



# Coral Sense

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# For Most of History...

Coral reefs, often called the rainforests of the sea, once thrived across the globe, supporting rich ecosystems and providing invaluable resources to both marine life and humanity.



# A Vital Ecosystem



Of all marine life is in reefs



People depend on reefs



Coastline protected by reefs



Of fish caught in developing countries is from reefs



# The Decline of Coral Reefs

- Coral reefs began showing signs of significant decline as early as the 1950s
- By the mid-1990s, scientists observed widespread coral bleaching events
- The situation worsened between 2014 and 2017 during the longest global coral bleaching event in recorded history, which devastated over 75% of reefs worldwide.



# The Turning Point



Pollution



Pathogens



Overfishing



Climate  
Change



Nutrient  
Changes



# The Call for Action

- The world calling for heroes to rise.
- Researchers, conservationists, and policymakers are seeking ways to protect what remains.
- But their tools are outdated, reactive instead of proactive, and cannot predict where to act before it is too late.



# Our Solution

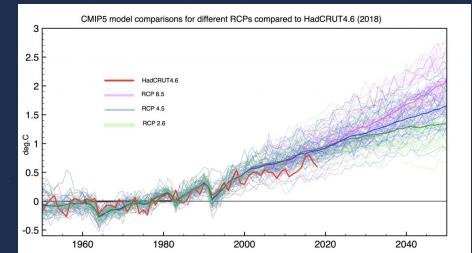
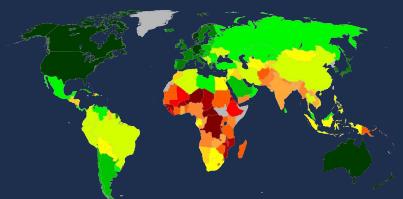
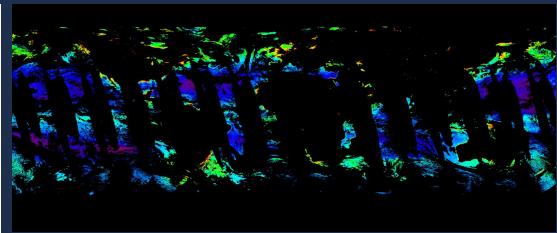
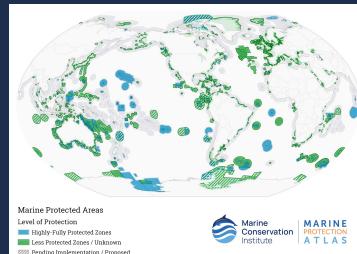
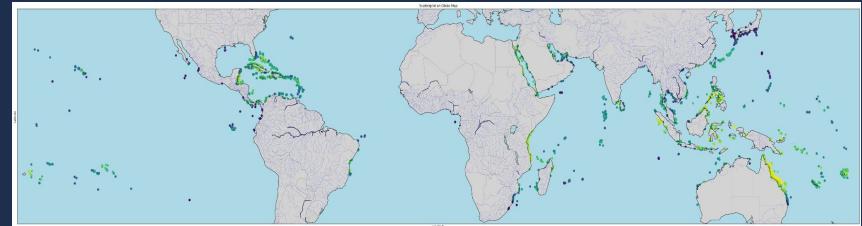
- Interactive Map interface
- Future predictions on reef health (hard coral cover) for locations around the world
- Time series predictions of coral bleaching
- Allows users to adjust key features

The screenshot shows the CoralSense website's homepage. At the top right, there is a navigation bar with links: Start Here, Coral Health, Datasets, About Us, Get Involved, and Launch Tool. To the left of the main content area, the CoralSense logo is displayed, featuring a stylized coral icon above the text "Coral Sense". The main content area has a dark blue background with a large, vibrant photograph of a coral reef on the right side, showing various colorful fish swimming among the corals. In the center of the page, the text "Welcome to CoralSense" is written in a white, sans-serif font. Below this, a quote is presented in a smaller white font: "'Coral reefs are a jeweled belt around the middle of the planet.' - Dr. Sylvia Earle, Oceanographer".

# Data Sources

~ 12,000 Training records

1. MODIS Aqua Level-3 Remote Sensing Reflectance (Rrs) Image Dataset
2. Global Bleaching Environmental Data
3. Reef Connectivity Dataset
4. Human Development Index
5. Marine Protected Areas
6. Reefs at Risk Dataset
7. Coupled Model Intercomparison Project (CMIP5) climate projections Dataset

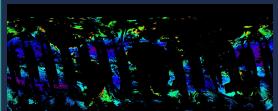


# Overview of Data Pipeline

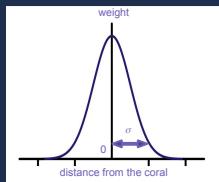


# Data Pipeline

MODIS  
Image Data



Gaussian Distance  
Weighting with  
 $\sigma = 1.0$



Weighted  
Images

4320 x 2160 x 3

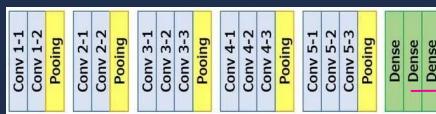
- Gaussian function applies a **bell curve** to assign weights
- **Closer points** = more weight
- **Farther points** = reduced influence

Resize  
Images

224 x 224 x 3

VGG16 is a pre-trained CNN model used for feature extraction from images

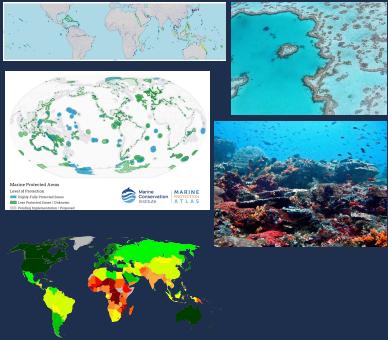
Transfer Learning  
(CNN-VGG16)



Extract  
features from  
second-to-last  
CNN layer

# Data Pipeline

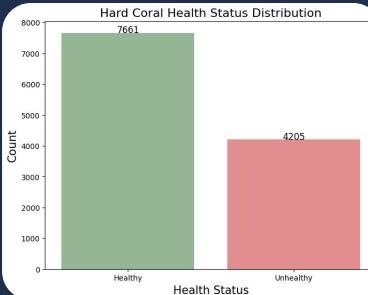
## Datasets 2-6



## Select 47 Relevant Features

- Geospatial and Temporal Data
- Environmental Conditions
- Ecological and Geographic Context
- Human Impact Metrics

## Categorize Target Variable: Hard Coral Class



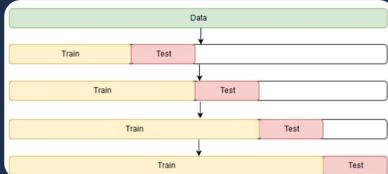
- Target variable derived from Hard Coral Percent Cover feature
- Percent cover  $> 20\%$  = Healthy reefs, dominant presence of hard corals
- Percent cover  $\leq 20\%$  = Unhealthy reefs, significant coral loss

# Modeling Overview

## Machine Learning Models

1. Logistic Regression
2. Random Forest Classifier
3. Extreme Gradient Boosting (XGBoost)
4. Support Vector Machine (SVM)
5. K-Nearest Neighbors (KNN)
6. Neural Network - Multi-Layer Perceptron (MLP) Classifier

Minimized AUC-ROC score using 5-fold Time Series Cross-validation

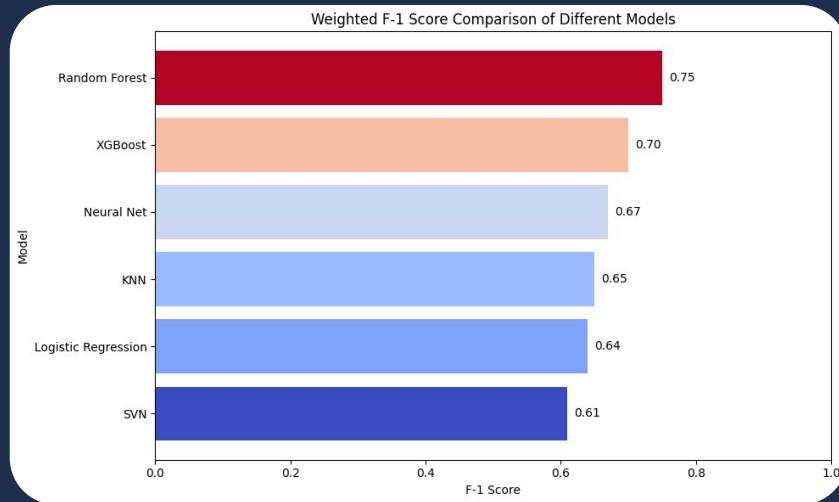


Best Model for Coral Health Prediction



# Model Performance (Hard Coral Class)

## Weighted F1 Scores



Evaluated multiple models and found **Random Forest** performed best for binary classification on test data metrics.

## RF Model Results: balanced training classes

Metric	Score
Weighted F-1	0.75
Accuracy	0.75
AUC-ROC	0.82

## RF Model Hyperparameters

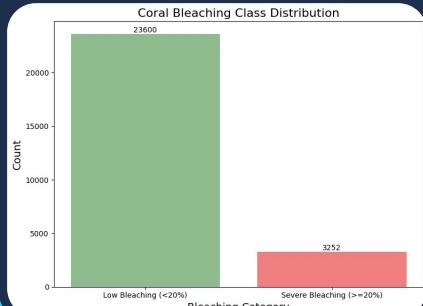
- Max Depth: None
- Min Samples per Leaf: 1
- Min Samples per Split: 2
- Number of Estimators (Trees): 500

# Time Series Forecasting

Tabular data from  
Datasets 2-6  
**(10 features)**



Categorize  
Target Variable:  
Percent Bleaching



Model Training and  
Evaluation

- Logistic Regression (baseline)
- Random Forest



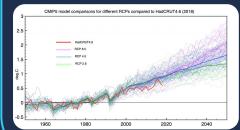
Best  
Model

- Target variable derived from Percent Bleaching feature
- Percent Bleaching  $\leq 20\%$  = Low Bleaching, healthy corals (retain color and algae)
- Percent Bleaching  $> 20\%$  = Severe Bleaching, stressed corals (lost color and vulnerable to diseases)

# Time Series Forecasting

## Data pipeline for forecasted values

CMIP5  
climate  
projections

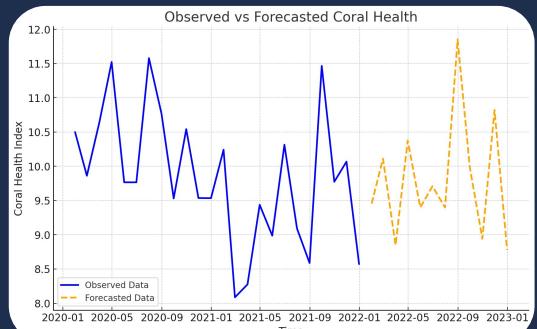


Select  
forecasted data  
for relevant  
features  
(2030, 2035, 2040)

Aggregate  
yearly for  
each reef

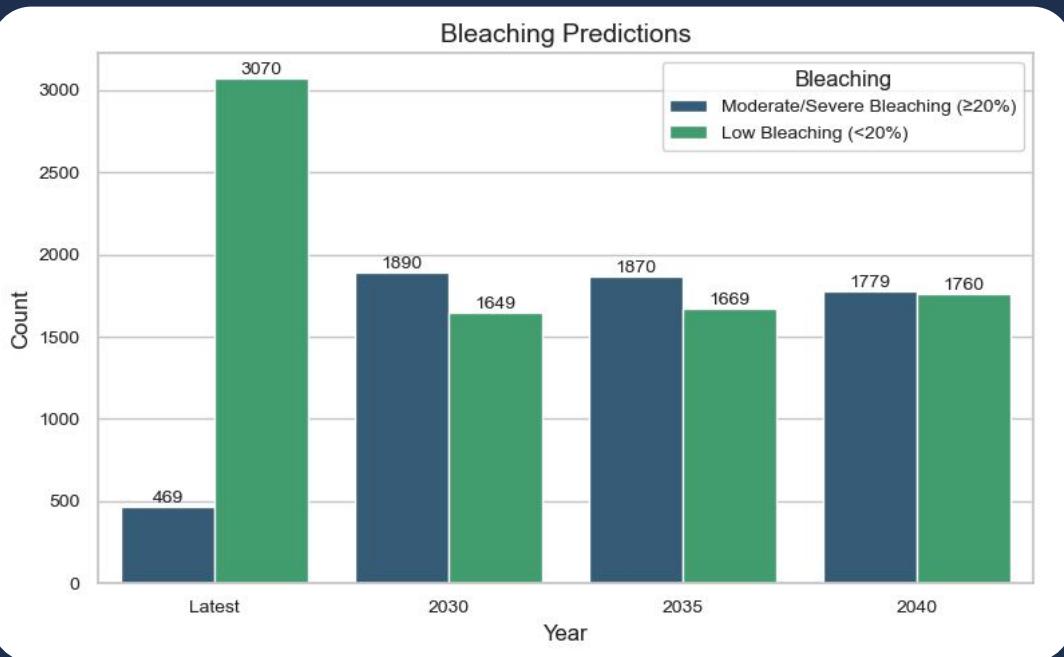


## Time Series Forecasting (2030, 2035, 2040)



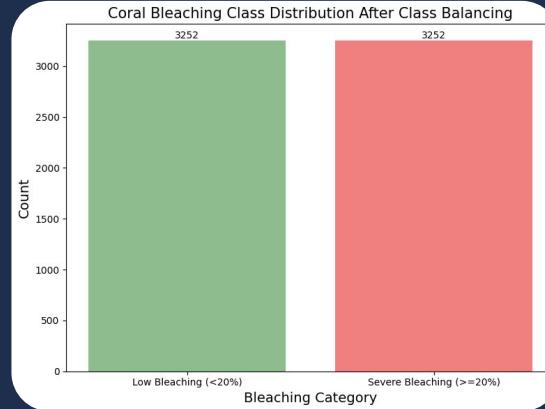
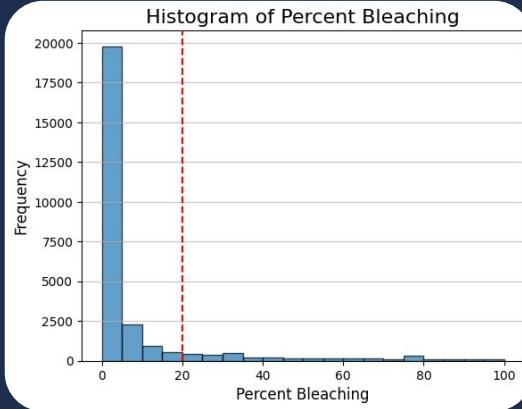
Best Model for  
Coral Health Prediction

# Time Series Results



- Time series model using Random Forest
- 5, 10, 15 year look-ahead prediction
- Future predictions further out in time are more noisy and require additional analysis

# Model Performance (Bleaching)

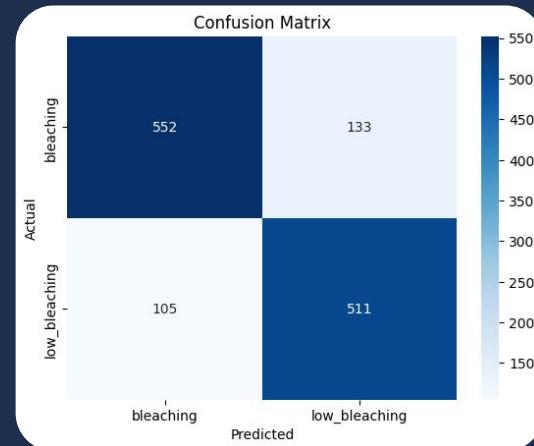


## RF Model Hyperparameters:

- Max Depth: 12
- Min Samples per Leaf: 4
- Min Samples per Split: 5
- Number of Estimators (Trees): 300

## RF Model Results:

Metric	Score
Weighted F-1	0.84
Accuracy	0.84
AUC-ROC	0.93



# Architecture

## Modeling

Colab + Google Cloud

colab



- Quick and efficient
- Advanced GPU access for powerful training model development
- Free

## Deployment

Docker, .pkl File, Google Cloud, Flask API



- Easy
- Seamless integration
- Python - Flask
- Efficient
- Cost effective

## Website

Node.js, React, Vercel



React



- Industry standard: React and Node.js
- Easy hosting on Vercel
- Works well with docker and Google hosted API endpoints
- Free

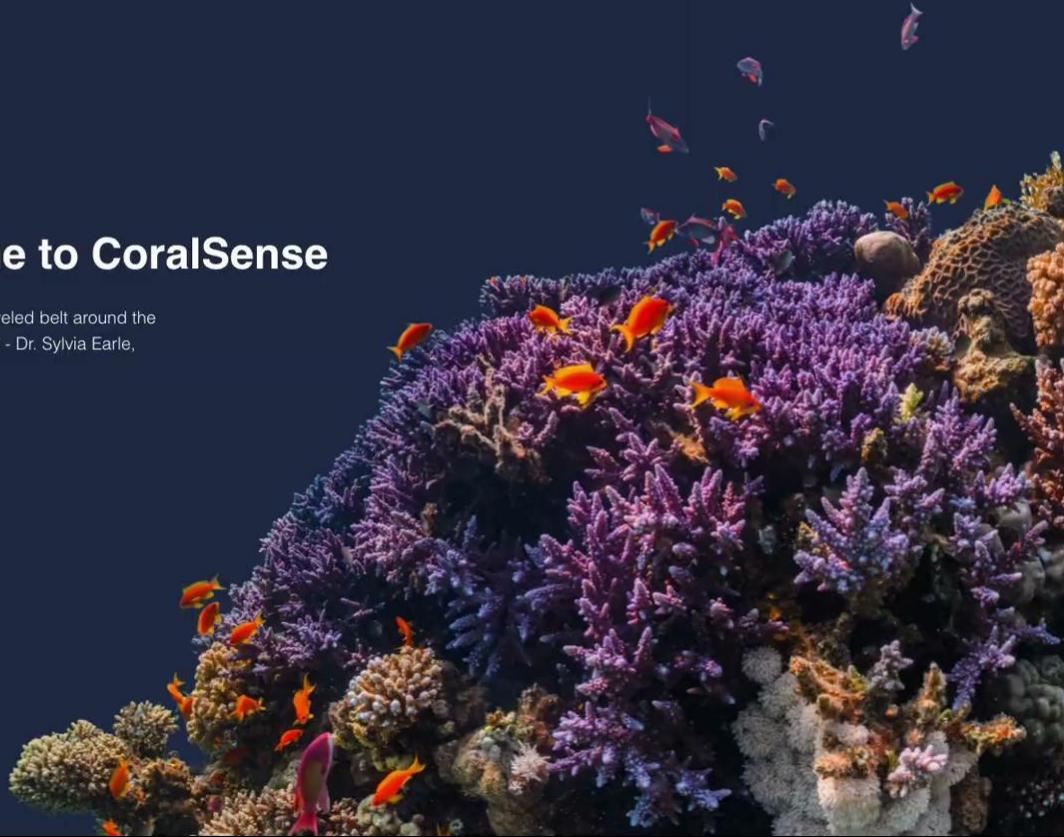
Architecture selected to optimize cost and MVP development speed

# What Can the Map Tool Do?

- Visualize Reef Locations
- Visualize Recent Coral Cover Records Globally
- Forecast the Future:
  - Visualize coral bleaching predictions through 2040 under an RCP 8.5, high carbon emissions scenario
- Enable Decision-Making:
  - Highlights high-priority reefs for immediate action and low-priority reefs for long-term strategies.
- Interactive Insights - users can:
  - Explore environmental factors affecting reef health.
  - Simulate the impact of changes in things like temperature or nutrient pollution on bleaching and hard coral cover

# Welcome to CoralSense

"Coral reefs are a jeweled belt around the middle of the planet." - Dr. Sylvia Earle,  
Oceanographer



# Next Steps



Integrate more feature projections into our prediction process



Collaborate with researchers collecting data on coral reefs



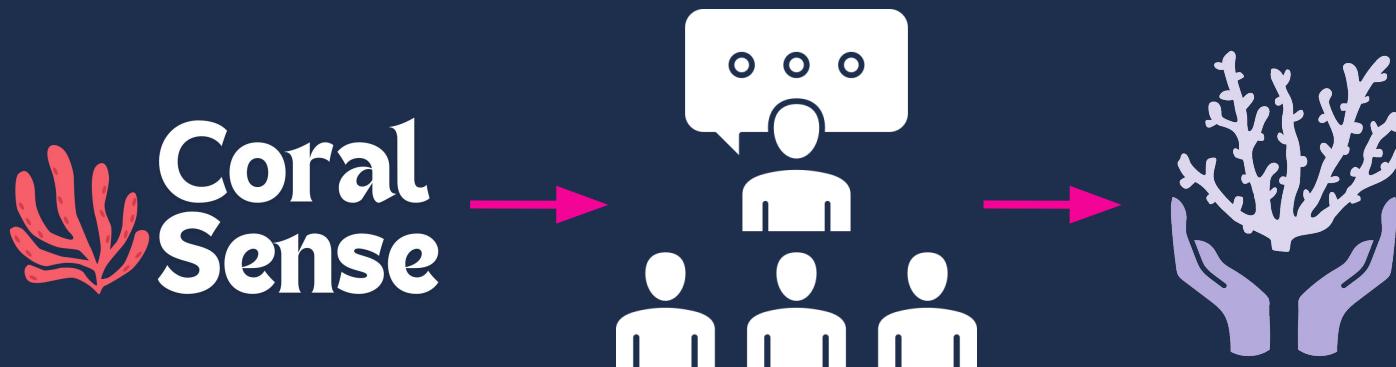
Develop educational and awareness promoting resources



Promote advocacy to protect coral reefs

# The Quest for Change

- CoralSense equips researchers, conservationists, and policymakers with the tools they need to make informed decisions.
- Together, they can protect coral reefs, support biodiversity, and safeguard the livelihoods of millions of people worldwide.



# Our Mission

“Our mission is to use machine learning to monitor and model global coral reef health, providing accessible tools and insights to protect these vital ecosystems. By empowering communities and policymakers with actionable data, we aim to ensure a sustainable future for coral reefs and our oceans.”



The background image shows a healthy coral reef ecosystem. A dense cluster of various coral species, including Acropora and Pocillopora, forms the base. Above them, numerous small, bright orange and yellow fish, likely Anthias or Lyretail Anthias, swim in schools, creating a sense of movement and life. The water is a clear, translucent blue.

#ThriveAgain!