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Kelp forest dynamics: links to climate and long term trends

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Kelp Forest Dynamics: links to climate and long term trends

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Photo credit: Tom Mumford

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Kelp Forest Dynamics

- Links to climate?
- Trends over the last century?
  - Strait of Juan de Fuca
  - South Puget Sound

Photo credit: Tom Mumford

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RESEARCH ARTICLE

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The dynamics of Kelp Forests in the Northeast Pacific Ocean and the relationship with environmental drivers

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Abstract

1. The dynamics of foundation species in ecosystems are key to the fate of many species. Kelp forests are foundation species in temperate ocean ecosystems and contribute to carbon storage, macronutrient dynamics, primary production and biodiversity of a myriad of associated species. Downward trends in their abundance globally have been of concern.
2. We analysed 26 years of aerial censuses (1989–2015) of two canopy kelp species in Washington State (USA) waters. We compared these modern censuses with censuses in 1911 and 1912 to determine the persistence of kelp cover over the past century. Using Autoregressive Integrated Moving Average (ARIMA) models, we compared kelp dynamics with likely environmental drivers, including local environmental variables and ocean indices for this region.
3. Kelp remains at historic levels in many areas, although some eastern populations in proximity to greater human populations are the exception to this pattern. Over the last 26 years, kelp abundance showed high spatial autocorrelation in western areas of Straits of Juan de Fuca, with more variable populations in the annual species and eastward towards Puget Sound. Both spe[illegible] covaried positively in their abun-

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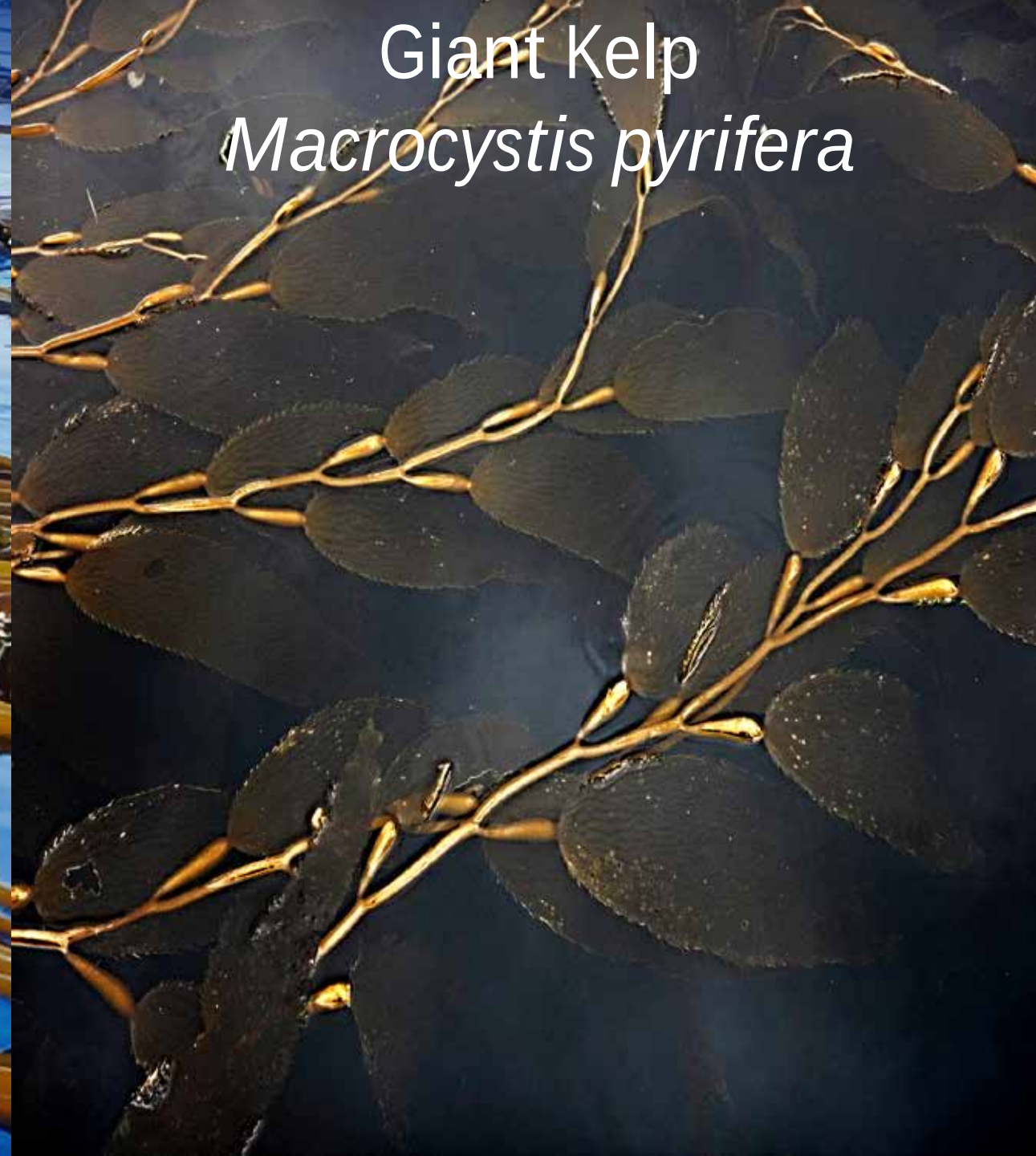
Bull kelp

Nereocystis luetkeana

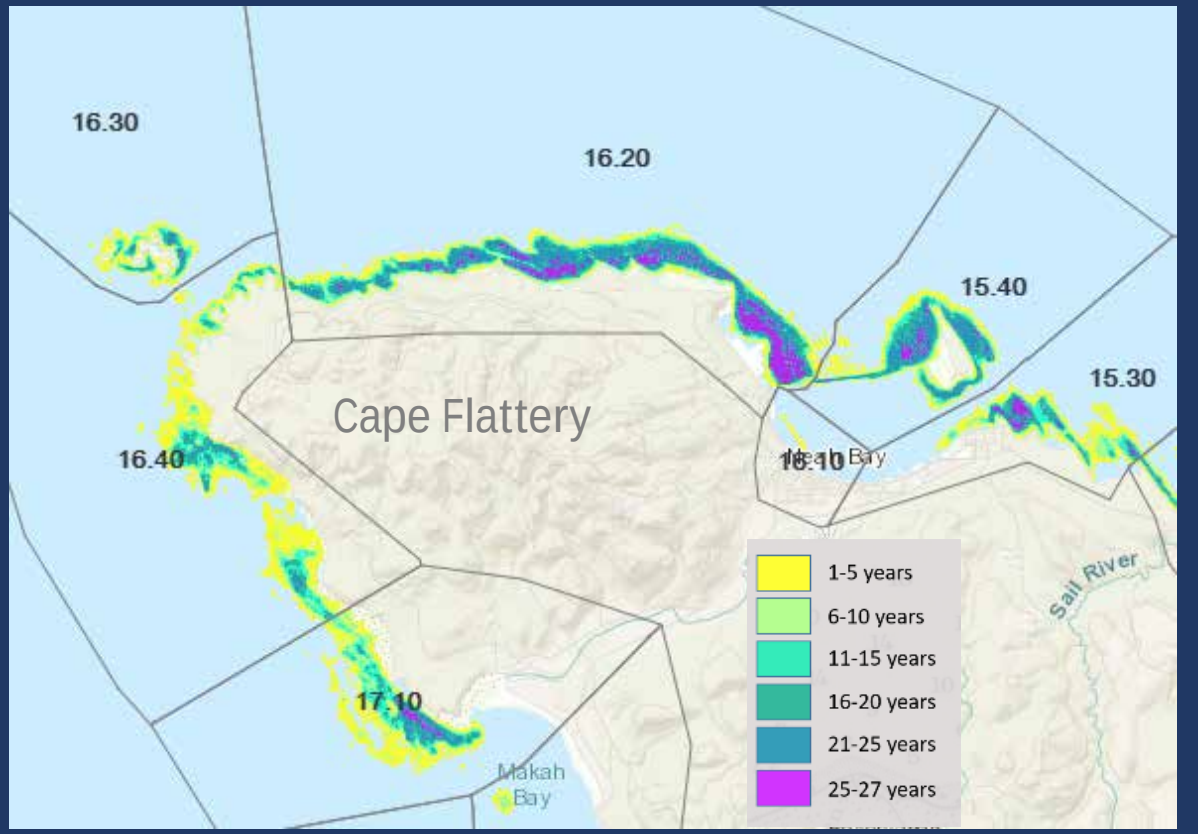
Photo credit: Tom Mumford

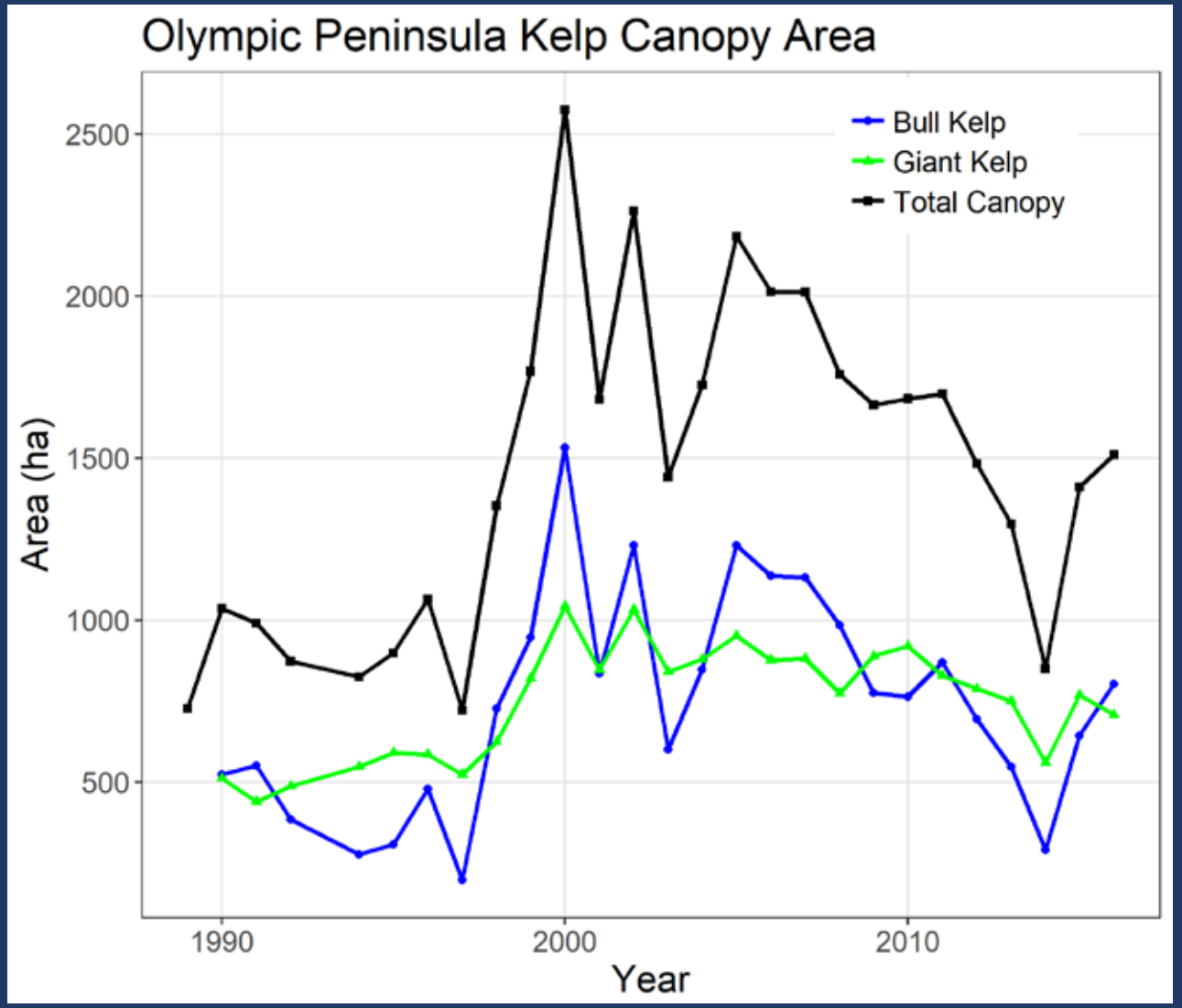


Giant Kelp

Macrocystis pyrifera

Annual monitoring of floating kelp canopy area along strait and outer coast (1989-present)

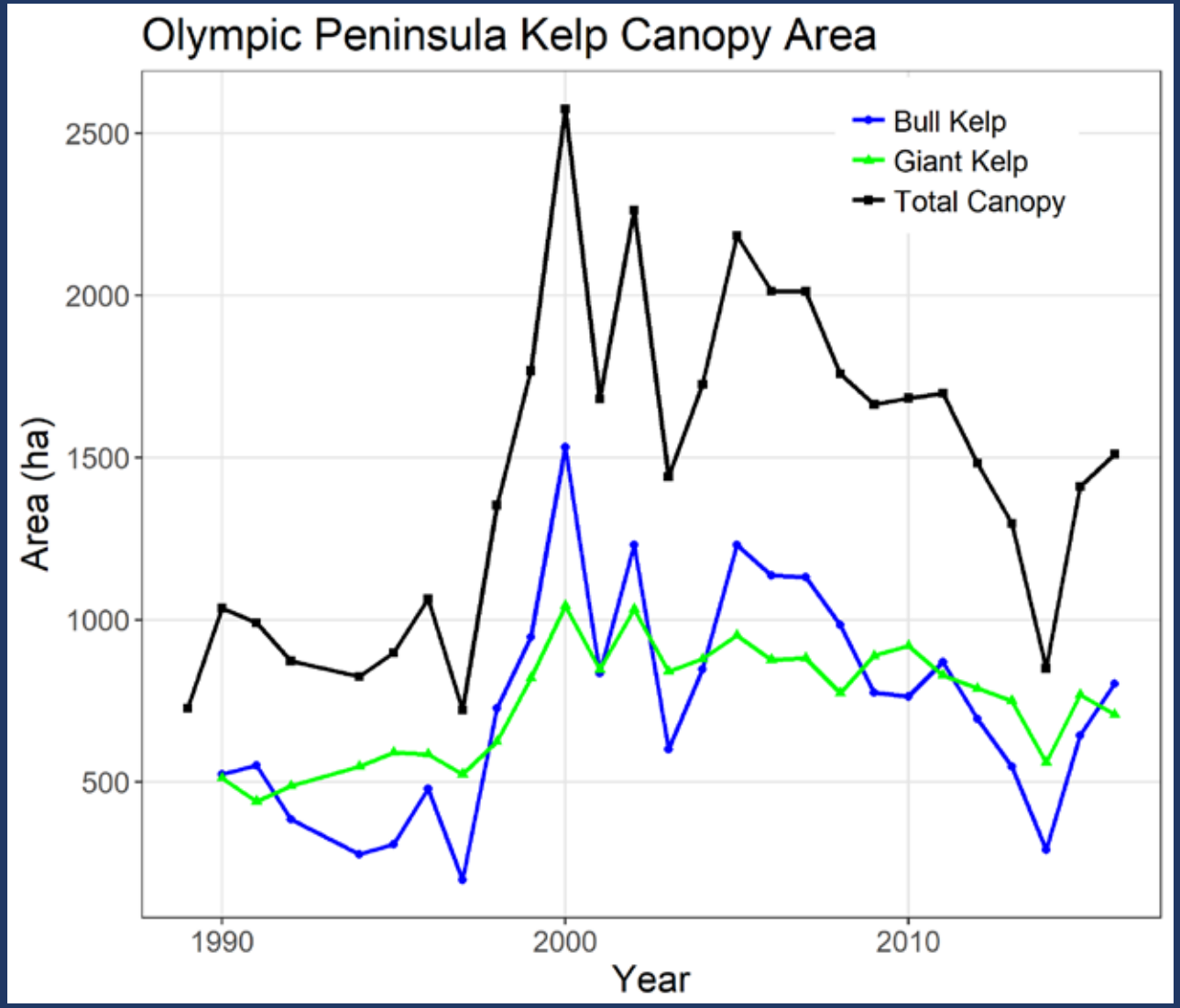




Pfister, Berry and Mumford, 2017. Journal of Ecology.

Dynamics in kelp canopy area along strait and outer coast (1989-present)

- Stable, yet high variability
- Abundance of two species positively correlated ($p < 0.001$)
- Best predictor of abundance was previous year's abundance
- Extreme lows in kelp abundance during extreme high temperatures (1997 and 2014)



Pfister, Berry and Mumford, 2017. Journal of Ecology.

Cross-correlation from ARIMA models - kelp canopy area and environmental variables

	Same year	1 year previous	2 years previous	3 years previous
North Pacific Gyre Oscillation (NPGO)	**.651**	**.760**	**.624**	**.371**
Oceanic Nino Index (ONI)	**-.305**	**-.329**	**-.062**	-.058
Pacific Decadal Oscillation (PDO)	**-.376**	**-.467**	-.263	-.209
Sea surface temp at Race Rocks	-.014	-.205	-.079	-.124
Upwelling Index	-.008	-.009	.162	.251

Bold values are significant at $p < .05$

Pfister, Berry and Mumford, 2017. Journal of Ecology.

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* SST increased by 0.72ºC during 1921-2015 ($p < .001$)

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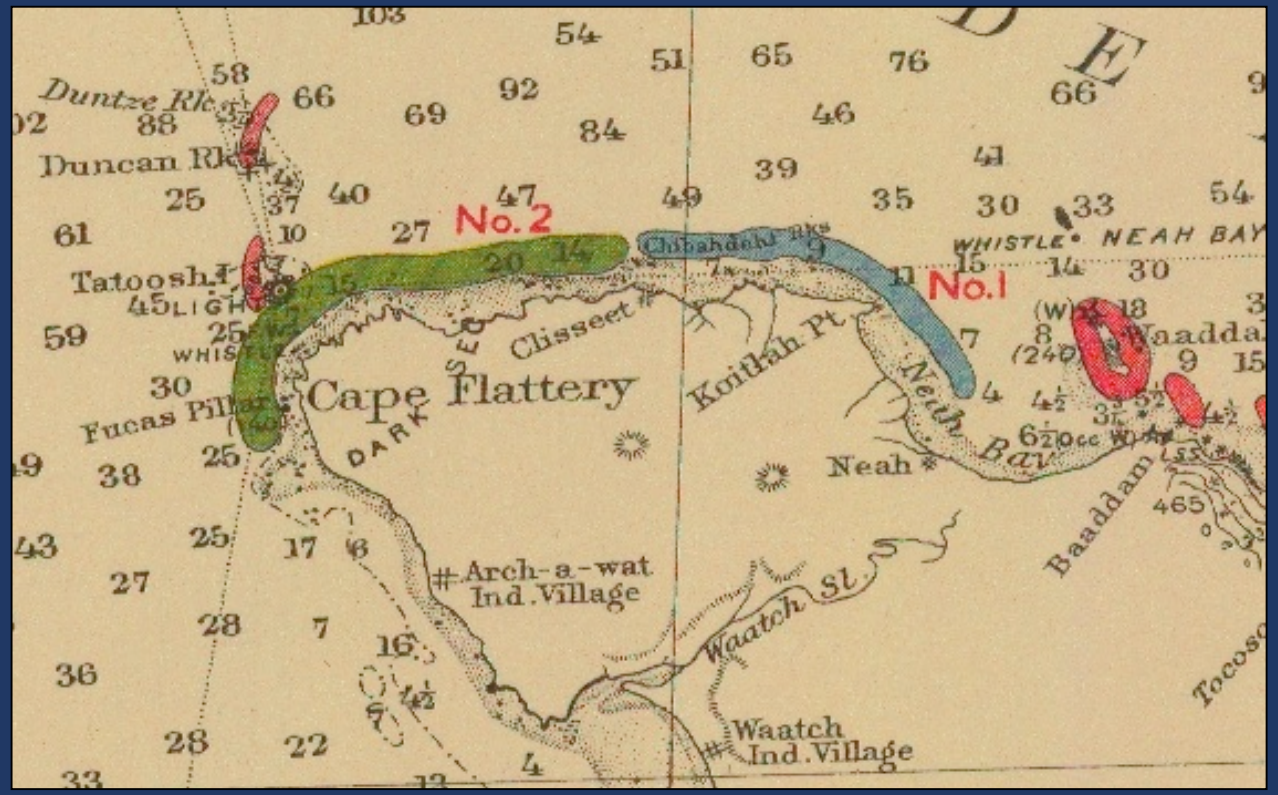
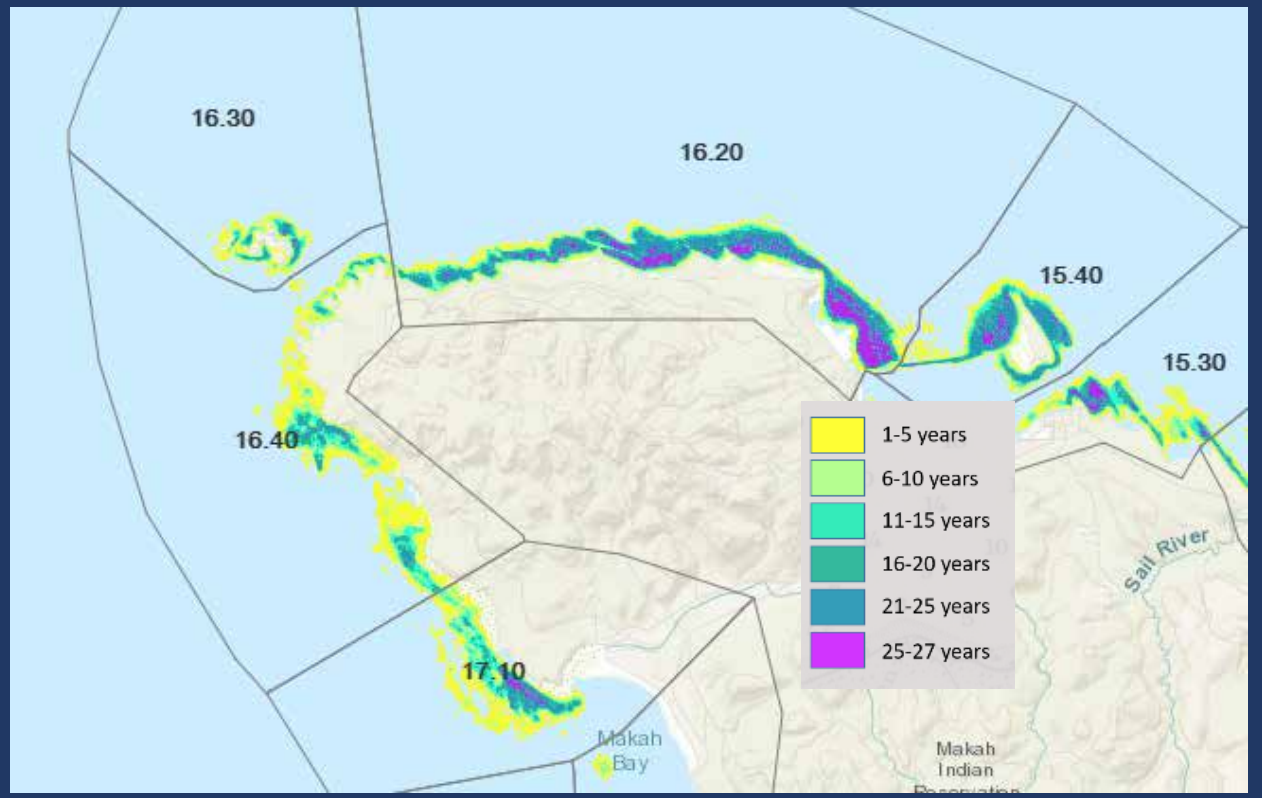
Floating kelp area along the strait over a century



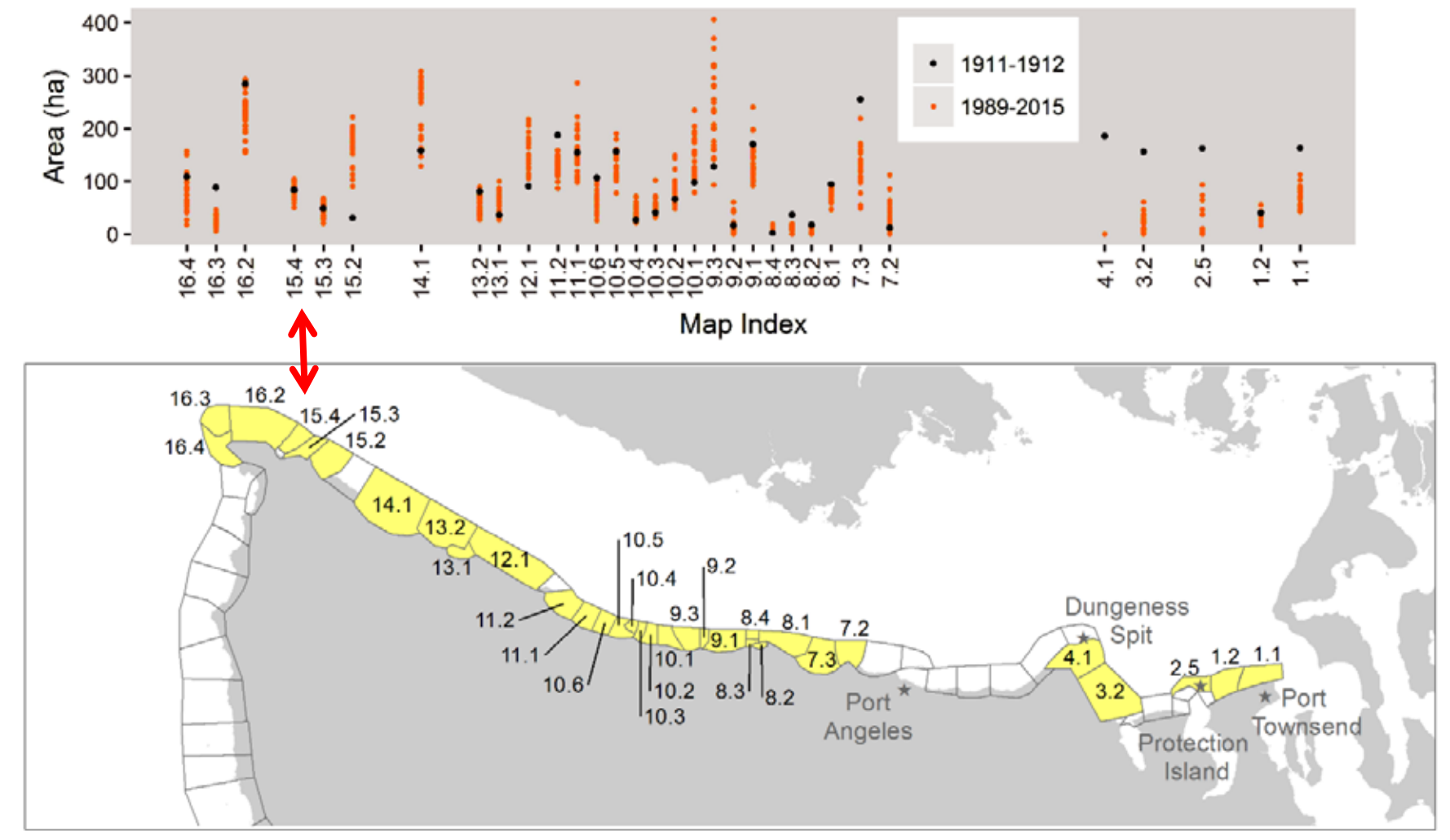
Rigg 1911-12
Fertilizer Resources



DNR 1989-2015
Annual Aerial Kelp Canopy Surveys

Explore the maps at geo.wa.gov - search for “kelp forests”

Kelp canopy generally stable in strait
- except perhaps at eastern boundary (ca. 1911 – present)



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Kelp Forest Dynamics

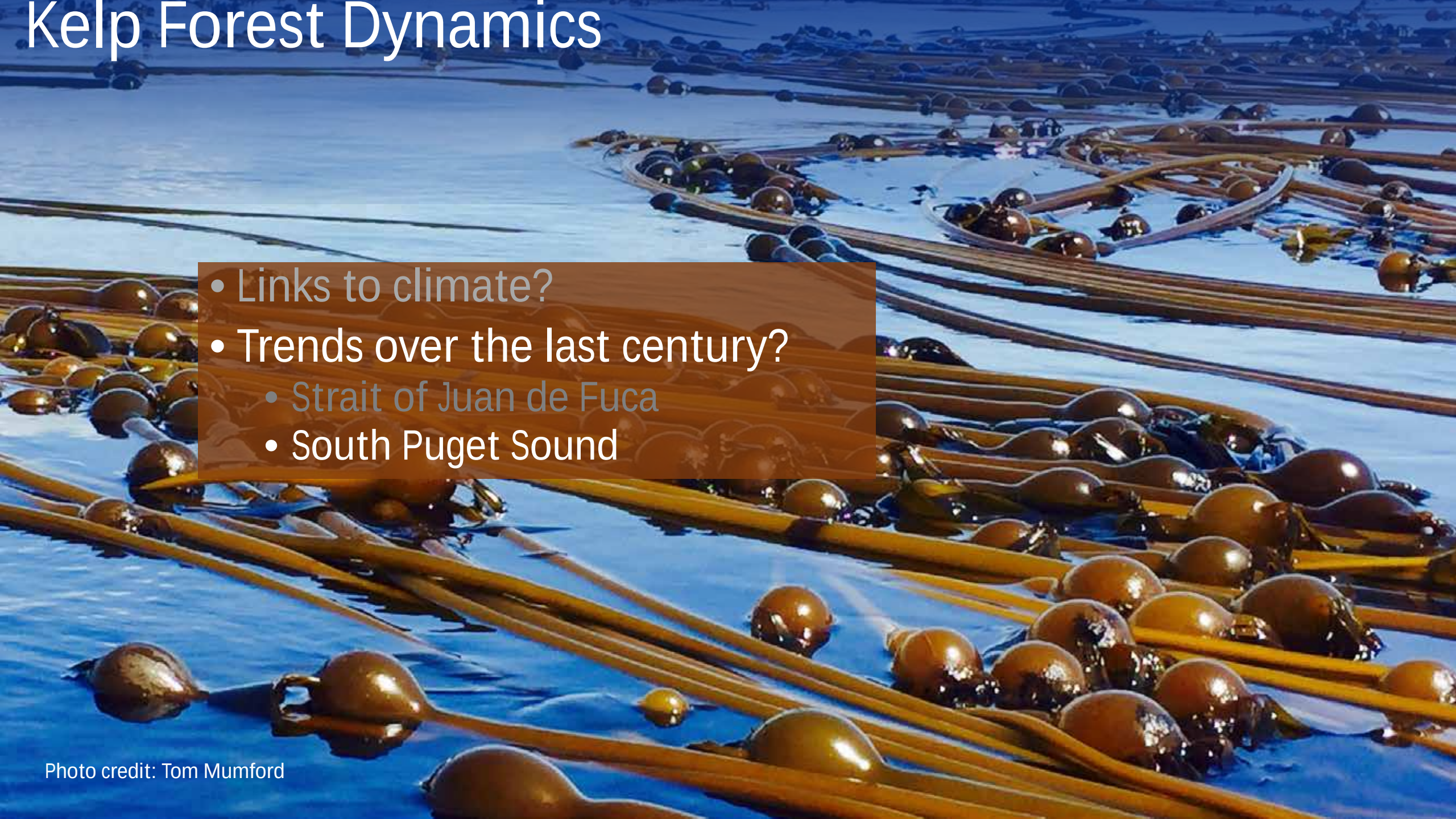

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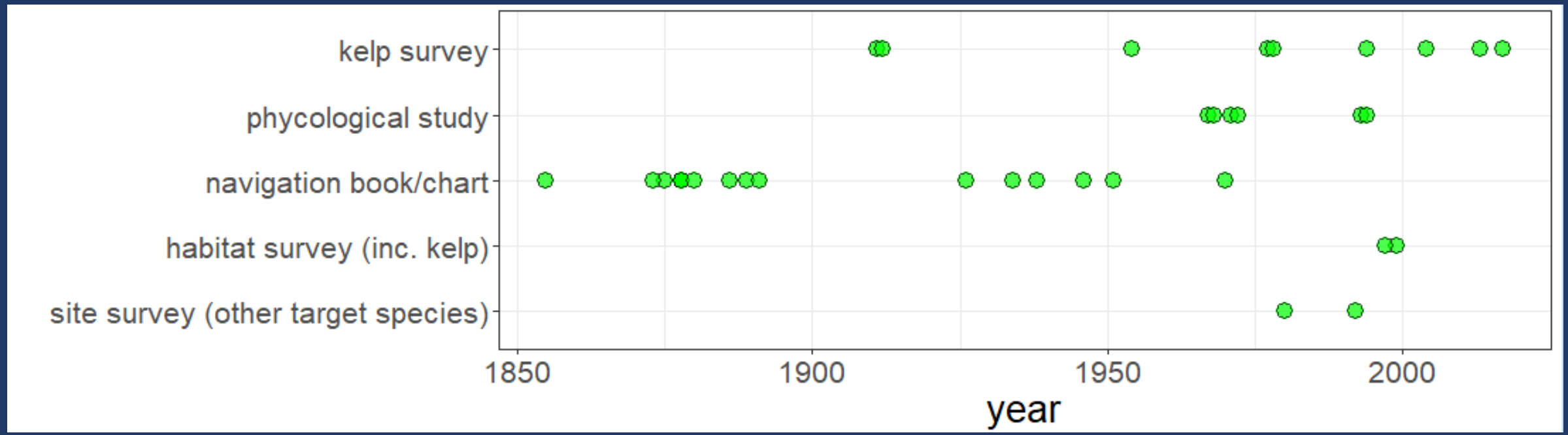
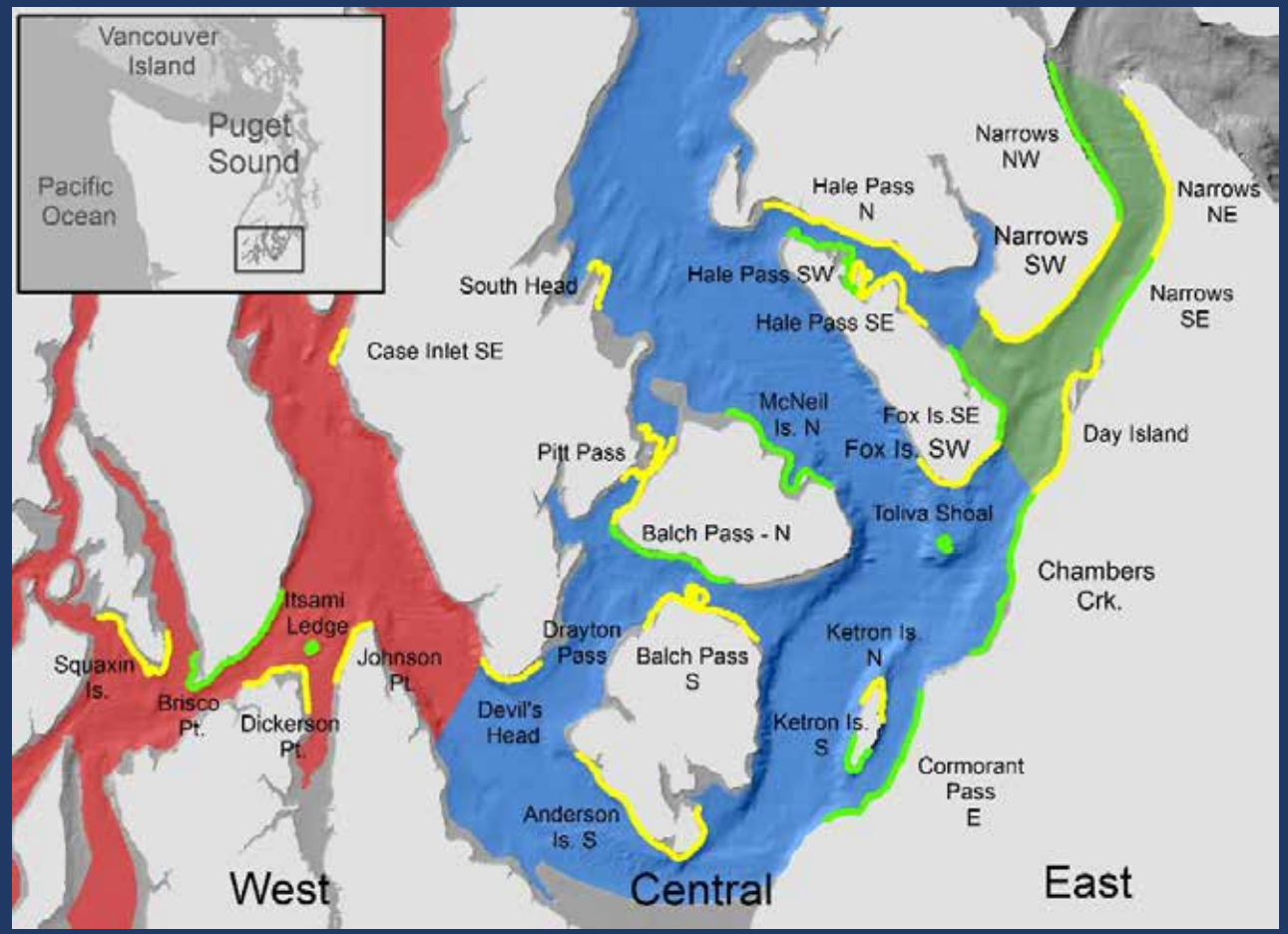
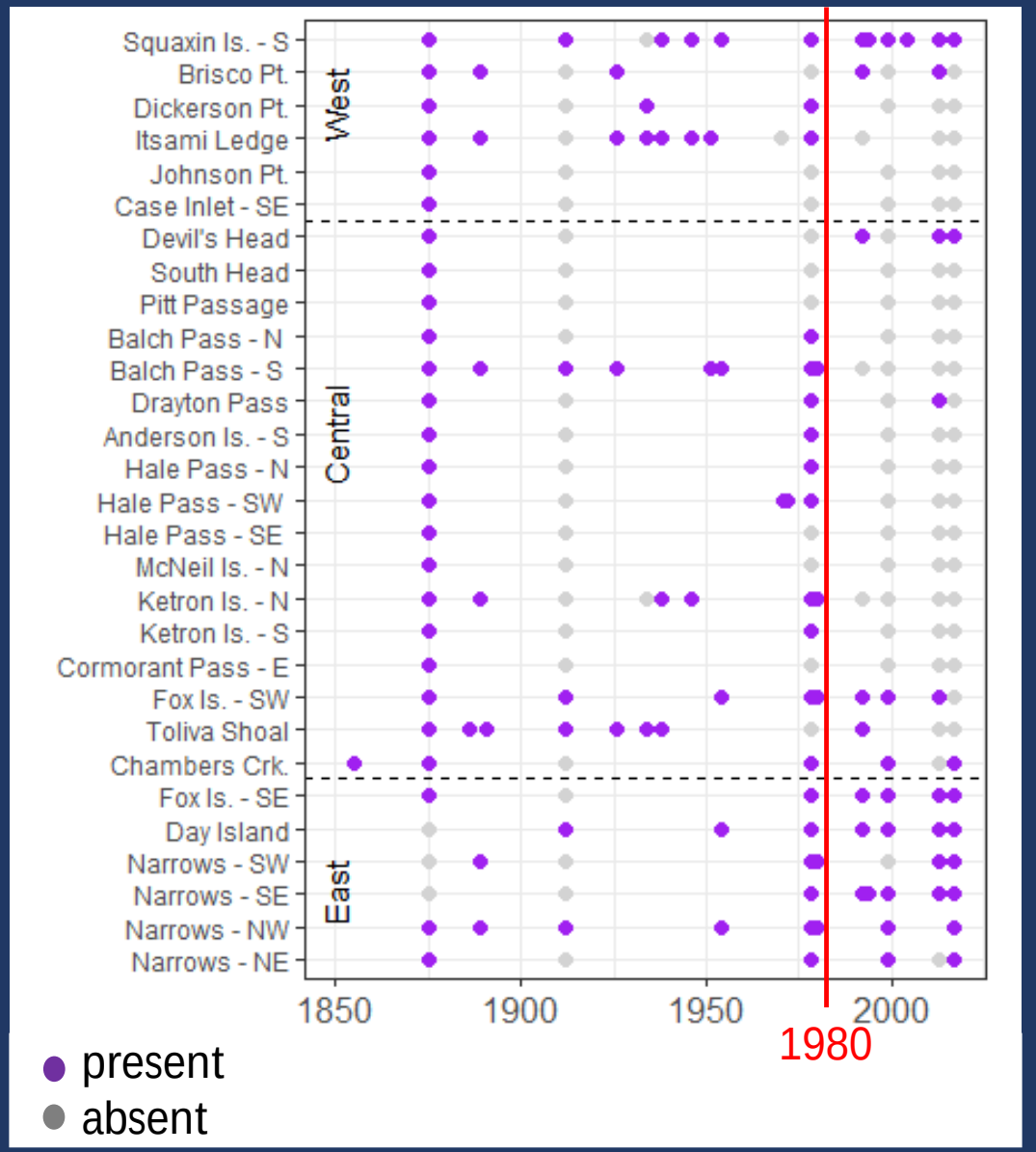
Photo credit: Tom Mumford

Changes in bull kelp distribution in South Sound? 1855-2017

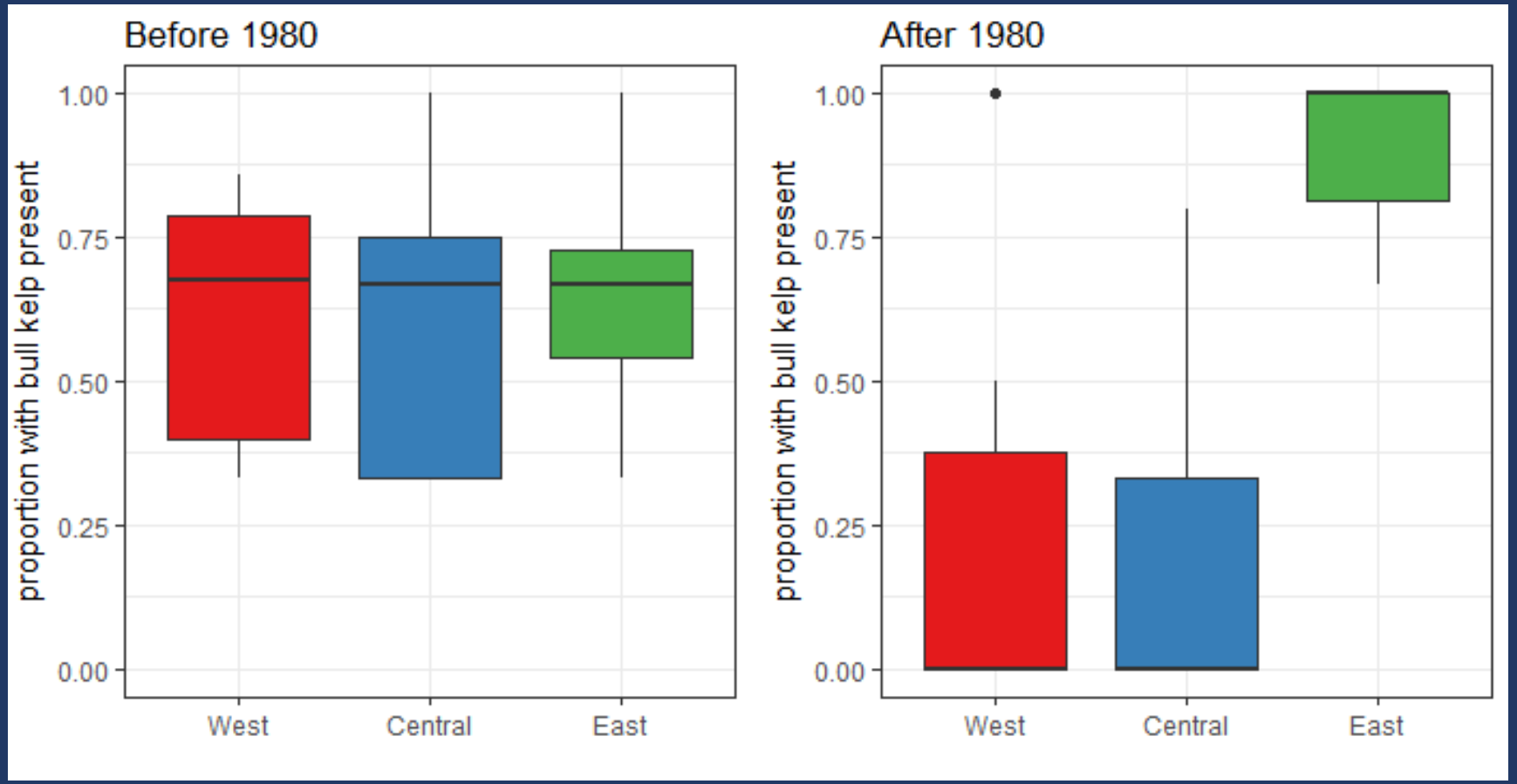


Most sites absent recently in West and Central

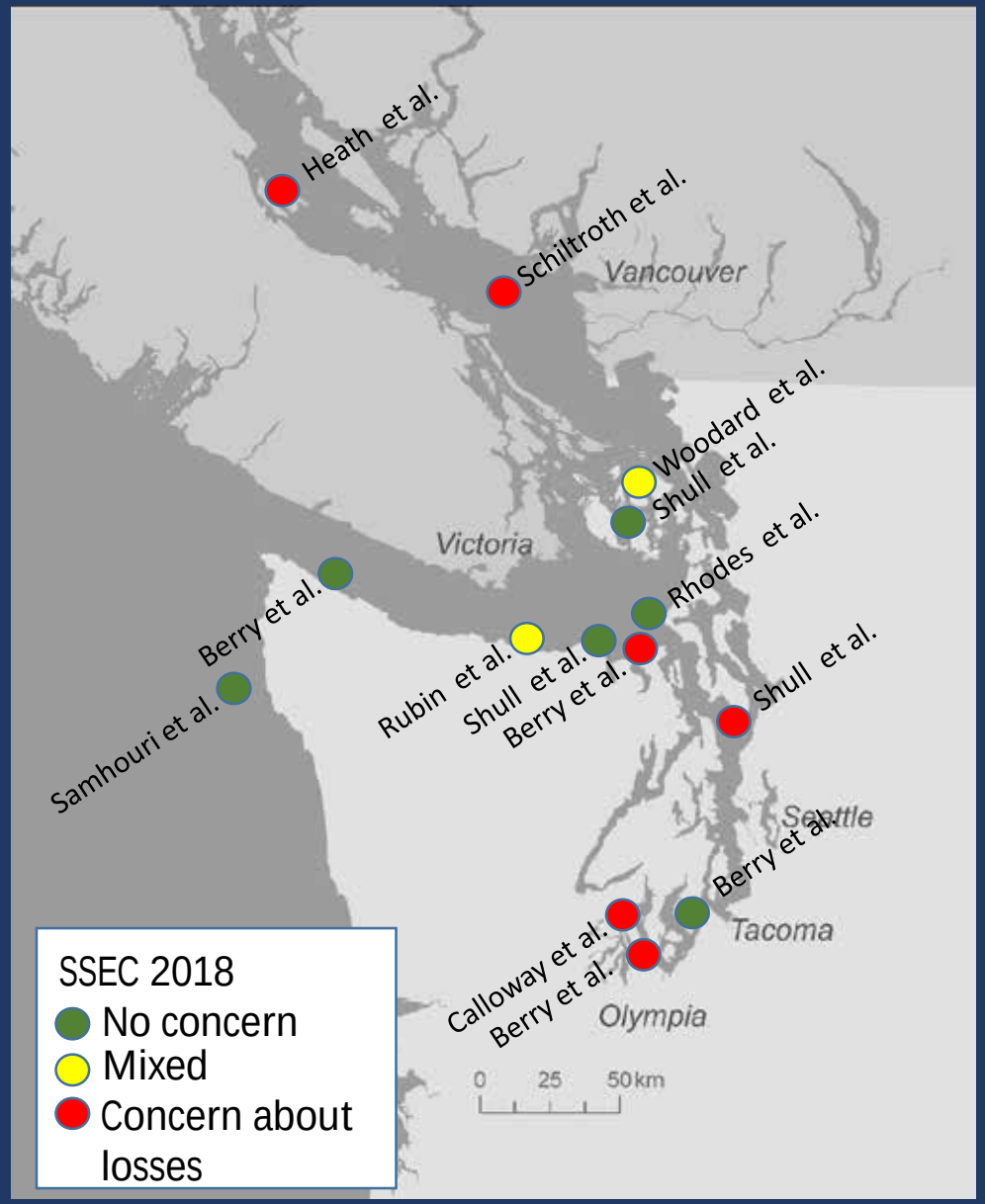




After 1980, proportion of observations with bull kelp lower in West and Central



Concern over losses in inner reaches of Salish Sea



Candidate stressors:

Elevated temperatures
Urbanization
Anthropogenic nutrients
Sedimentation
Over-fishing
Community shifts

Kelp Forest Dynamics

- Climate drives kelp abundance
  - NPGO leading indicator along outer coast and strait
- Trends over last century are spatially distinct
  - Concerns about losses in the inner reaches

Photo credit: Tom Mumford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