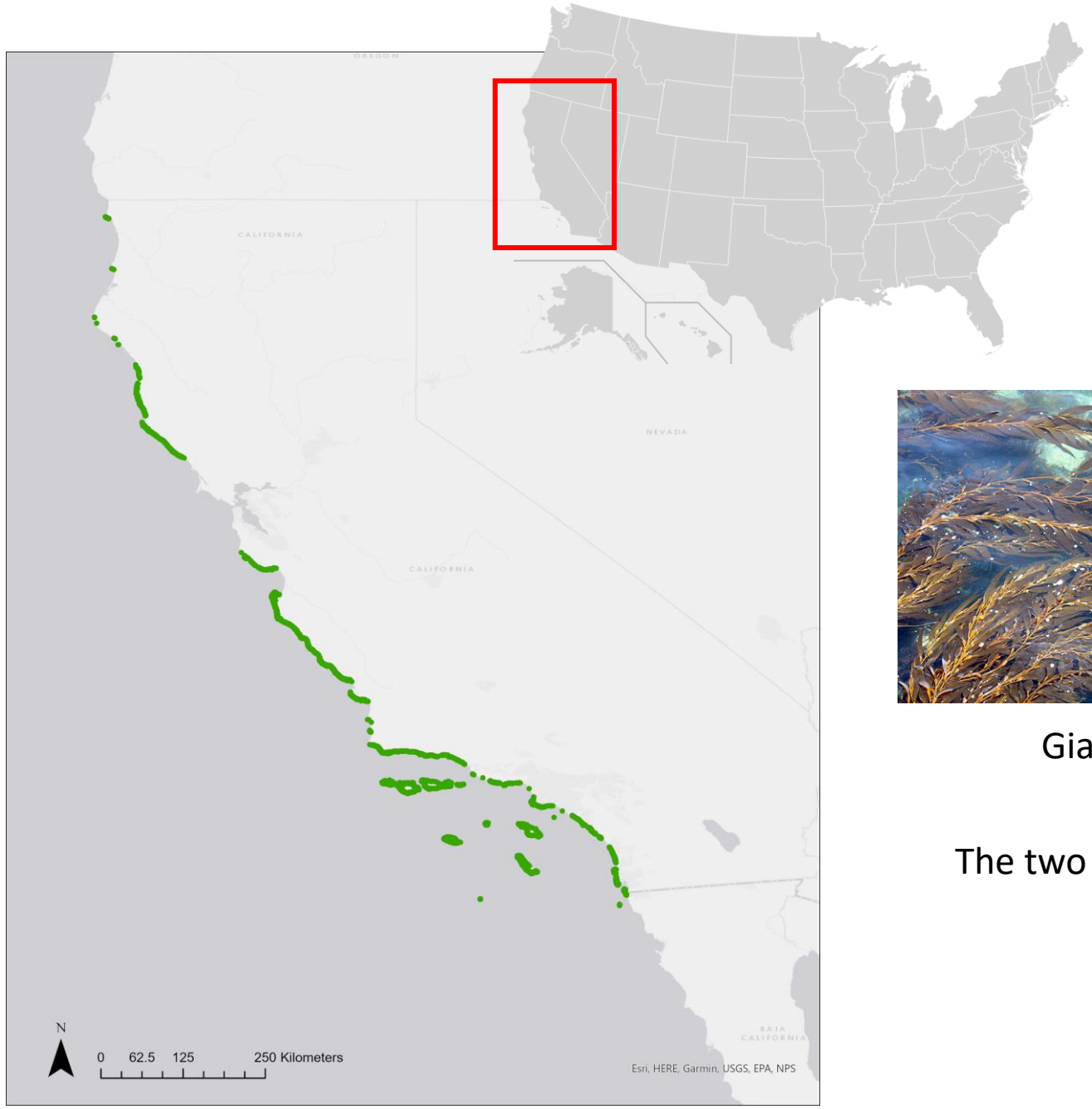
Evaluating kelp resistance and resilience in marine protected areas of California

Emelly Villa, Kyle Cavanaugh, Tom Bell, Jenn Caselle, Mark Carr, Dan Malone, Kate Cavanaugh

ITRS

Tuesday January 10th, 2023

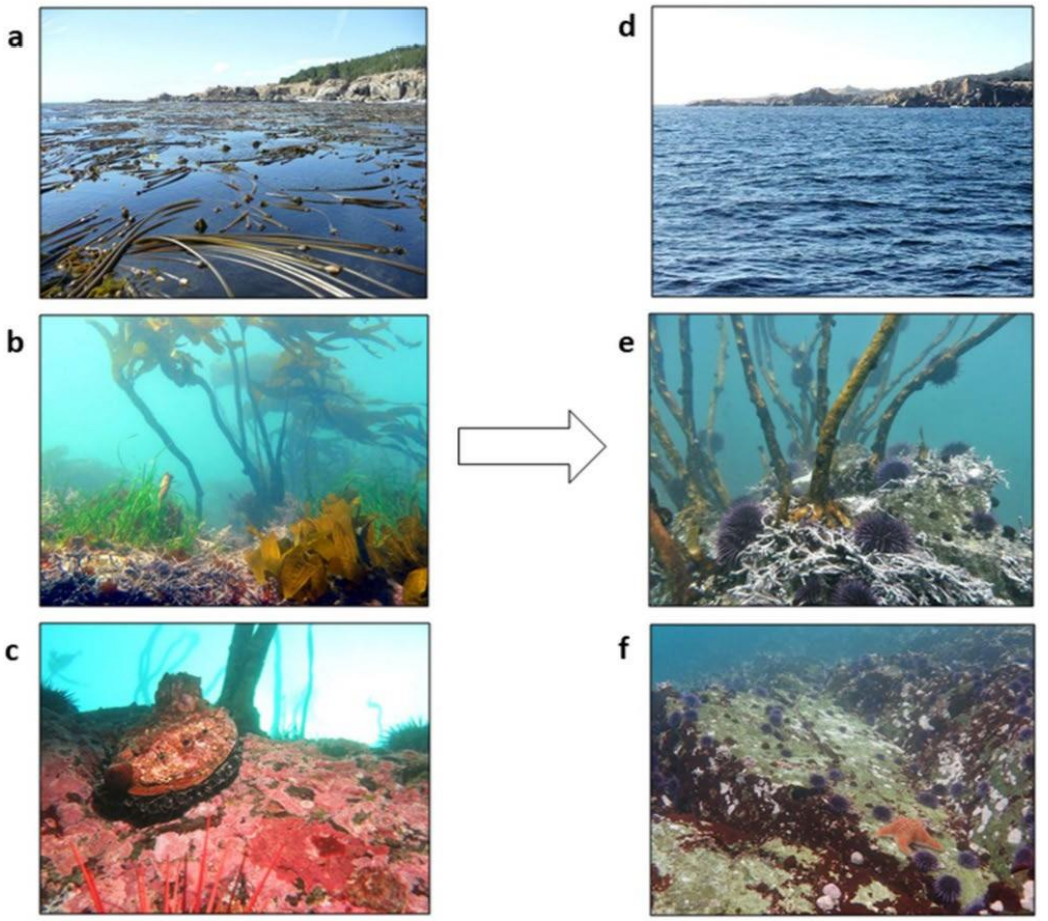


Giant Kelp

Bull Kelp

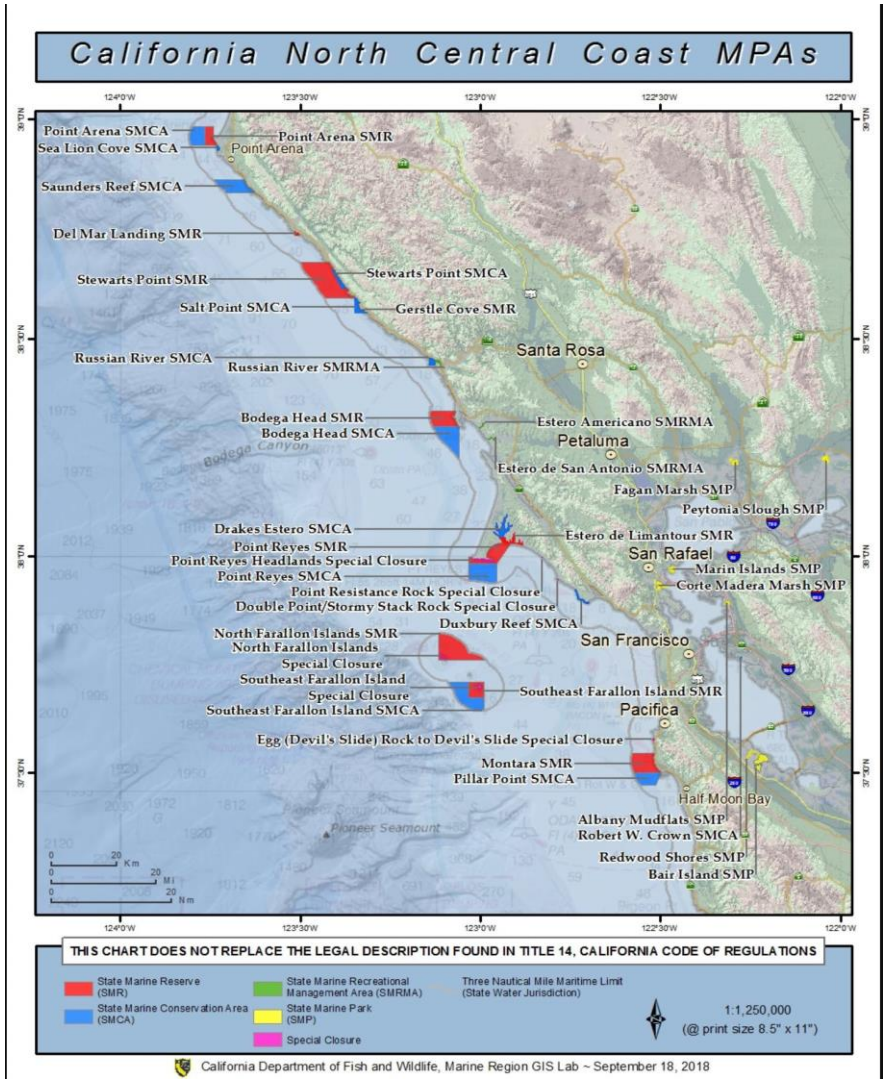
The two dominant macroalgae in the Northeast Pacific

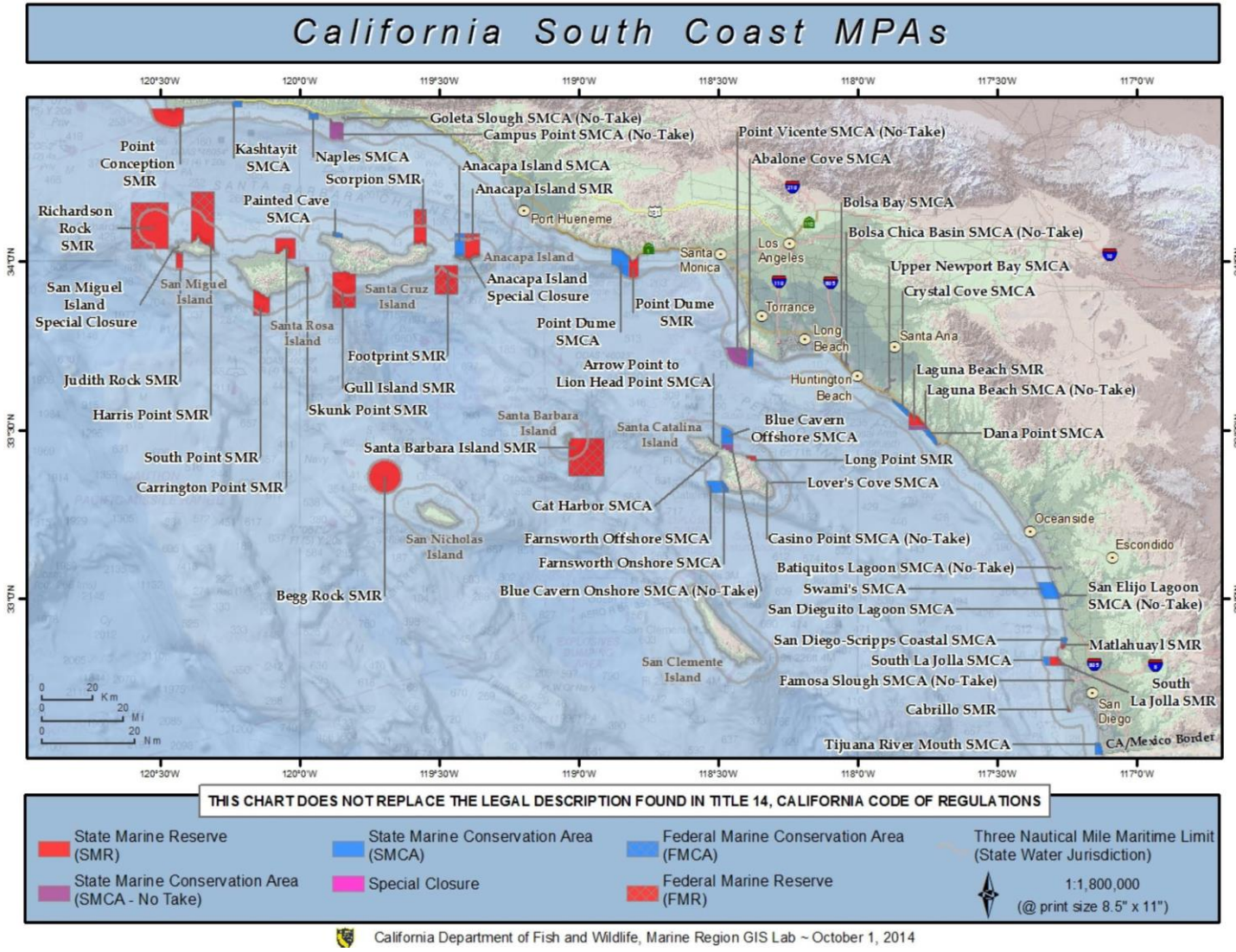
The addition and removal of top predators which often results in dramatic changes in ecosystem structure and nutrient cycling



Janna Nichols 2021, Rogers-Bennett and Catton 2019

Marine Protected Areas (MPAs)





Do MPA's have an affect on kelp abundance in California?

Find a reference site

Resilience and resistance values of kelp canopy in MPAs

BACI analysis

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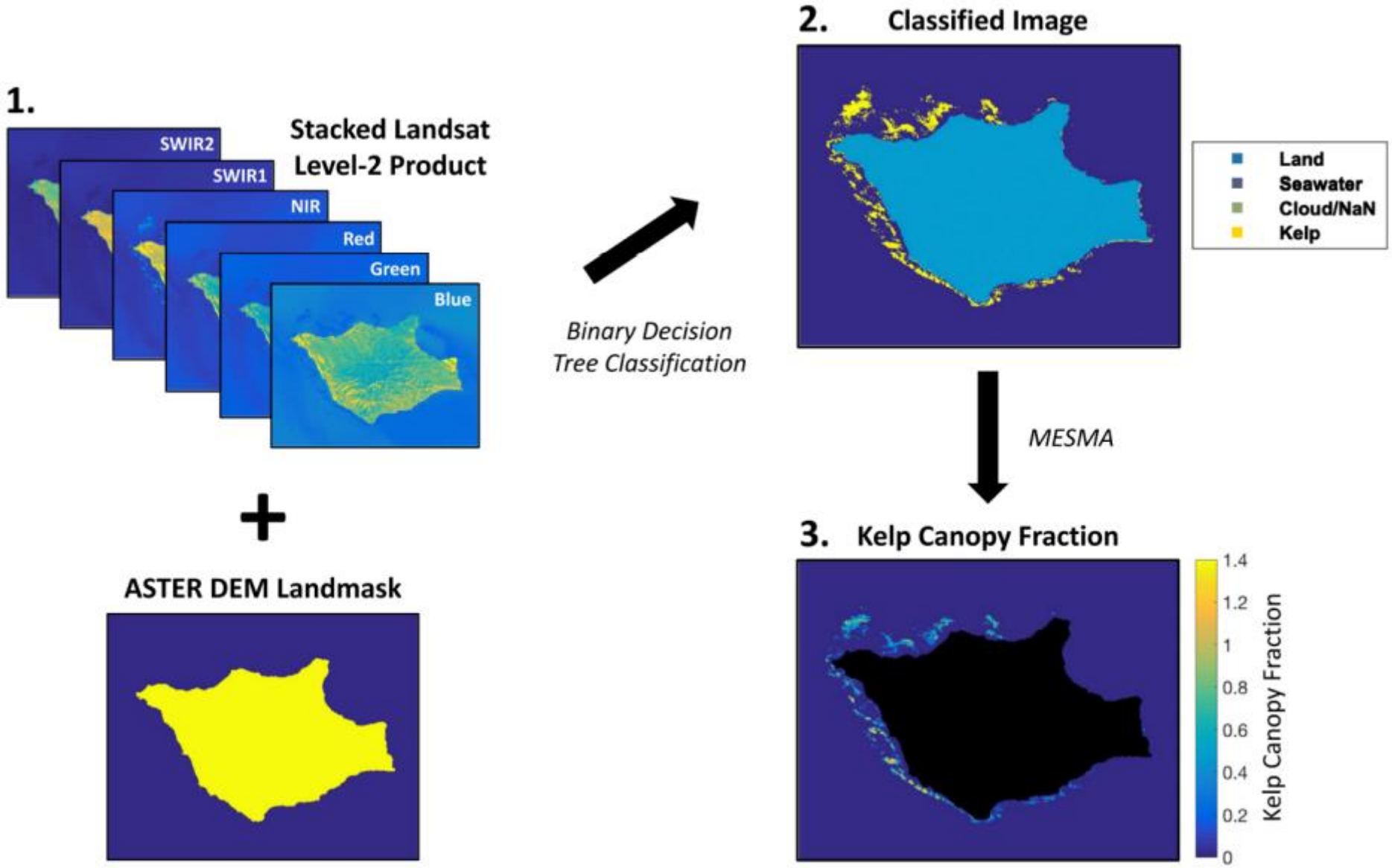
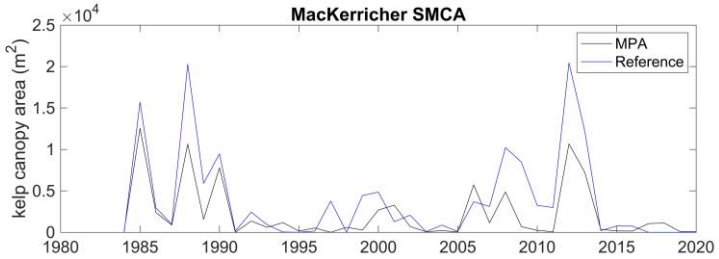
Classifying Kelp with Landsat

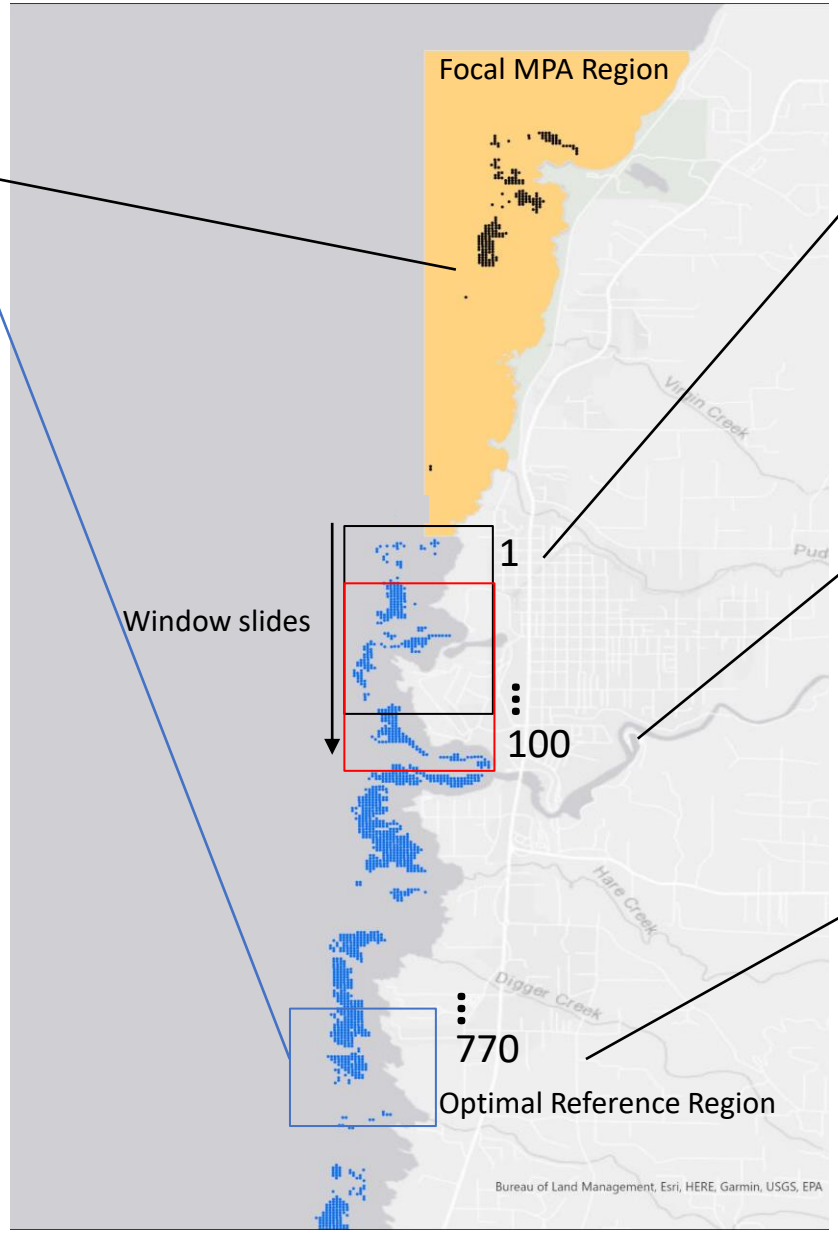


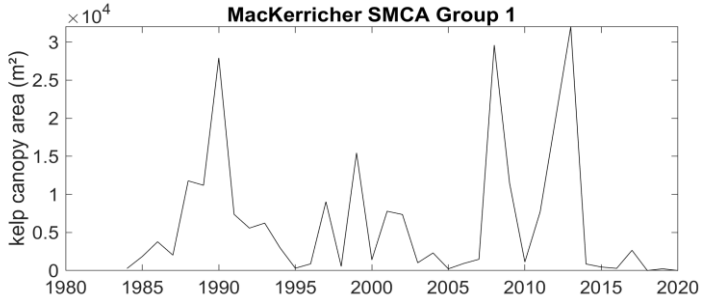
Modified from Bell, 2020

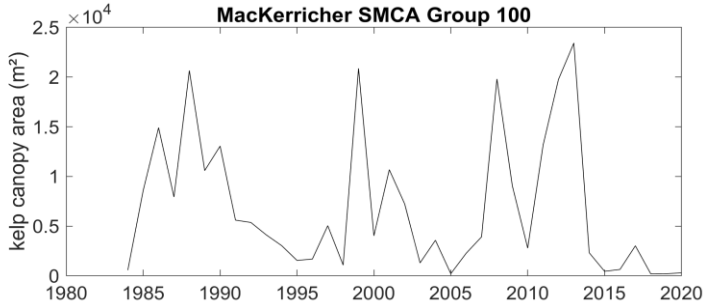
Method

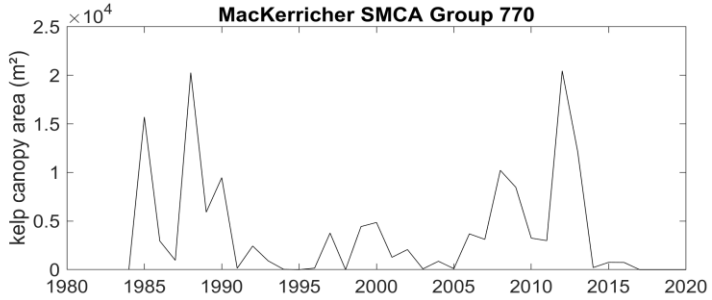


- Satellite based time series of kelp abundance (1984-present)
- Reference site should follow a similar historical pattern to MPA

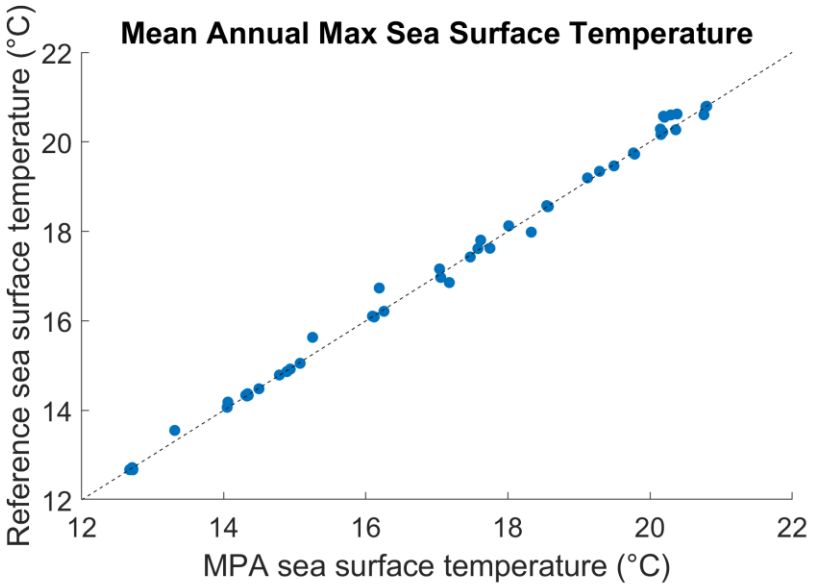


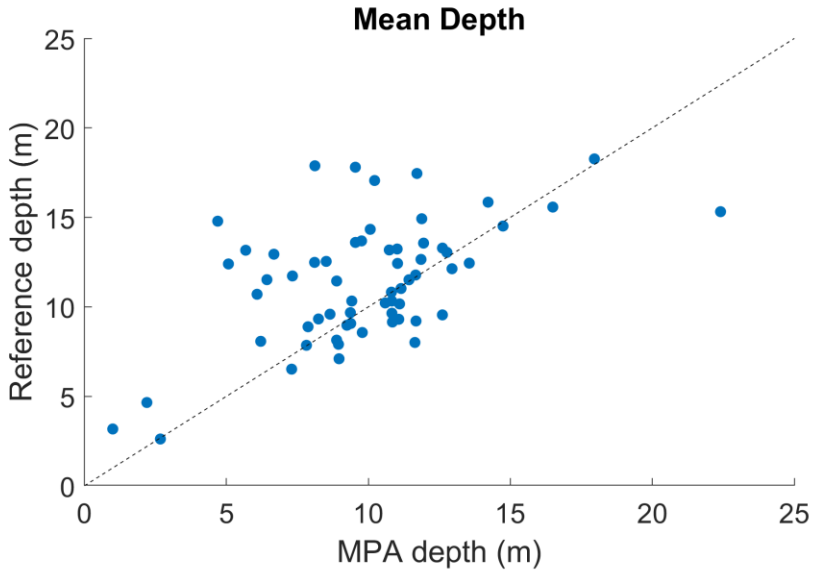


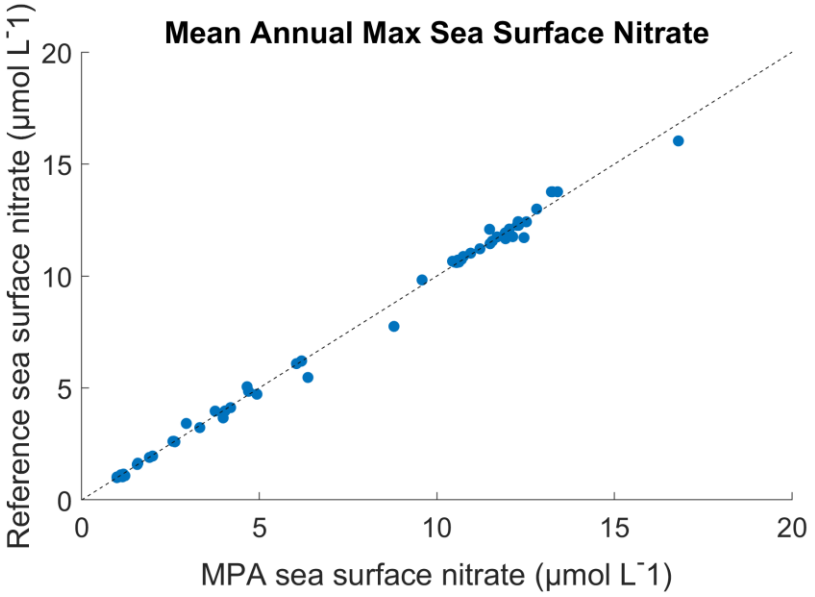


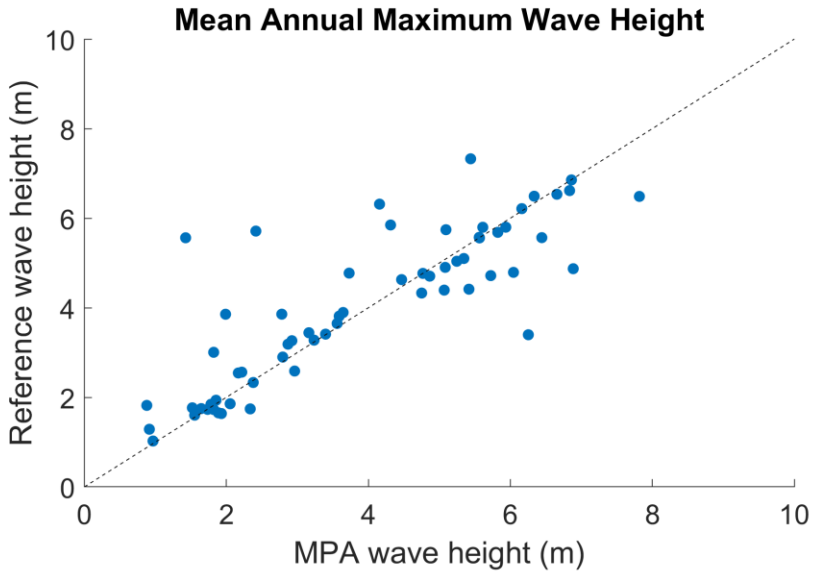


Reference Site selection Environmental Variables Validation









Do MPA's have an affect on kelp abundance in California?

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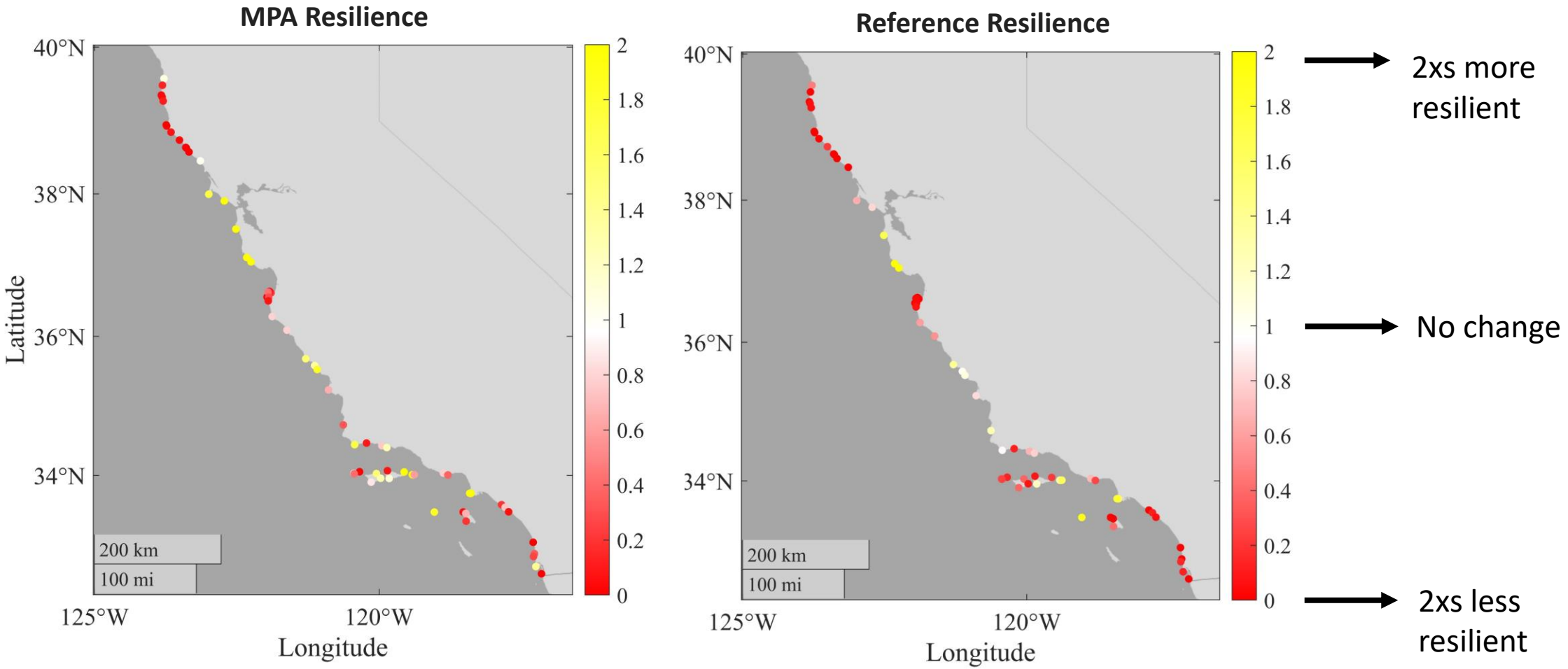
Resilience and resistance values of kelp canopy in MPAs

BACI analysis

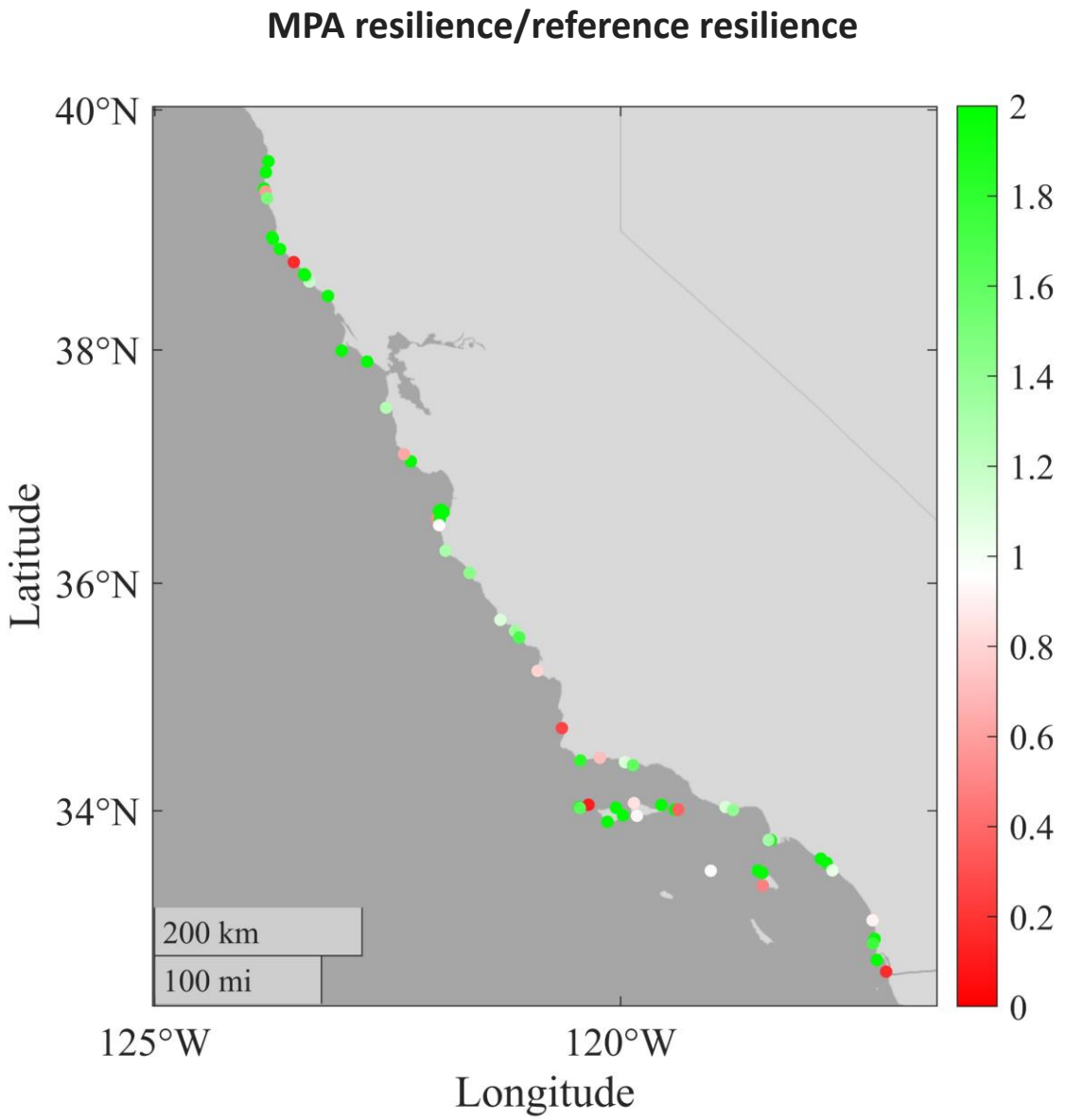
MPAs showed greater resilience to the 2014-2016 heatwave

N=55 paired MPA and reference sites



$$\text{Resilience} = \left(\frac{\text{mean annual maximum kelp canopy area from } \mathbf{2016\text{-}2020\ (post\ heatwave)}}{\text{mean annual maximum kelp canopy area from } \mathbf{2004\text{-}2013\ (pre\ heatwave)}} \right)$$

MPAs showed greater resilience to the 2014-2016 heatwave



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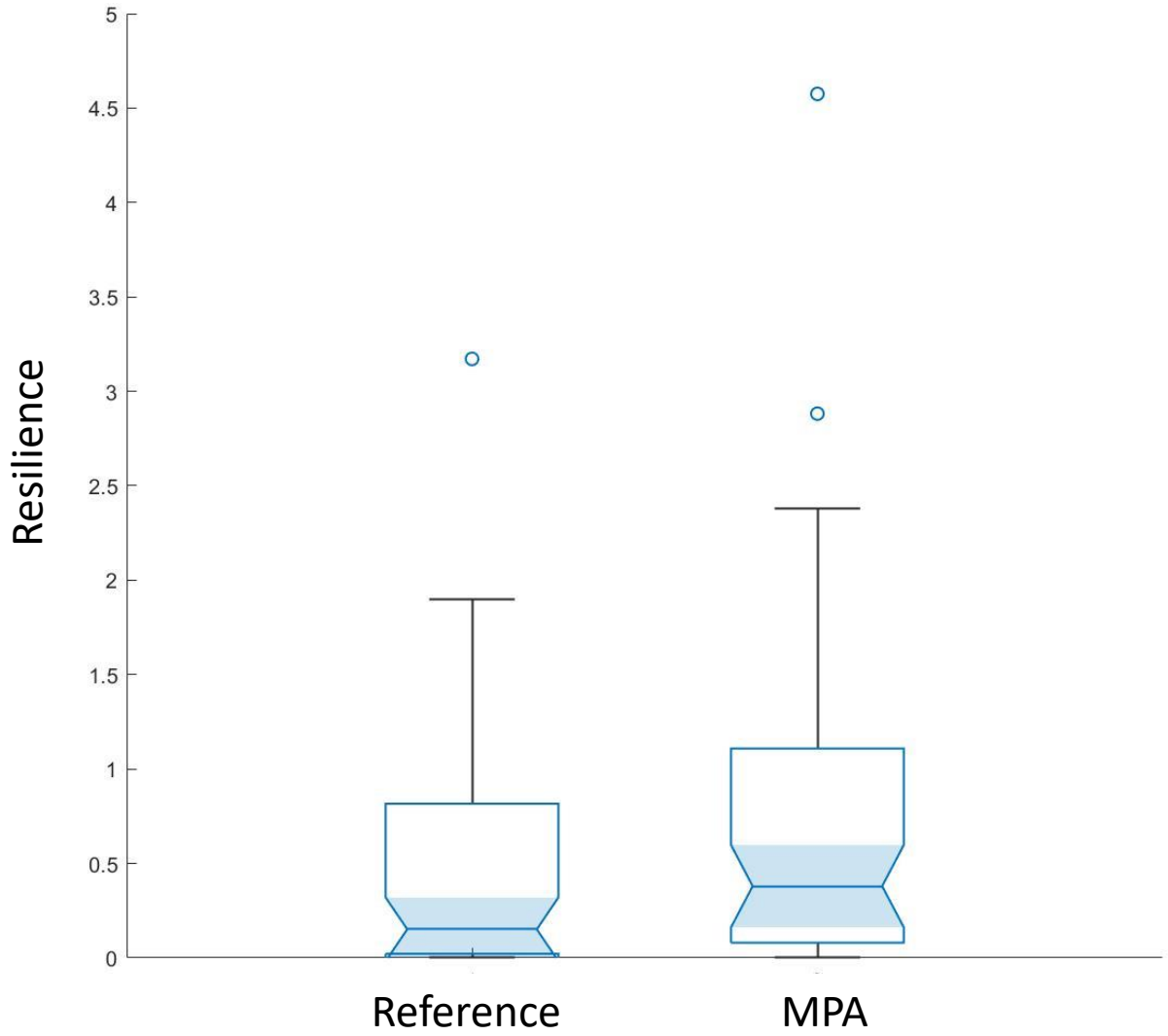


Kelp in MPAs are 2x more resilient

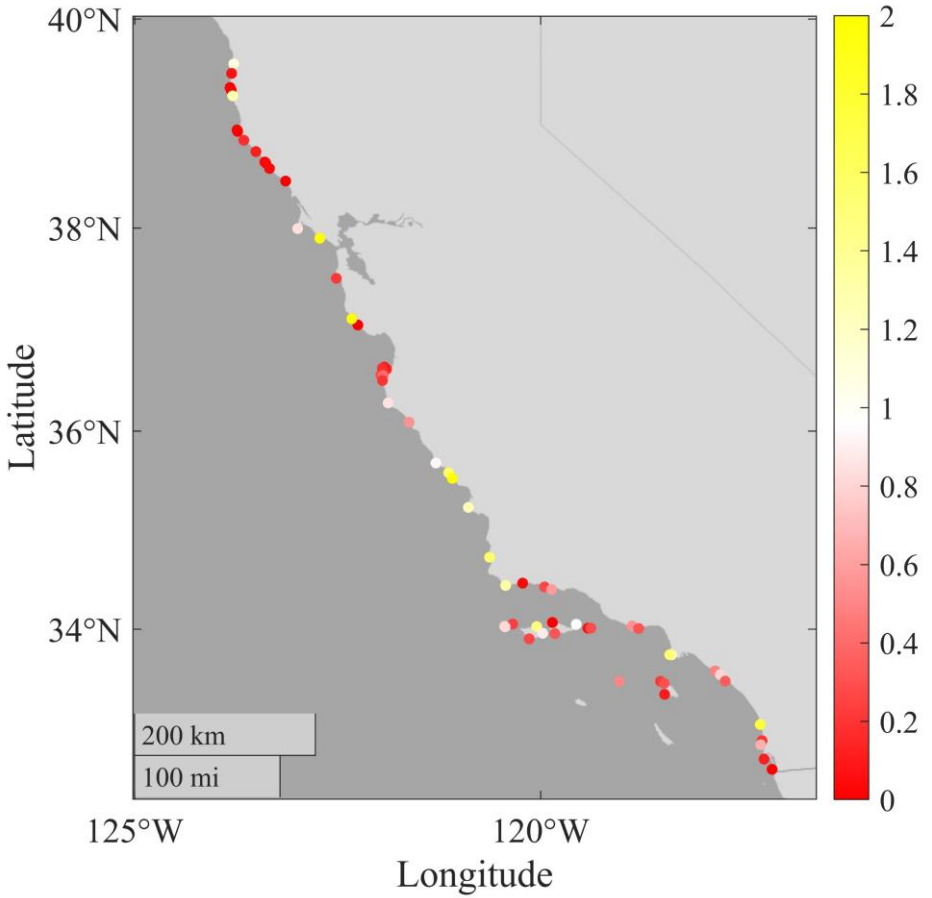
Median MPA: 0.60

Median Reference: 0.22

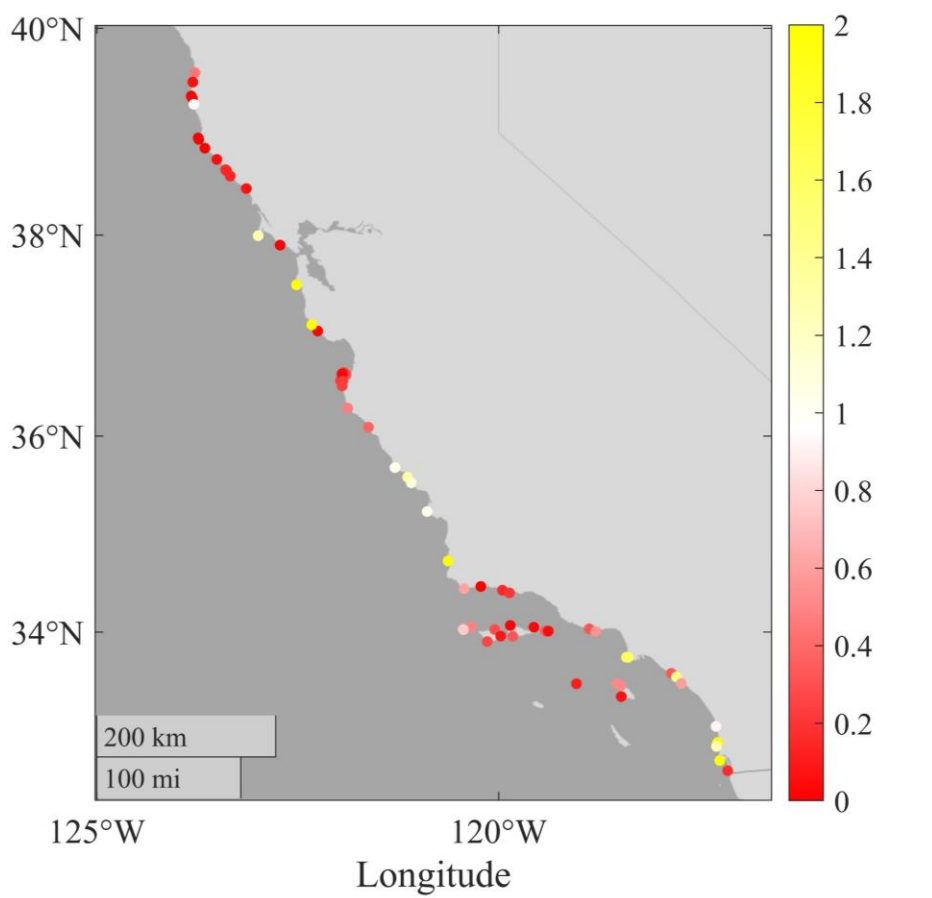
Resistance to the 2014-2016 heatwave

N=55 paired MPA and reference sites

MPA Resistance

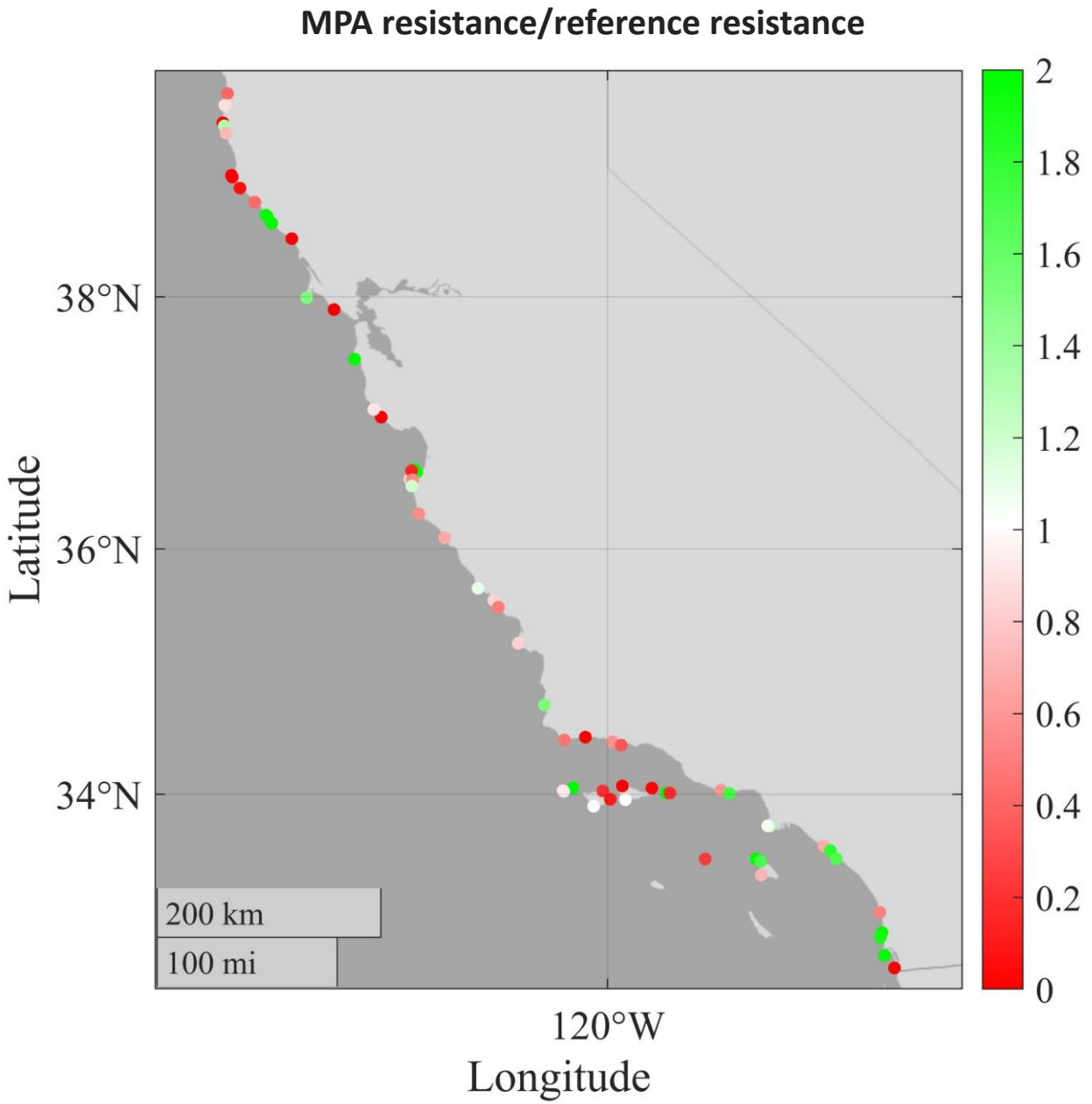


Reference Resistance

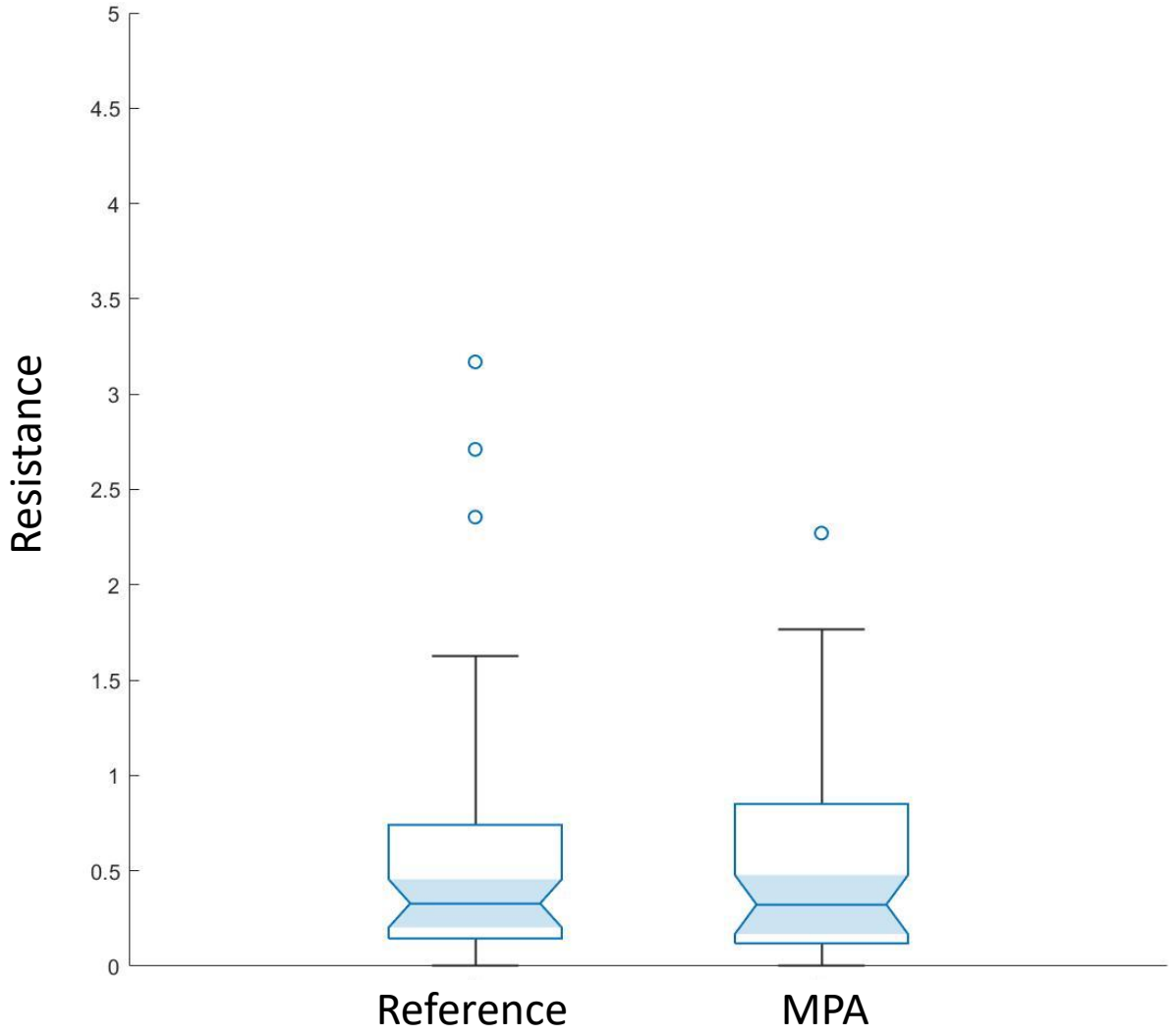


$$\text{Resistance} = \left(\frac{\text{mean annual maximum kelp canopy area from } \mathbf{2014\text{-}2016 \text{ (during heatwave)}}}{\text{mean annual maximum kelp canopy area from } \mathbf{2017\text{-}2020 \text{ (post heatwave)}}} \right)$$

No significant impact on MPAs in resistance



Resistance Rank Sum Test: Recovery from 2014-2016 heatwave at MPA wide Scale



Median MPA: 0.32

Median Reference: 0.33

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Resilience and Resistance values of kelp canopy in MPAs

BACI analysis

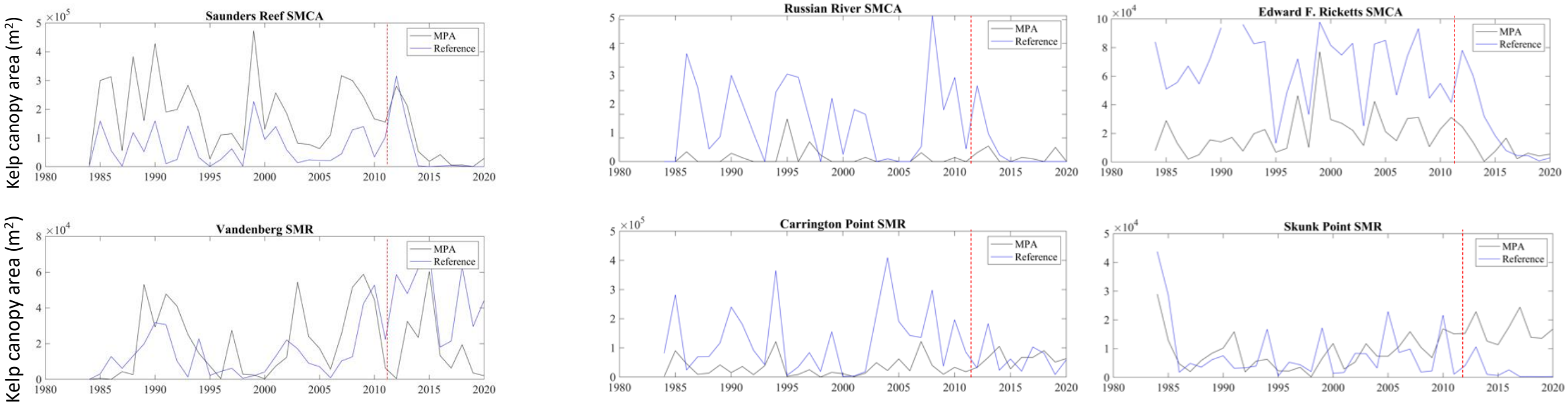
BACI test shows no significant difference after MPA implementation

$$Value_{i,j} = \beta_0 + \beta_1 BA_i + \beta_2 CI_j + \beta_3 BA_i CI_j + \epsilon$$

Positive: Average difference from before to after is greater in the MPA site

2 negative average change

4 positive average change



Wauchope et al. 2021

Summary

- We developed a way to determine reference regions for MPA using satellite kelp data
- Calculated resilience and resistance for each MPA and their reference sites
- Kelp in MPAs are 2xs more resilient post heatwave than their reference sites
- There was no significant impact on MPAs in resistance
- BACI Test Shows no significant difference after MPA implementation

Acknowledgements

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