

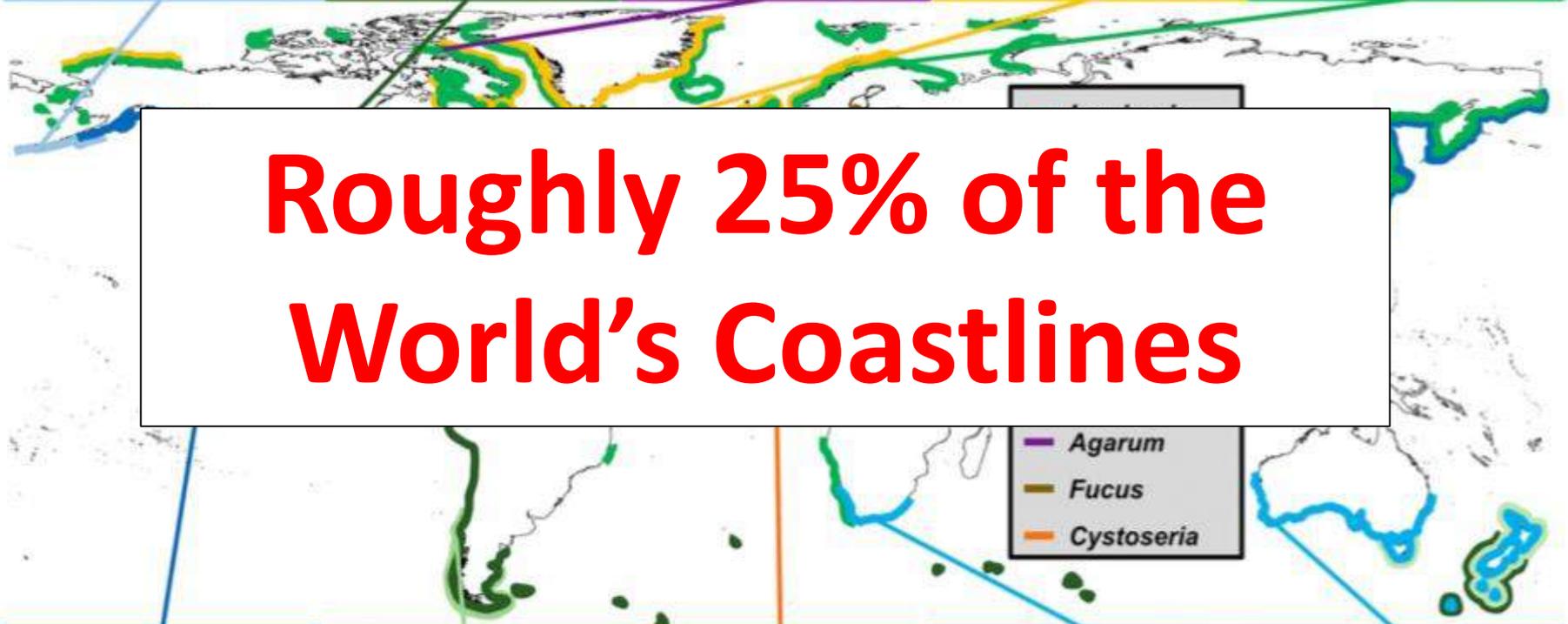
# Using Citizen Science to Understand Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery

Jarrett Byrnes, Kyle Cavanaugh, Laura  
Trouille, Isaac Rosenthal, and Alison Haupt

*UMass Boston, UCLA, Zooniverse, Cal State Monterey  
Bay*







**Roughly 25% of the  
World's Coastlines**



# The Paradigmatic Aleutian Trophic Cascade

Otter



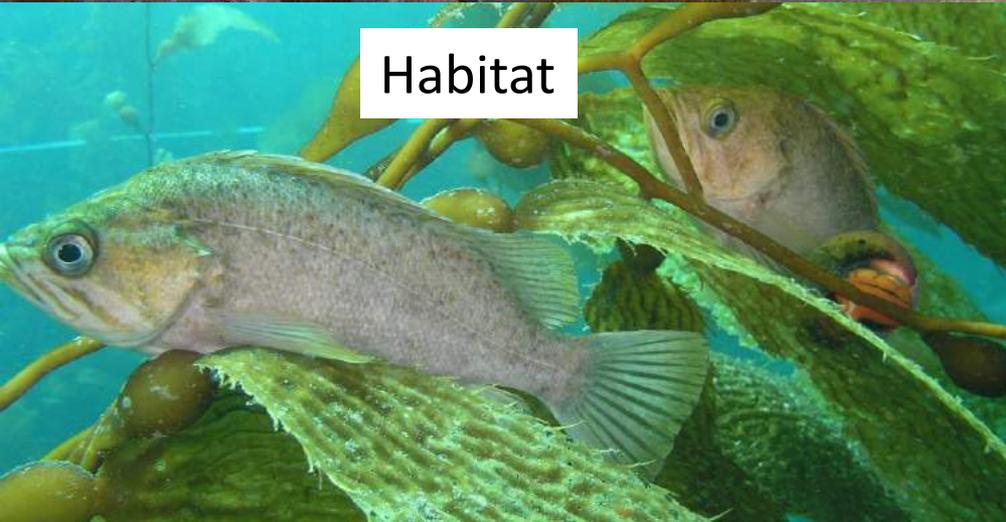
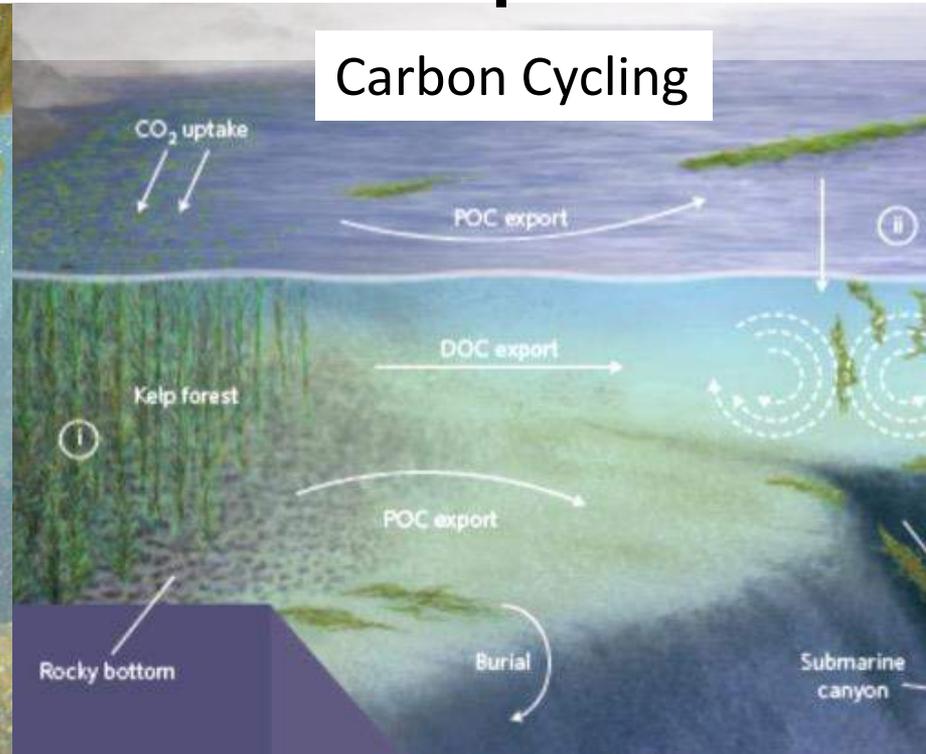
Urchin



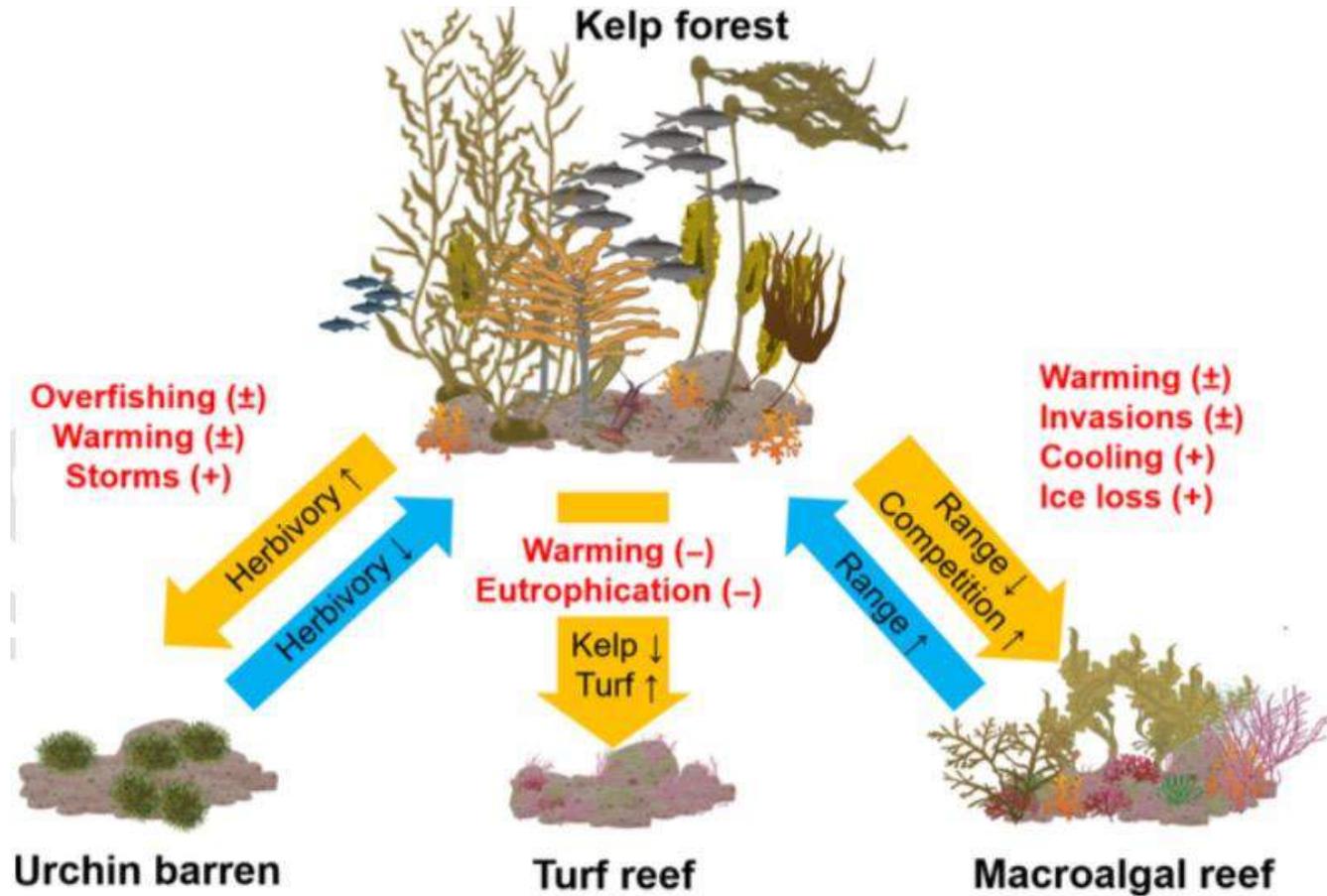
Kelp



# Paradigmatic Foundation Species



# Human Inputs can Radically Alter Kelp Forests





Have we  
observed  
changes in kelp  
abundances?



But this is how we count kelp...





# Giant Kelp forms Surface Canopies



# Giant Kelp is Global!

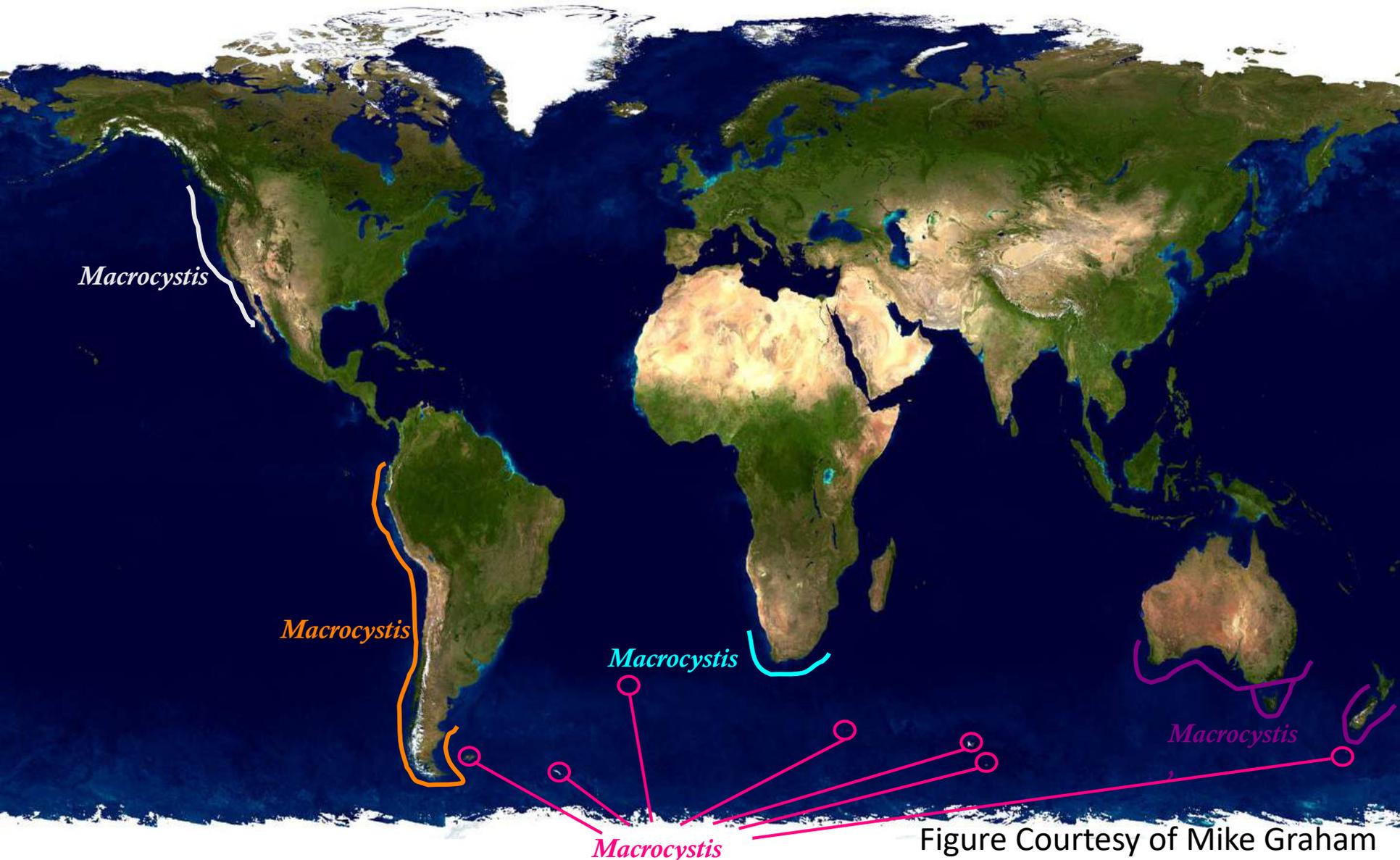
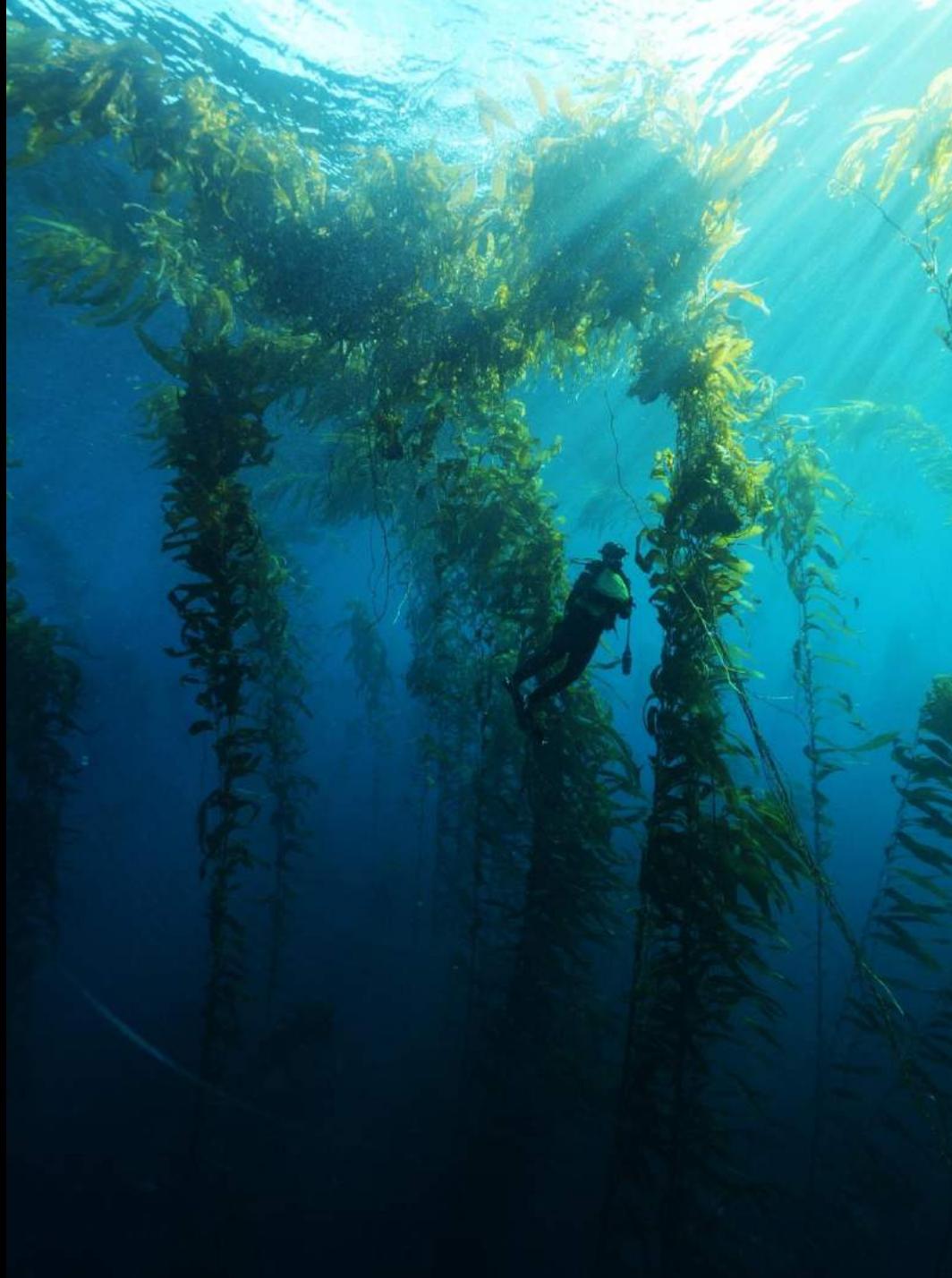
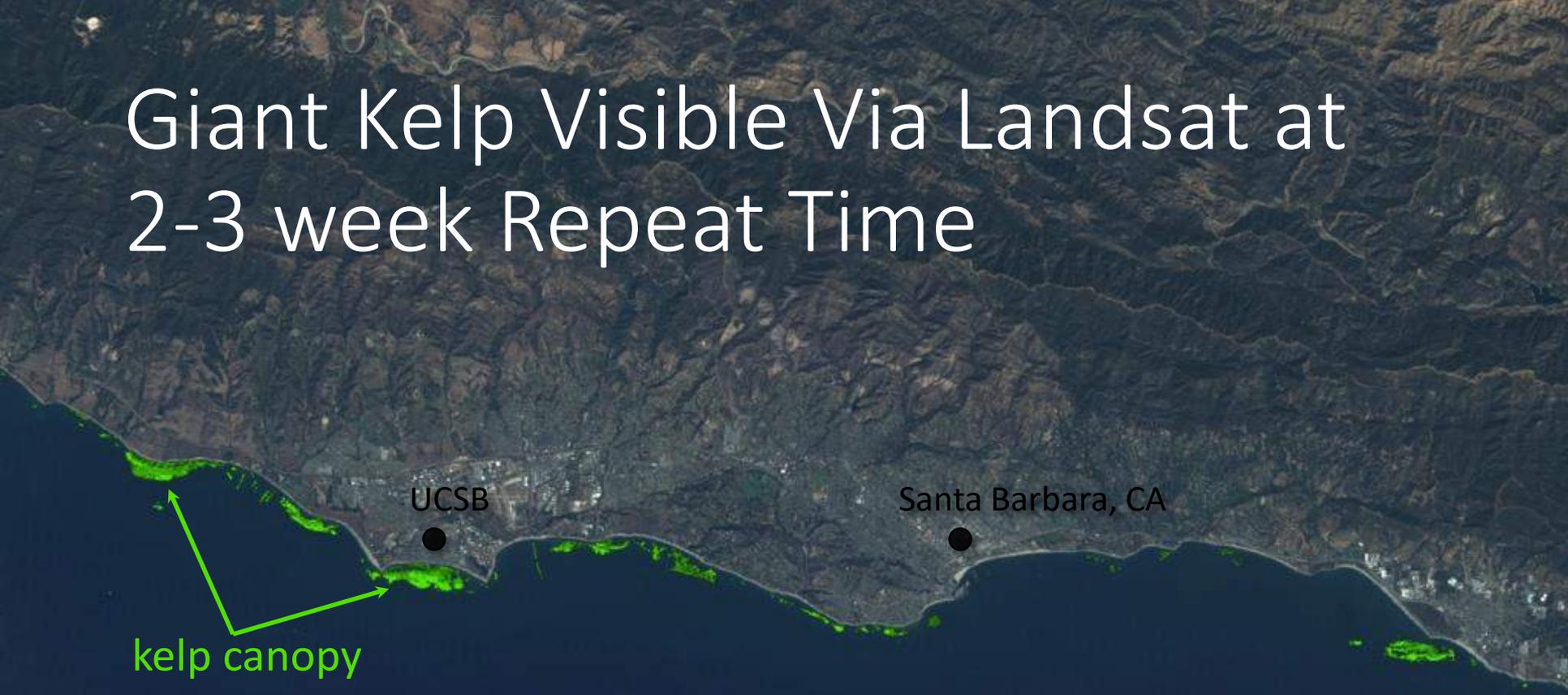


Figure Courtesy of Mike Graham



# Giant Kelp Visible Via Landsat at 2-3 week Repeat Time



UCSB

kelp canopy

Santa Barbara, CA

1. This is a really nice cleaned image
2. Classification by armies of undergrads took ~600 hours for \*just\* Santa Barbara
3. What about scaling with citizen science?

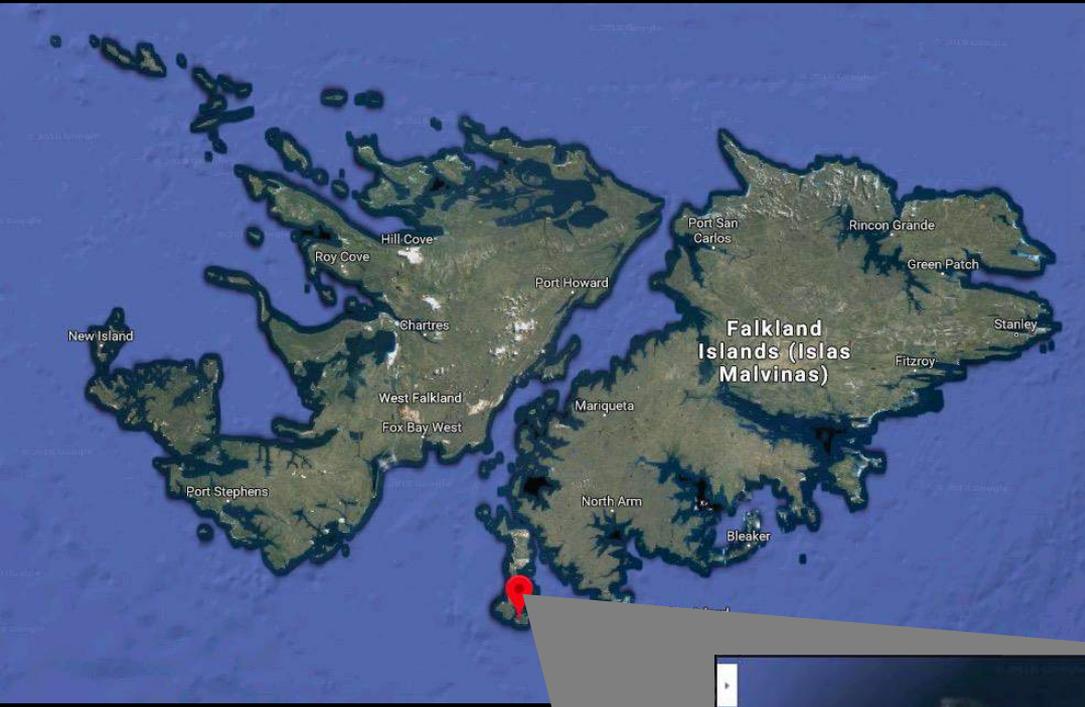


# DISCOVER FLOATING FORESTS

We are trying to understand how forests of kelp grow and change over time. We need your help to find these forests in pictures from space!

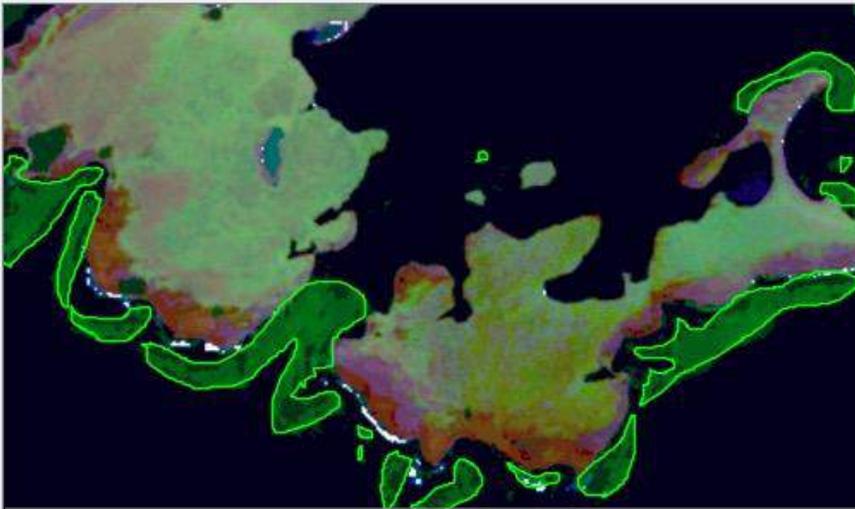
[GET STARTED](#)

# How do we Classify?





# Floating Forests ✓



- Each image seen 4 times, dropped if no kelp present
- If kelp is seen in first 4, image is seen 15 times total



## TASK

## TUTORIAL

Mark the kelp. Try to mark each patch individually.



Kelp patches

15 of 1 required drawn

### NEED SOME HELP WITH THIS TASK?

Bad Image

Clouds

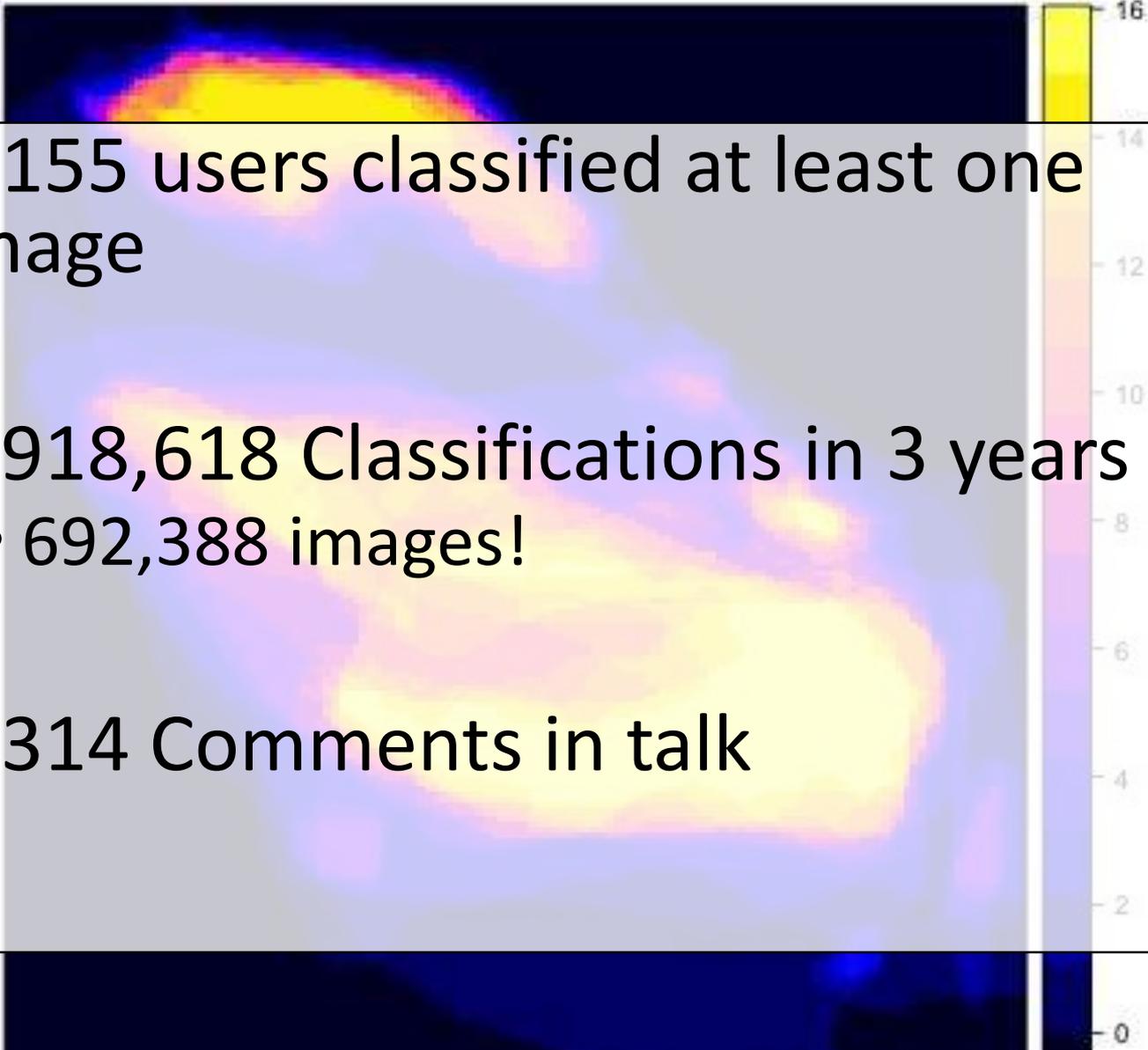
No Kelp

Done

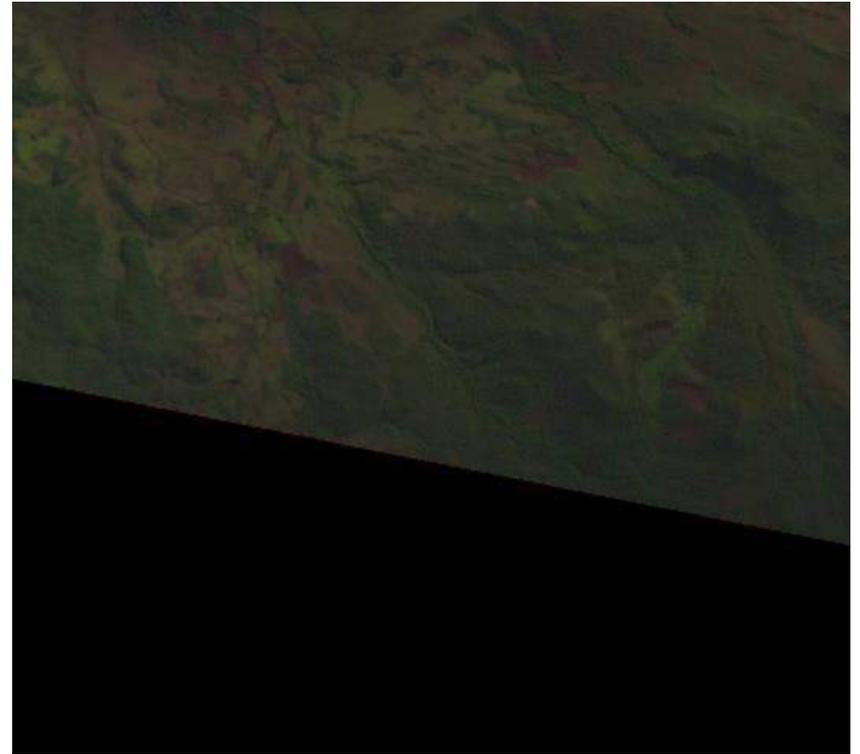


# Round 1 (California and Tasmania) By the Numbers

- 7,155 users classified at least one image
- 2,918,618 Classifications in 3 years
  - 692,388 images!
- 7,314 Comments in talk

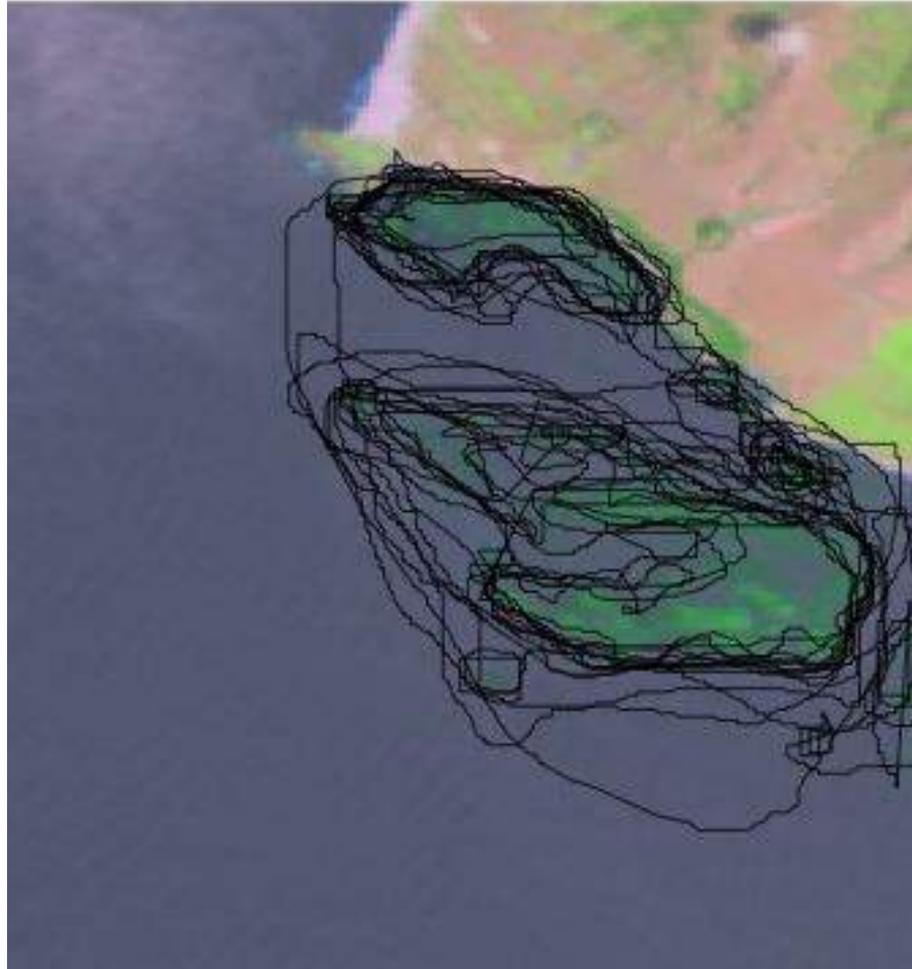


# Citizen Scientists Helped us Find Bugs in our Image Processing



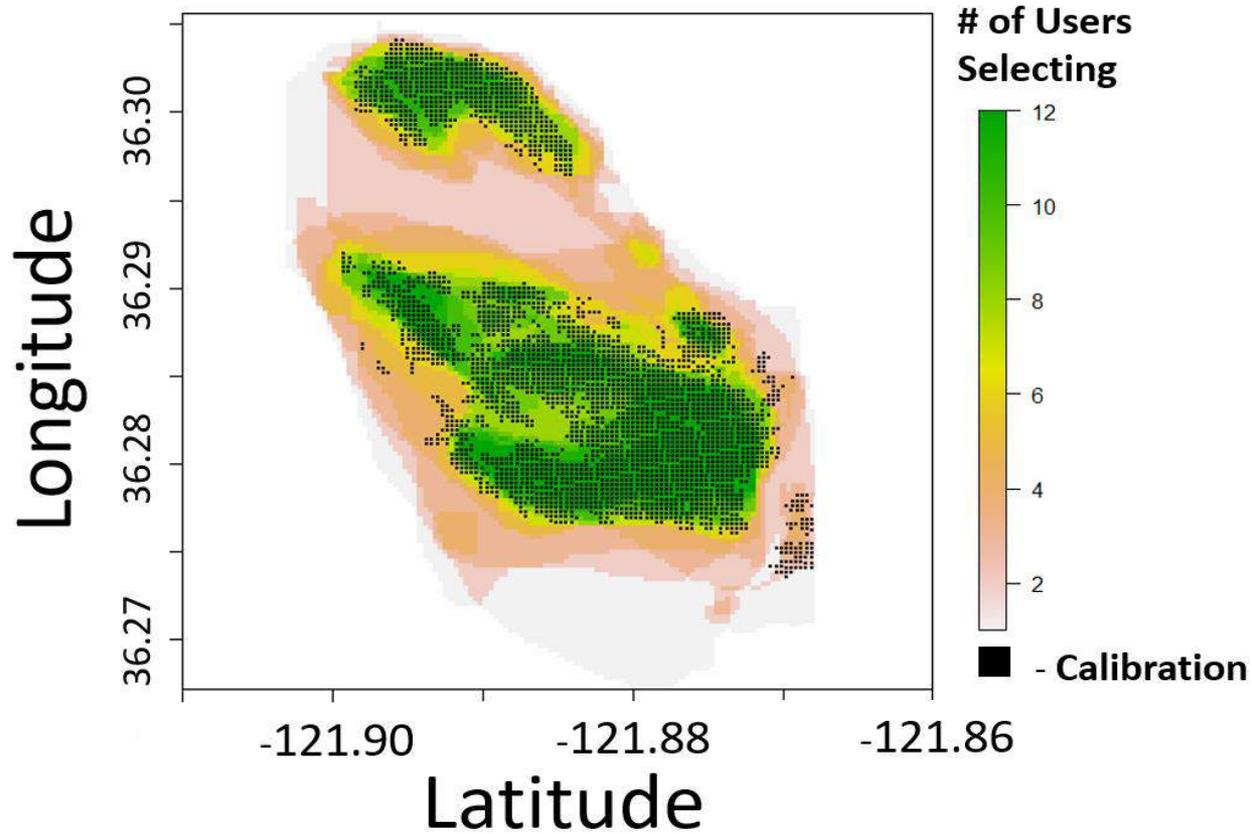
**Solution: We re-wrote our image processing pipeline...and one of the citizen scientists joined our science team**

# How Good are Citizen Scientists?



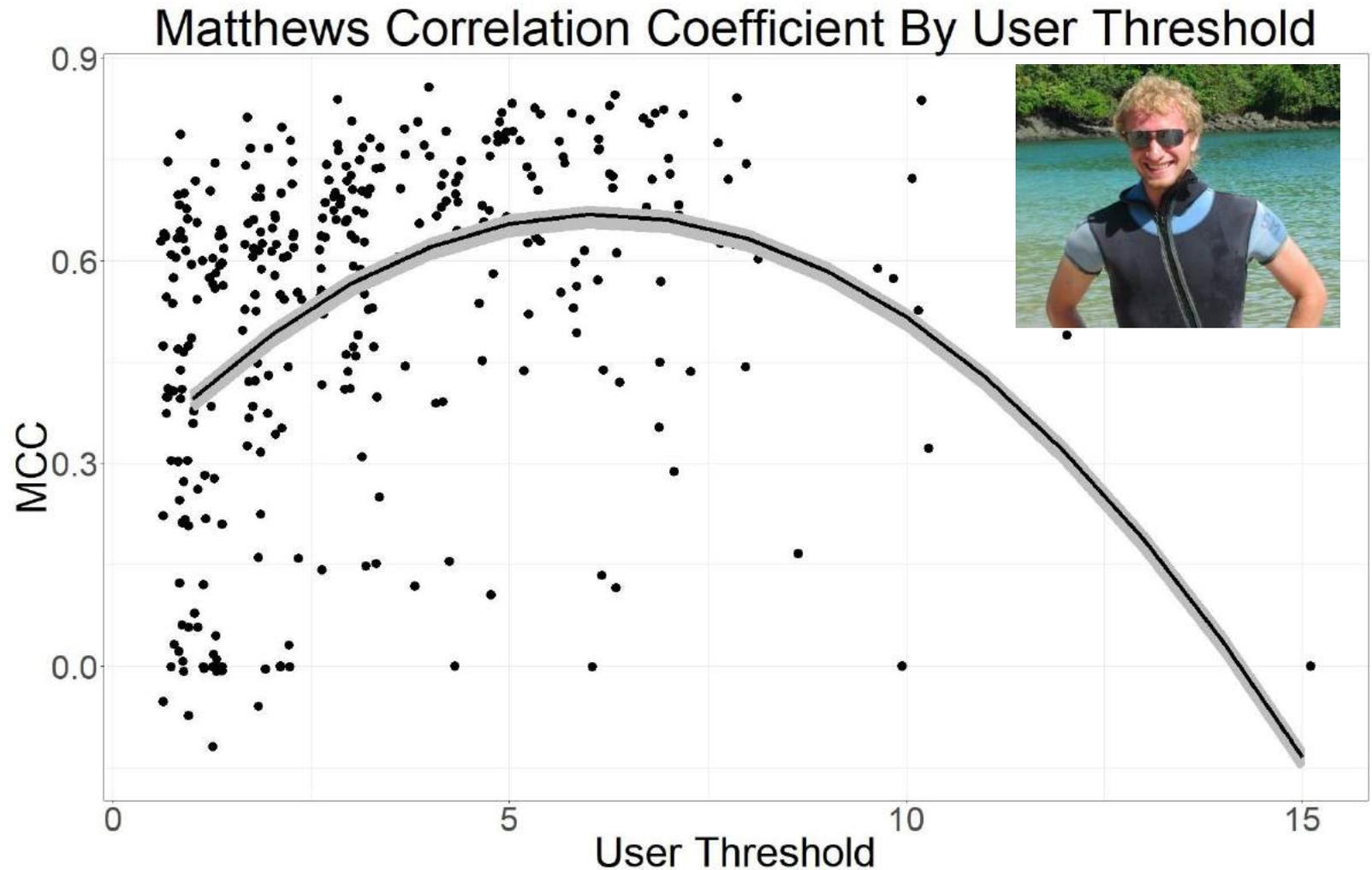
Calibration Image from Kyle Cavanaugh

# Validation of Consensus Classifications

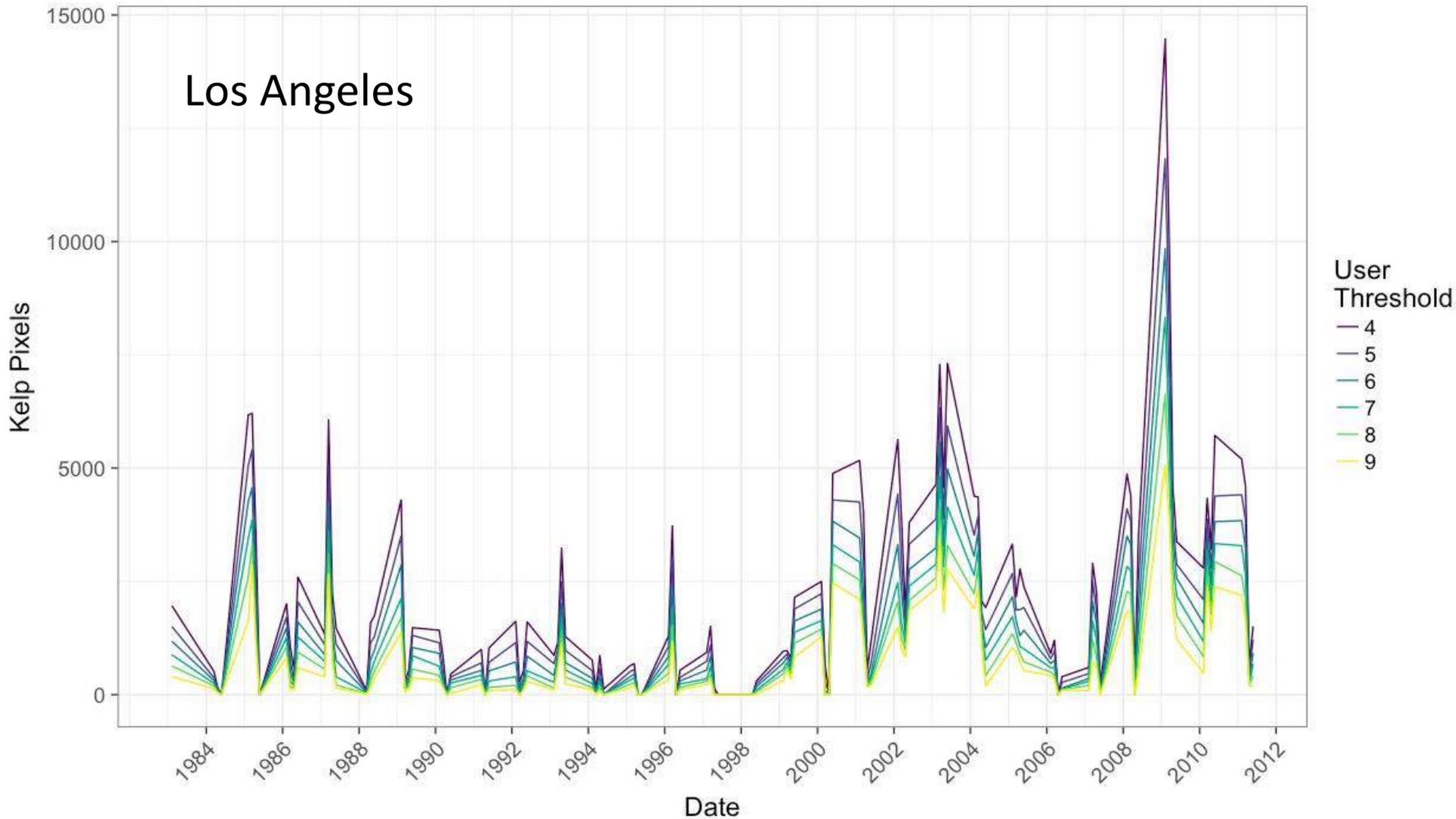


Calibration data from  
Kyle Cavanaugh and  
Tom Bell

# 6 is the Magic Number: ~70% accuracy



# Consensus Choices Doesn't Qualitatively Alter Time Series



# Floating Forests 2.0



PROJECTS ABOUT GET INVOLVED TALK BUILD A PROJECT NEWS

SIGN IN REGISTER



Floating Forests

ABOUT CLASSIFY TALK COLLECT

## DISCOVER FLOATING FORESTS

[Learn more](#)

### FLOATING FORESTS STATISTICS



84% Complete

4,836

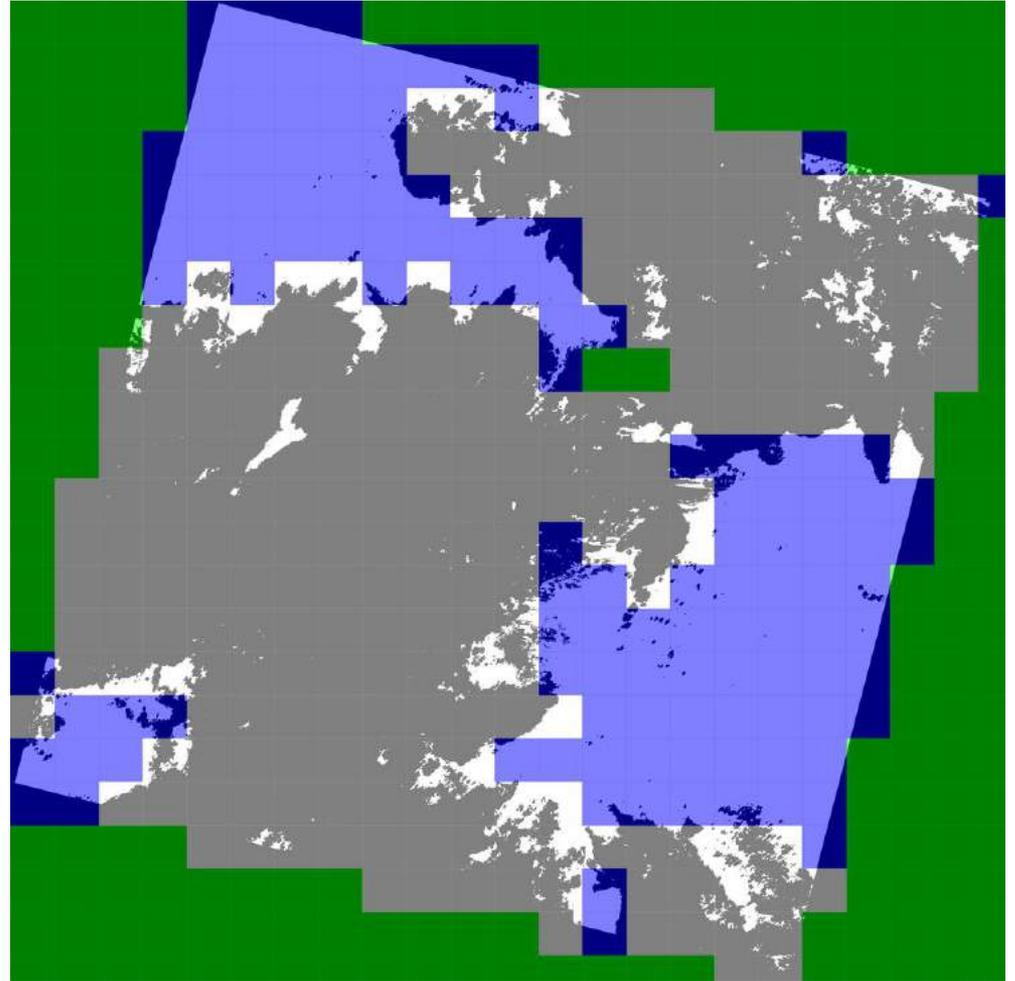
166,663

18,825

15,916

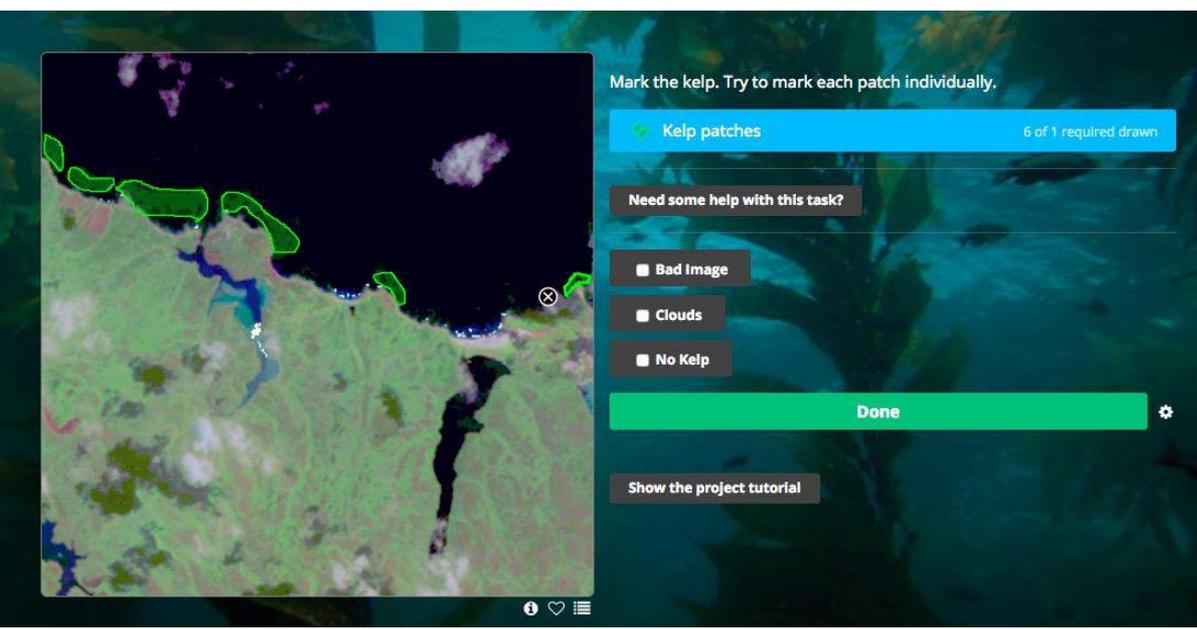
# The New Open Source Pipeline

1. L1 Imagery acquired from ESPA with surface reflectance product
2. One scene sliced into 350x350 pixel squares
3. Images filtered for excess cloud or land presence
4. Image color corrected to boost green channel
5. Final filter to remove mostly water images (citizen science method)



# Multiple Interfaces to Improve Accessibility

## Classify

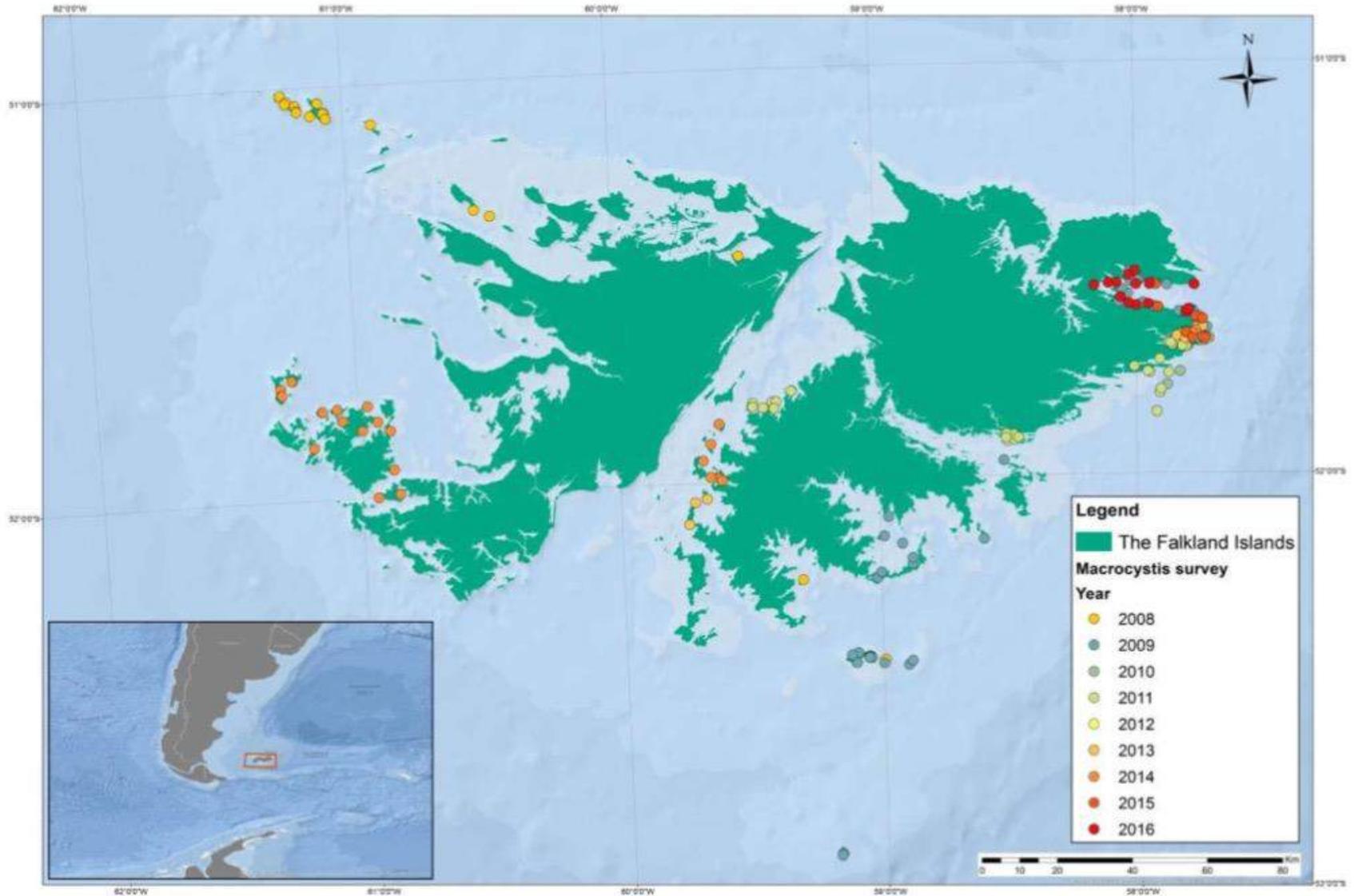


## Kelp/No Kelp

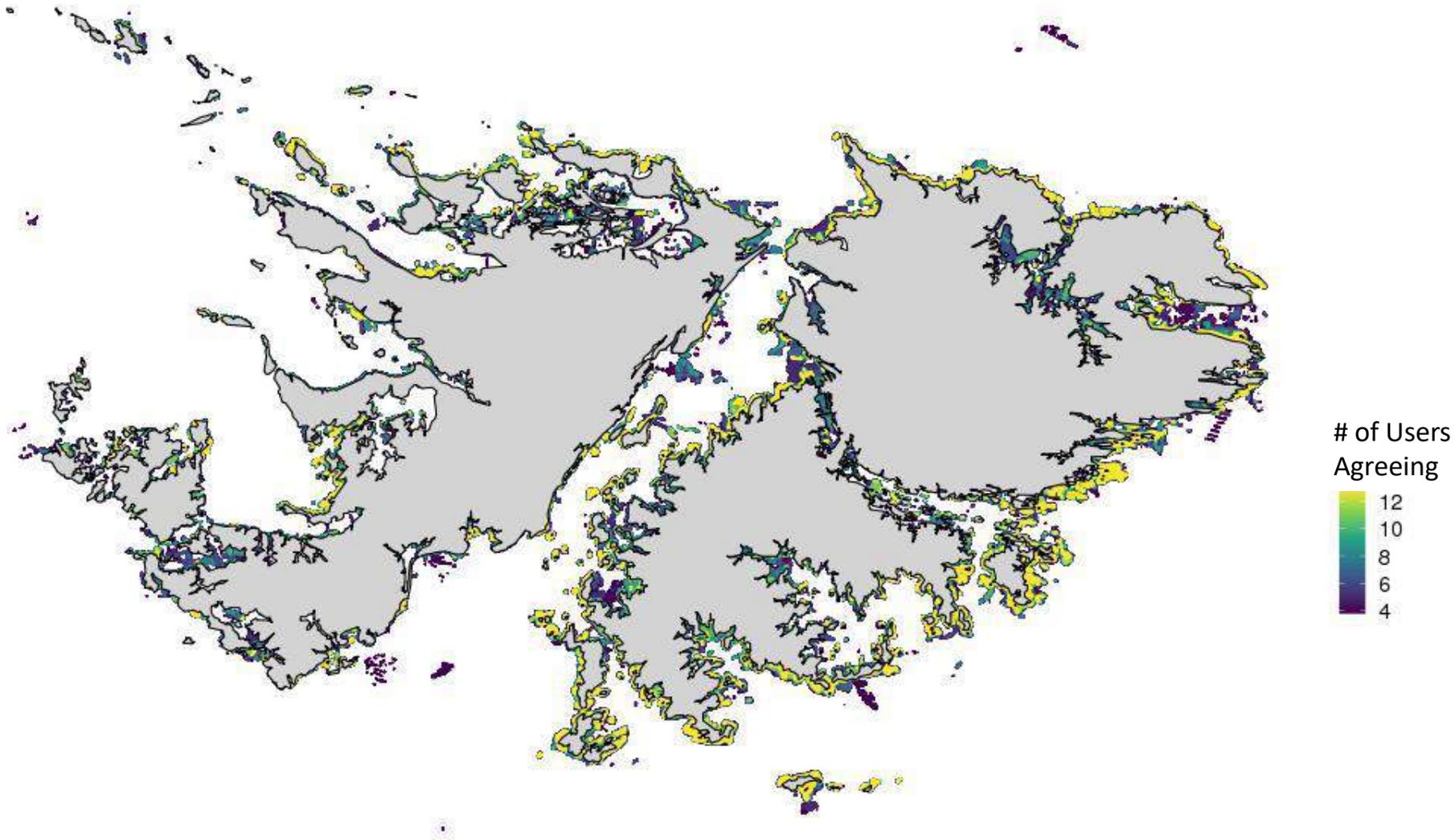


Zooniverse mobile app!

# Our test-case: The Falklands Islands

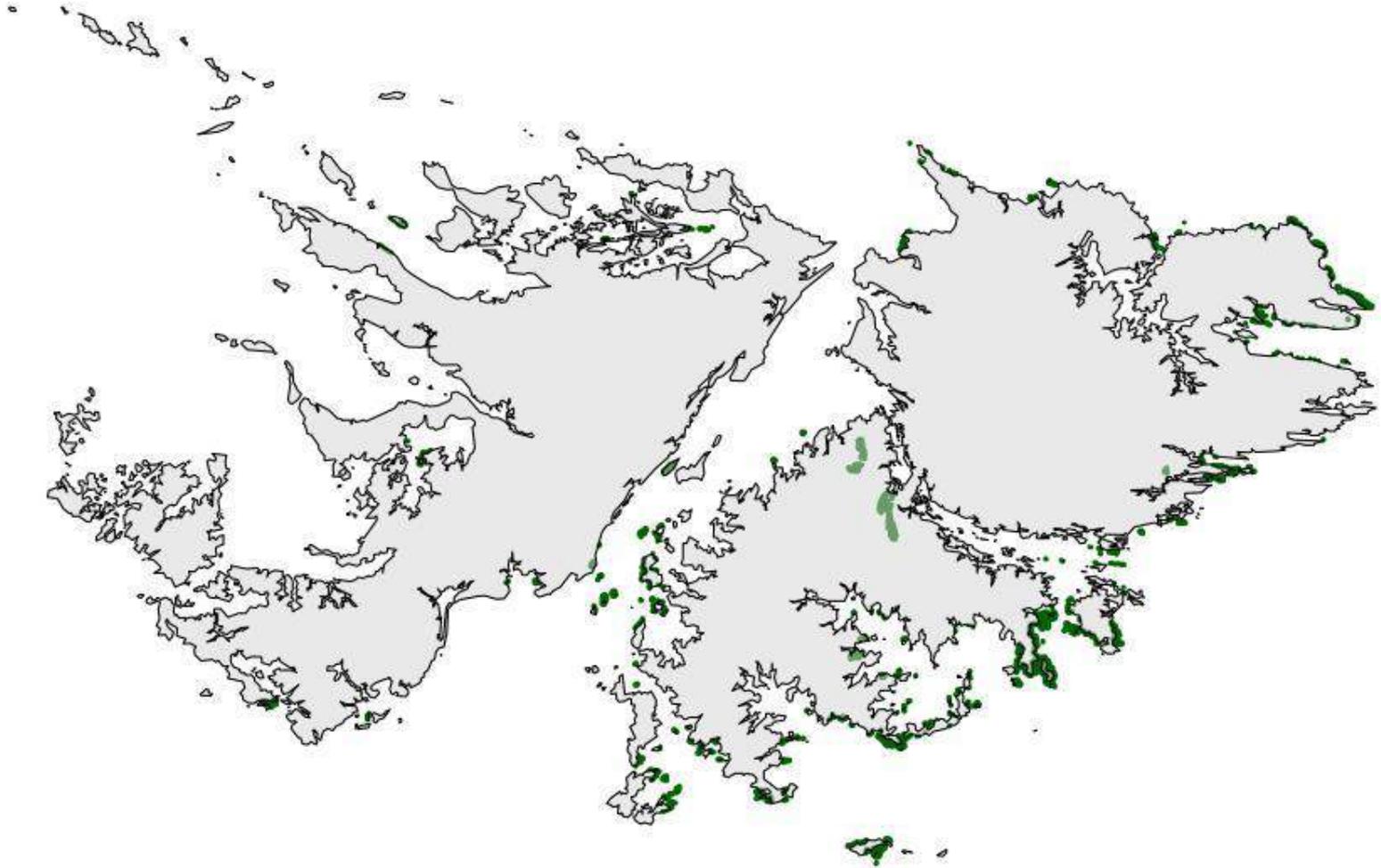


# Our Consensus Map of Falklands Kelp Forests



# Seasonality from Citizen Science

Austral Winter



# Immediate Application: Carbon Markets in the Falklands

2030 Scenario	Carbon value (USD ton <sup>-1</sup> CO <sub>2</sub> e)	Standing stock (million USD)	Sequestered year <sup>1</sup> (Million USD)
Trading price UK * <sup>1</sup>	99.77	21.71	23.84
SCC for 'business as usual' (BAU) emissions scenario * <sup>2</sup>	51.60	11.23	12.33
SCC for 2.5 degree maximum warming scenario * <sup>2</sup>	351.00	76.39	83.88
SCC (Stern) * <sup>3</sup>	376.20	81.88	89.90
Average value	219.64	47.81	52.49



From Bayley et al. 2017 - Giant kelp 'Blue carbon' storage and sequestration value in the Falkland Islands.

# A Landsat Citizen Science Interface for YOU!



PROJECT #2864

View project

Project details

About

Collaborators

Field guide

Tutorial

Media

Visibility

Talk

Data Exports

Workflows

Subject Sets

NEED SOME HELP?

Read a tutorial

Ask for help on talk

Glossary

OTHER ACTIONS

Delete this project

Input the basic information about your project, and set up its home page.

## Avatar



Pick a logo to represent your project. To add an image, either drag and drop or click to open your file viewer. For best results, use a square image of not more than 50 KB.

## Background image



This image will be the background for all of your project pages, including your project's front page. To add

## NAME

Floating Forests

You cannot change a live project's name. Your project's URL is </projects/zooniverse/floating-forests>

## DESCRIPTION

DISCOVER FLOATING FORESTS

This should be a one-line call to action for your project that displays on your landing page. Some volunteers will decide whether to try your project based on reading this, so try to write short text that will make people actively want to join your project. 275 of 300 characters remaining.

## INTRODUCTION



We are trying to understand how forests of kelp grow and change over time. We need your help to find these forests in pictures from space!

Add a brief introduction to get people interested in your project. This will display on your landing page. 1362 of 1500 characters remaining.

## WORKFLOW DESCRIPTION

# From Landsat to Citizen Science Projects Seamlessly

- Containerized web service to take in KML files and query ESPA for imagery
- Building image filtering/modifying interface
- Our UI designer starts on Monday!



**WE WANT YOU!**

# The Future of Floating Forests



*Kelp on the Edge*



*Kelp in the City*

# The Floating Forests Team



Jarrett E.K. Byrnes, Kyle C. Cavanaugh, Alison J. Haupt, Laura Trouille, Isaac Rosenthal, Thomas W. Bell, Andrew Rassweiler, Alejandro Pérez-Matus, Jorge Assis, Claire Butler, Briana Harder



# Integrating Floating Forests into the Classroom at CSUMB

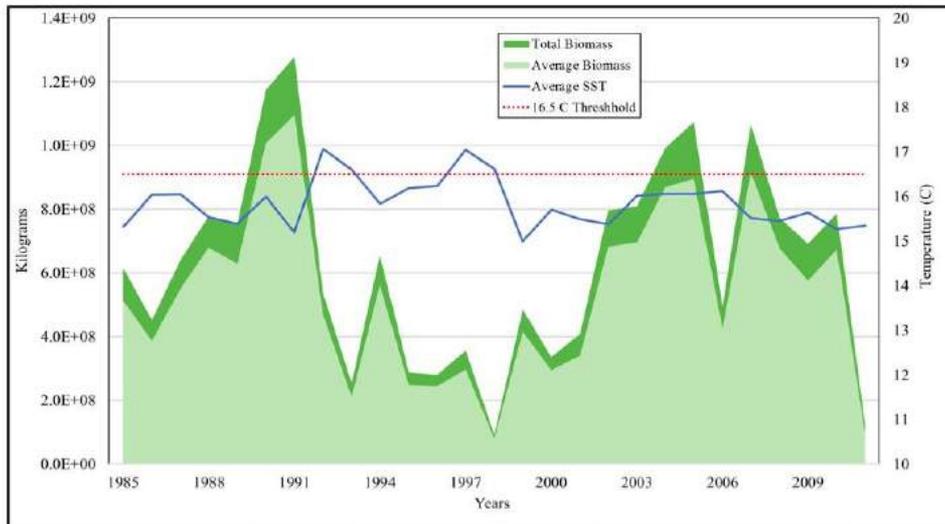


Figure 4. A visual comparison between the total biomass (Kg), average biomass (Kg) and average SST ( $^{\circ}$ C) (plotted on secondary y axis) per year for all sites, for the sample time of 1985-2011, along the Eastern Pacific coastline.

