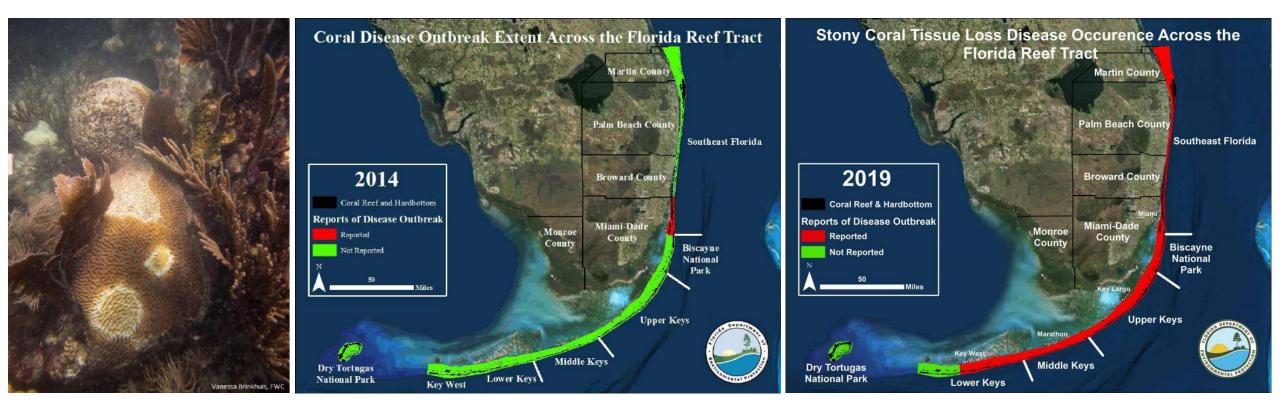


Fore-C: Forecasting coral disease outbreaks across the tropical Pacific Megan Donahue, Scott Heron, Jamie Caldwell, Mark Eakin, Bill Leggat, Tracy Ainsworth, Bernardo Vargas-Angel, Erick Geiger, Gang Liu, Jaqueline De La Cour, Austin Greene

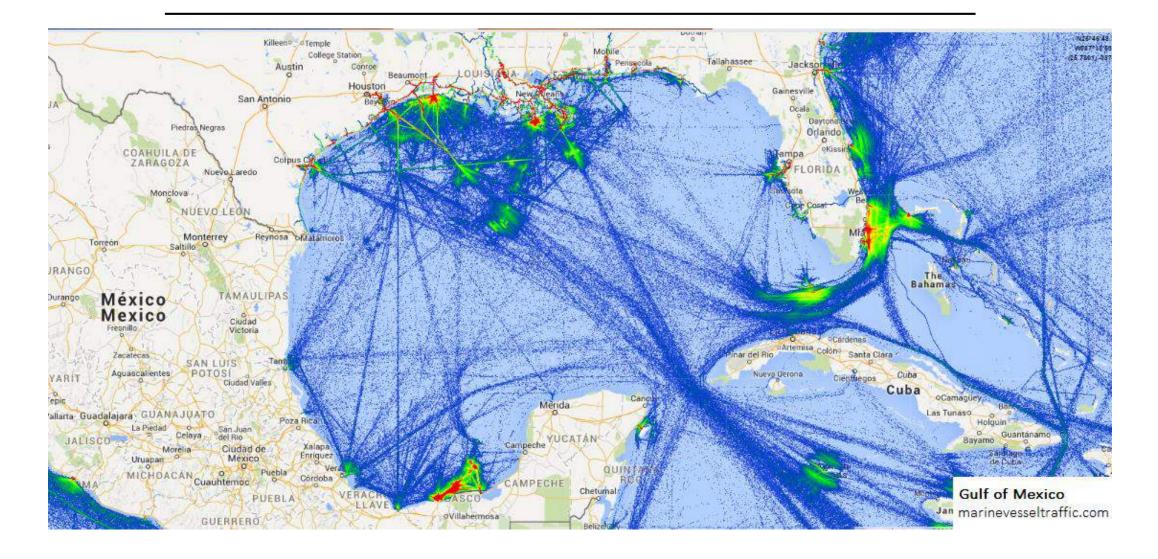
Corals reefs provide ecosystem services



Unprecedented & ongoing outbreak



Unprecedented & ongoing outbreak

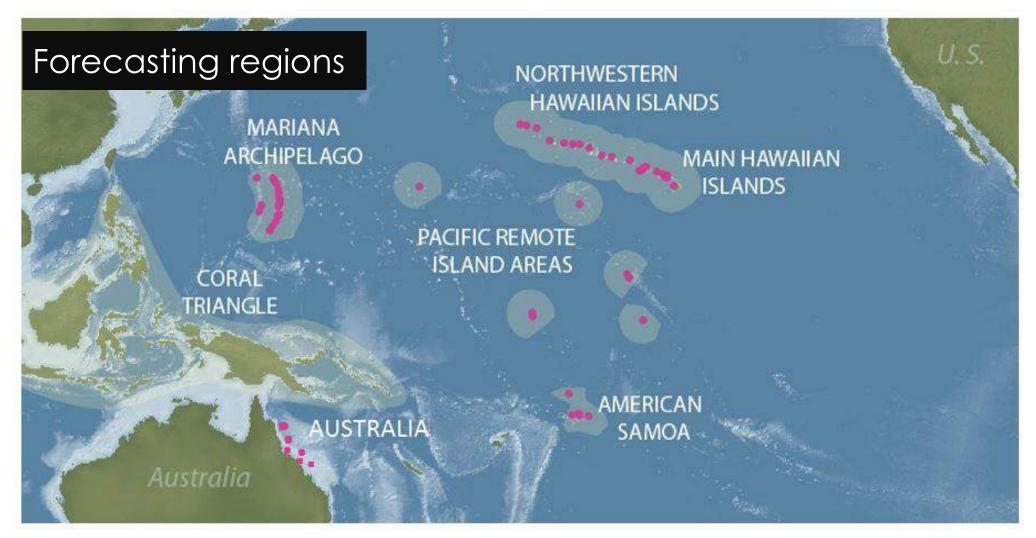


Drivers of coral disease spread





Overarching objective for Fore-C



Overarching objective for Fore-C

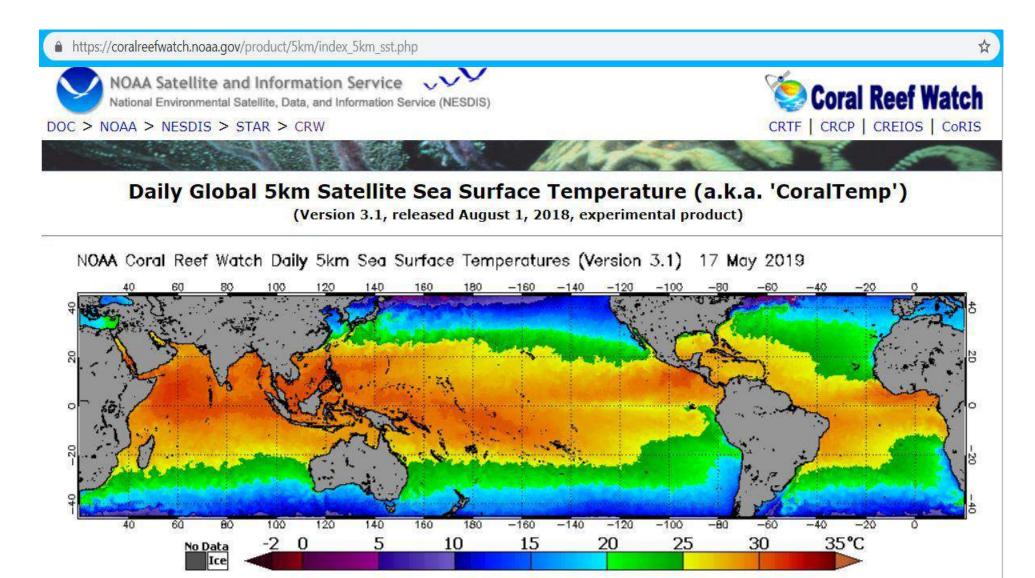


Photo: Bette Willis

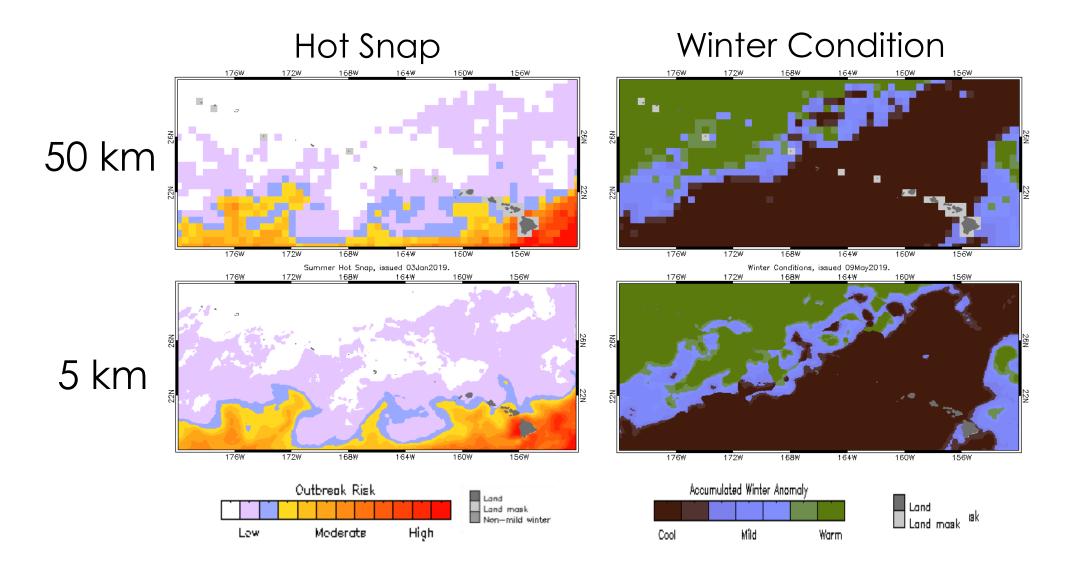
Temperature as a disease driver

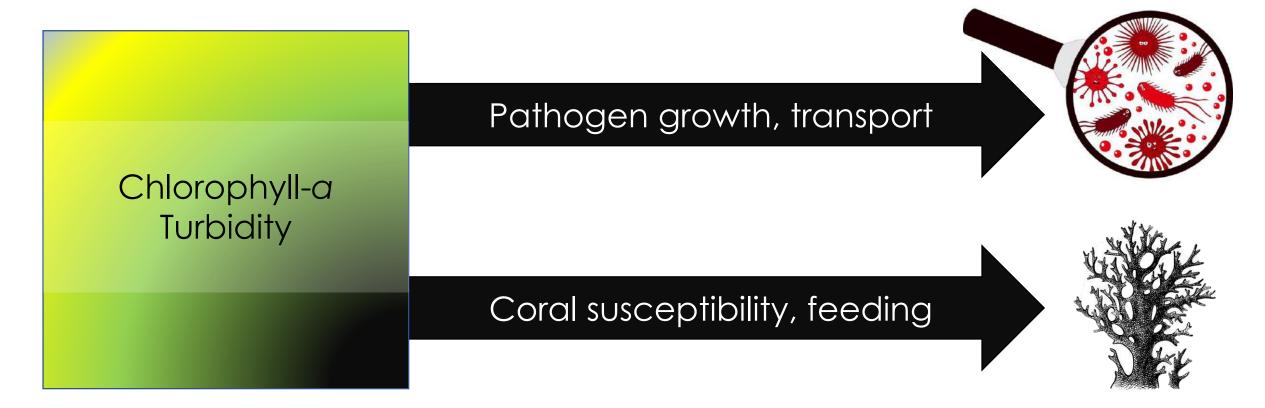


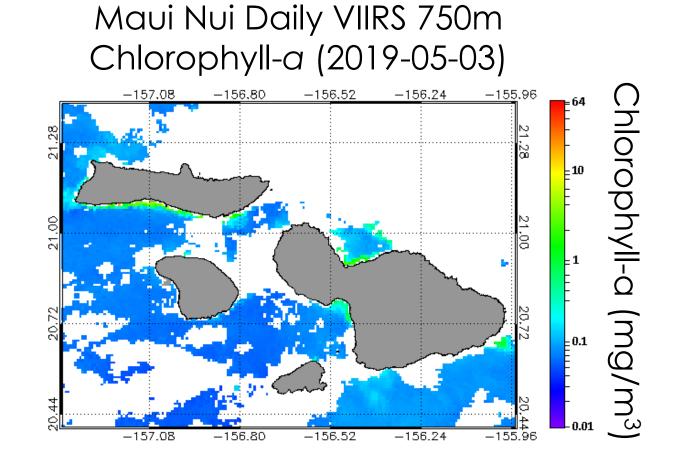
Temperature as a disease driver

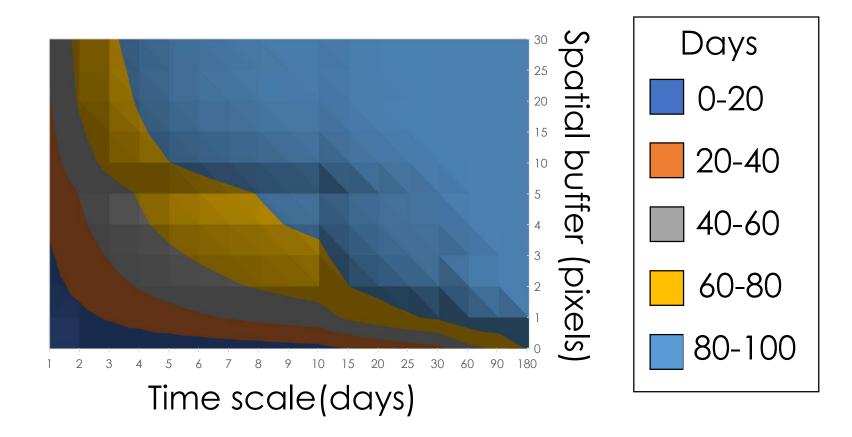


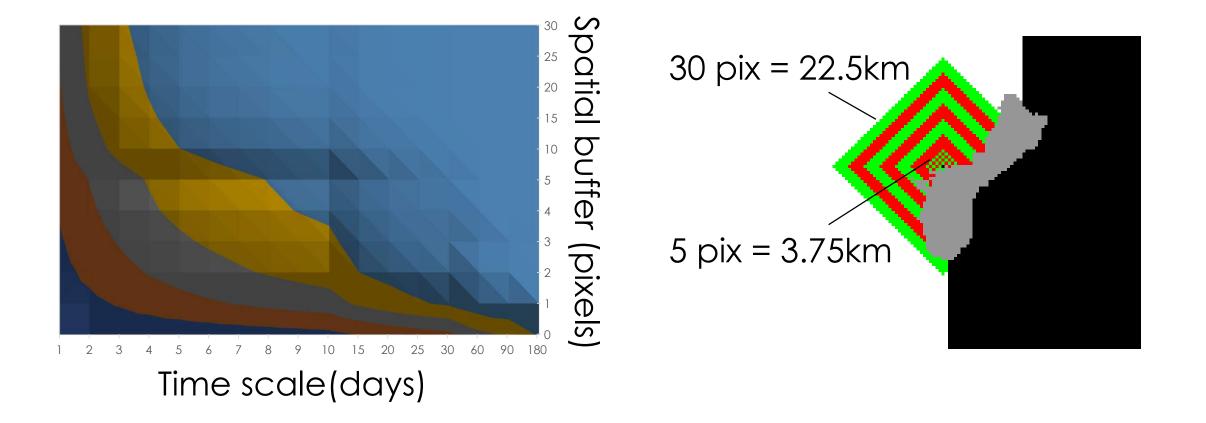
Temperature as a disease driver

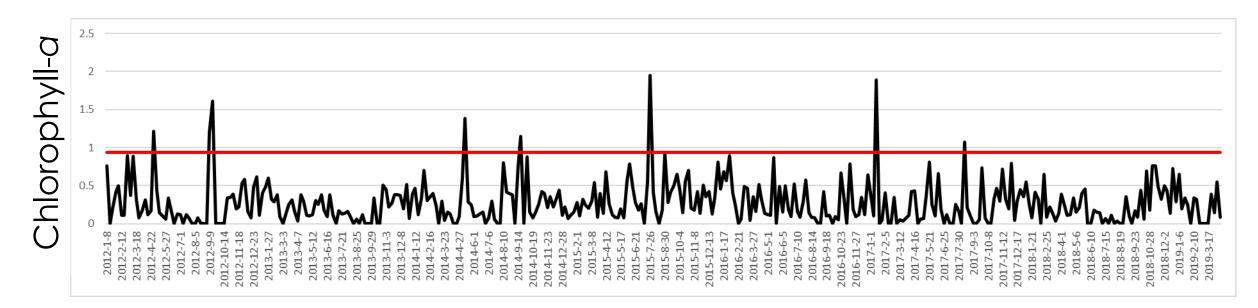












Week

Other disease drivers

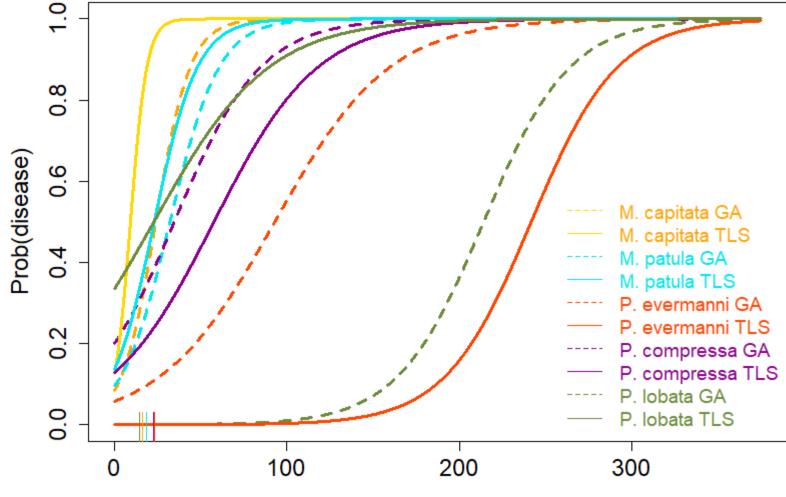
- Colony size
- Coral density
- Coral community composition
- Depth
- Irradiance
- Wave exposure
- Stream exposure
- Coastal development
- Agriculture and golf runoff
- Human population size



Results from Hawaii



Large corals = higher disease risk



Colony size (cm)

Growth anomalies



Associated with human activities in watersheds adjacent to shallow, semiprotected coral reefs



Associated with reef structure, water motion, and temperature exposure

Preliminary results from Guam





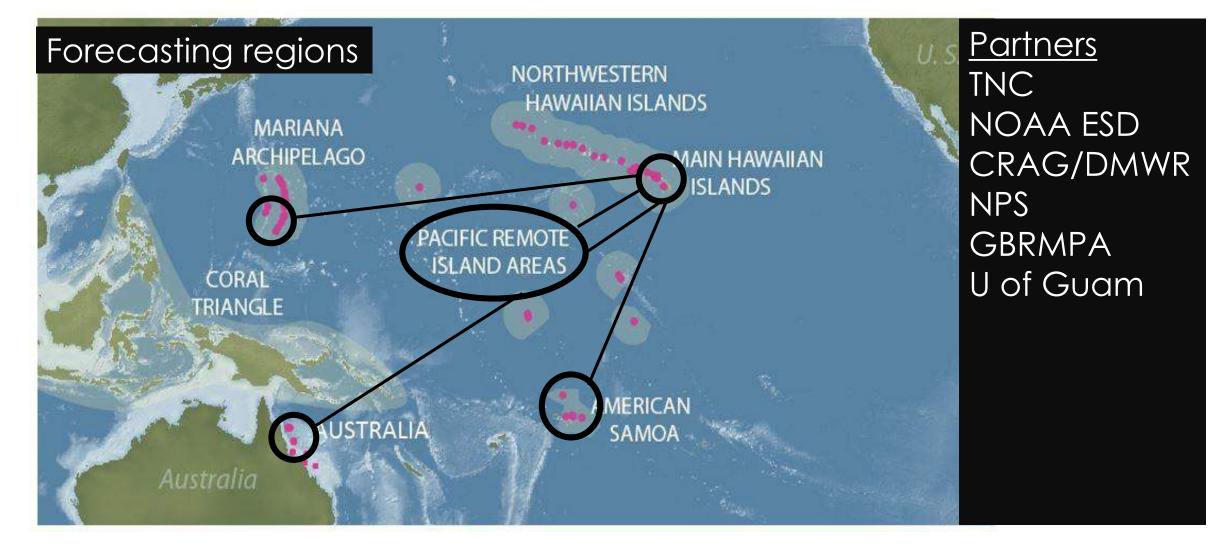
Disease risk influenced by colony size, beaching history, chlorophyll-a

Learn more at Austin's poster

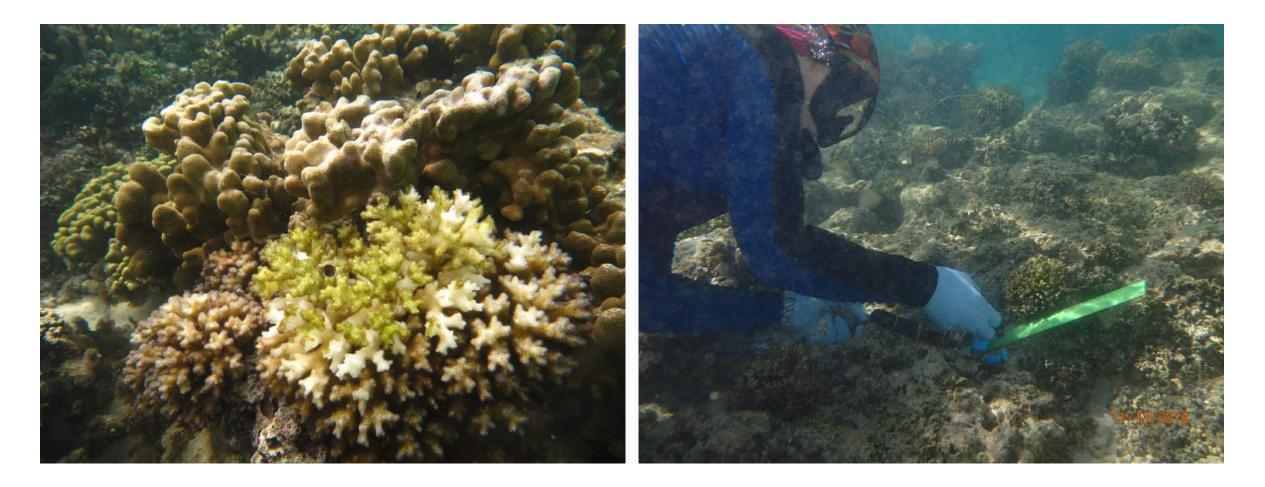


Predictive modeling of coral disease in Guam with satellite environmental metrics Austin Greene¹, Laurie Raymundo², Jamie Caldwell^{1,3}, Scott Heron^{4,5}, Erick Geiger^{5,6}, C. Mark Eakin⁵, Megan Donahue¹ 1: Hawaii Institute of Marine Biology, School of Ocean and Earth Science and Technology, University of Hawaii 4: Marine Geophysical Laboratory, College of Science and Engineering, James Cook University: Australia 2: University of Guam Marine Laboratory, University of Guam Station 5: NOAA/NESDIS/STAR Coral Reef Watch 3: Department of Biology, Stanford University 6: Global Science and Technology, Inc., College Park, MD Abstract Coral disease contributes to long-term declines in the health of coral reefs, threatening \$2.7 Trillion USD in ecosystem services¹. Driven in part by environmental stress on the coral host, disease outbreaks are highly variable in space and time and pose a significant challenge to managers. Using nearly a decade of repeated coral health surveys from six sites in Guam we produced colony-scale predictive models of the coral disease White Syndrome affecting 33 coral species. These models suggest colony size, prior bleaching history, and Chlorophyll a (Chl a) are strong drivers of White Syndrome in Guam. Introduction Methodology Results Approach: Model of individual coral colony disease risk in response to Increases p(WS): Many coral diseases increase in prevalence or severity Increased colony size in species (Fig. 2A) with environmental or anthropogenic stress including environmental drivers, local biological factors, and prior site history Chronic Chl a stress (26 week mean) warming ocean temperatures, sedimentation, and Thermal anomalies (hot or cold) Maximum bleaching prevalence on transect increased outrient concentration^{2,3} Degree Heating Weeks (DHW) Site-scale drivers such as prior bleaching history, algal in the past year **Bleaching Hotspot** - Summer cover, and overfishing also contribute to increased VIIRS ocean color (5-pixel rosette) Decreases p(WS): coral disease3-5 Season of survey - 12 week heat stress (CRW DHW, Fig. 2B) White Syndrome (WS) is a management concern - Acute heat stress (CRW Bleaching Hotspot) across the Pacific characterized by actively sloughing Proportion of nearby colonies tissue, freshly denuded coral skeleton, and algal - Acute Chi a stress (4 week maximum) susceptible to WS (31 species) colonization at lesion margins⁶. Winter Local coral species diversity WS typically exists at low prevalence, but may rapidly Species-standardized colony size All model fixed effect estimates in Fig. 2C expand into high-mortality outbreaks at regional scales. Discussion Prior bleaching relative to Data Sources maximum (2009-Present) - Likelihood of WS is highly sensitive to site-scale Prior bleaching within 365 days Ongoing surveys of coral disease in Guam: processes such as coral size distribution - 72,910 colonies surveyed from 2009-Present Satellite ocean color metrics viable as approximate Model specification Statement of the local design - Quarterly surveys at 6 sites, 3 fixed transects per site measures of acute and chronic stress driving coral - Mixed effect logistic regression of WS-present (1) or WS-absent (0) - Data recorded included colony species, size class, disease Nested random intercepts for survey year, survey season, site, health conditions present, and disease severity WS appears driven by a combination of biological transect within site, and coral species surveyed factors and environmental stress at multiple Disease observations validated by expert observer Random slope of colony size on species surveyed (Raymundo) timescales **Future directions** Environmental stress measurements Assess which model decision rule is best suited for - NOAA Coral Reef Watch (CRW) 5 km thermal stress manager responses to a predicted disease increase Model drivers of WS severity after disease onset products VIIRS 750 m K₄(490) (turbidity) and Chl a Model additional diseases in the Guam dataset: (5-pixel rosette over sites, via Geiger/NOAA CRW) Skeletal Eroding Band, Black Band Disease, Brown Remove collinear driver Band Disease, Growth Anomaly Assess model performan Acknowledgements Determine model sensiti Thank you to NASA ROSES for funding this research as part of the Fore-C project (NNX17AI21G). Model nerformance Thank you to our collaborators Tracy D. Ainsworth, Fixed effect R² is 6.6% William Leggat, Courtney Couch, Bernardo Vargas-Fixed + Random effect R² is 43.7% Angel, Gang Liu, Jacqueline De La Cour, Joleah B. Model accuracy: Lamb, and Bruce Monger. Balanced accuracy maximized at a decision rule of 9% (p(WS)=0.09, Fig. 2D), where 78% of cases are correctly AMESCOO predicted as WS-present (true positive) or WS-absent (true Figure 1, study survey locations (Left), igure 2, predicted WS risk in response to colony size (2A) and DHW (2B), Stanford sites: West Agana (Top Right) and Tanguisson (Bo negative) to fixed effect estimates (2C) and model accuracy me

Outbreak response network

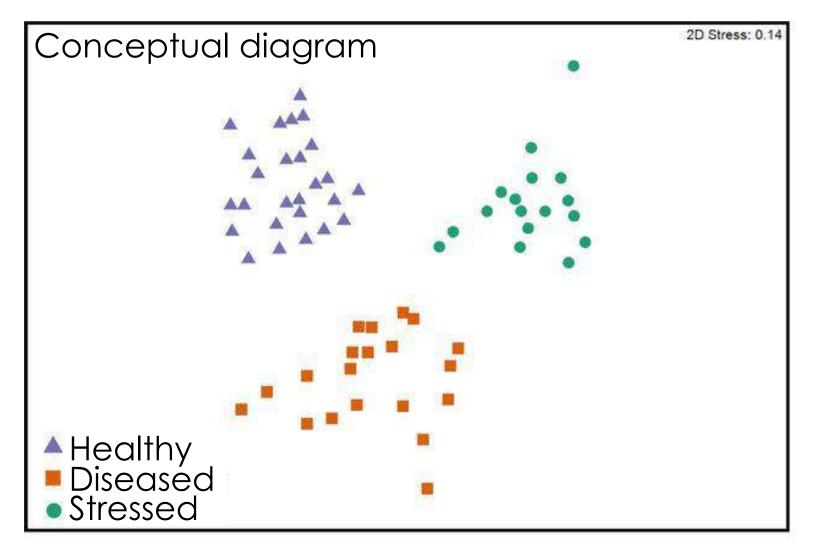


Guam outbreak

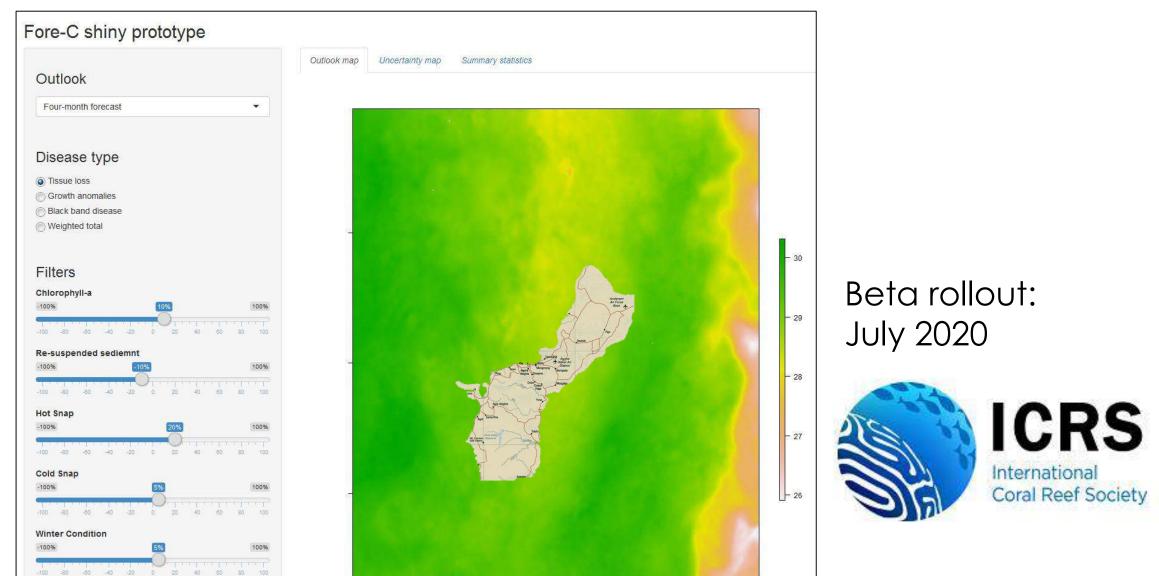


Photos: Laurie Raymundo

Guam outbreak



Initial prototype



Thank you





