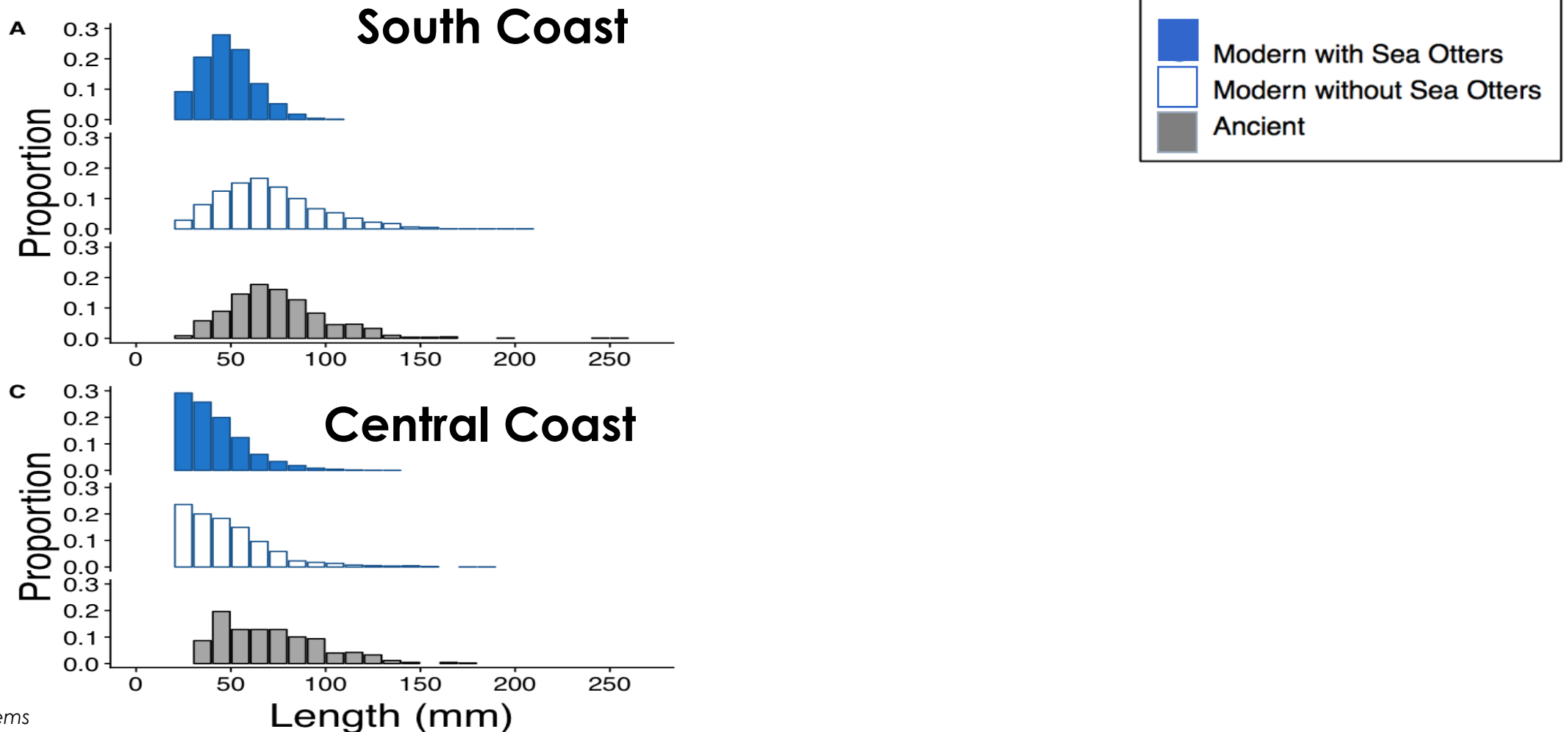
## Ancient Mussel Sizes



# Compared Modern Mussel Sizes With & Without Sea Otters to Ancient Mussel Sizes



# Ancient Mussel Sizes $\approx$ Modern Mussel Sizes at Sites Without Sea Otters



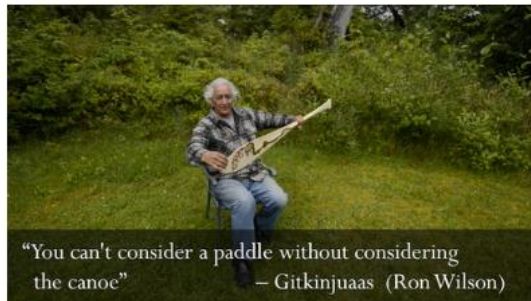
# Indigenous People Managed Their Relationship With Sea Otters & Shellfish



Daisy Hanson and Waakitaam, Peter Hanson  
Ka:'yu:'k't'h' & Che:k:tles7et'h' Nation

“The way our people did in the past, is that they kept sea otters away from where we were, close by, like all around the islands out here. They hunted them there and kept them off the sea urchin beds so they didn't take everything. It could be done again.”

# Ancient Management of Coupled Human-Kelp Forest Systems



- Spatially-Explicit & Selective Hunting
  - Ancestral marine spatial planning!
- Seasonal Restrictions
- Proprietorship of Ocean Areas Contingent on Sustained Productivity
  - Accountability
- Governance Protocols Based on Respect, Responsibility & Reciprocity

# UPDATED Mental Model of Pre-Historic Kelp Forests

1. Sea Otters Were Well Below Carrying Capacity in Places
2. Coexistence Among People, Sea Otters, Shellfish, & Kelp
  3. Spatial Mosaic of Kelp Forest Patches
  4. Realized Niche < Fundamental Niche
5. Rethink Sea Otter Recovery Measures & Objectives Today



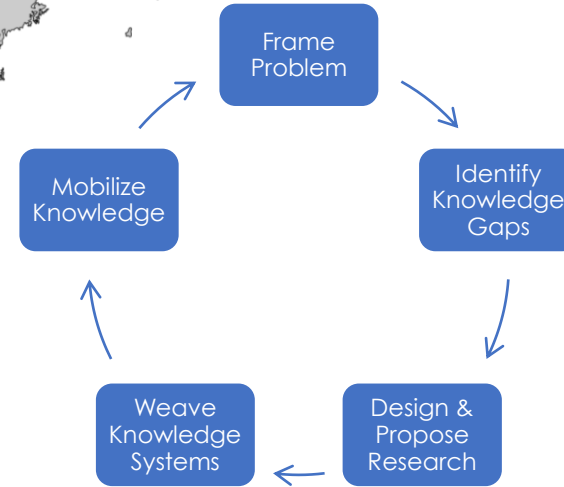
“It is easy to be interesting. It is much harder to be useful.”

~Phil Levin

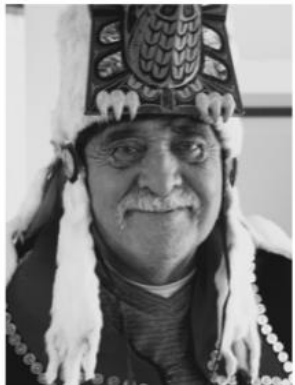
# Coastal Voices

## Research & Knowledge Mobilization Initiative

- Indigenous Leaders, Knowledge Holders, Natural & Social Scientists, Practitioners, Artists
  - Knowledge Co-Design, Co-Creation, Co-Delivery



## Steering Committee of Hereditary Chiefs Representing 19 Nations/Tribes



Wigvilhba Wakas  
Heiltsuk



Gitkinjuas  
Haida



Skil-Hillans



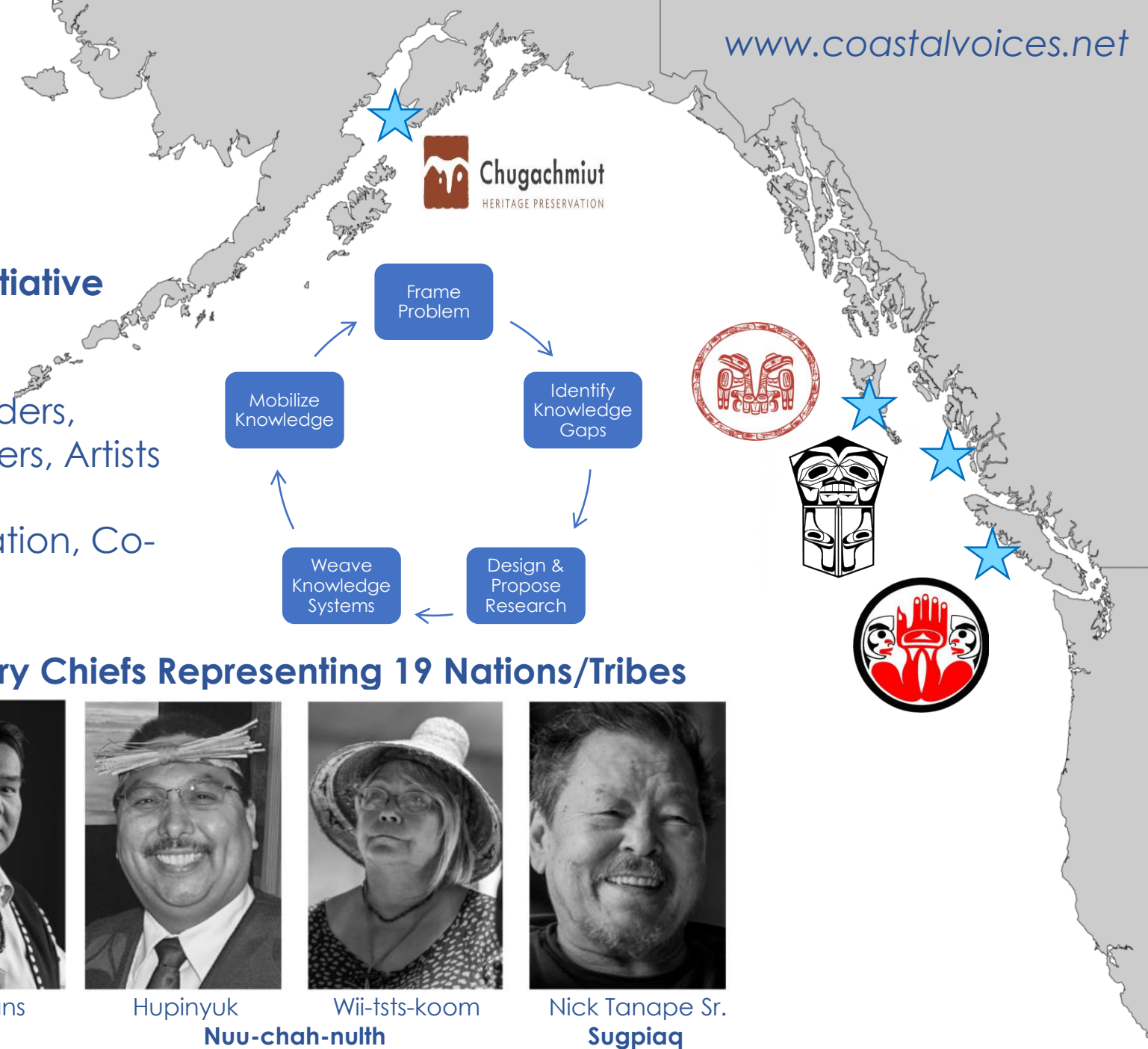
Hupinyuk  
Nuu-chah-nulth

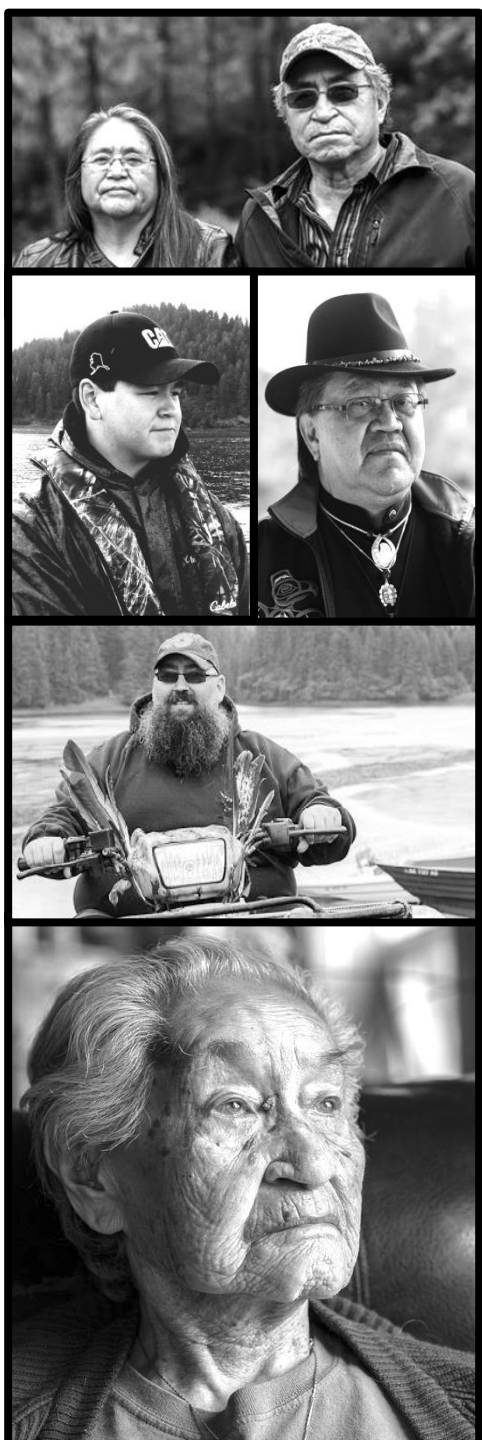


Wii-tsts-koom



Nick Tanape Sr.  
Sugpiaq





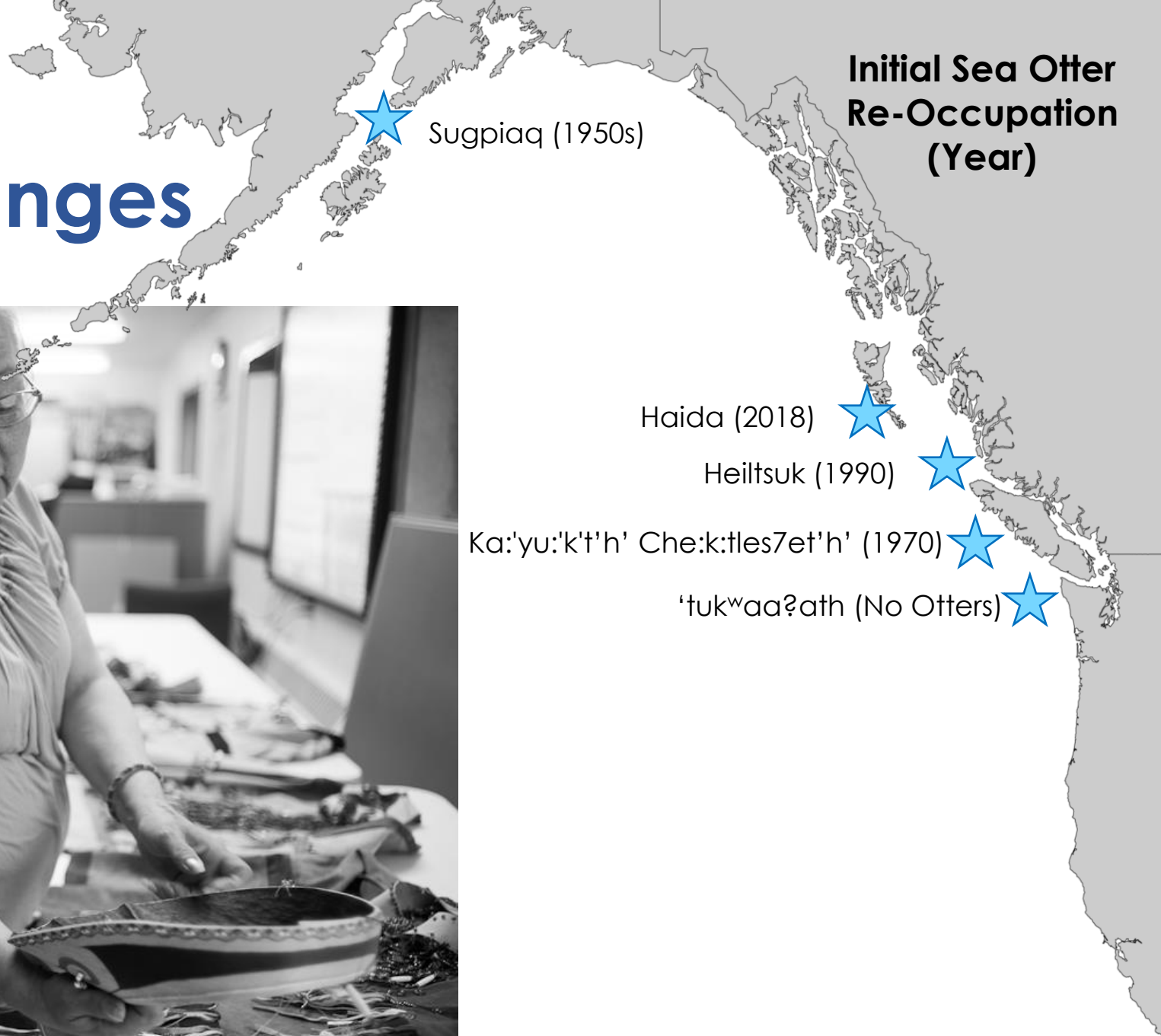
# What Enables Adaptation?



Jenn Burt

1. Strengthen Indigenous Governance Authority
2. Implement Adaptive Co-Management Plans
3. Bridge Indigenous & Western Knowledge
4. Build Learning Platforms

# Community Knowledge Exchanges



# Social-Ecological Model of Management Scenarios



Hannah Kobluk



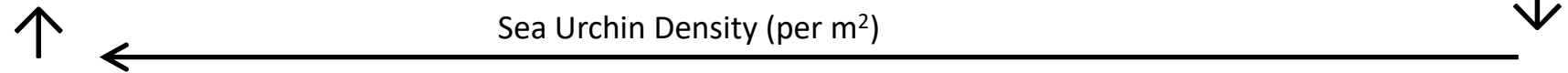
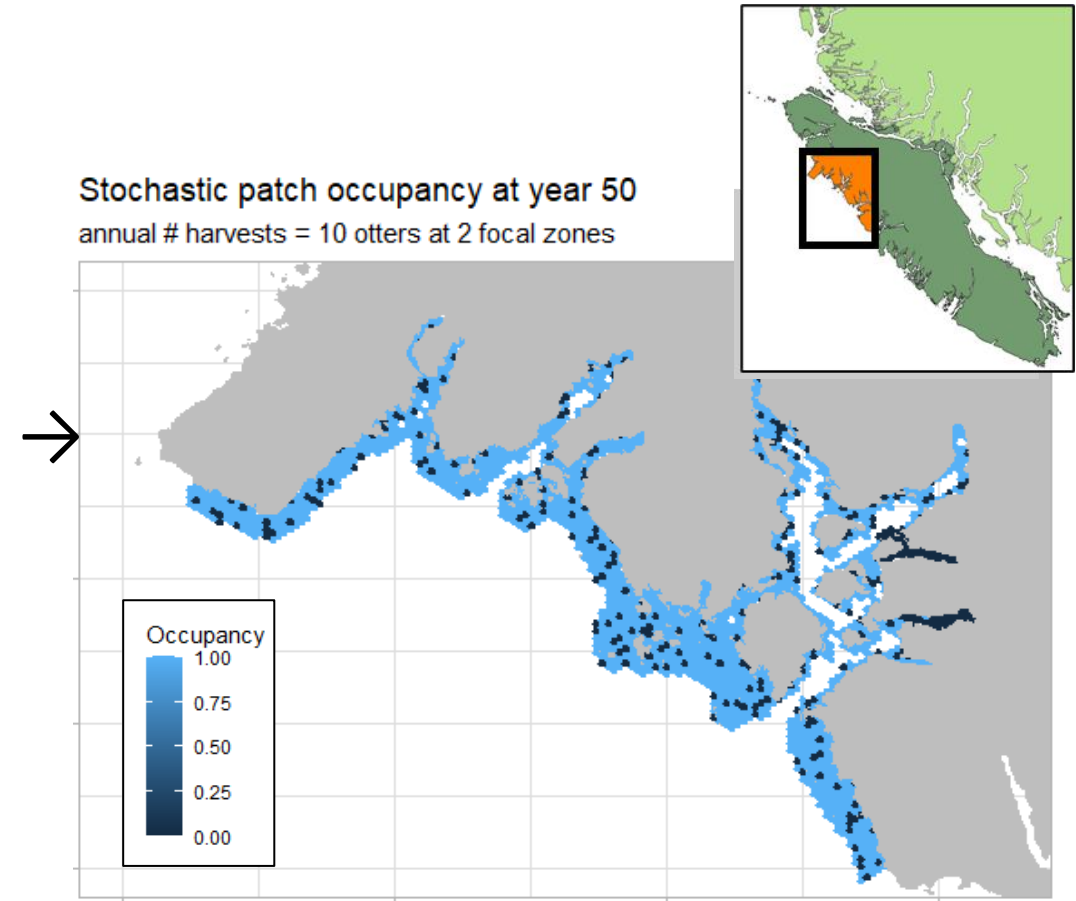
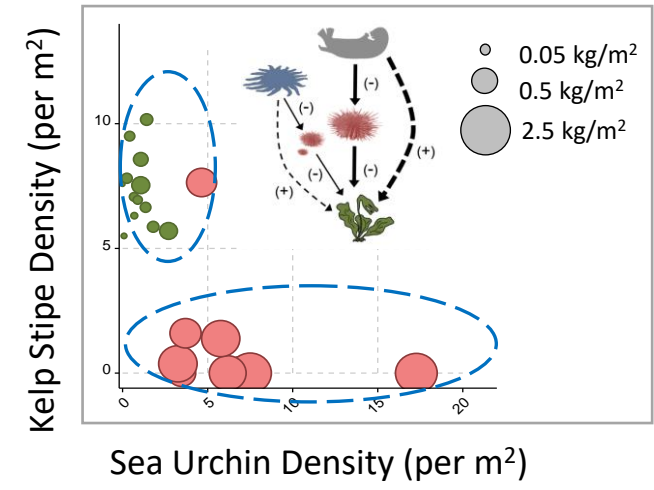
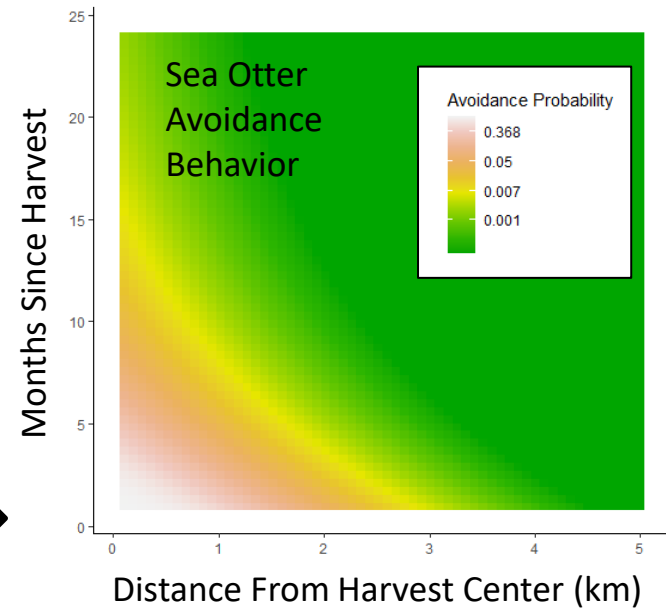
Kii'iljuus Barbara Wilson



Tim Tinker  
Wigvilhba Wakas



Wee-wim-ti-eek, N'yasim



# Social-Ecological Resilience



History & Prehistory of Kelp Forest Regime Shifts



Resilience of Indigenous Intertidal Kelp Harvest





# Resilience of Y'áka Kelp Harvest (*Egregia menziesii*)



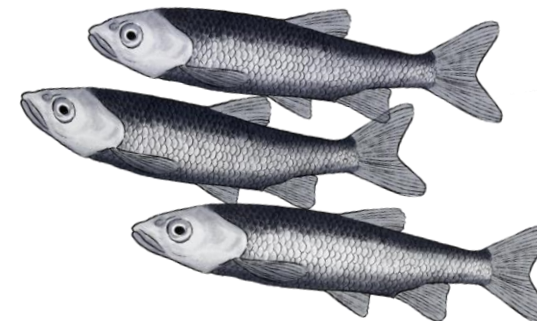
Heiltsuk Nation



Hannah Kobluk

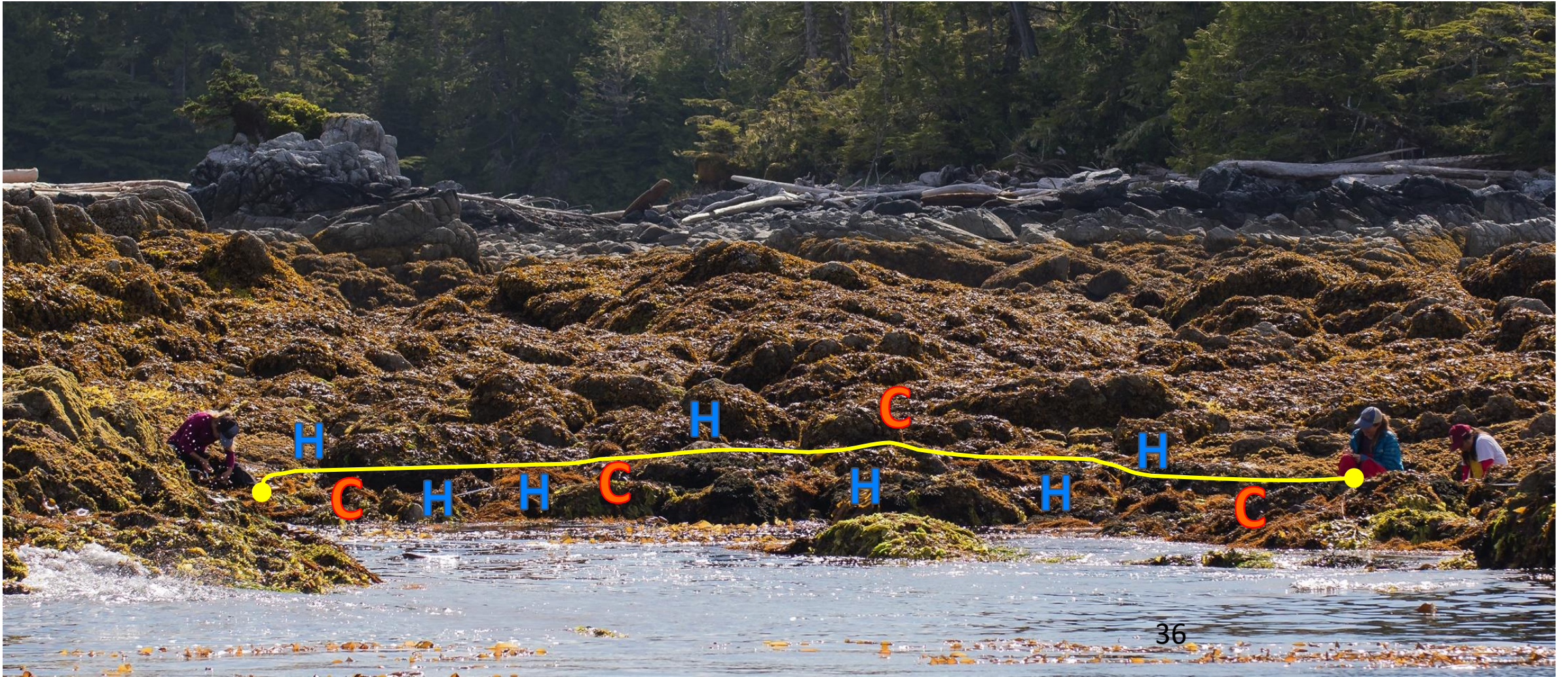


1. How do traditional harvest practices affect recovery?
2. What environmental conditions alter recovery?
3. What ancestral stewardship practices are used today?



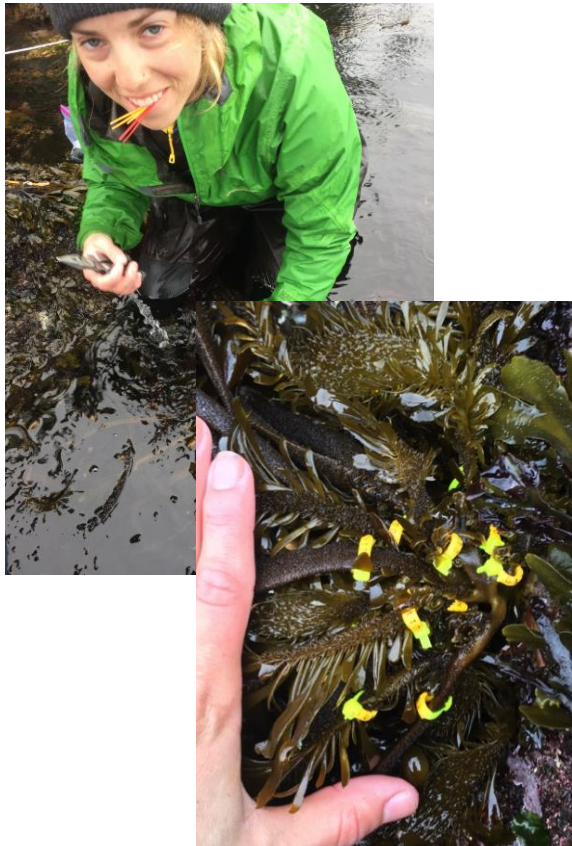
Kobluk et al. 2021 *People & Nature*

# Harvest Experiment



# Harvest Experiment

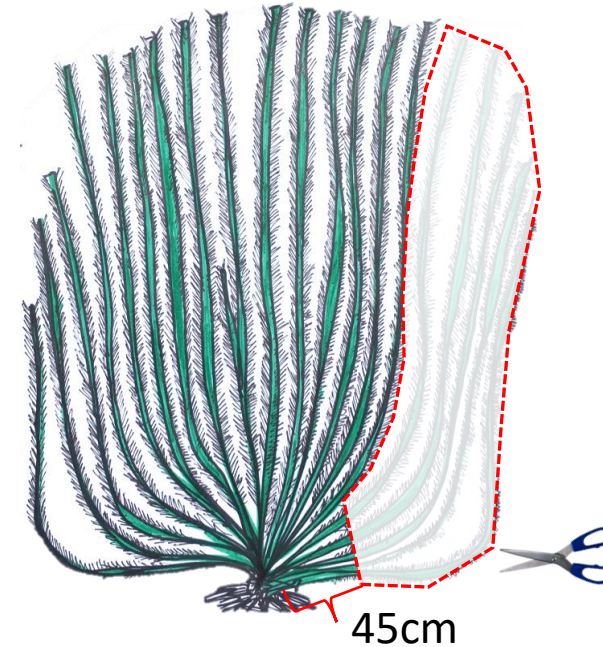
→ Tagged



→ Measured

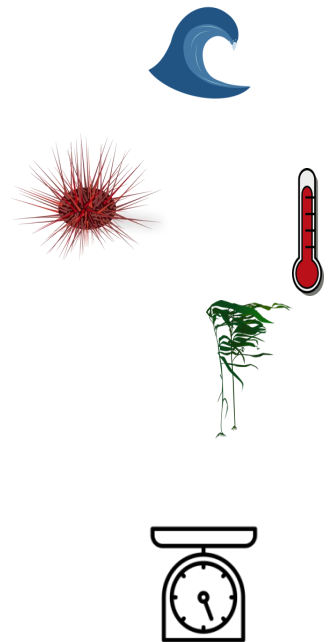


→ Harvested



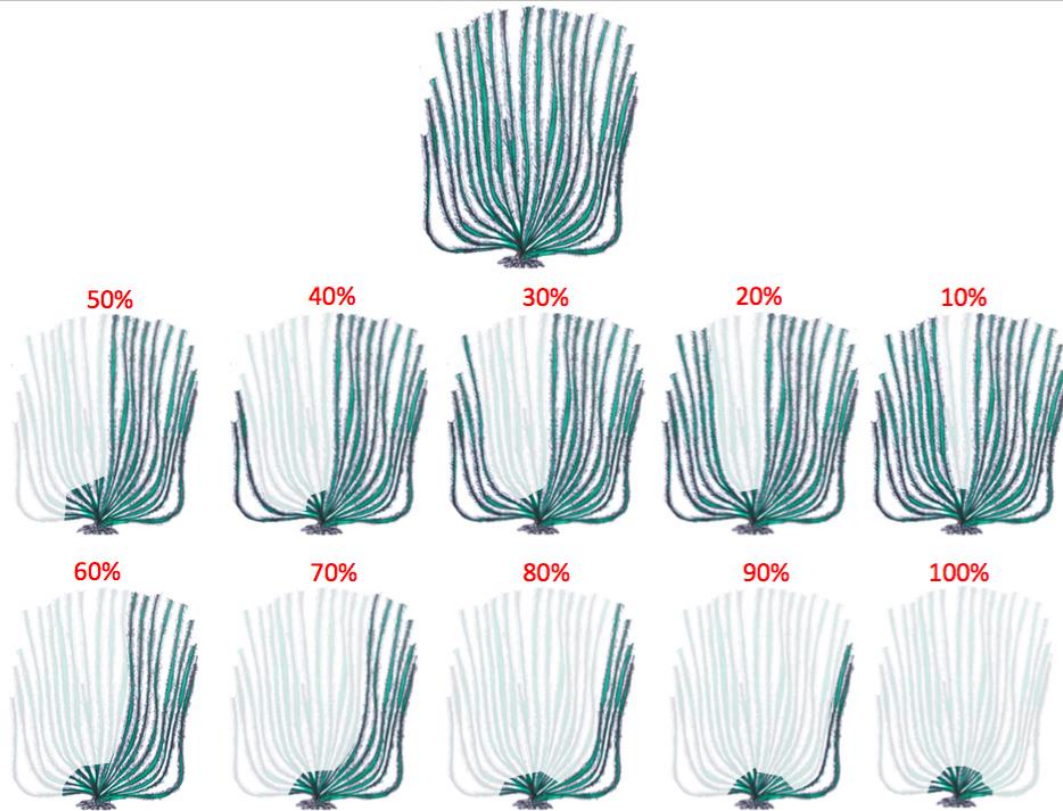
Traditional Practice:  
25% of plant, cut at 45cm,  
In spring

→ Measured

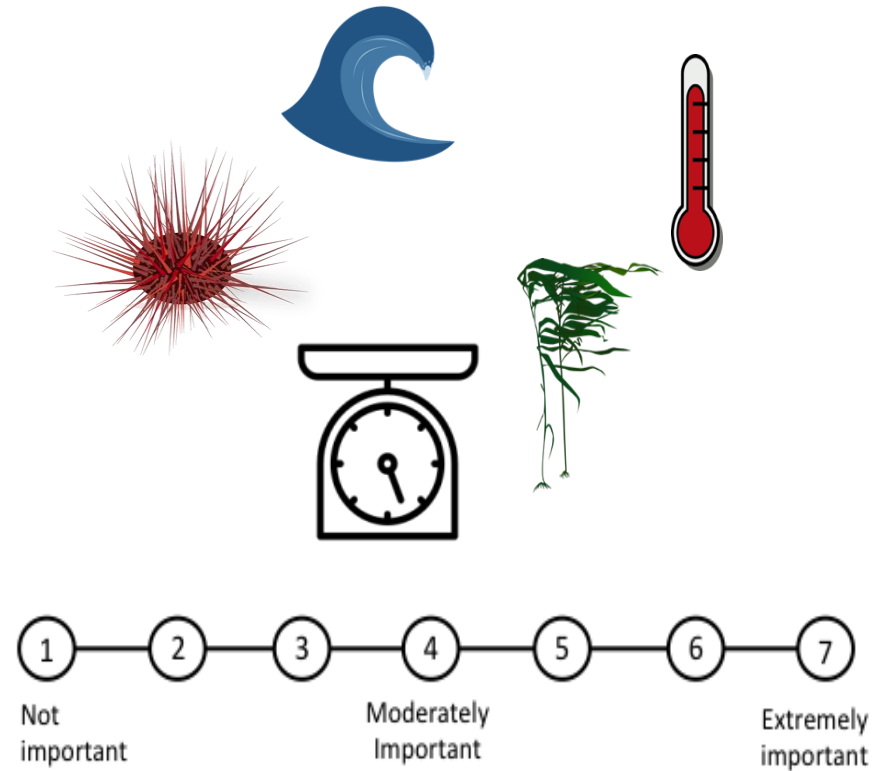


# Indigenous Knowledge Interviews

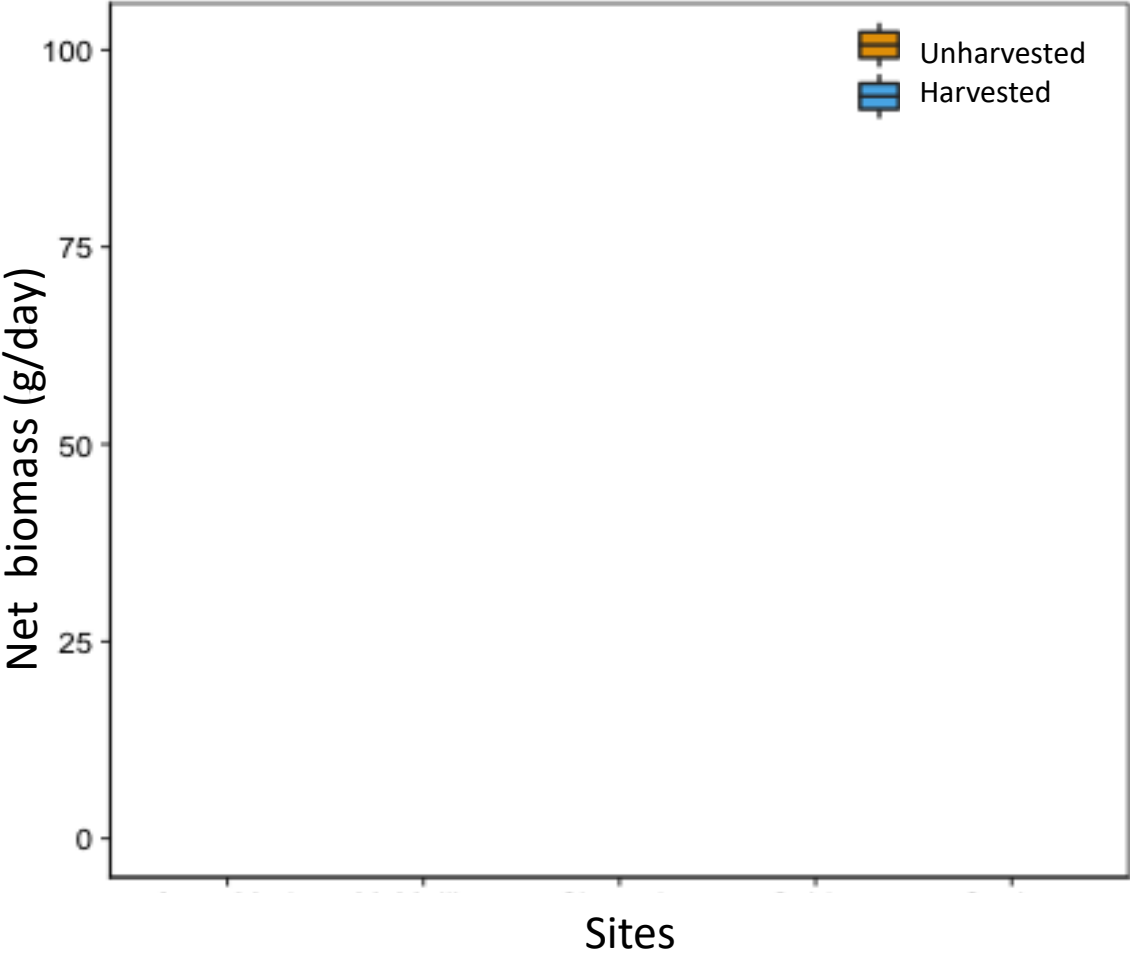
How Much?



How Important?

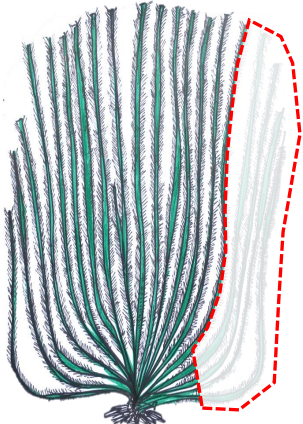
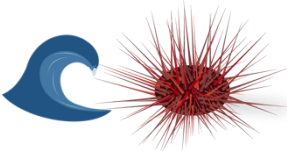
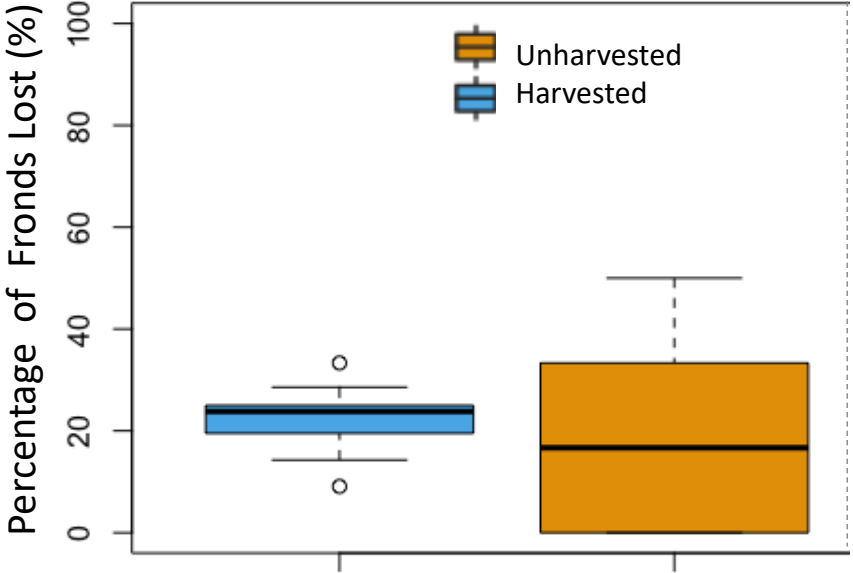


# All Plants Recovered to or Exceeded Their Pre-Harvest Biomass



# Traditional Harvest Rate Mimics Natural Disturbance

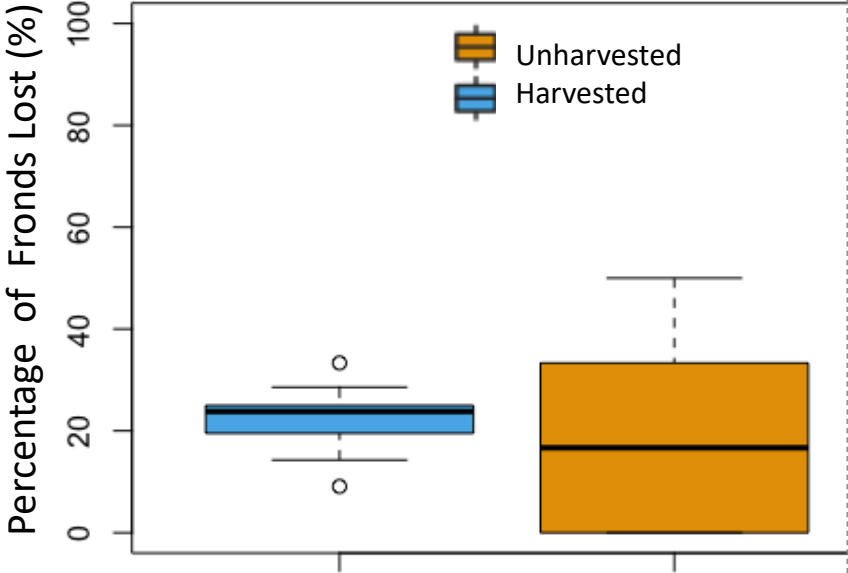
*Experiment*



Conservative level of harvest

# Reported Harvest is Higher

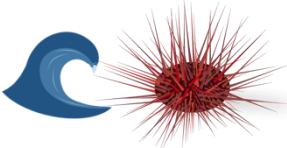
*Experiment*



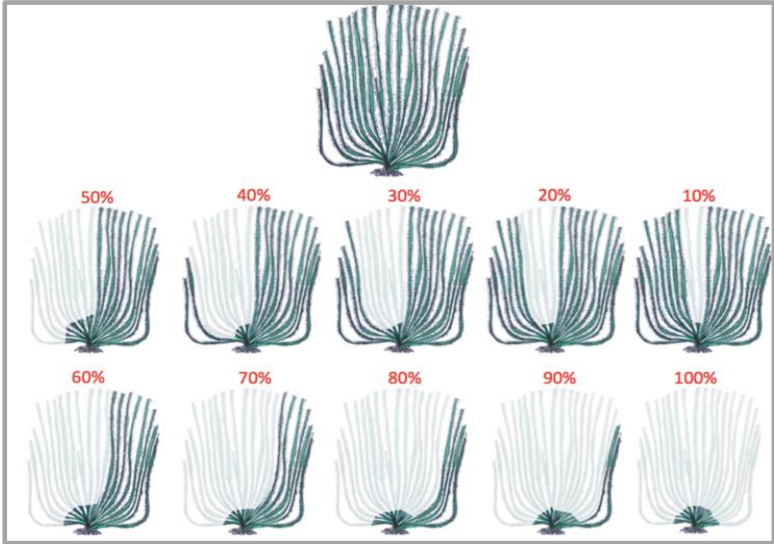
Experimental  
harvest



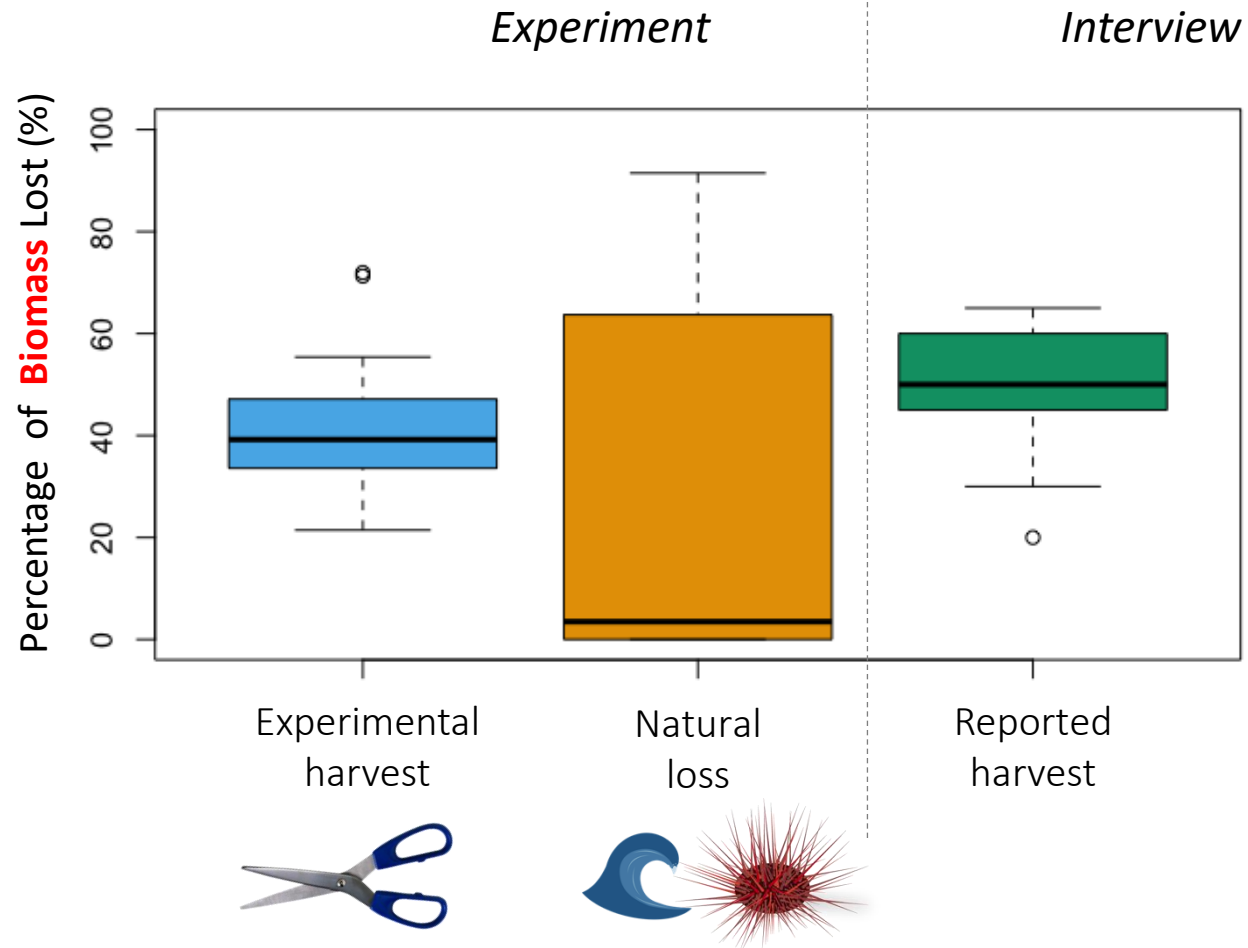
Natural  
loss



*Interview*








# Depends on Measure of Recovery



# What Conditions Alter Recovery?

## Local Expert Knowledge

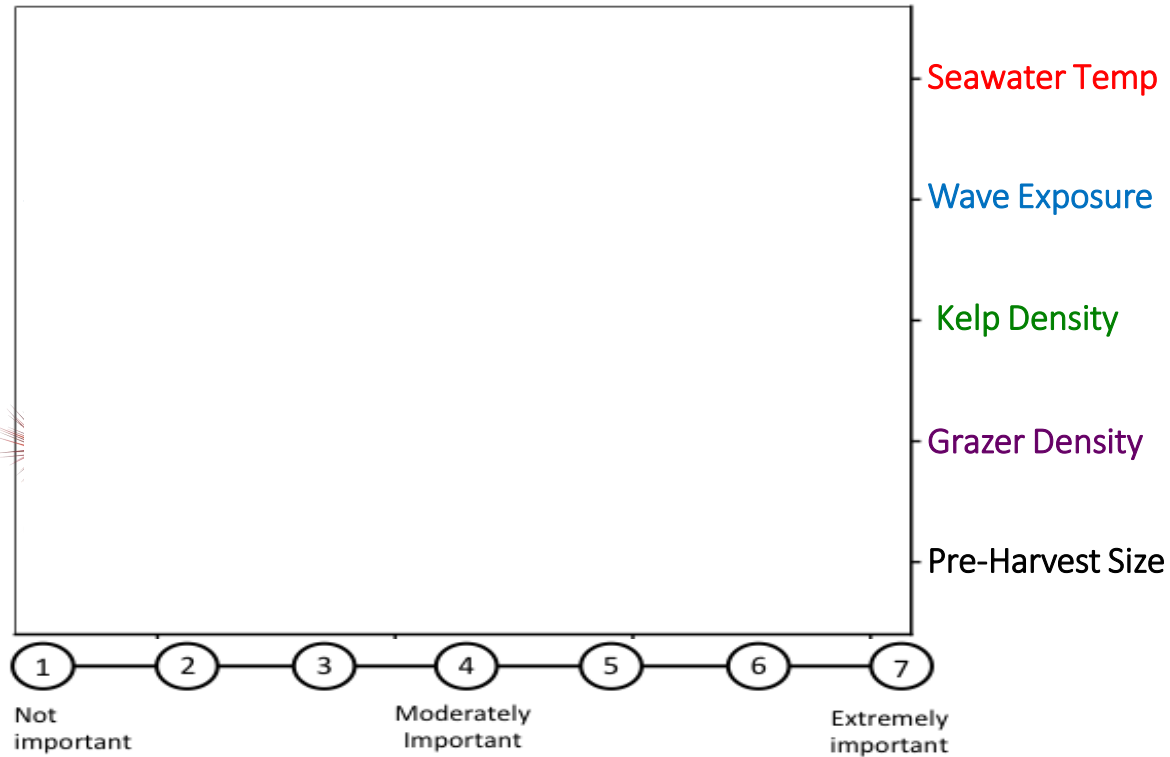
	1	2	3	4	5	6	7	Not important	Moderately Important	Extremely important
	1	2	3	4	5	6	7	Not important	Moderately Important	Extremely important
	1	2	3	4	5	6	7	Not important	Moderately Important	Extremely important
	1	2	3	4	5	6	7	Not important	Moderately Important	Extremely important
	1	2	3	4	5	6	7	Not important	Moderately Important	Extremely important

## Ecological Models

# What Conditions Alter Recovery?

Local Expert Knowledge

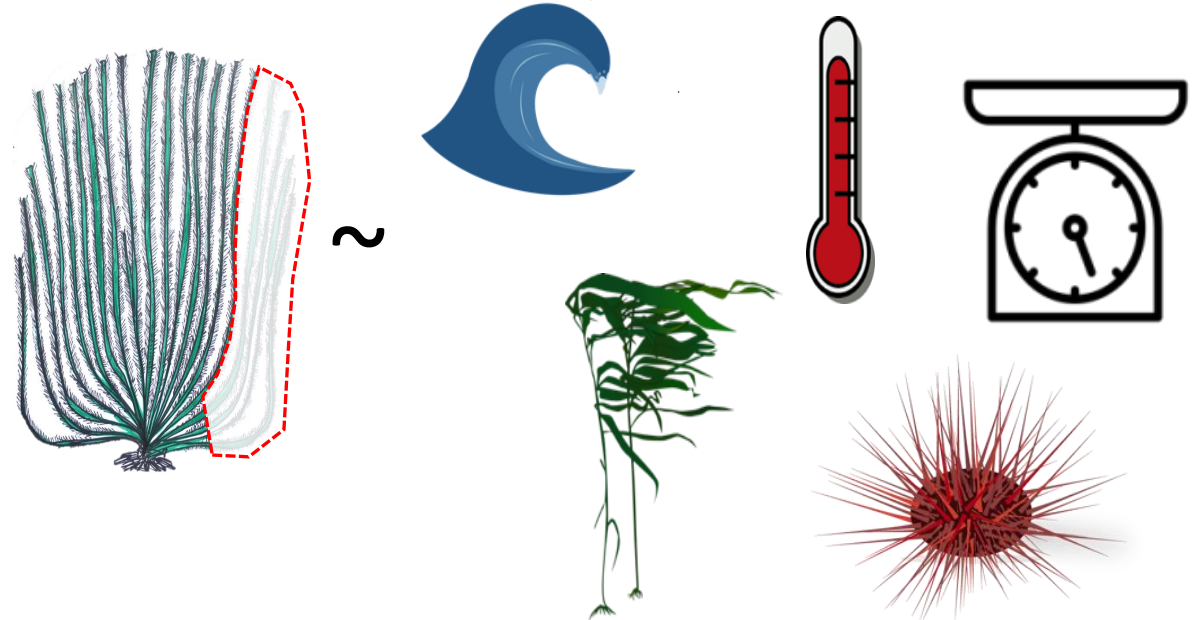
Ecological Models



# What Conditions Alter Recovery?

Local Expert Knowledge

Ecological Models

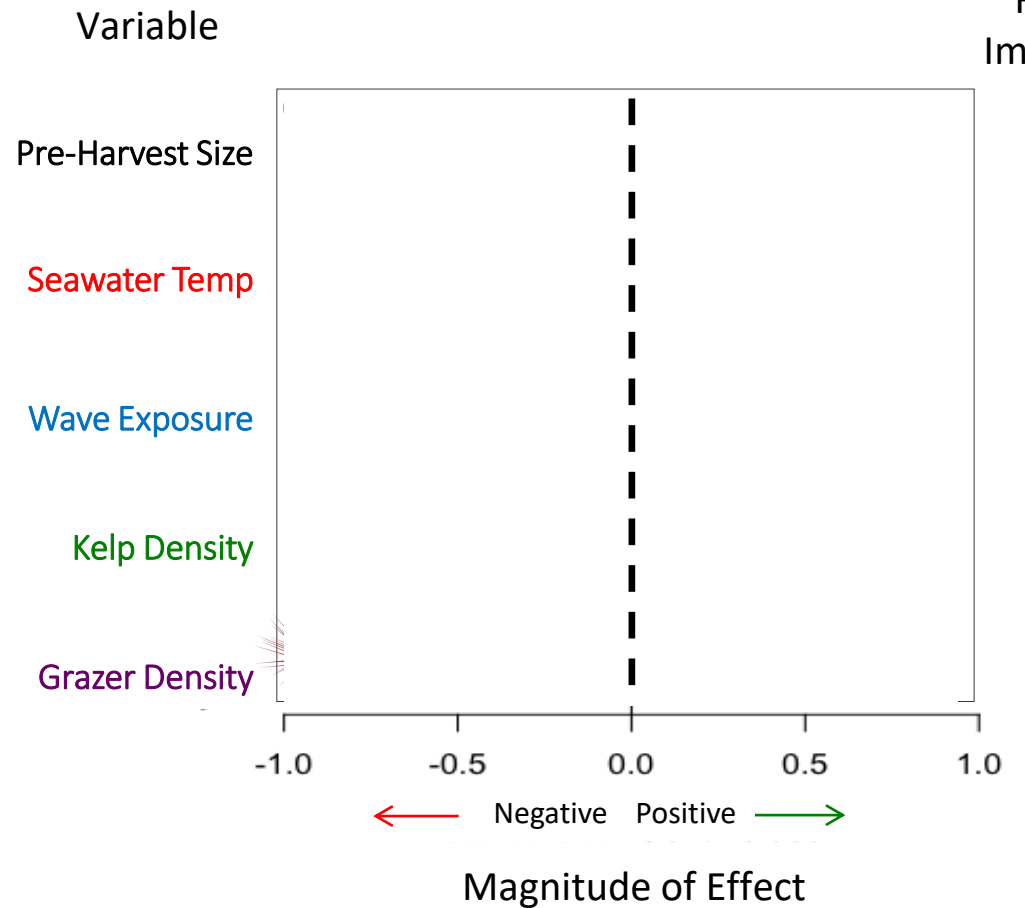


# What Conditions Alter Recovery?

Local Expert Knowledge

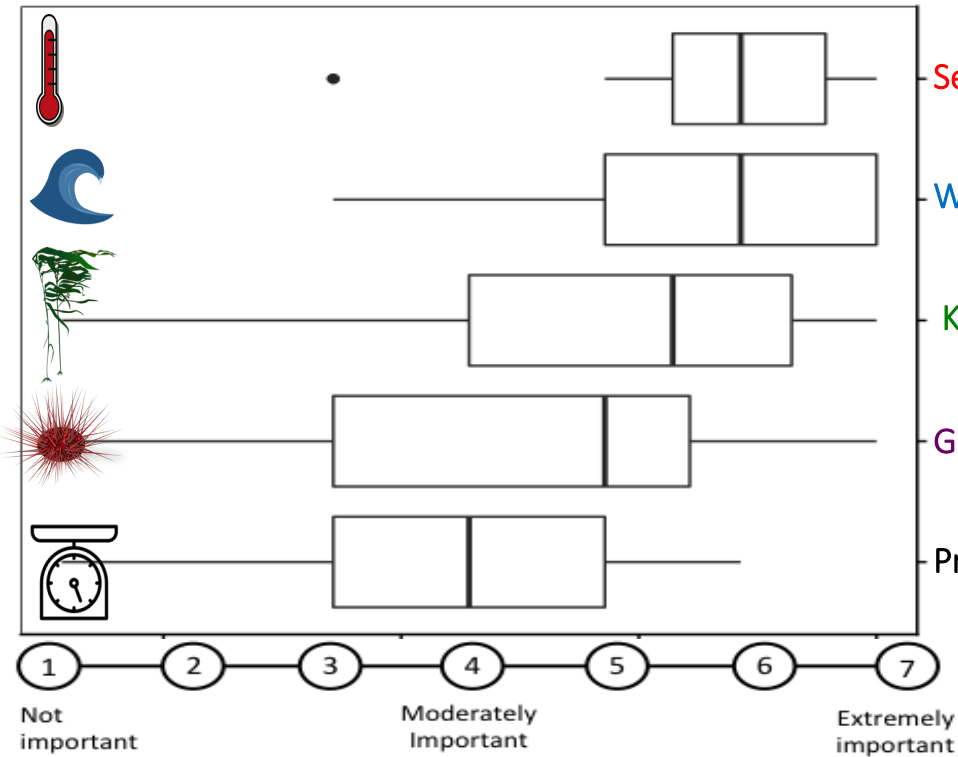
Ecological Models

Relative Importance



# What Conditions Alter Recovery?

## Local Expert Knowledge



## Ecological Models

Variable

Relative Importance

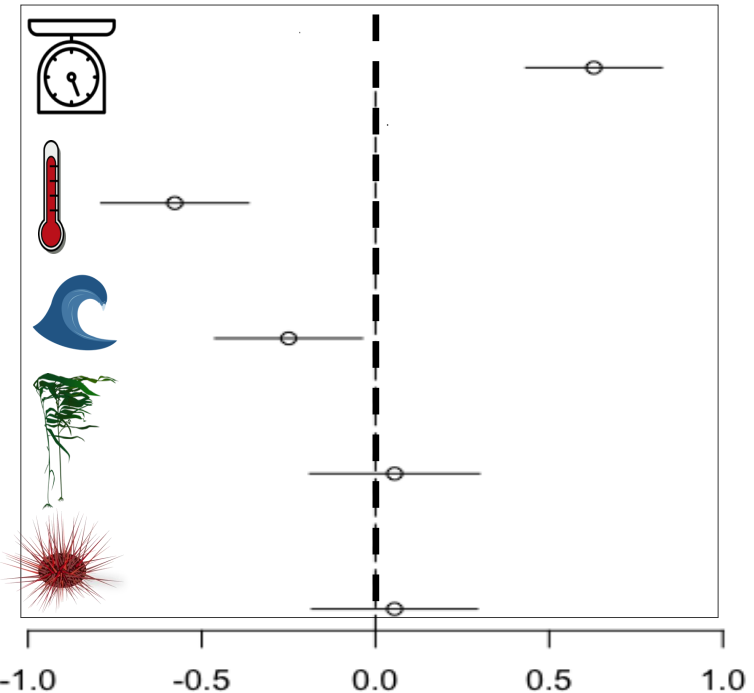
Pre-Harvest Size

Seawater Temp

Wave Exposure

Kelp Density

Grazer Density



← Negative Positive →

Magnitude of Effect

Parallel Understanding of Environmental Conditions Effecting Recovery

# Kelp Gardens



1. Kelp Recovered Faster & Greater Than Expected
2. Traditional Harvest Mimicked Natural Loss
3. Plant Size & SST Effected Recovery
4. Indigenous Stewardship Practices Promoted Recovery & Growth
5. Vulnerable to Warming SST (0.7°C) & Erosion of Traditional Practices

# Ancestral Sea Gardens Exist Across the Pacific

---



# Navigating Towards Ecologically Safe & Socially Just Operating Space

1. Link Ecosystems and People
2. Consider Reciprocal Interactions
3. Democratize Ocean Science - Include Multiple Knowledge Systems & Values
4. Look Back in Time to Sharpen Our Understanding of the Present & View of the Future

Haawa Ĝiáxsixa Kleko Qyuanna Thank you



Council of the  
Haida Nation



Heiltsuk Integrated Resource  
Management Department



Uu-a-thluk  
Nuu-chah-nulth



Central Coast Indigenous  
Resource Alliance



Chugachmiut  
Sugpiaq/Alutiiq

