

IDENTIFYING CORAL BLEACHING BASED ON VISUAL FEATURES

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1. MOTIVATION

- Coral reefs are critical for marine biodiversity and coastal protection.
- Bleaching events caused by rising sea temperatures threaten reef survival.
- Current coral health assessments rely on manual visual surveys: slow and subjective or ML computationally intensive solutions with black box solutions

2. GOAL

- Build an automated tool to detect and quantify coral bleaching from underwater images.
- Combine semantic segmentation with texture/color based features to assess coral health objectively.
- Provide interpretable indicators for reef managers and conservation programs.
- Go beyond color-only approaches by analyzing structural texture changes associated with bleaching.
- Beyond color-only approaches or ML models by analyzing texture and whiteness
- Support scalable, repeatable reef monitoring across global coral datasets.

3. DATA

REEF SUPPORT:

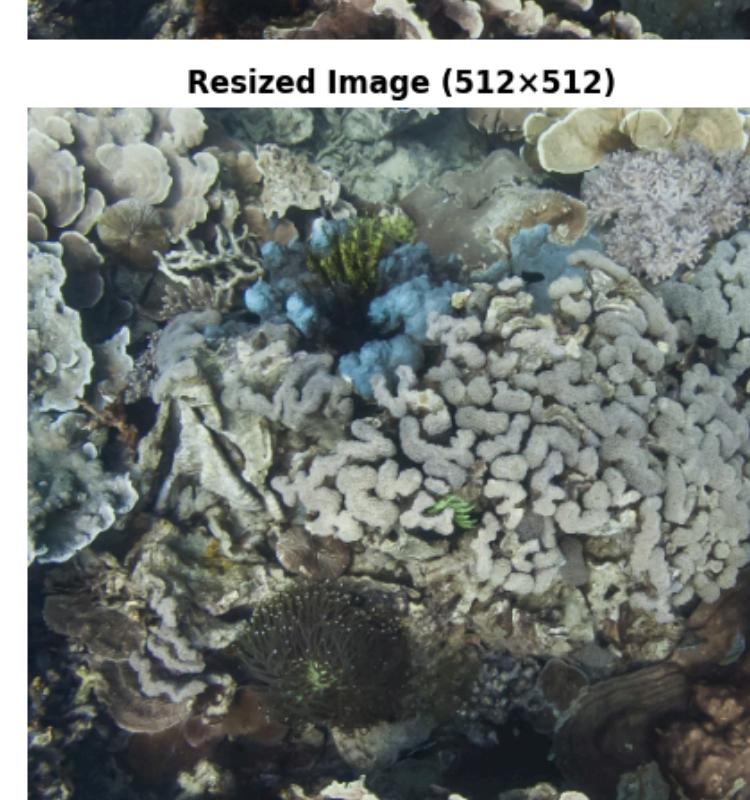
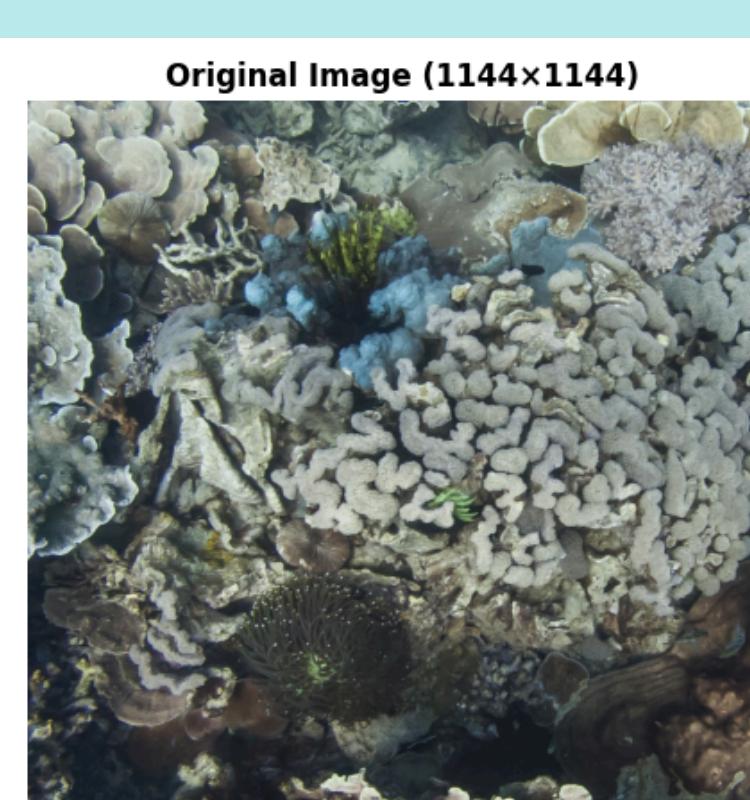
- Benthic data (hard/soft/non-coral masks)
- Bleaching dataset (bleached/non-bleached/non-coral masks)

UNIFIED DATASET:

- Images from both datasets joined.
- Benthic masks and Bleaching masks normalized/merged to coral/non-coral



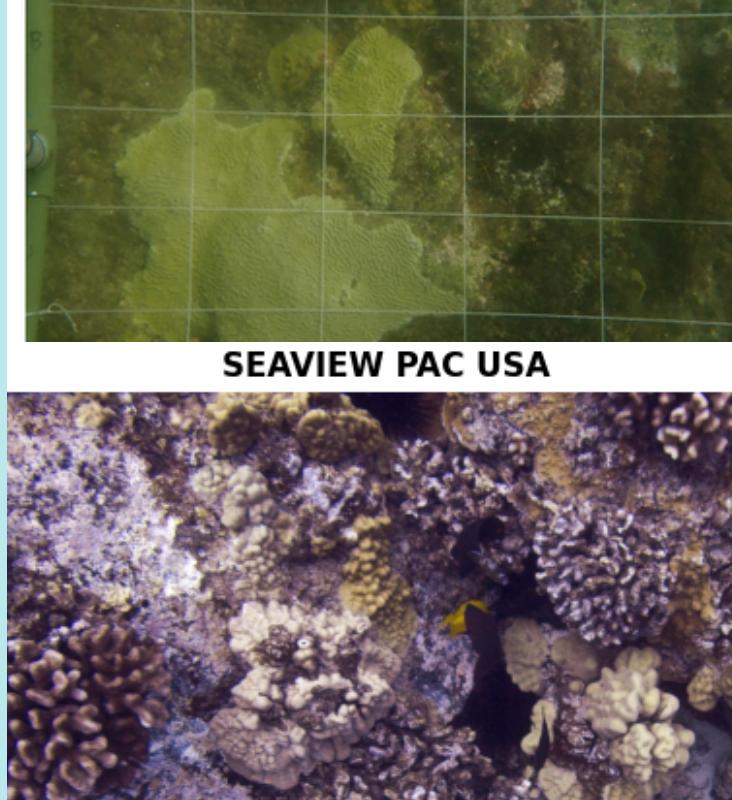
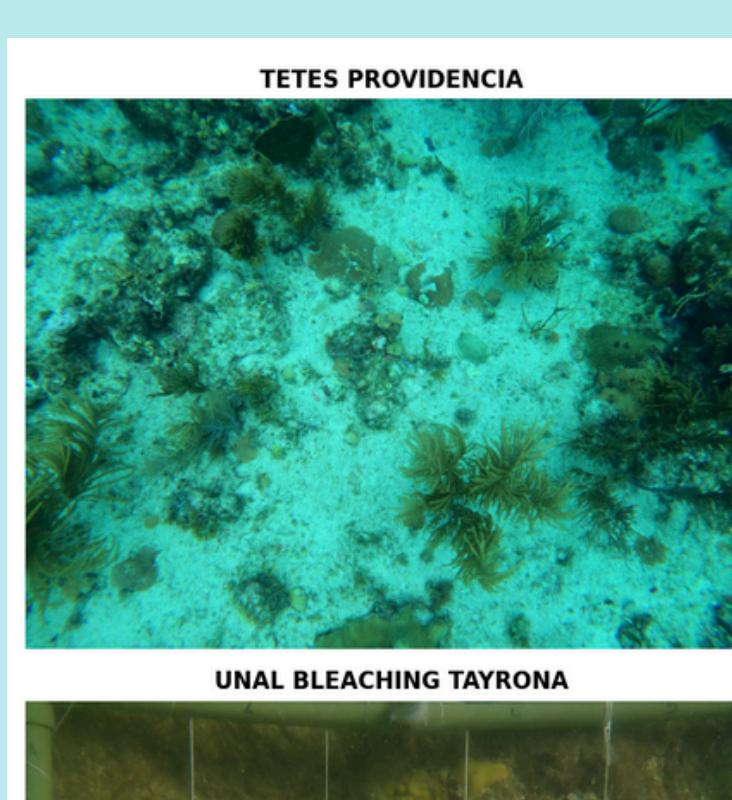
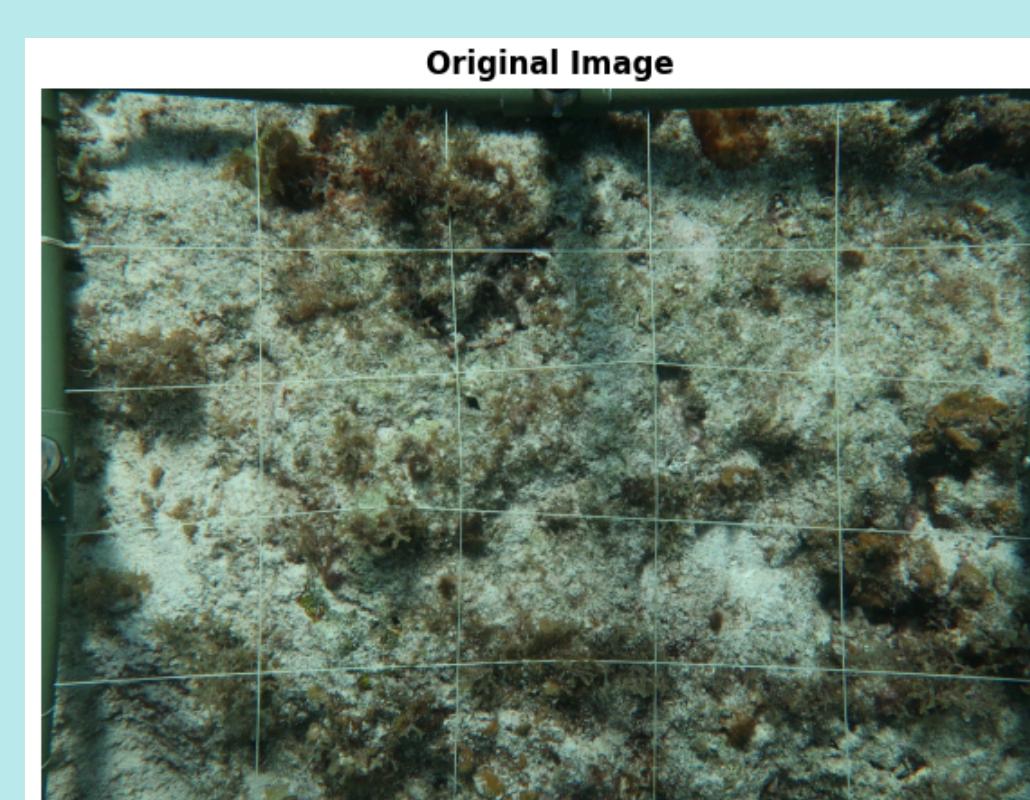
RESIZE → 512x512



4. PREPROCESSING

REMOVE EMPTY/SMALL/INVALID MASKS

SITE-STRATIFIED SPLIT



SEAVIEW PAC USA

5. Methodology

Segmentation:

U-Net (EfficientNet-BO encoder), BCE+Dice loss, Adam; evaluated with mIoU/Dice.

Segmentation into coral and non-coral classes

Normalization:

Grayscale/white-balance and histogram equalization to control lighting and site differences.

Texture features:

Laplacian variance (edge/rugosity), Local Binary Patterns, GLCM contrast/entropy.

Color features:

Luminance ↑, saturation ↓, raw-red ↓, albedo ↑ as bleaching increases. Mean/median score per image, standardized.

Summaries & thresholds:

Per-site baselines, z-scores, control charts; joint triggers = feature thresholds + thermal context (e.g., NOAA DHW).

| | | | | | | |
|------------------------|------------------|-----------------|--------------------|---------------------|------------------------|---------------------|
| median_raw_red_z | 1.00 | -0.31 | -0.33 | 0.18 | -0.41 | -0.21 |
| median_albedo_z | -0.31 | 1.00 | 0.75 | 0.42 | 0.82 | 0.42 |
| median_luminance_z | -0.33 | 0.75 | 1.00 | 0.47 | 0.82 | 0.42 |
| median_saturation_z | 0.18 | 0.42 | 0.47 | 1.00 | 0.74 | 0.38 |
| median_whiteness_score | -0.41 | 0.82 | 0.82 | 0.74 | 1.00 | 0.51 |
| bleached_percentage | -0.21 | 0.42 | 0.42 | 0.38 | 0.51 | 1.00 |
| | median_raw_red_z | median_albedo_z | median_luminance_z | median_saturation_z | median_whiteness_score | bleached_percentage |

6. Results

Model metrics:

- IoU = 0.69
- Accuracy = 0.89
- Regression equation: $\beta = R_{xx}^{-1} r_{xy}$
- Corr(median_whiteness_score, % bleaching) = 0.51
- Corr(mean_whiteness_score, % bleaching) = 0.58
- Corr(texture_score, % bleaching) = 0.35
- Corr(severity_score, % bleaching) = 0.58

7. Conclusion + discussion

Advantages:

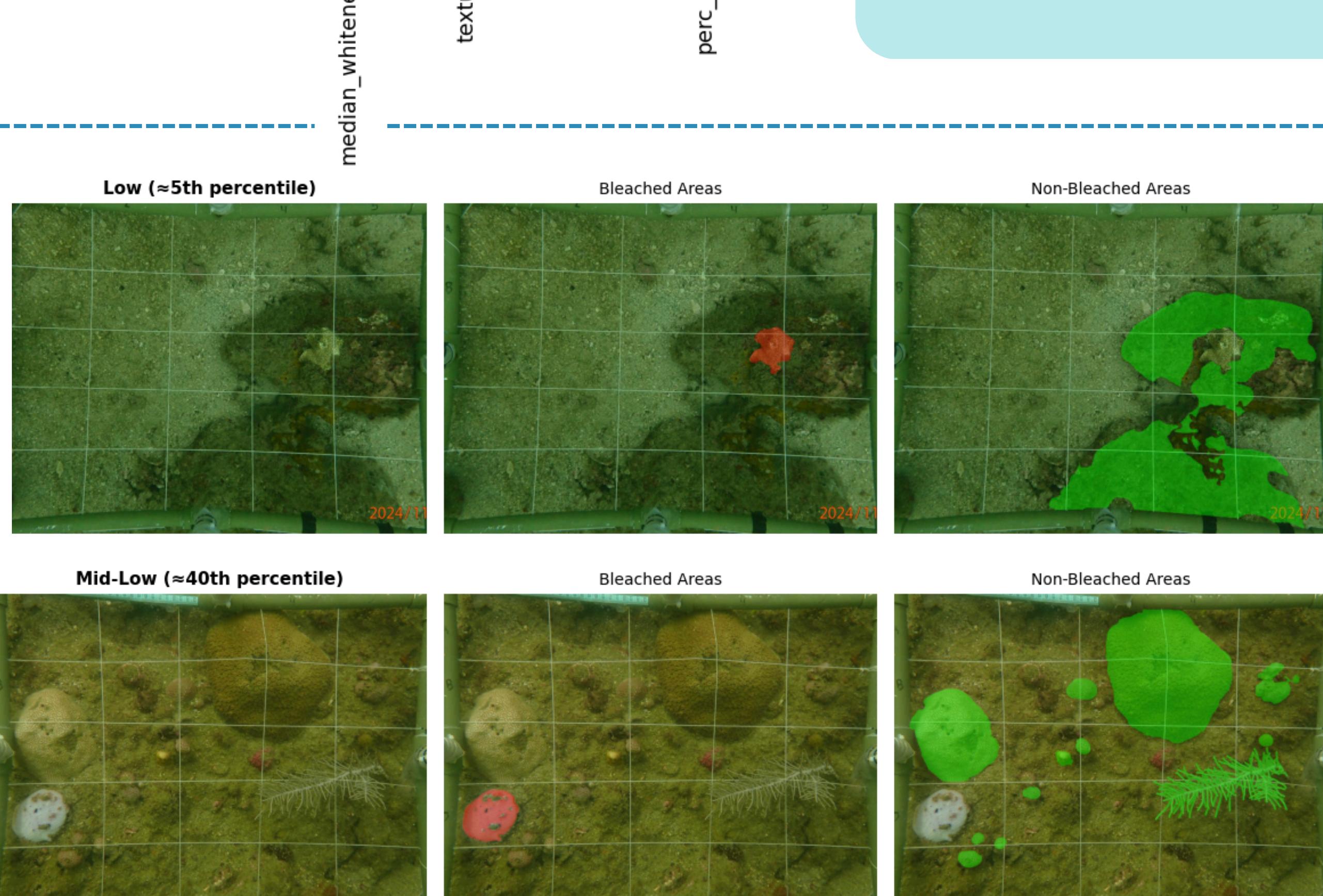
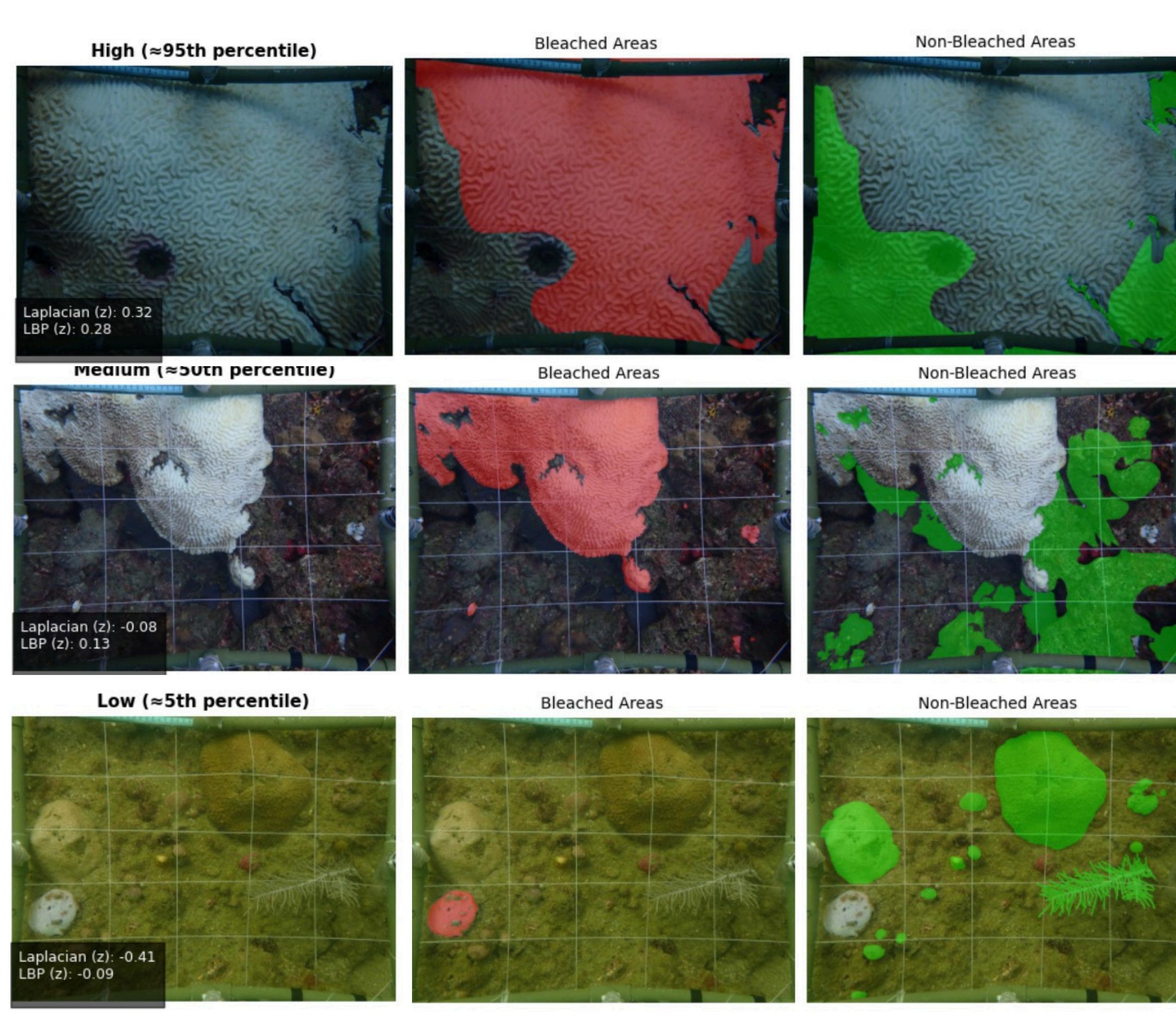
- Novelty: texture + whiteness (no ML), severity research
- Background-safe approach
- Interpretability: Physical Phenomenon

Field Implications:

- Quantitative coral condition monitoring with explainable metrics.
- Lays groundwork for a hybrid ML + feature-based coral health index.

Limitations:

- Standardization.
- Linear relationship between features and bleaching.
- Ignore non-linear effects.



Next steps:

State-of-the-art model for segmentation.
Fuse texture + color + (further features) into a unified Coral Health Score Model.
Backed by health severity labelled data and/or temporal change.

