

Mapping Floating Aquatic Vegetation (Kelp) with Imaging Spectroscopy at Spatial Scales from 4 to 60 m using Linear Spectral Mixture Modeling



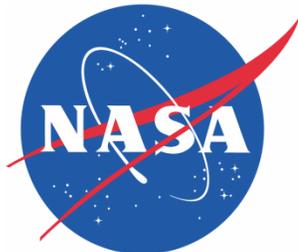
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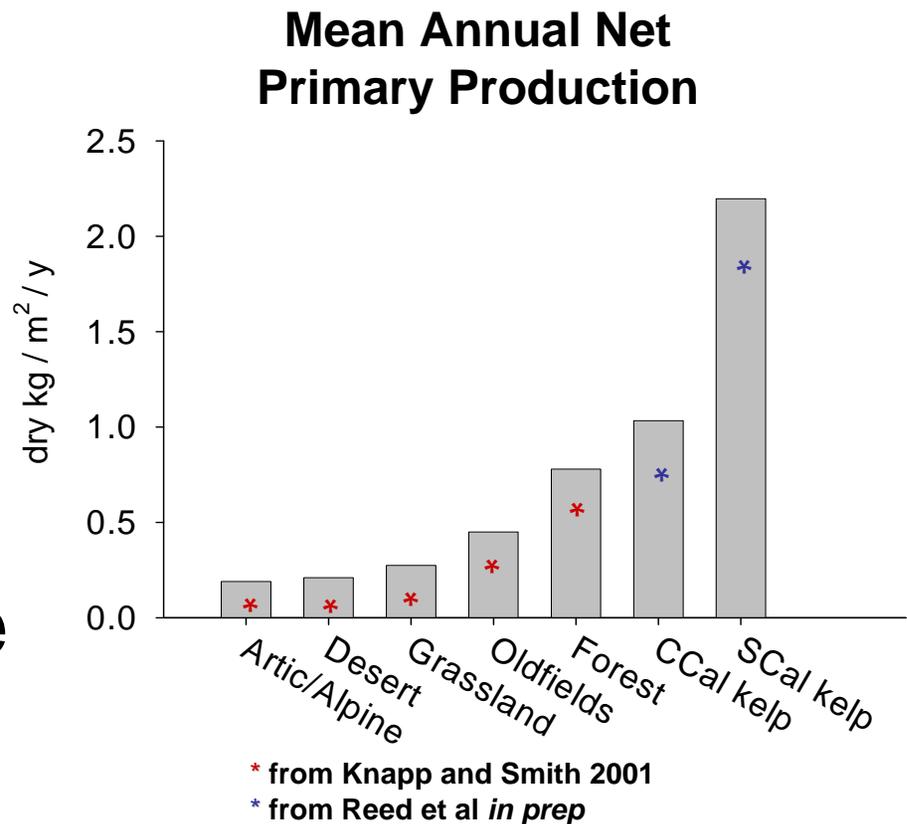
Mapping Floating Aquatic Vegetation using HypsIRI?

- The HypsIRI VSWIR sensor will likely have a 60 m spatial resolution
- This is a relatively coarse spatial resolution for mapping floating aquatic vegetation
- Reference data, airborne remote sensing and spaceborne remote sensing span a wide range of spatial resolutions
- **We need to investigate methods for mapping FAV that will work well across this range of spatial resolutions**



Giant Kelp (*Macrocystis pyrifera*)

- Found on shallow sub-tidal temperate reefs throughout the world
- Very high productivity
- High economic and ecological importance



Santa Barbara Coastal LTER

- Long Term Ecological Research site founded in 2000 to investigate ecological processes of giant kelp forests
- AVIRIS data
 - Acquired August 12, 2007
 - 4.3 m spatial resolution (Twin Otter)
 - Can be resampled to coarser spatial resolutions



SBC LTER

Santa Barbara Coastal LTER AVIRIS Data



UCSB

Santa Barbara

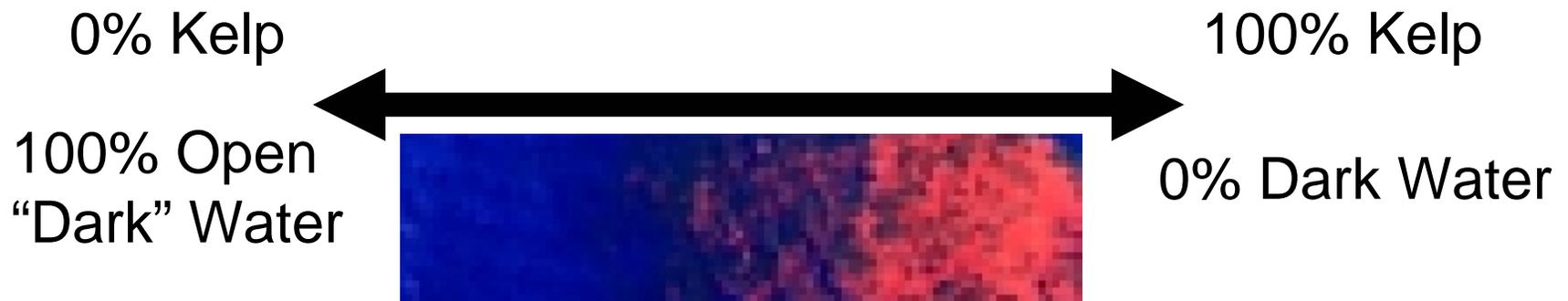
Carpinteria

← 35 km →



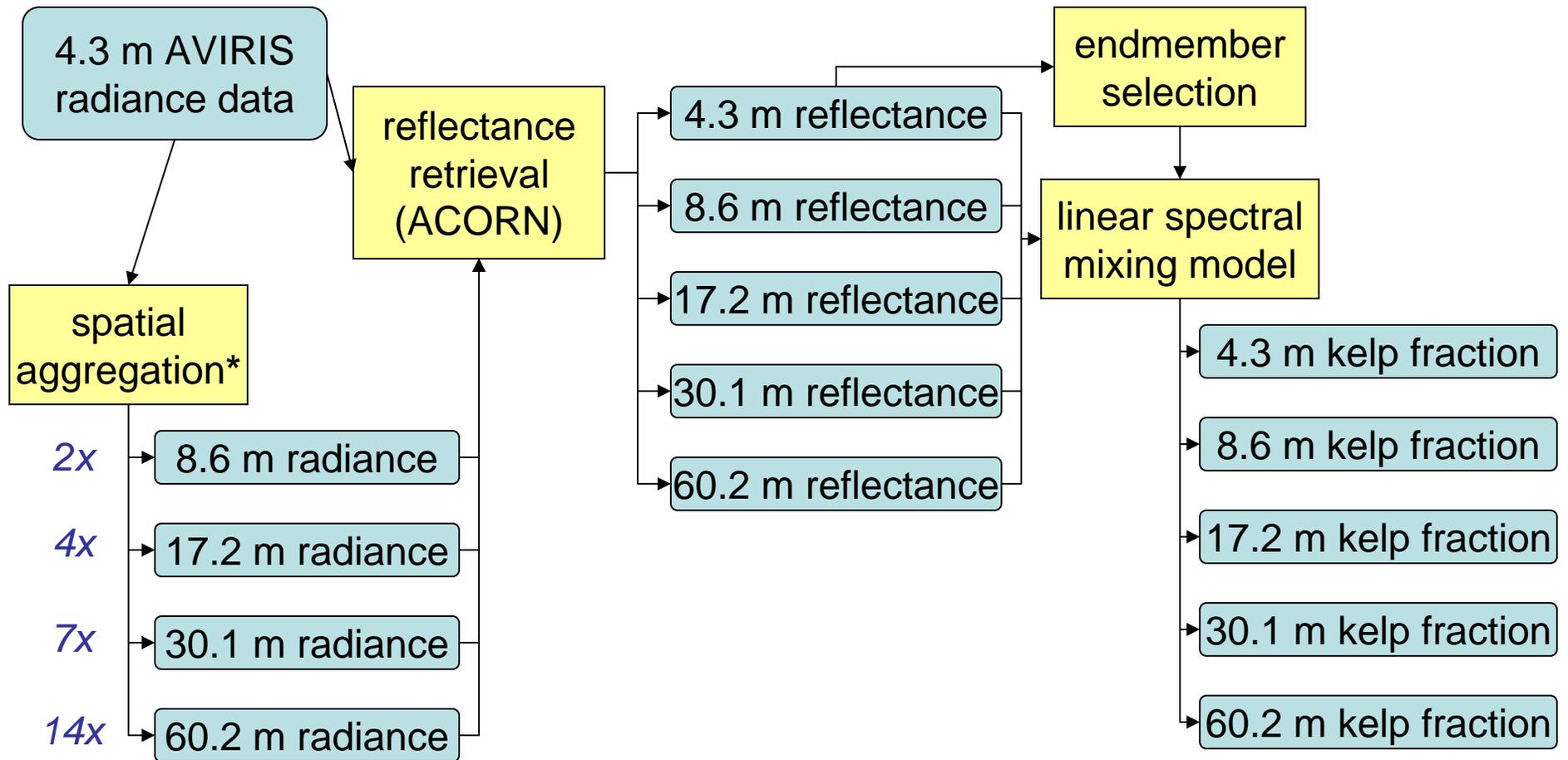
Methods

- Linear spectral mixture analysis
 - Models image spectra as a combination of two or more endmembers

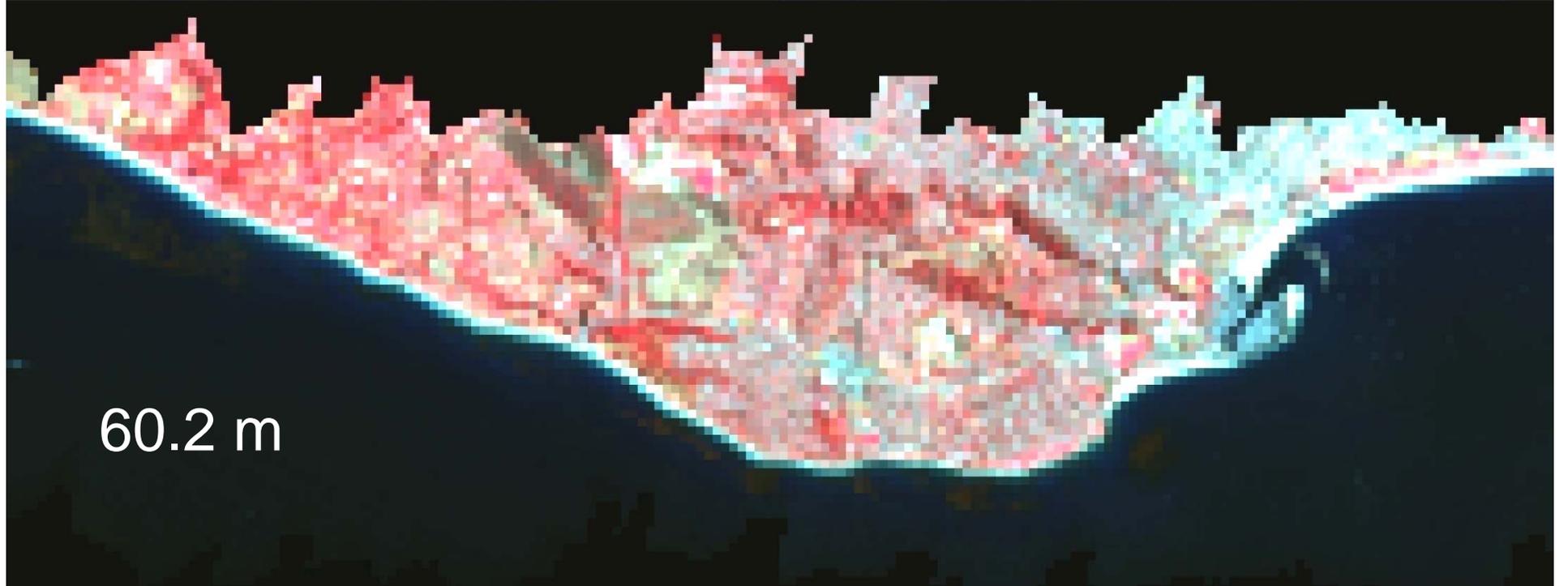


- **Is kelp fraction modeled by linear spectral mixture analysis consistent over a wide range of spatial scales?**

Kelp Fraction Modeling Methodology



*equal weighting

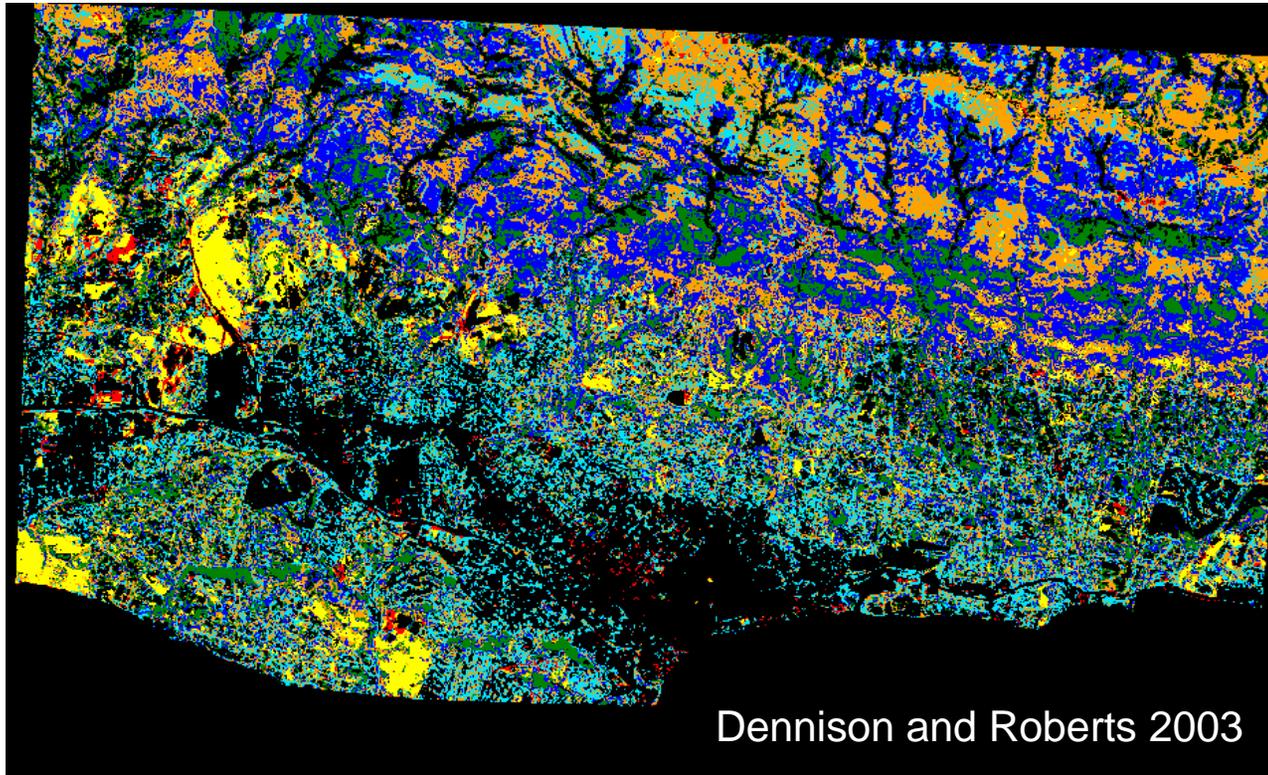


Endmember Selection

- Kelp endmember candidate endmembers
 - 25 high NDVI and/or high NIR reflectance pixels selected at 4.3 m spatial resolution
- Dark water candidate endmembers
 - 15 low albedo pixels selected at 4.3 m resolution
- A “training” spectral library was constructed using transects across several areas of varying kelp cover (312 spectra total)

Endmember Selection

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- All e end use
- The the libra AVI



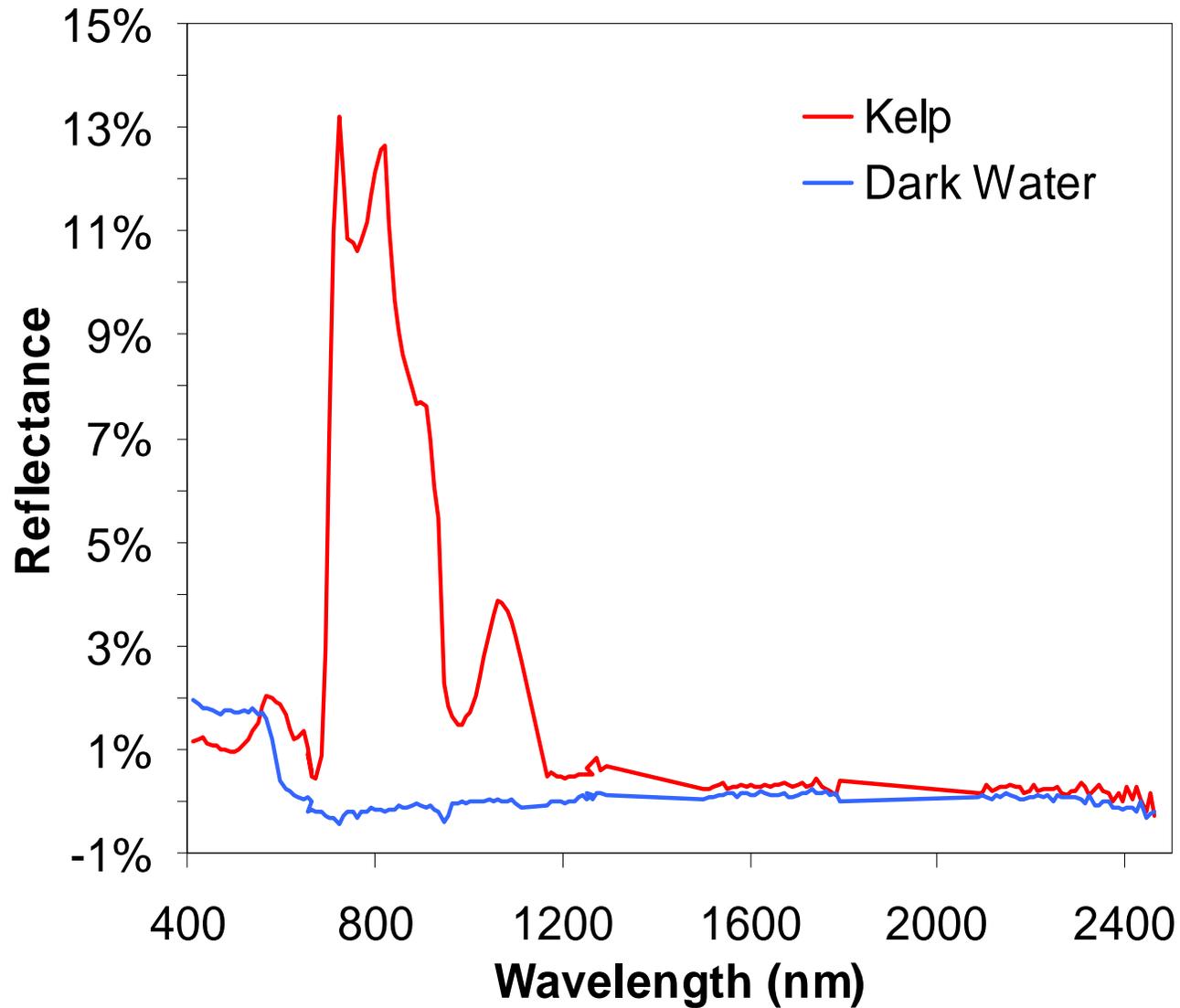
Orange	<i>Adenostoma fasciculatum</i>	Green	<i>Quercus agrifolia</i>
Blue	<i>Ceanothus megacarpus</i>	Yellow	Grass
Cyan	<i>Arctostaphylos spp.</i>	Red	Soil

dark

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Selected Endmembers

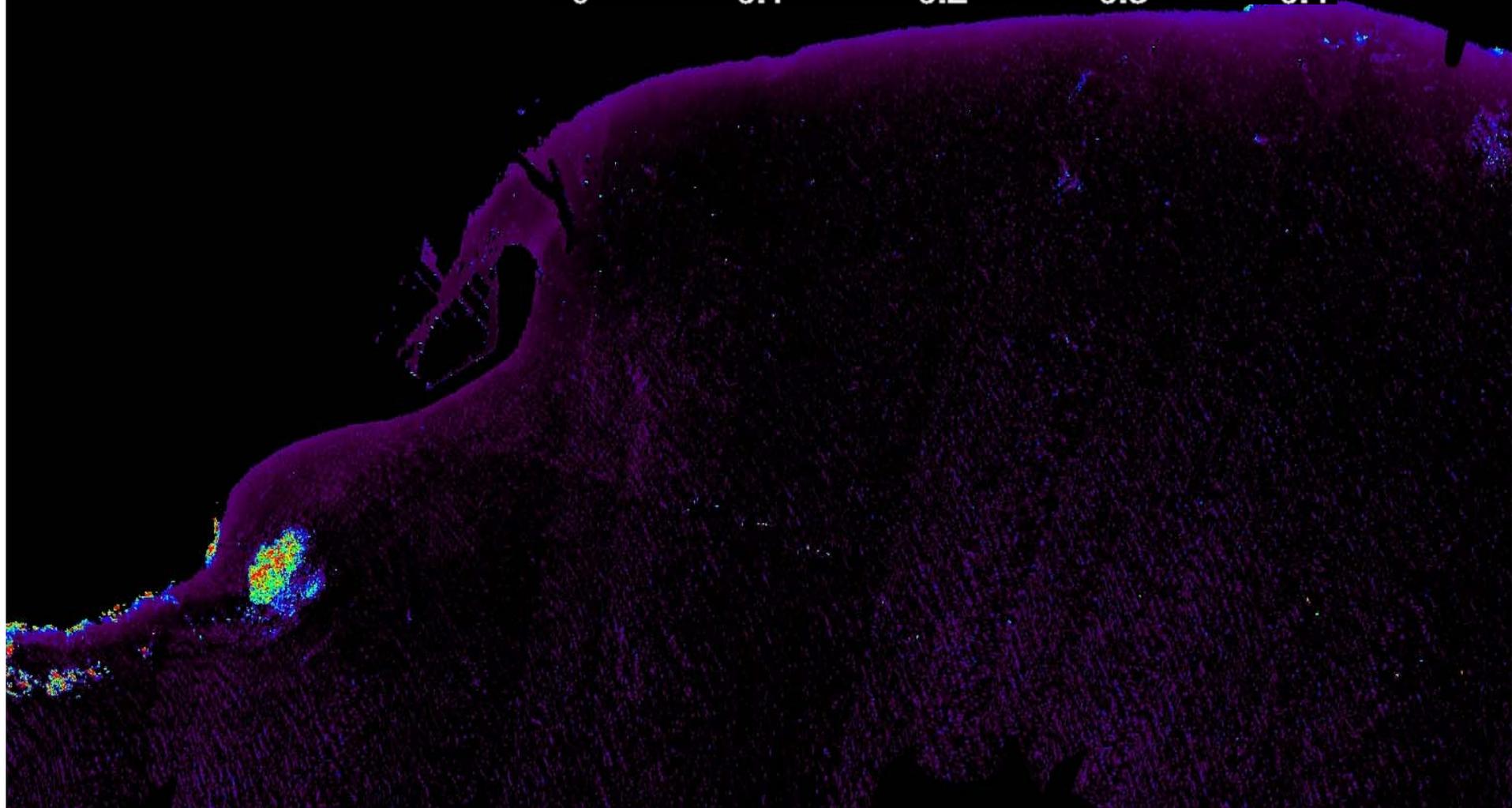
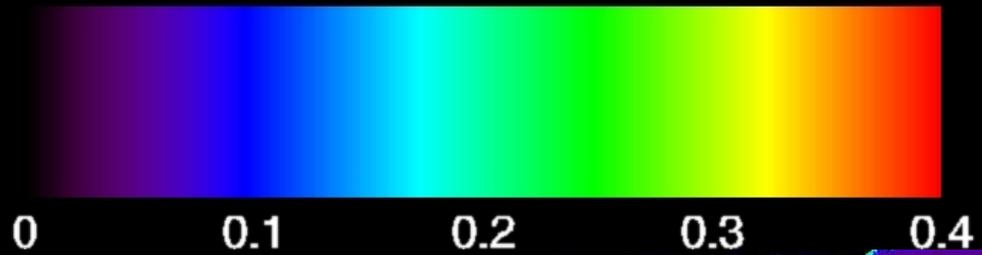


Kelp Fraction Modeling

- Kelp and Dark Water endmembers were used to model images at all spatial resolutions
- Two thresholds were used to screen out non-water/non-kelp pixels
 - 1% SWIR reflectance threshold
 - 0.5% RMSE threshold (indicates poor model fit)

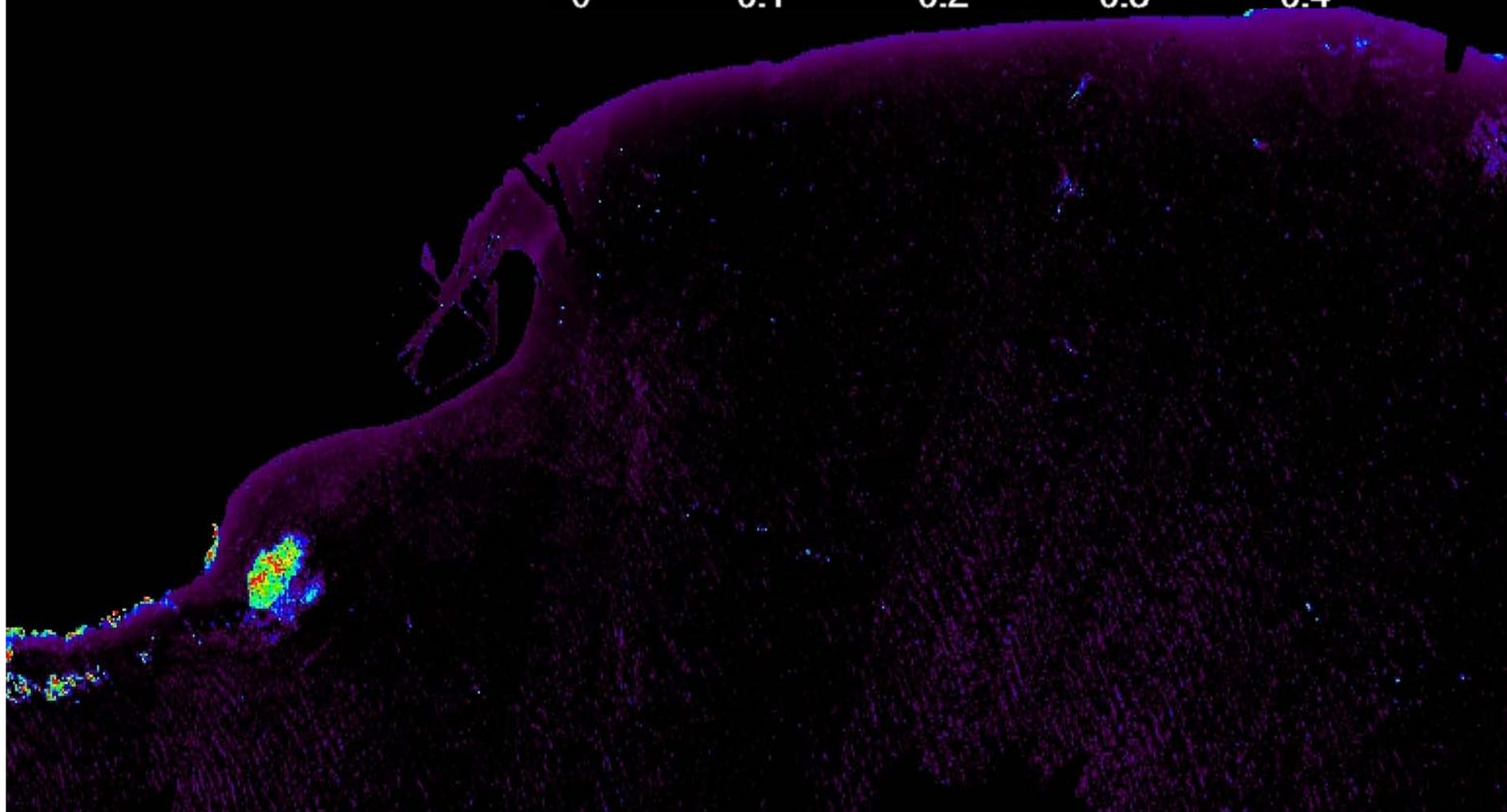
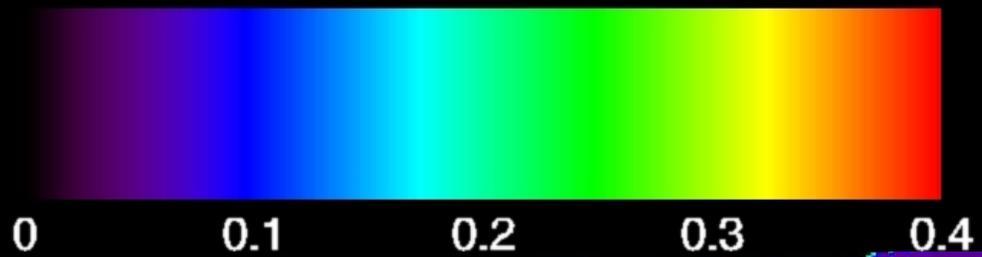
4.3 m

Kelp Fraction



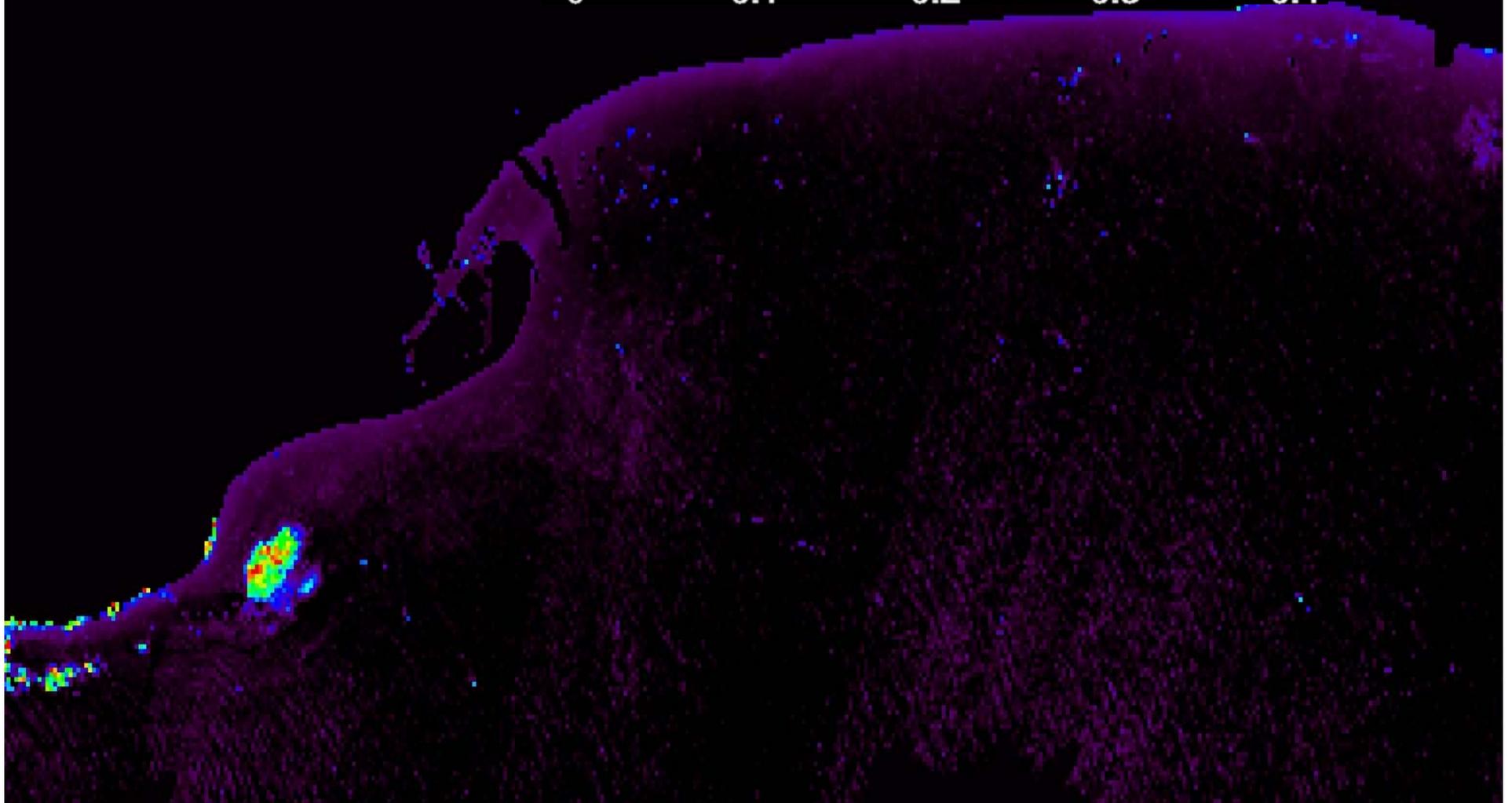
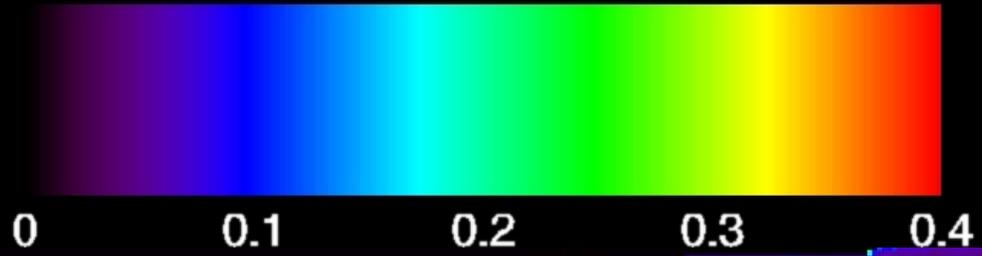
8.6 m

Kelp Fraction



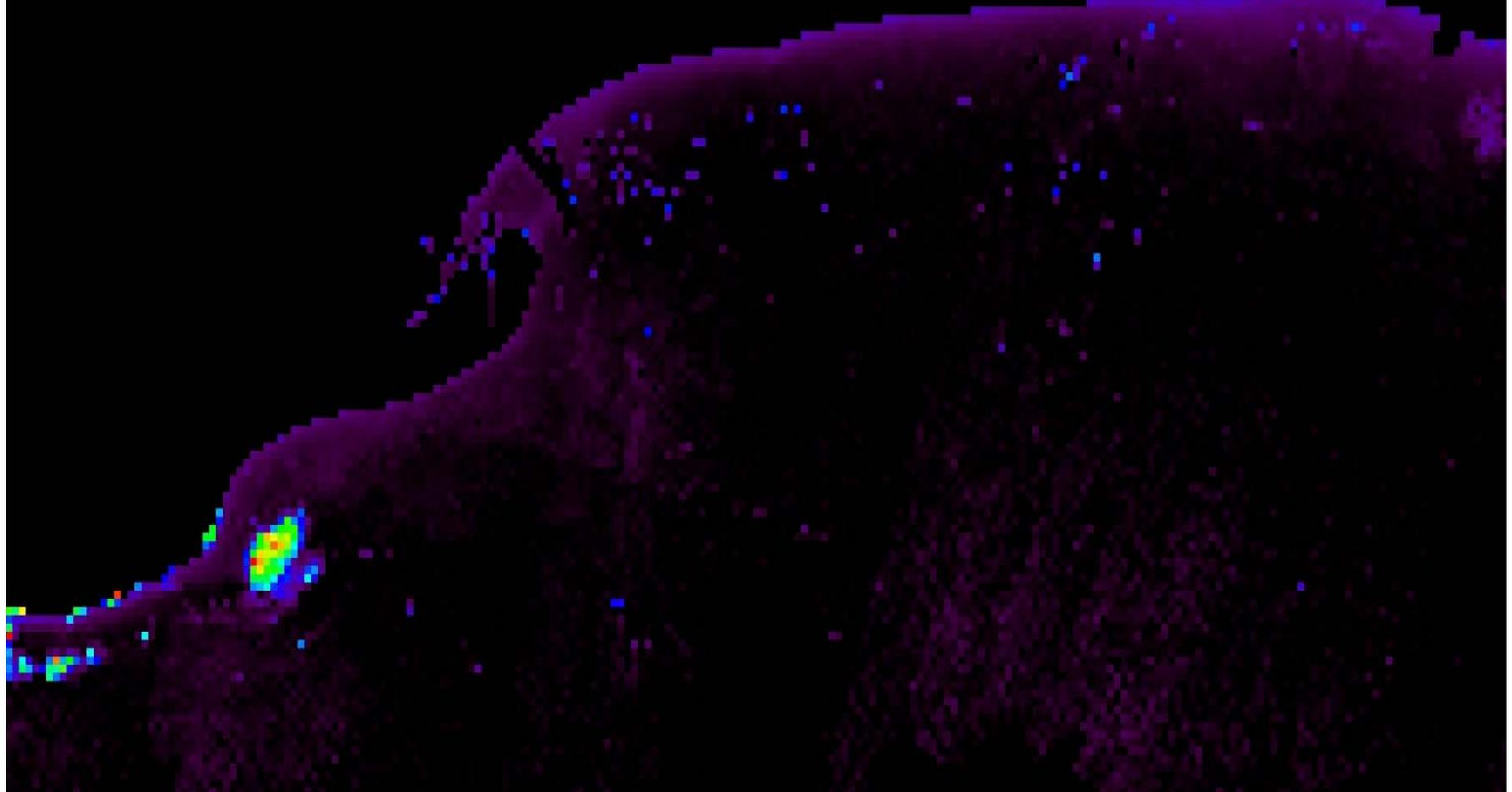
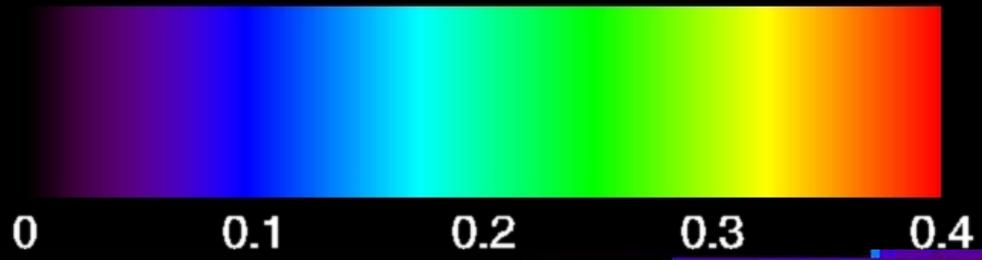
17.2 m

Kelp Fraction



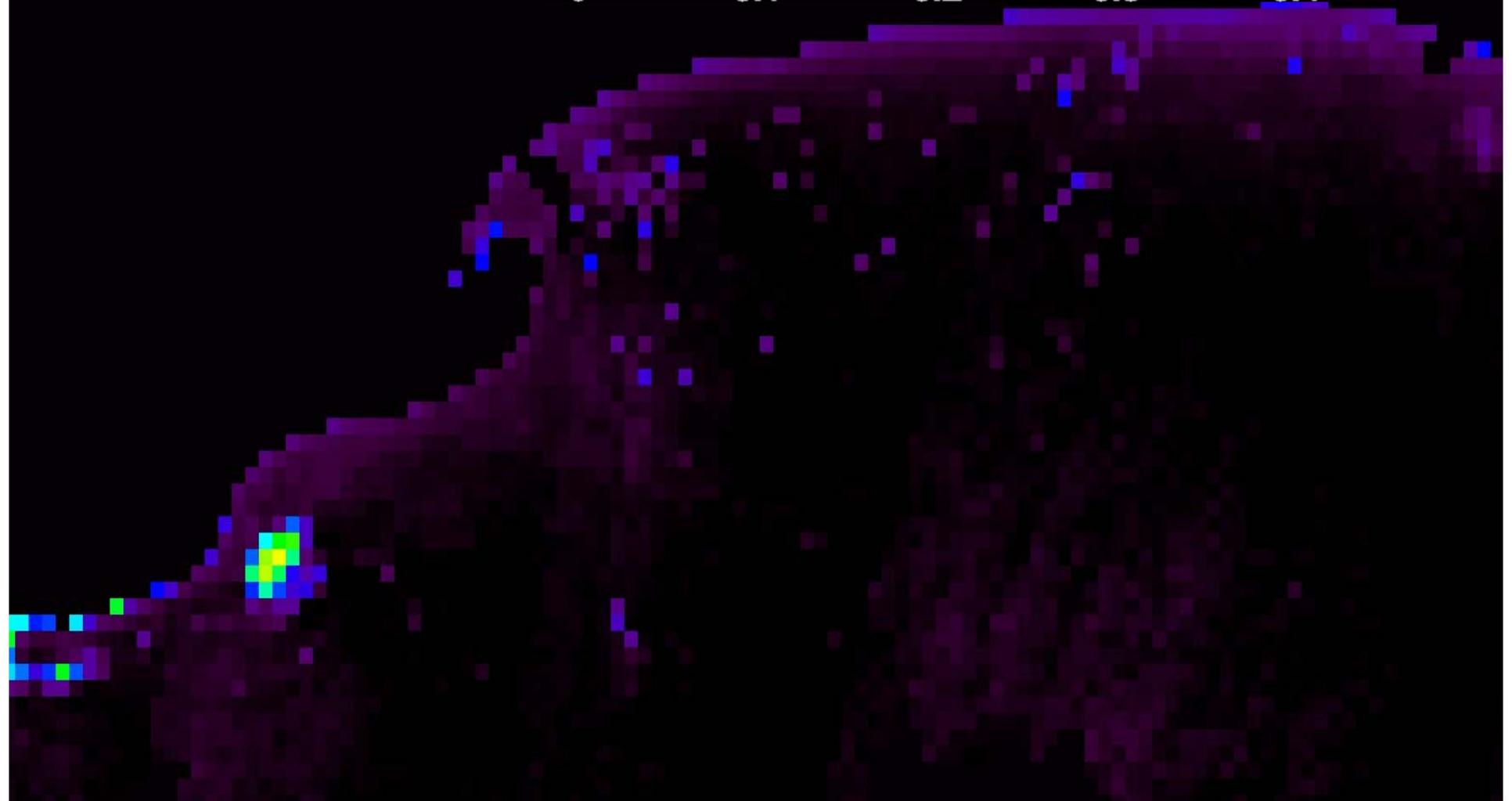
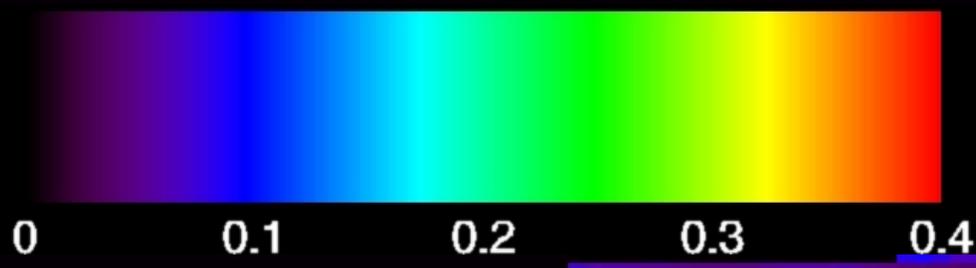
30.1 m

Kelp Fraction



60.2 m

Kelp Fraction

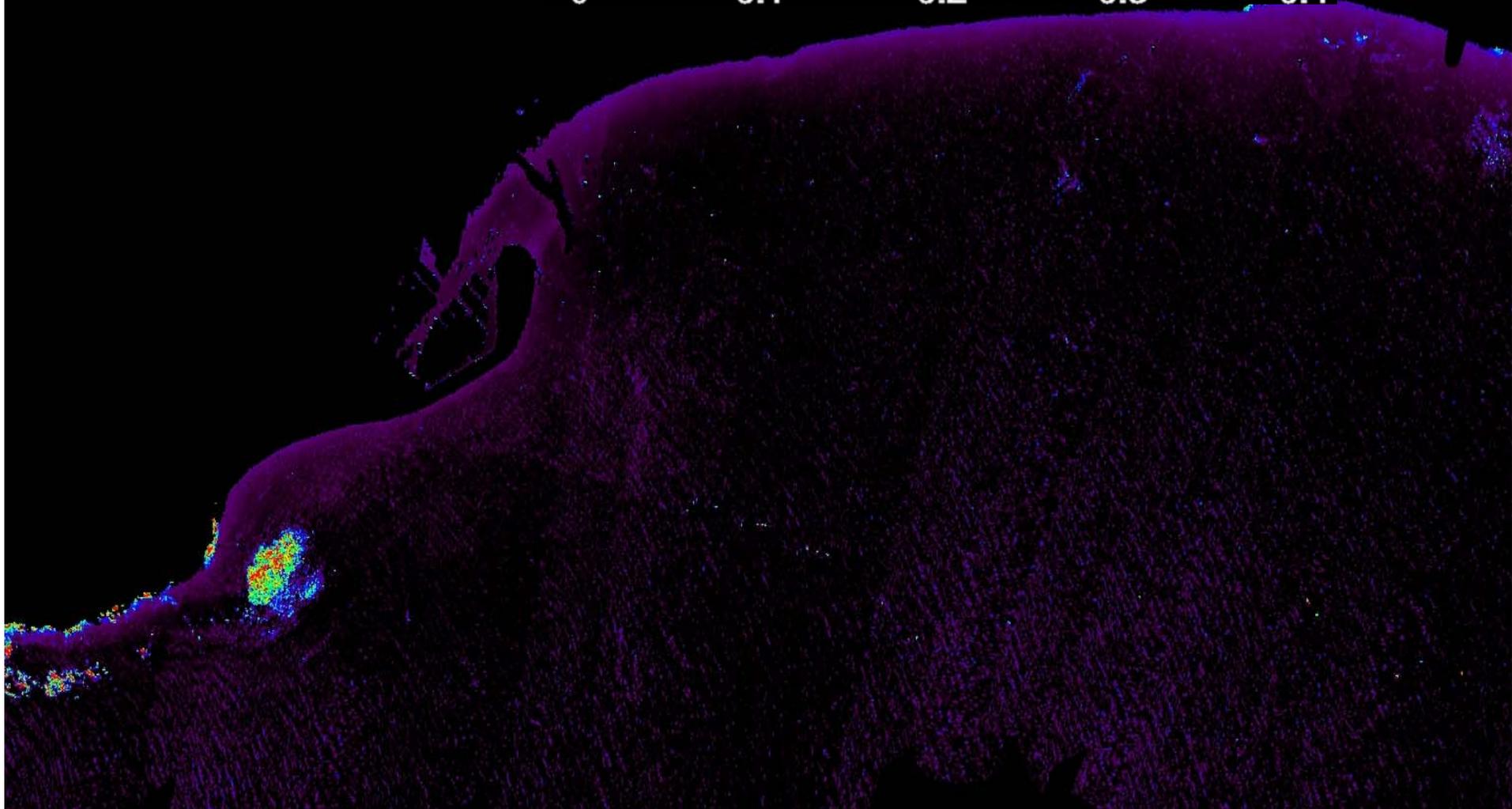
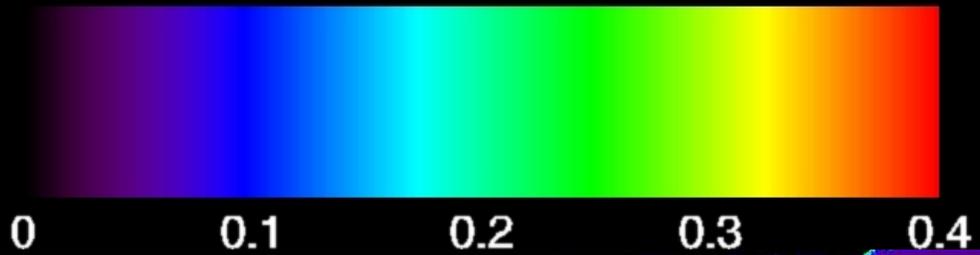


Kelp Fraction Scaling Comparison

- 4.3 m kelp fraction can be averaged up to 60.2 m spatial resolution
- The scaled 4.3 m kelp fraction can then be compared against 60.2 m kelp fraction

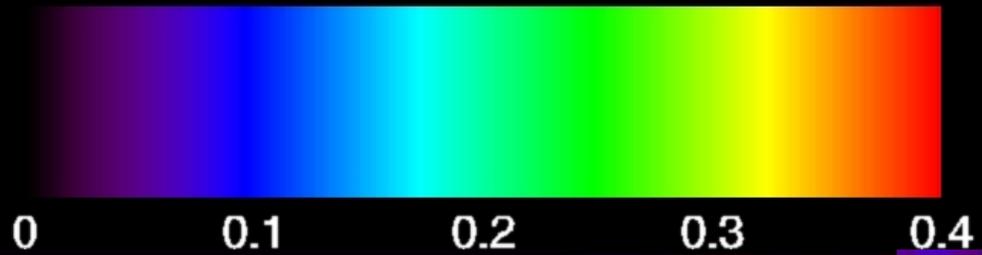
4.3 m

Kelp Fraction



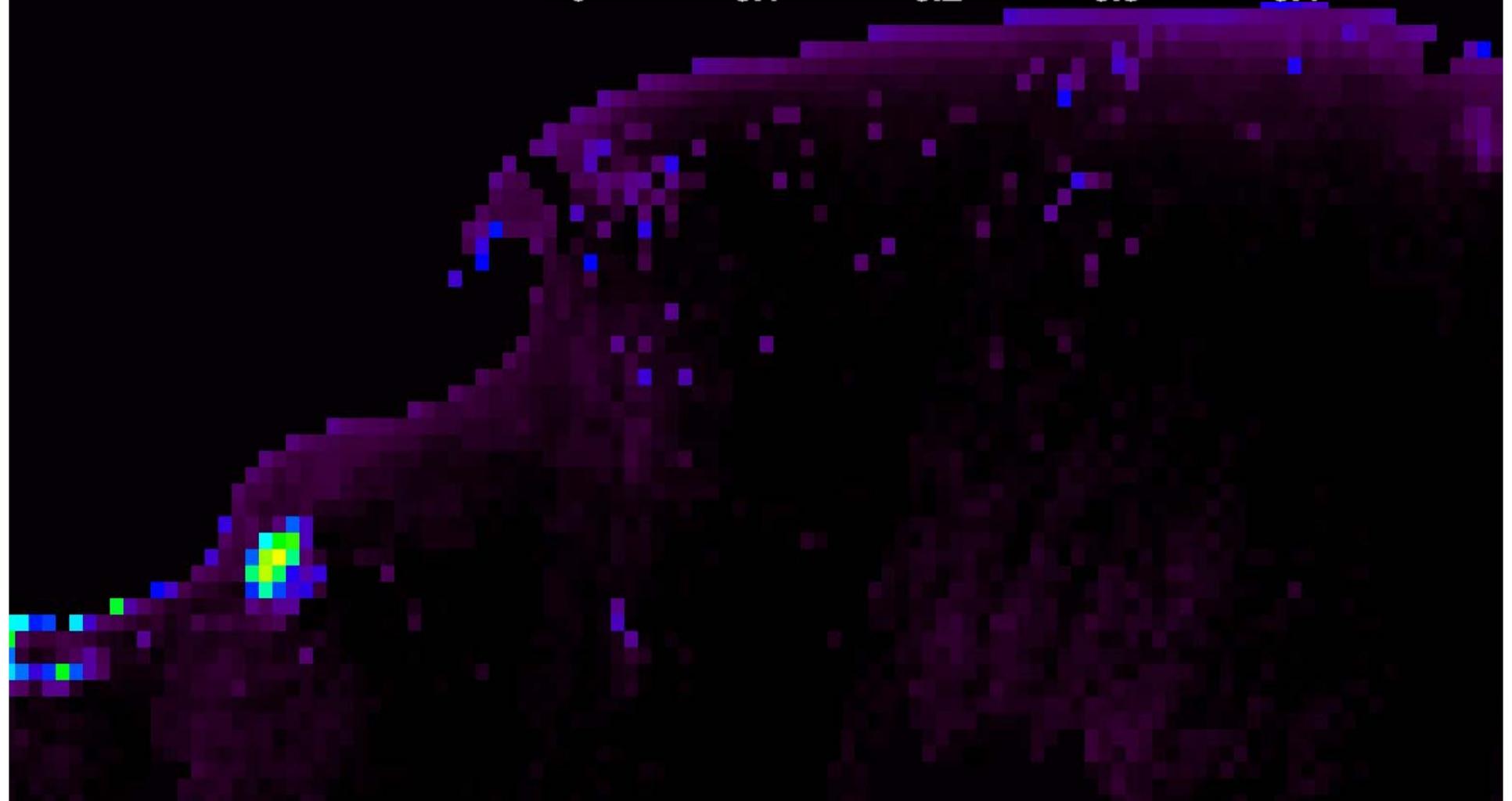
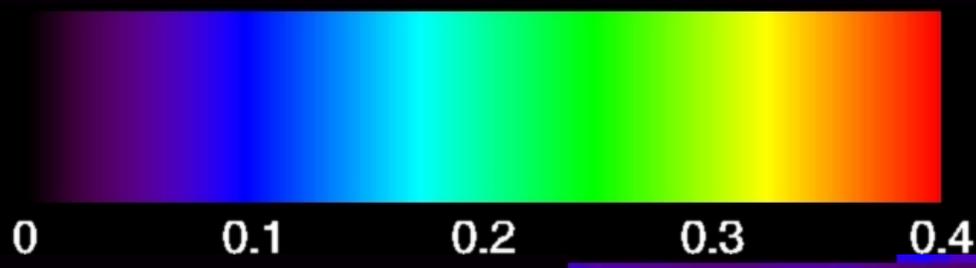
4.3 m rescaled
to 60.2 m

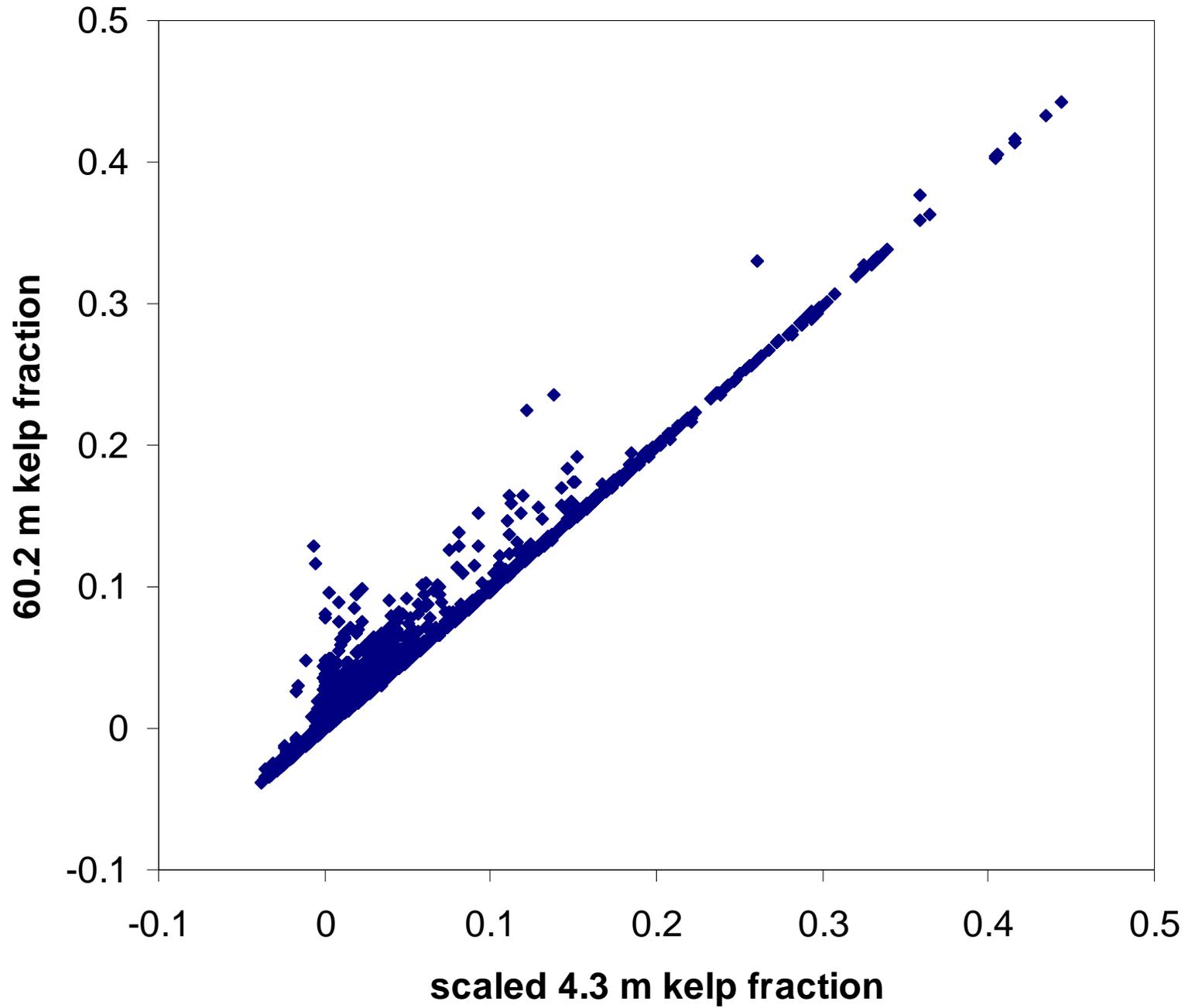
Kelp Fraction

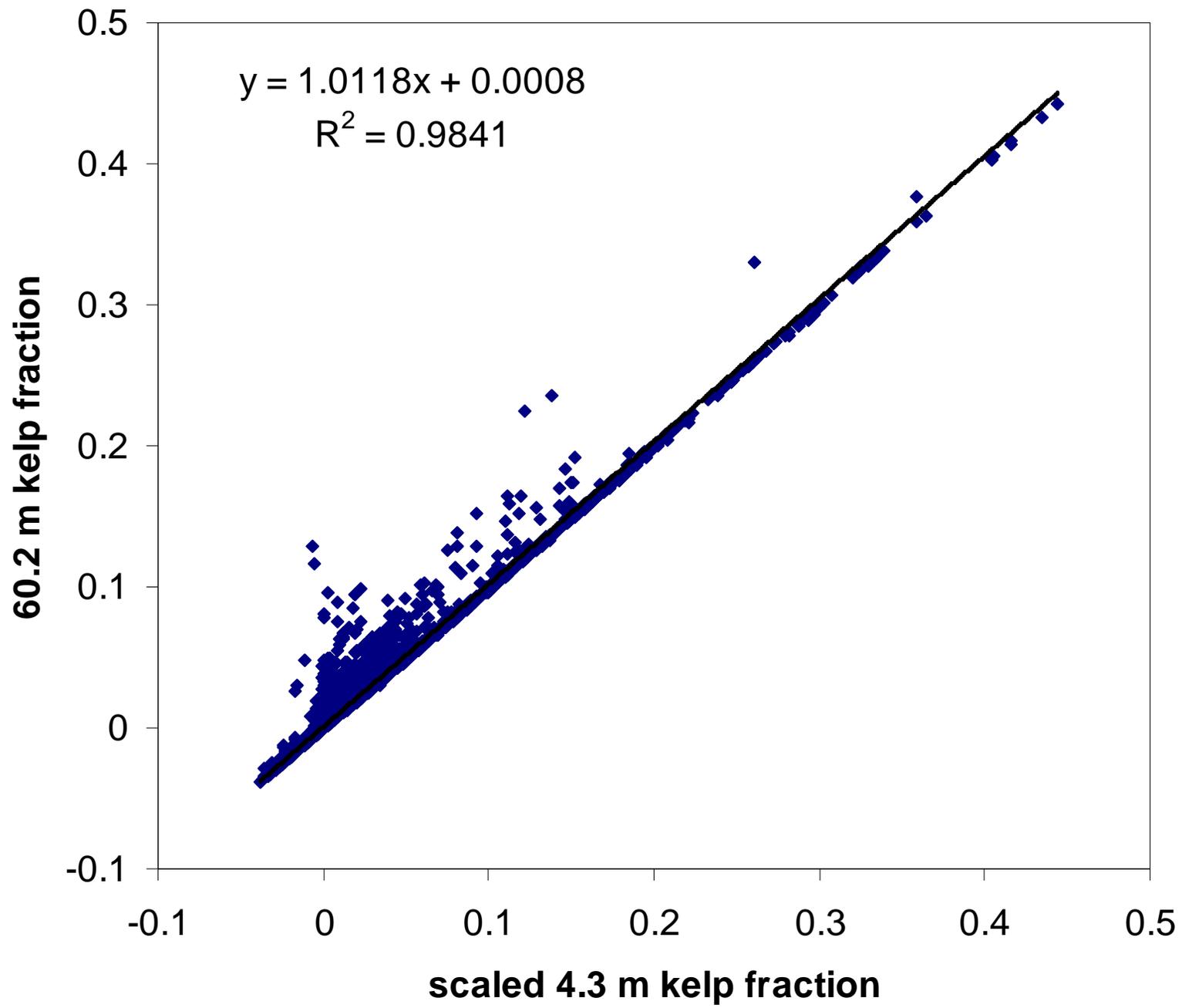


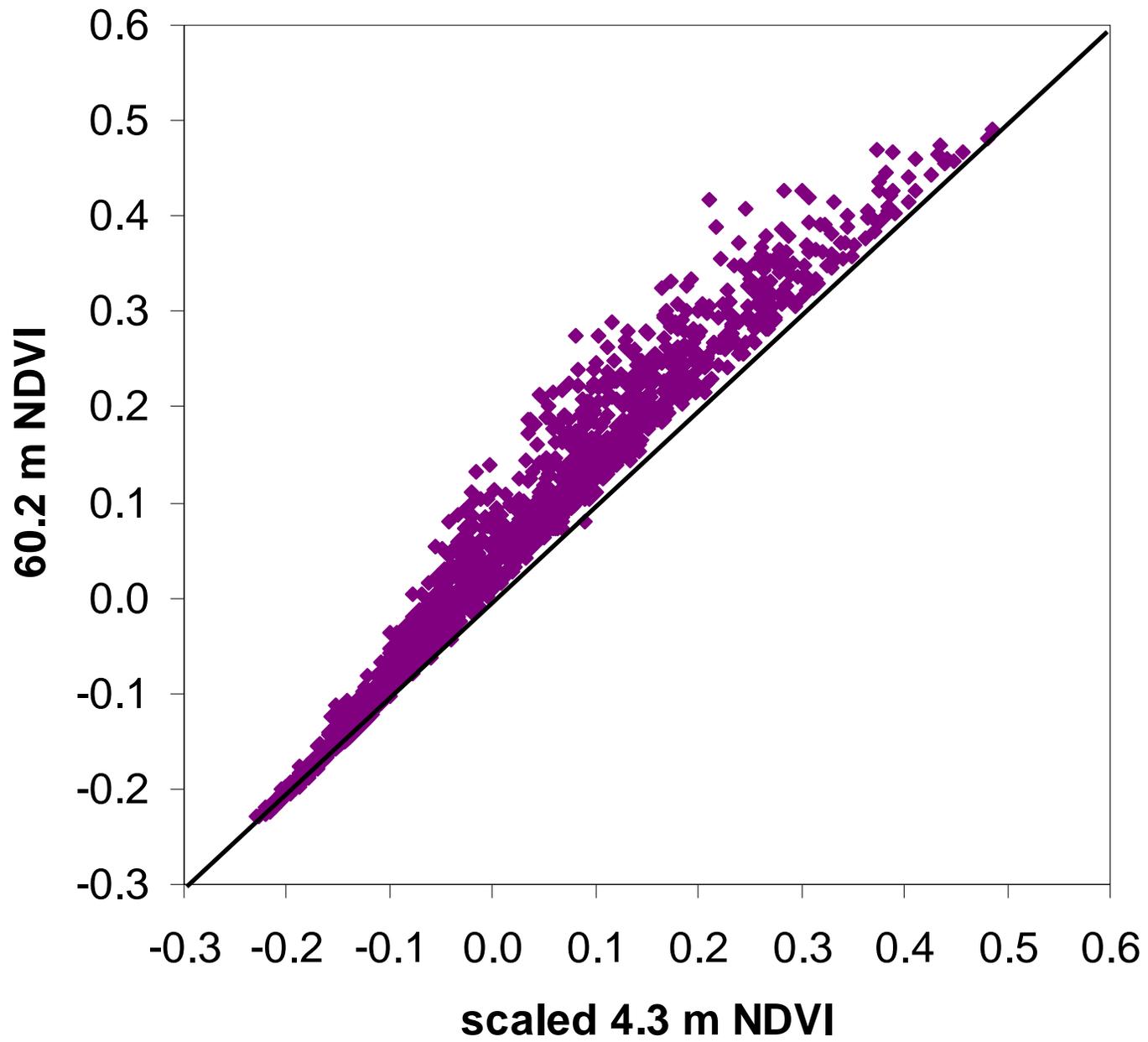
60.2 m

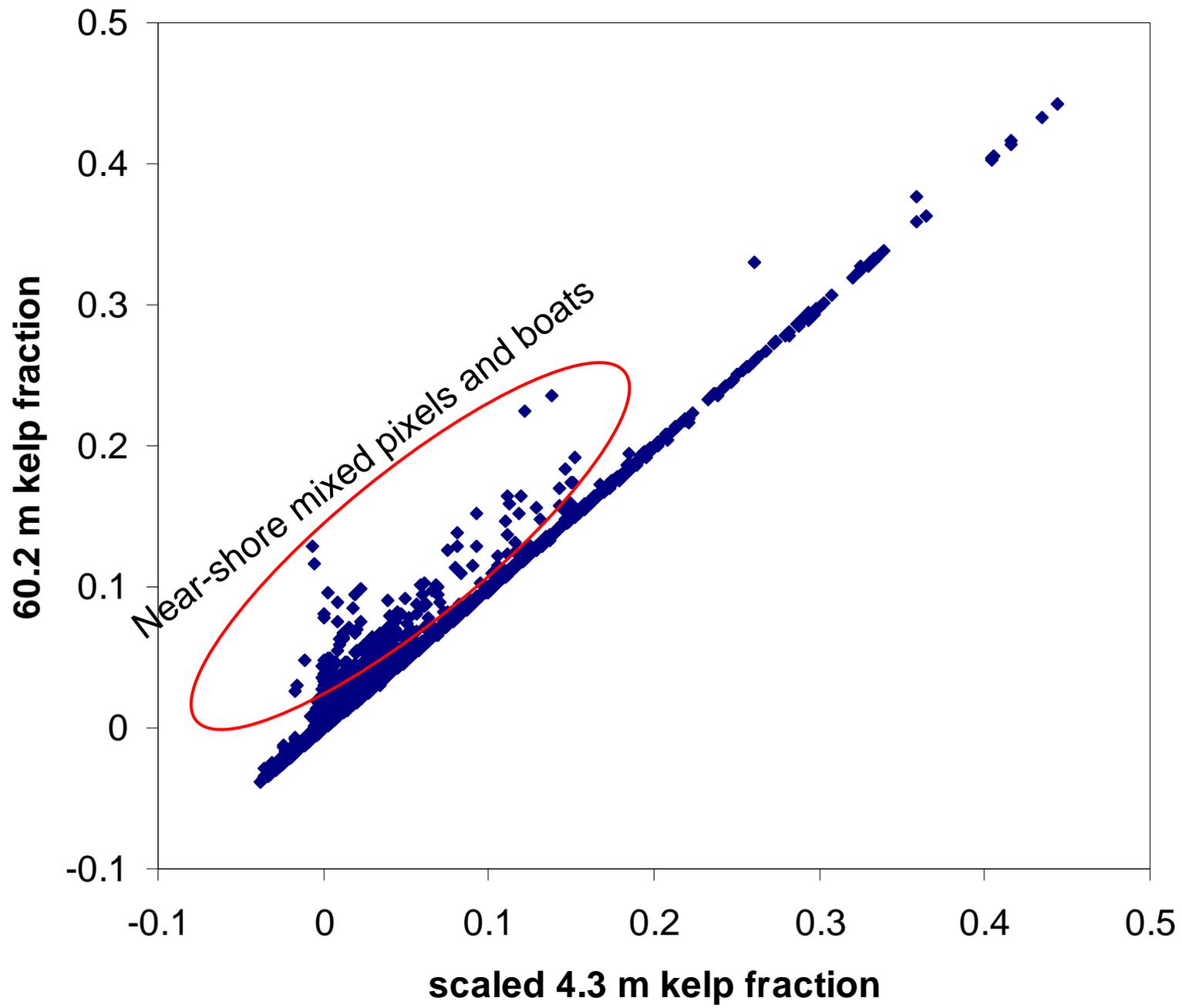
Kelp Fraction





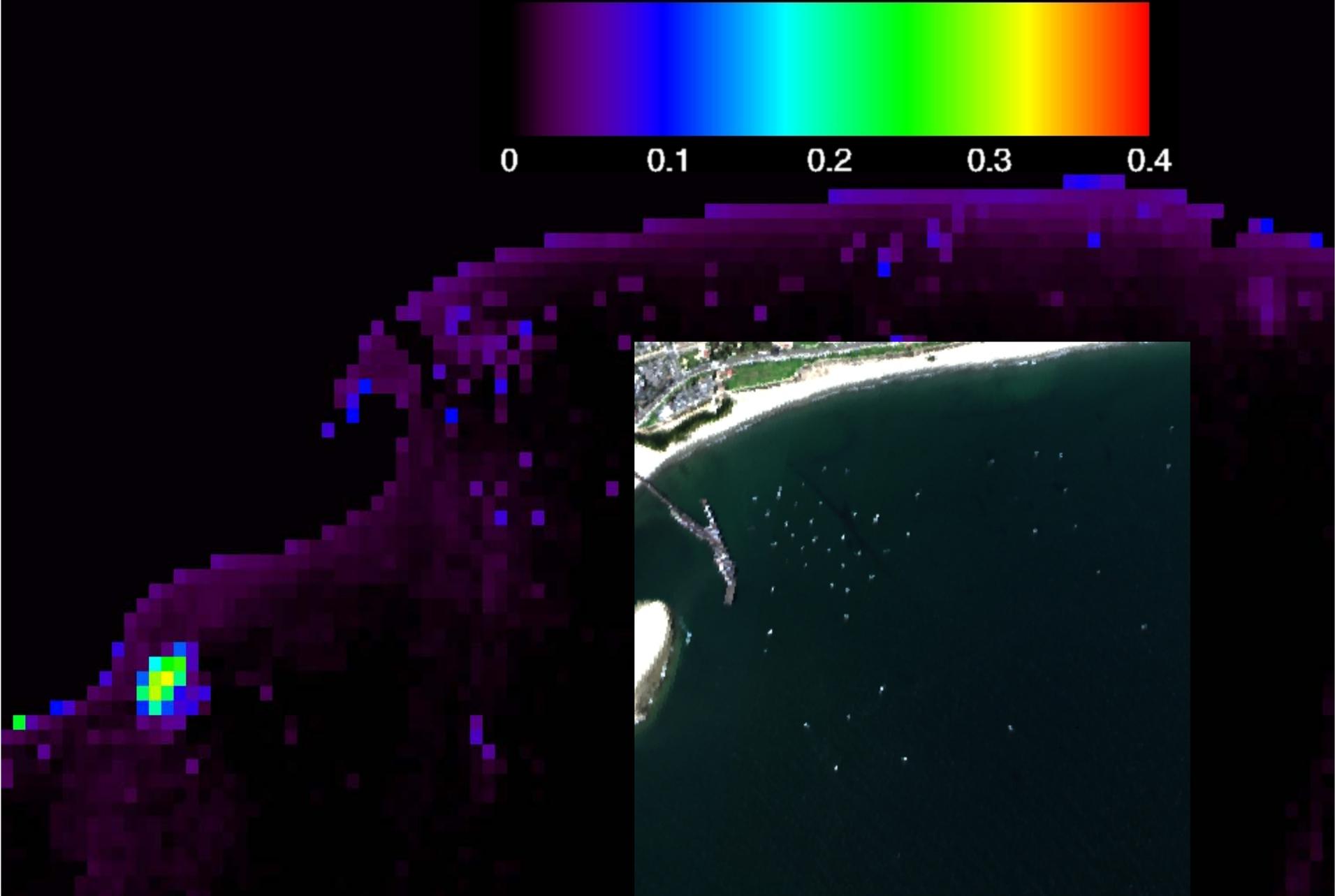
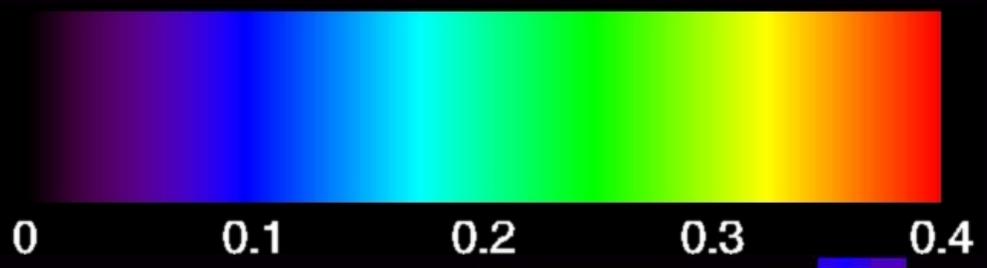






60.2 m

Kelp Fraction



Scaling Comparison

- At 60.2 m spatial resolution, 41472 pixels were modeled with a kelp fraction

Kelp Fraction Difference (60.2 m vs. scaled 4.3 m)	% of All Pixels w/ Kelp Fraction
<10%	99.99%
<5%	99.93%
<3%	99.77%
<1%	99.22%

- However, these percentages are inflated by a large number of open water pixels that do not contain kelp

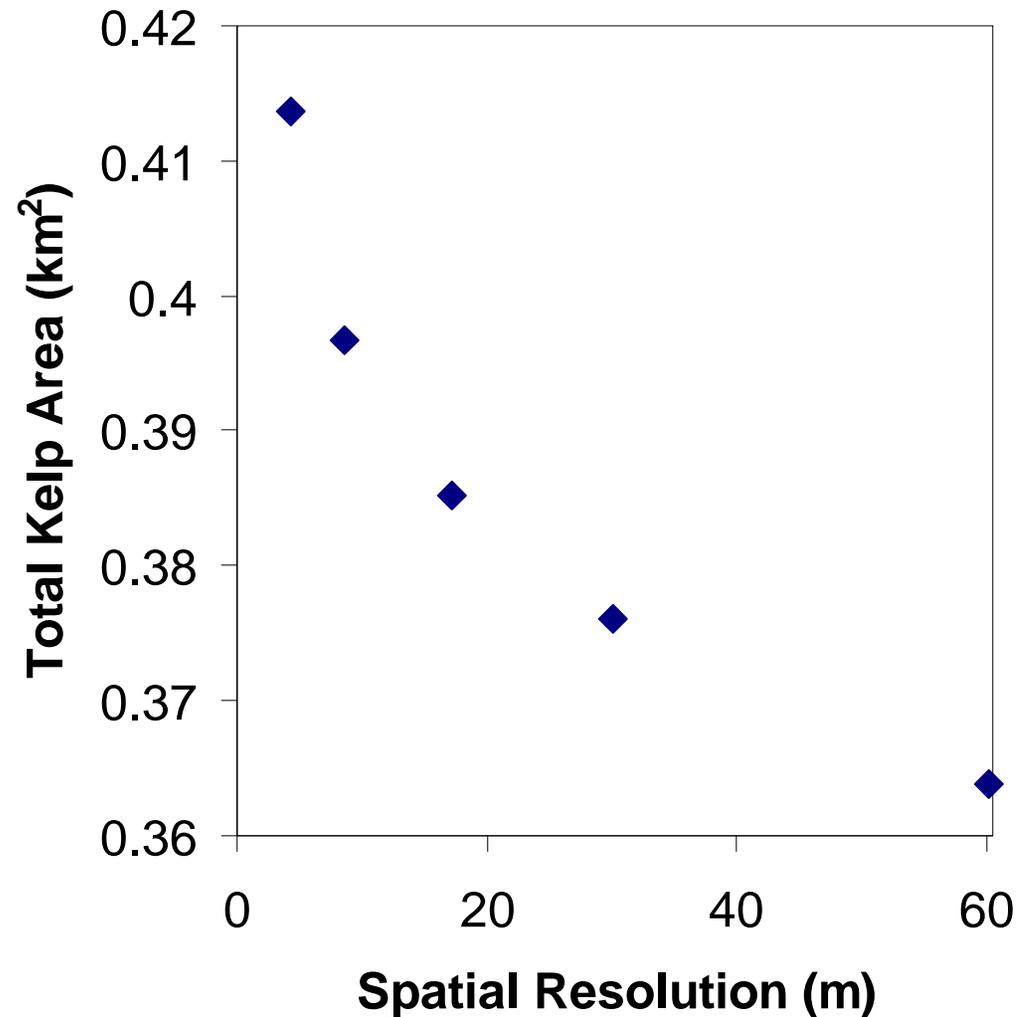
Scaling Comparison

- 903 60.2 m pixels were modeled with a kelp fraction greater than 5%

<u>Kelp Fraction Difference</u>	% of All Pixels w/ Kelp Fraction > 5%
< 10%	99.67%
< 5%	97.12%
< 3%	92.47%
< 1%	82.50%

Total Kelp Area

- We used the 5% kelp fraction threshold to calculate total kelp area
- Total kelp area decreases by 12% as spatial resolution goes from 4.3 to 60.2 m

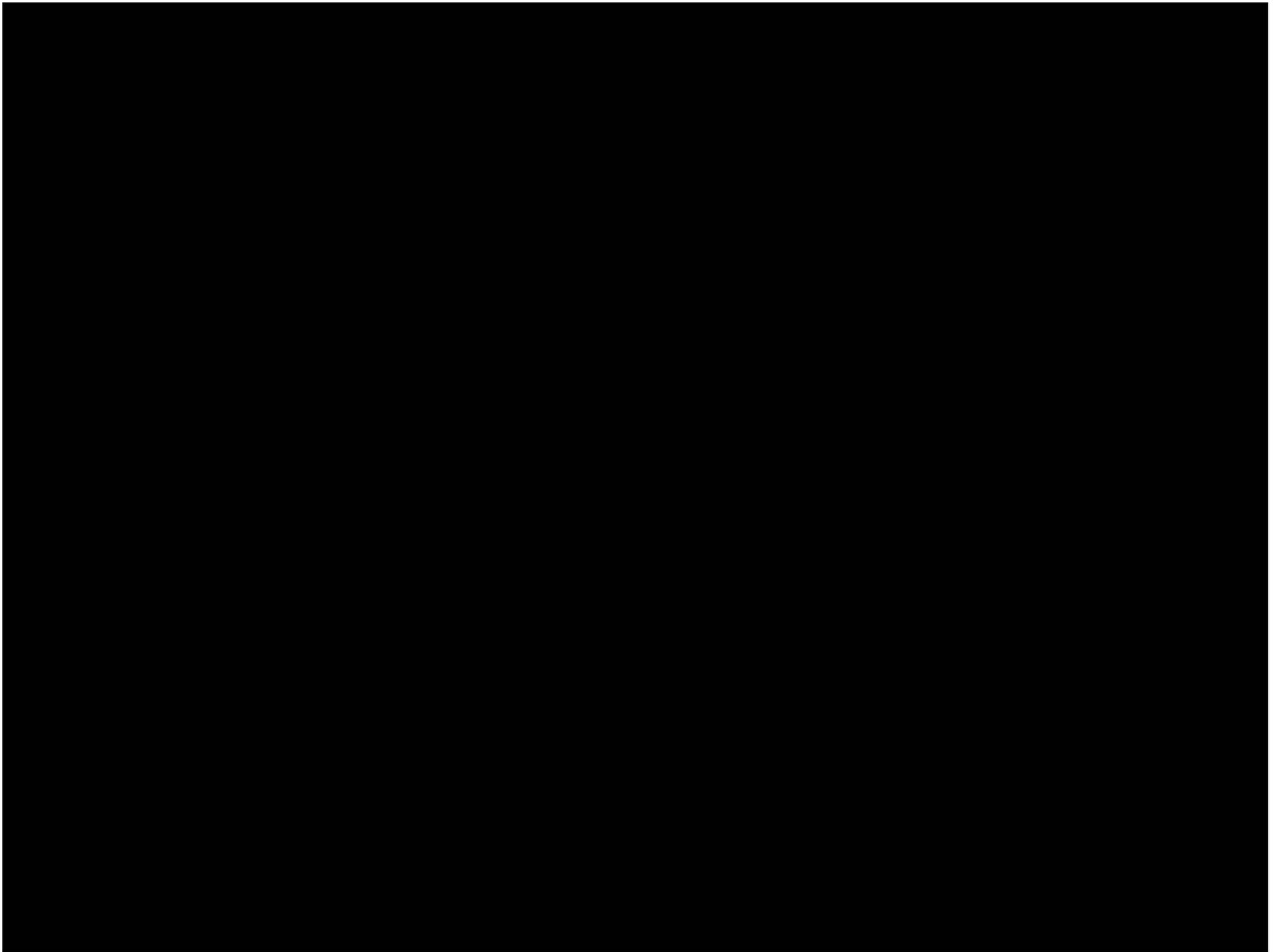


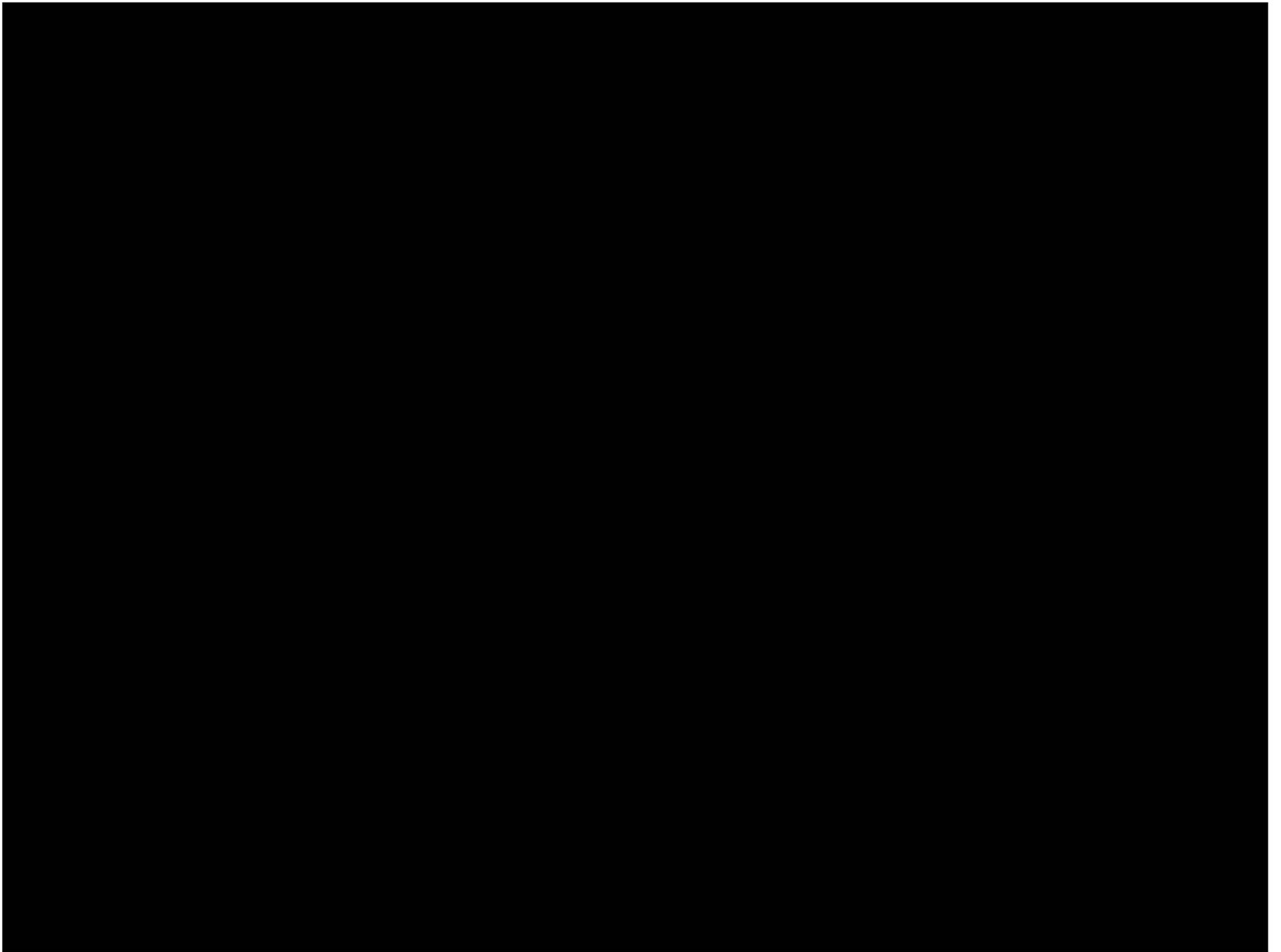
Conclusions

- Kelp fraction scales well from 4 m to 60 m spatial resolution
 - Good agreement of kelp fraction modeled at different spatial resolutions
 - Scaling up does result in lower estimate of total kelp area
- 60 m HypsIRI VSWIR data will likely be useful for FAV mapping
 - More investigation of appropriate scaling techniques is needed

Directions for Future Research

- Comparison of kelp fraction with LTER kelp frond density survey data
- Actual simulation of HypsIRI VSWIR spatial/spectral properties
- Masking spectral anomalies (e.g. mixed pixels containing boats)
- The two-endmember model is probably too simple
 - Doesn't account for variable plankton or sediment concentrations in water
 - Doesn't account for water depth
 - Doesn't account for sun glint





Very Preliminary Comparison of Kelp Fraction and Frond Density

- Annual LTER kelp transects from July 2007 were compared with 4.3 m kelp fraction
- Spatial and temporal issues
 - 1 or 2 m wide transects vs. 4 m AVIRIS
 - Not yet confident of locations of transects in AVIRIS data
 - July vs. August timing

