



Increase in Giant Kelp Biomass and Carbon Storage after the Construction of an Artificial Reef in the Southern California Bight



Introduction

- Giant kelp (*Macrocystis pyrifera*) acts as ecosystem engineers by creating immense forests in temperate subtidal rocky reef habitats
- As primary producers, giant kelp remove dissolved carbon dioxide (CO₂) from the ocean and therefore the atmosphere
- Coastal degradation and warming temperatures have led to a decline in California kelp forests
- In 2020 the Vantuna Research Group (VRG) and NOAA built an artificial reef off of the Palos Verdes (PV) Peninsula in Los Angeles County
- If man-made structures can support giant kelp establishment and canopy growth, construction of artificial reefs could help combat global climate change through increased carbon absorption

Research Question

How much carbon is stored by giant kelp on the Palos Verdes Artificial reef?

Methods

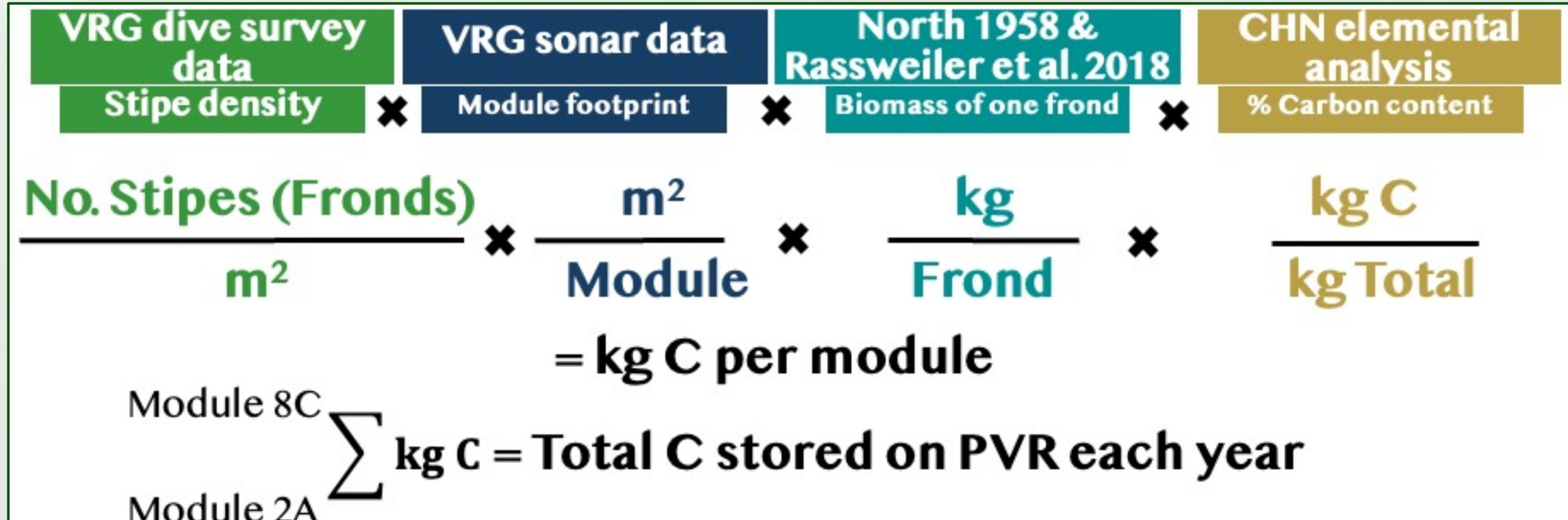


Figure 1. Calculations performed to estimate carbon stored by Palos Verdes Artificial Reef and input data sources

- Stipe density:**
- Counted giant kelp holdfasts and stipes (fronds) on 60 m² transects on 18 artificial reef modules each fall since construction in 2020 as a part of SCUBA dive surveys
- Module footprint:**
- Used bathymetric data from SONAR to obtain size (m²) of each module
- Frond biomass:**
- Predicted the biomass of an average giant kelp frond at depths typical of PVR (Fig. 1)
 - Estimated relative wet biomass of stipe (B_S) and blades (B_B) for each frond (data from Rassweiler et al. 2018 (n = 114))
 - Converted wet weight to dry weight using ratio from Wickham et al. 2019
- % Carbon content:**
- Collected, dried, and ground eight giant kelp blade samples
 - Estimated carbon content of blades (C_B) using Automated Organic Elemental Analyzer
 - From Rassweiler et al. 2018, subtracted 12% from C_B for stipe carbon content (C_S)
 - Multipled dry B_S by C_S and dry B_B by C_B to obtain total carbon content of both stipes and blades each year (Table 1)
 - All data manipulation and calculations performed in R using the 'tidyverse' package

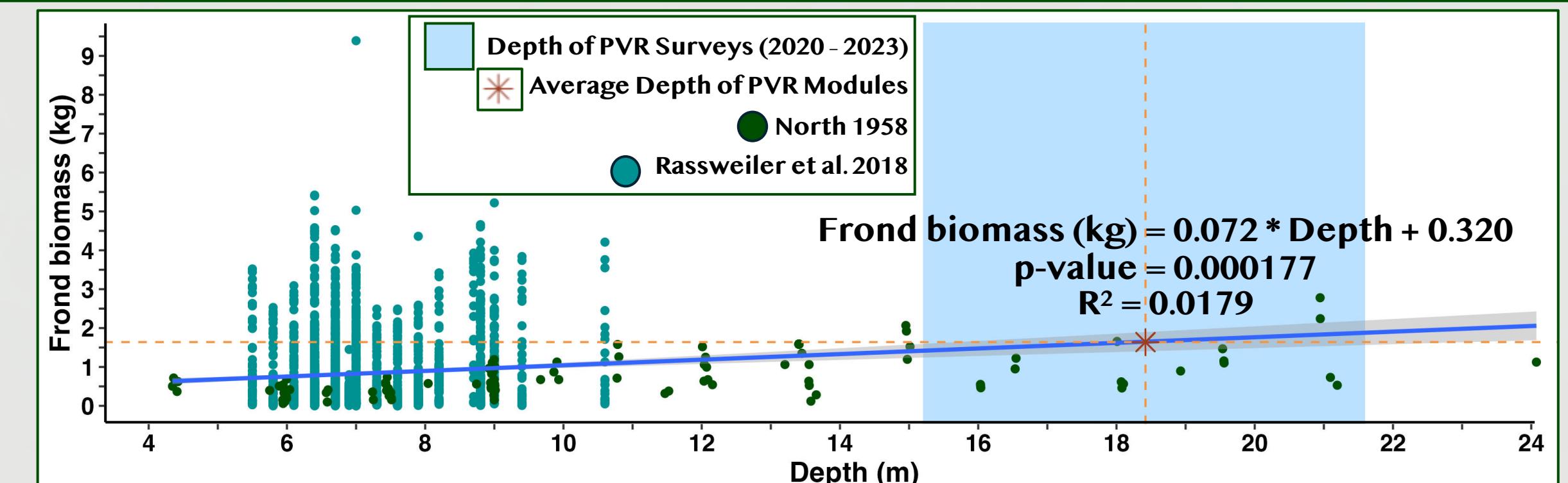


Figure 2. Giant kelp frond biomass by depth in southern California. Each point represents a single observation of a frond from North 1958 (n = 143) or Rassweiler et al. 2018 (n = 283). Blue line displays linear model with 95% confidence interval shaded in grey. Star marks average depth of modules, and associated frond biomass estimate used in calculations.

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Results

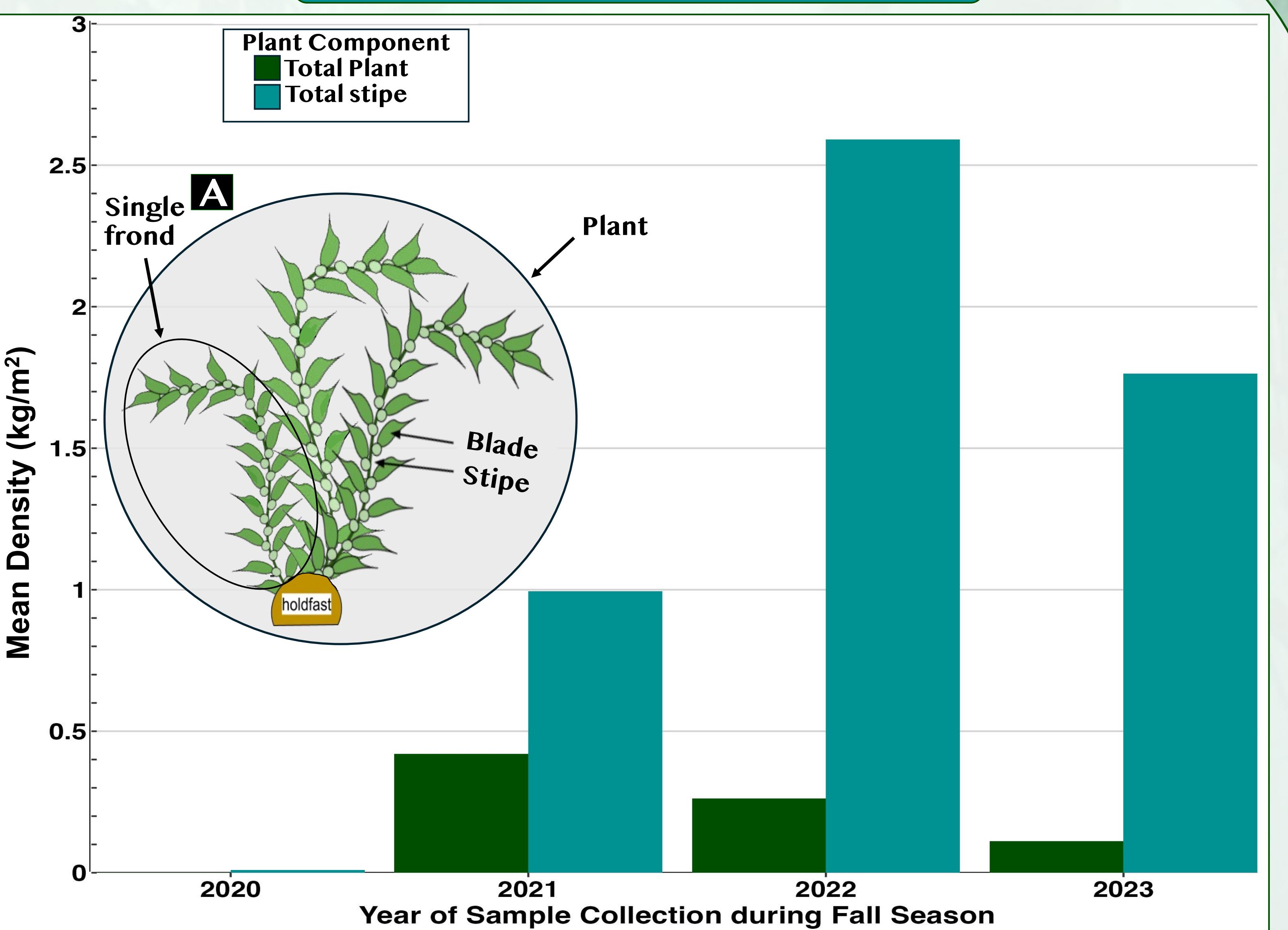


Figure 3. Annual mean density (kg/m²) estimates of giant kelp stipes and plants on all 18 PVR modules. Mean giant kelp stipe density increased from 2020 to 2022 and decreased from 2022 to 2023. Mean giant kelp plant density increased from 2020 to 2021 and decreased gradually from 2021 to 2023. Fig. 3A. Illustration of giant kelp plant components (Single frond design by Jayde Meng 2022).

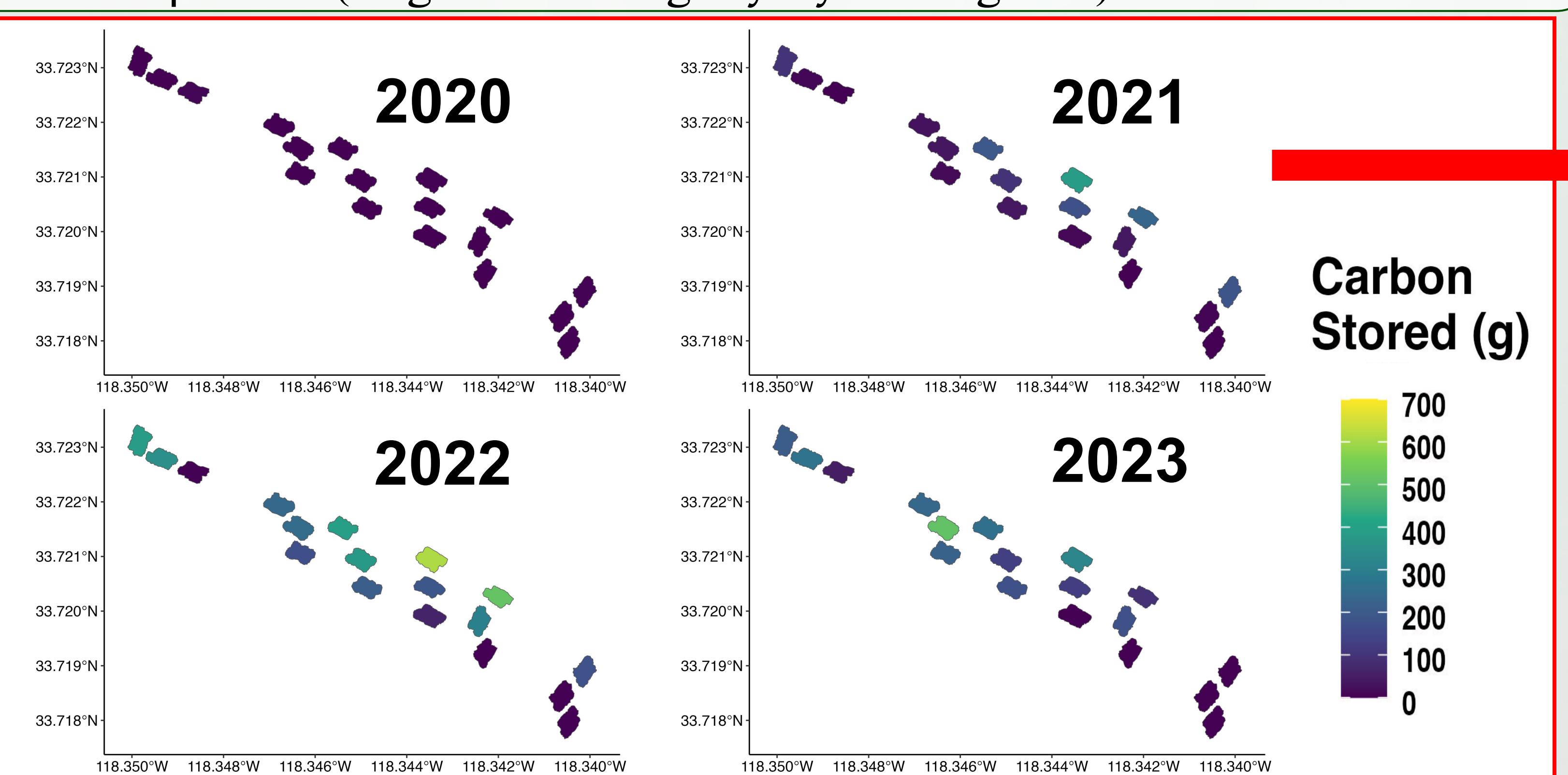


Figure 4. Total amount of carbon stored during the fall-season by giant kelp on each PVR module from 2020 - 2023.

Sample Year	Total Carbon Stored (g)
2020	14.1
2021	1529.4
2022	4225.7
2023	2756.9

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Conclusions & Future Directions

- Fall-season giant kelp stipe density estimates on each PVR module can be used to predict total biomass
- Biomass estimates and carbon-content analyses can determine the total amount of carbon stored by giant kelp
- Giant kelp abundance is spatially and temporally variable, and influenced by both physical and biological factors
- In the future, quarterly surveys on each PVR module will allow us to estimate total annual carbon storage

Study Site

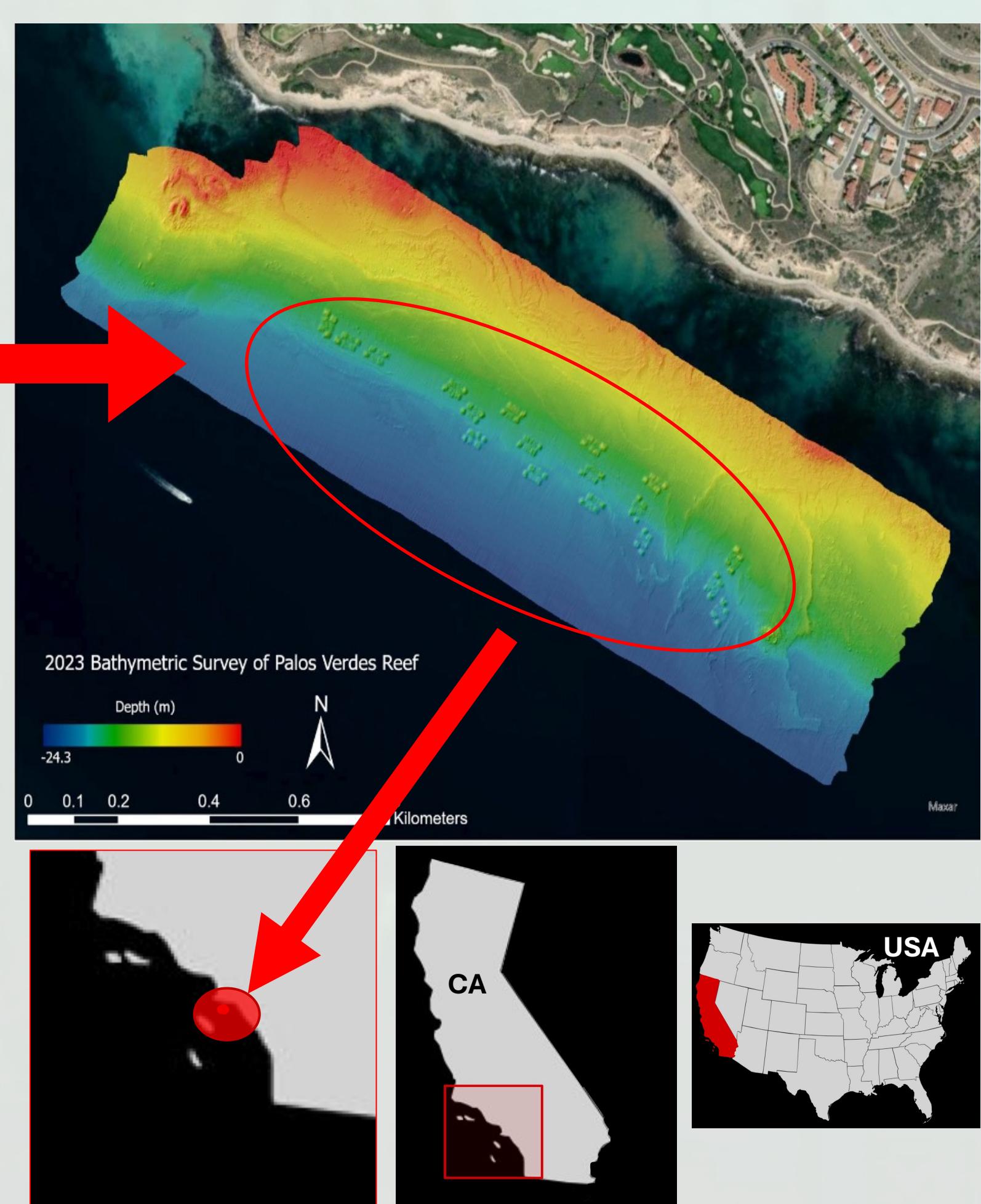


Figure 6. Aerial image of Palos Verdes Reef July 2023 (Julianne Steers (SCMI))



Figure 5. Bathymetry and location of each module at PVR (Williams et al. 2023)

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