Environmental Monitoring of Coral Bleaching and Disease in the Hawaiian Islands

Prepared for the 5th Annual Hawaiian Island Symposium

Honolulu, 2-3 May 2012

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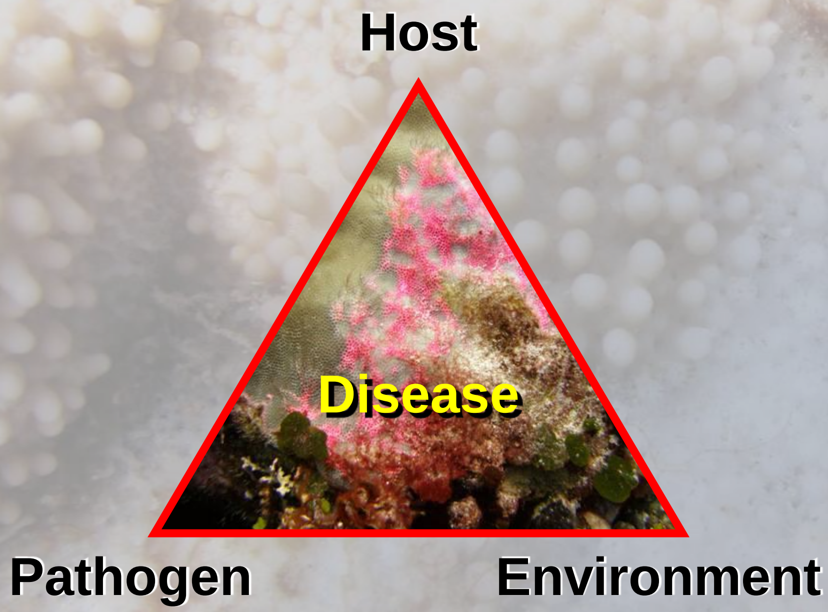
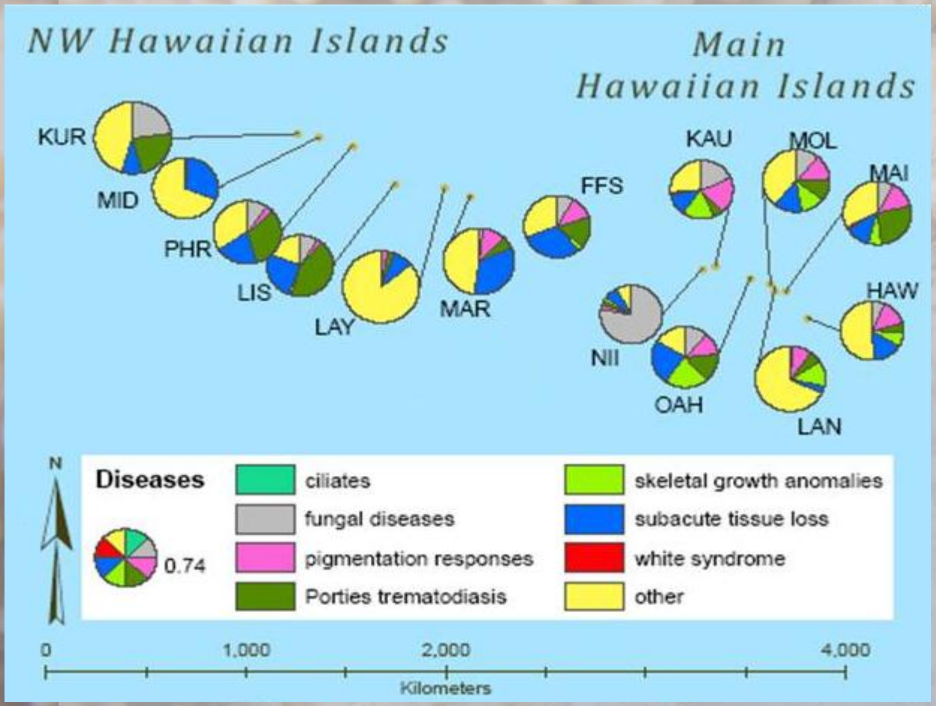
Coral Diseases: Why do temperatures matter?

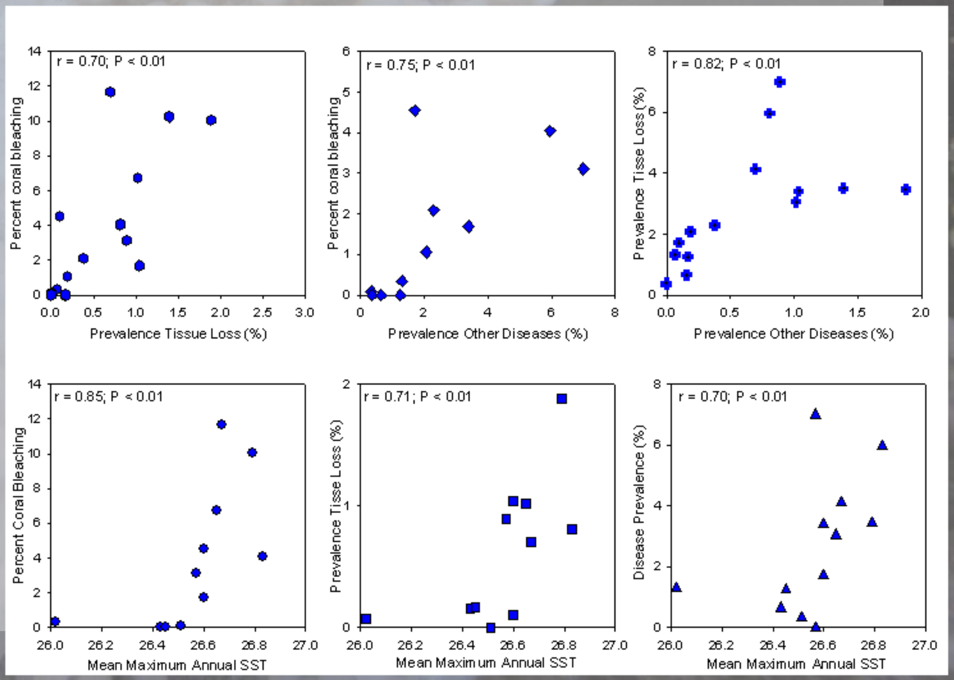


- Decreased resistance to disease under increased thermal conditions –corals are already stressed by anomalous high temperatures.
- Increased growth rate of pathogens –pathogens are more virulent at higher temperatures.
- Initiation of transcription of toxin genes.
- Combination of above.

Project Inception and Objectives



- Direct request from local POC of the LAS to better understand links between disease and temperature in the Hawaiian Islands



Approach

Environmental Monitoring of Coral Disease and Bleaching in the Hawaiian Islands Workshop

–Tentative Agenda –

August 24–26, 2009

NOAA Pacific Islands Regional Office

1601 Kapiolani Blvd, 11 Floor, Honolulu HI 96814

Purpose of Workshop

Exchange knowledge and understanding of the causal relationship between the physical environment and coral disease and bleaching to better serve management needs

Workshop Objectives

1- Bring together managers and scientists to discuss the topic of environmental correlates of disease and bleaching in the Hawaiian Islands

2- Identify products and solutions to meet management needs for coral disease and bleaching in the Hawaiian Islands

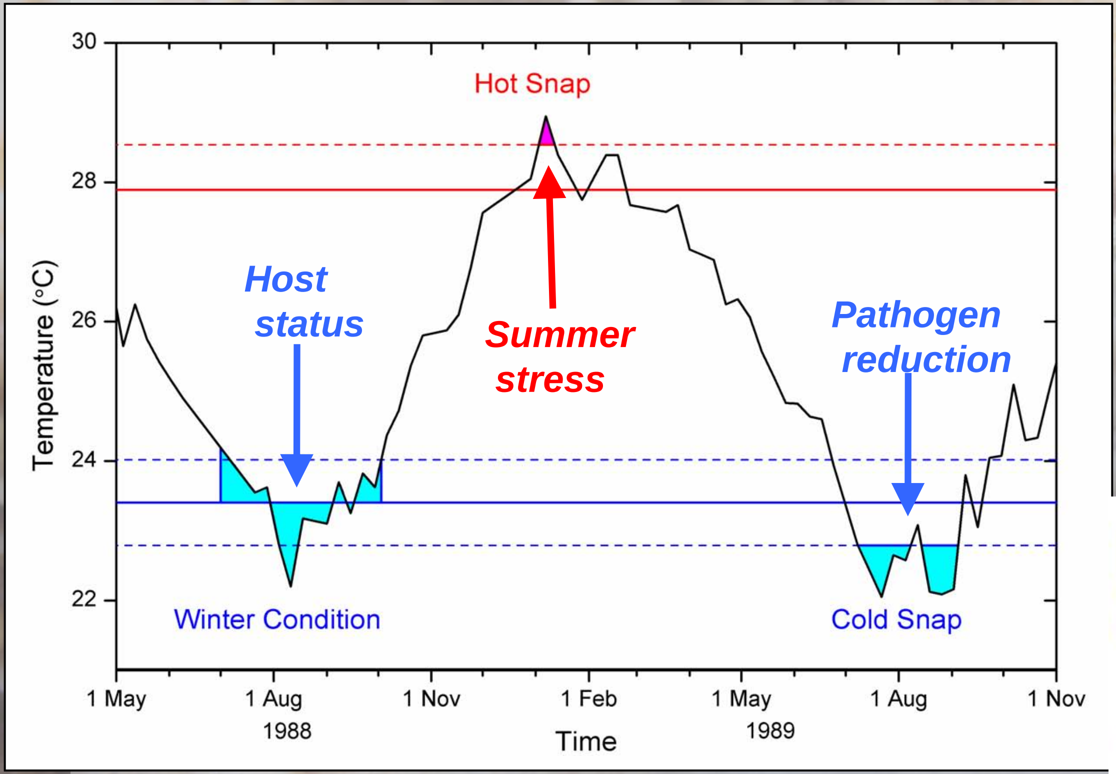
3- Discuss and identify information gaps to meet local management needs

4- Undertake the development of an experimental predictive tool to assess the risk of bleaching and disease outbreaks in Hawaii, that is based on satellite-derived SST metrics

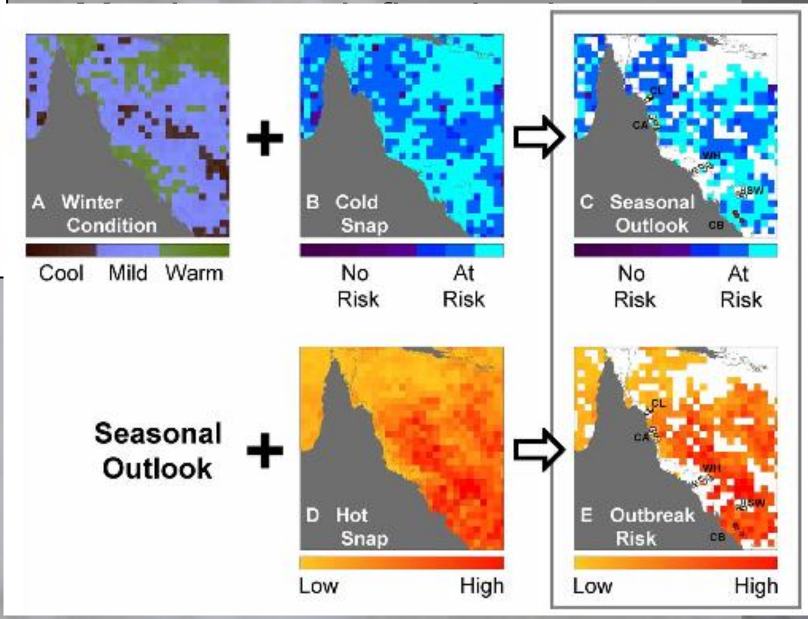
Coral Reef Watch

- Investigate the causal relationships between disease and bleaching and temperature.
- *Compile all exiting data including coral disease, in situ SST, and satellite SST.
- Undertake development of experimental predictive tool for risk of bleaching and disease outbreaks in Hawaii, based on satellite-derived SST metrics.
- Conduct complementary field surveys to validate a predictive coral disease outbreak risk algorithm with higher resolution.
- Report outcomes to managers and provide instructions on tool use.

Rational and Metrics



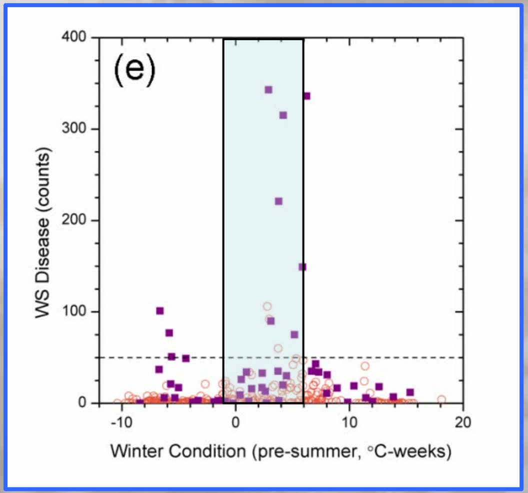
Building on the work by Bruno et al. 2007, new metrics were developed to separate the potential impacts of summer and winter temperatures on disease abundance.



Metrics are defined using summer and winter temperature mean (solid) and variability (dashed).

Heron et al. 2010

Rational and Metrics



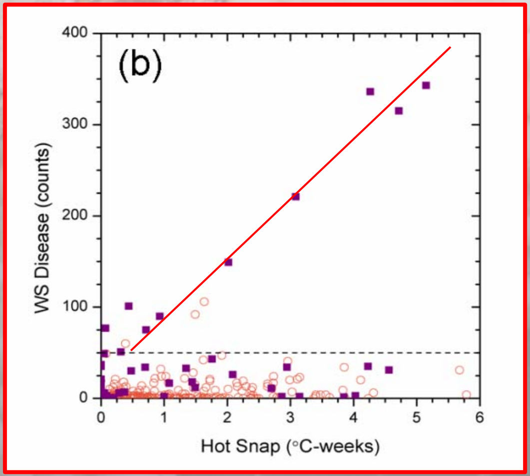
Outbreak observed where:

- MILD Winter Conditions (i.e ., neither hot nor cold)
- with NO Cold Snap

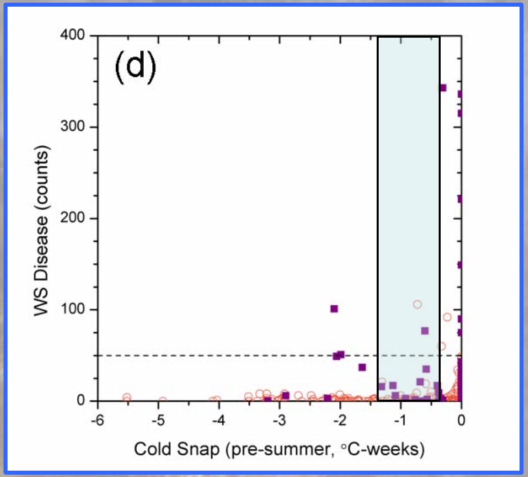
preceded

- Hot Snap thermal stress.

(n.b., filled squares high host cover; open circles low host cover)

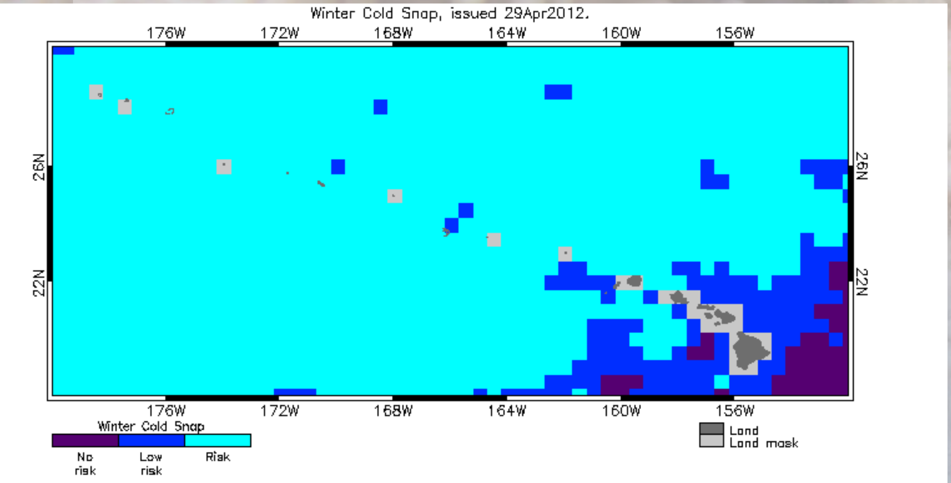


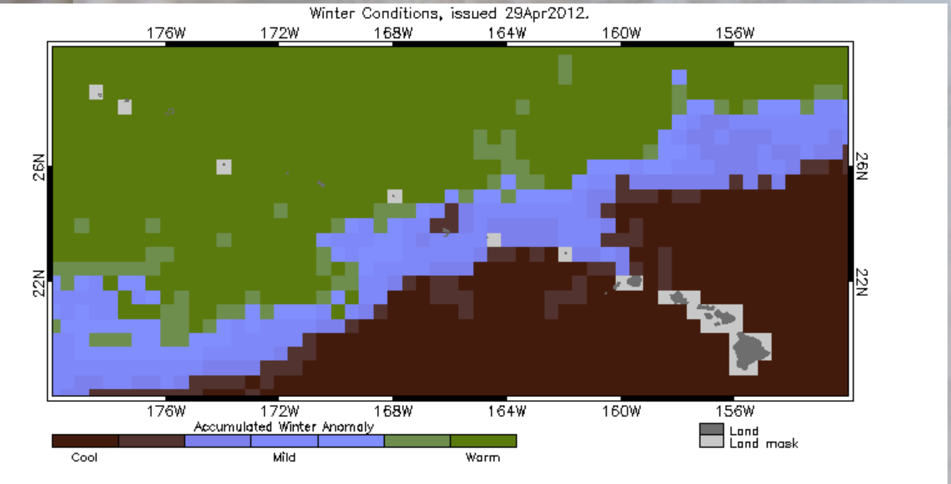
r^2 = 0.953 for data above outbreak threshold (dashed line)

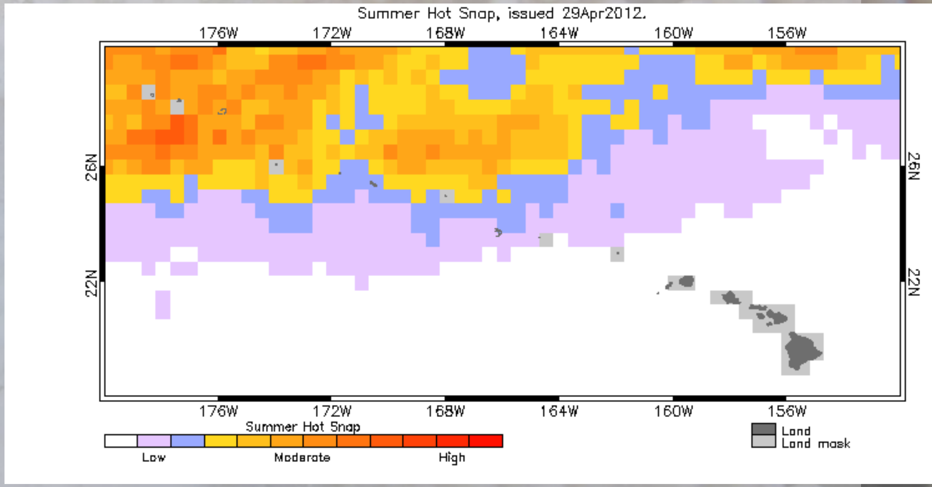


Heron et al. 2010

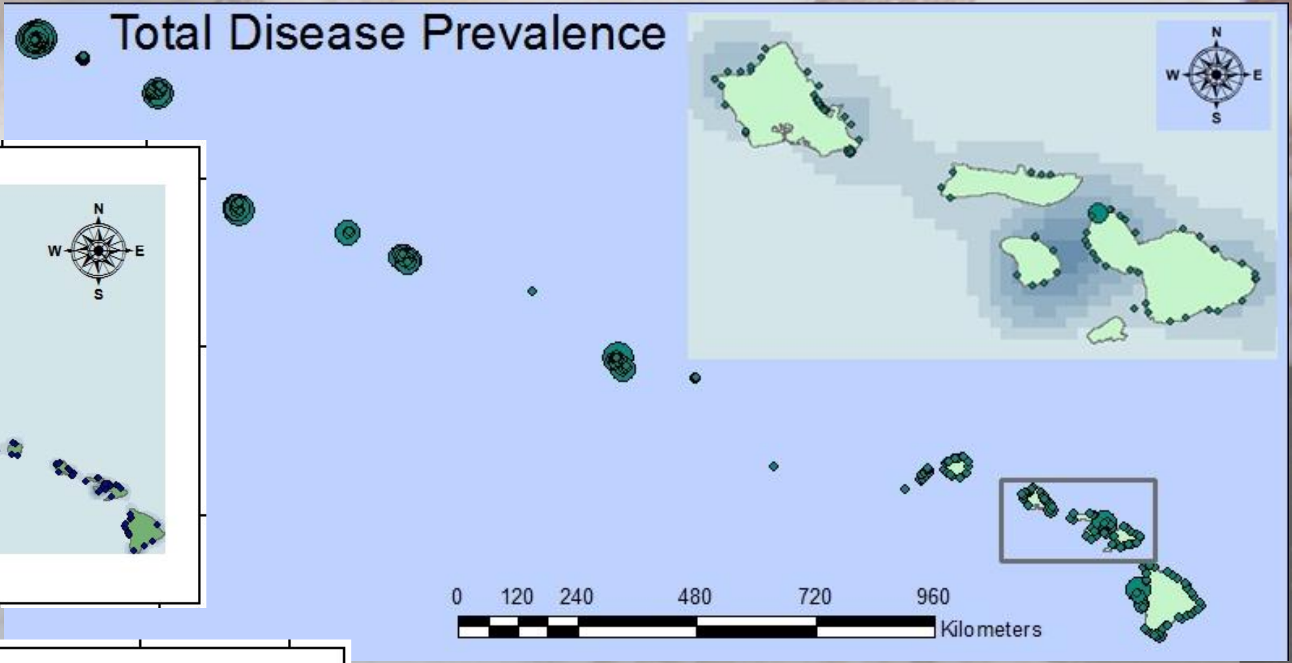
Decision Tree Metrics: Hawaiian Archipelago

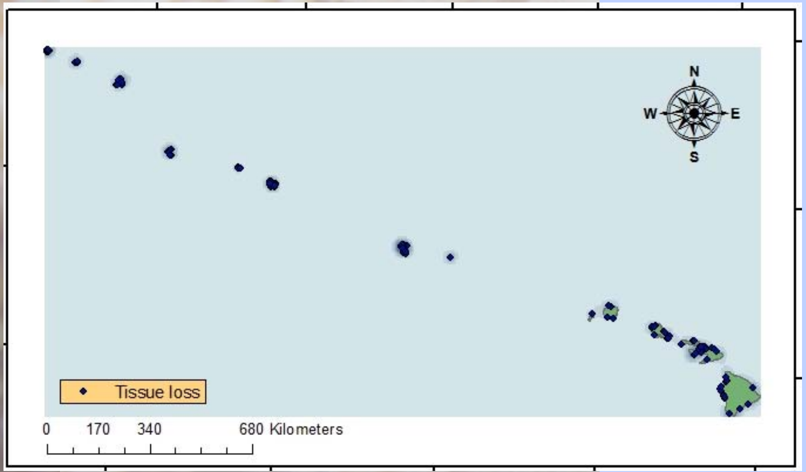


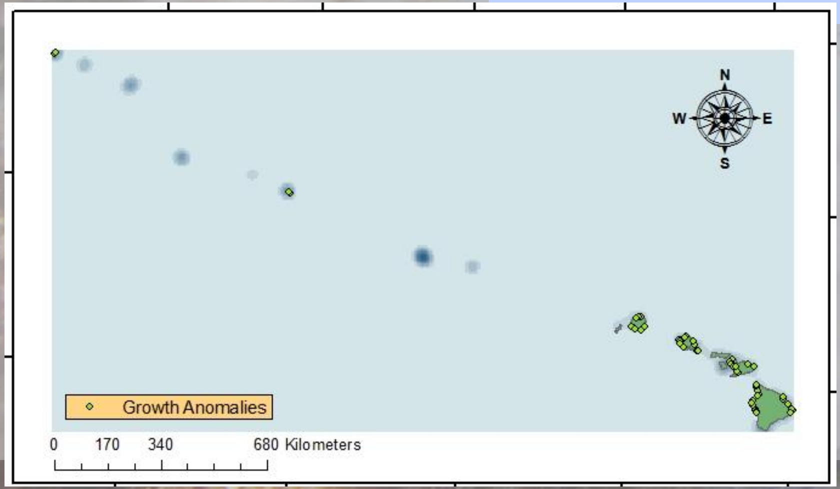


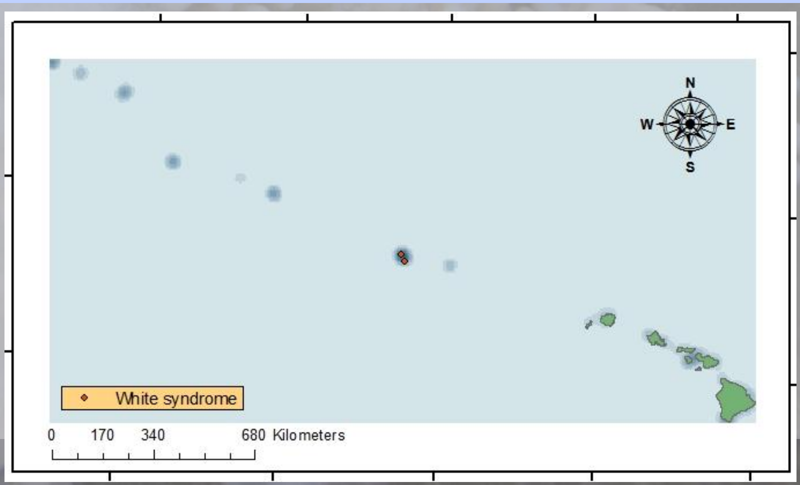


Hawaiian Islands Coral Disease Database
HICORDIS

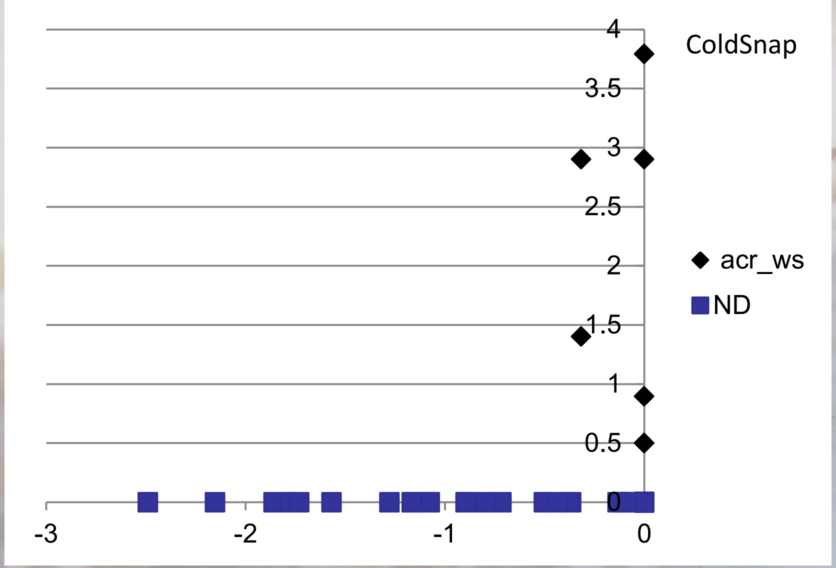


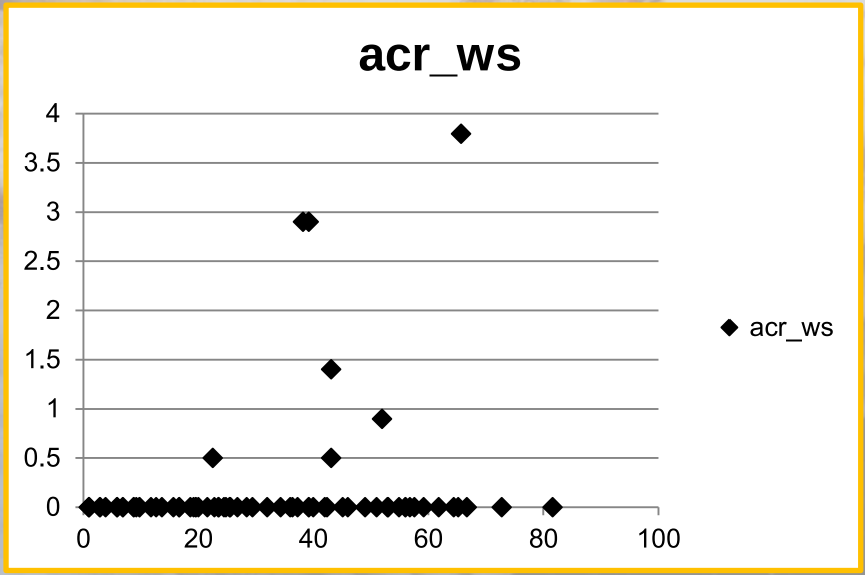


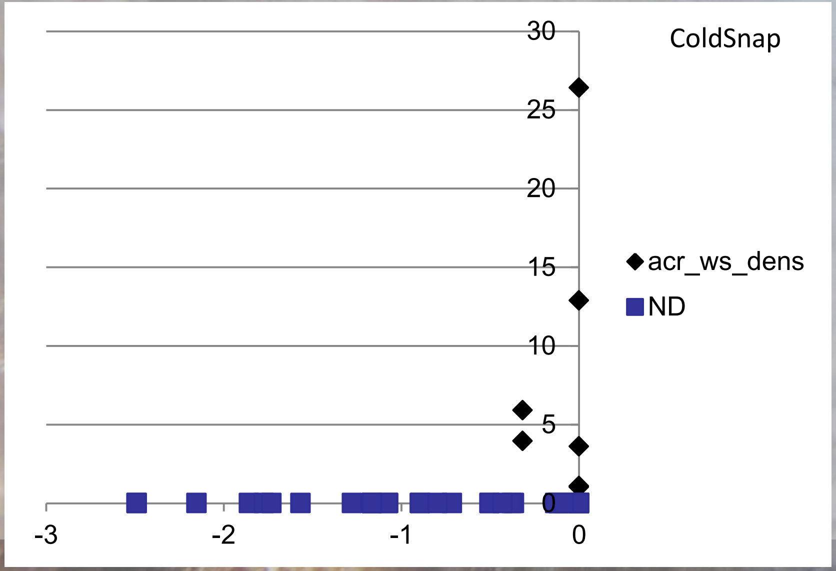


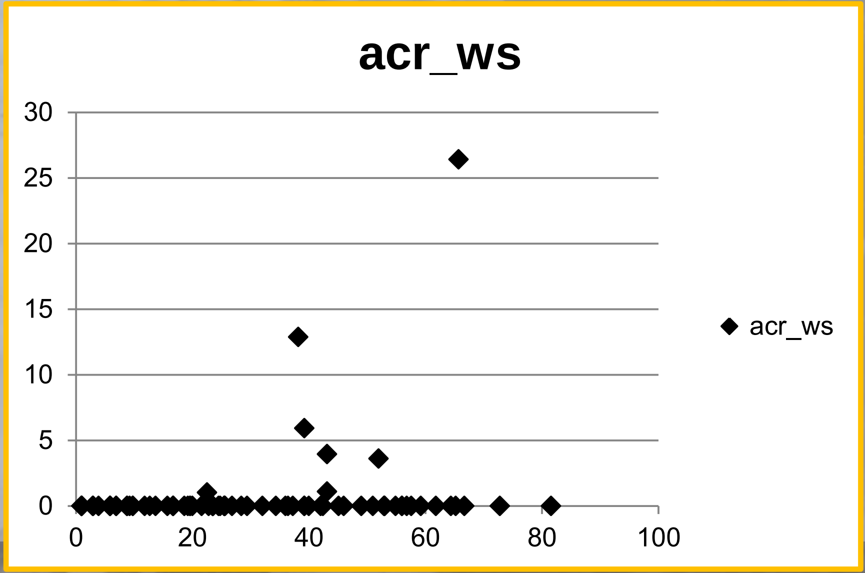


Retrospective Analysis: *Acropora* White Syndrome

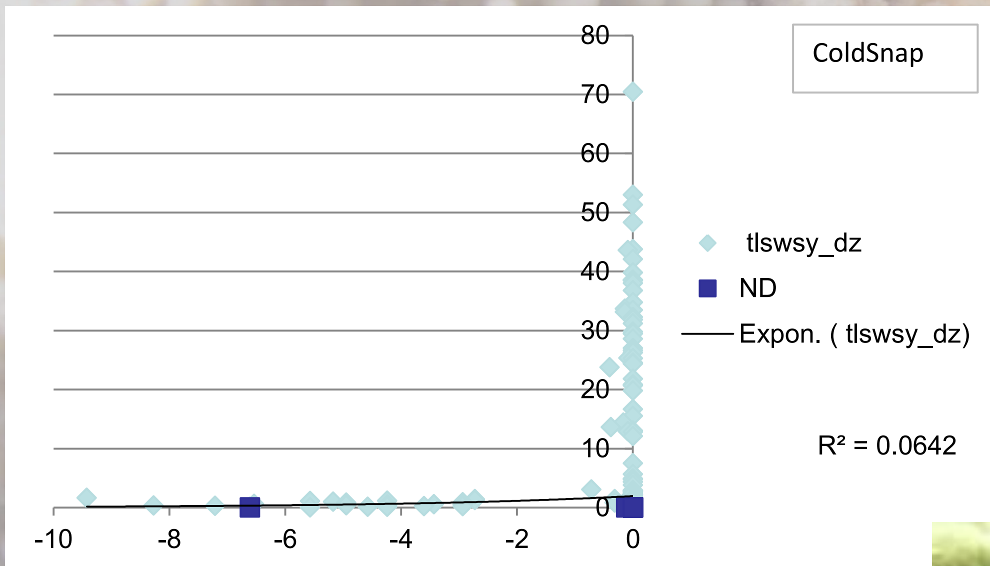






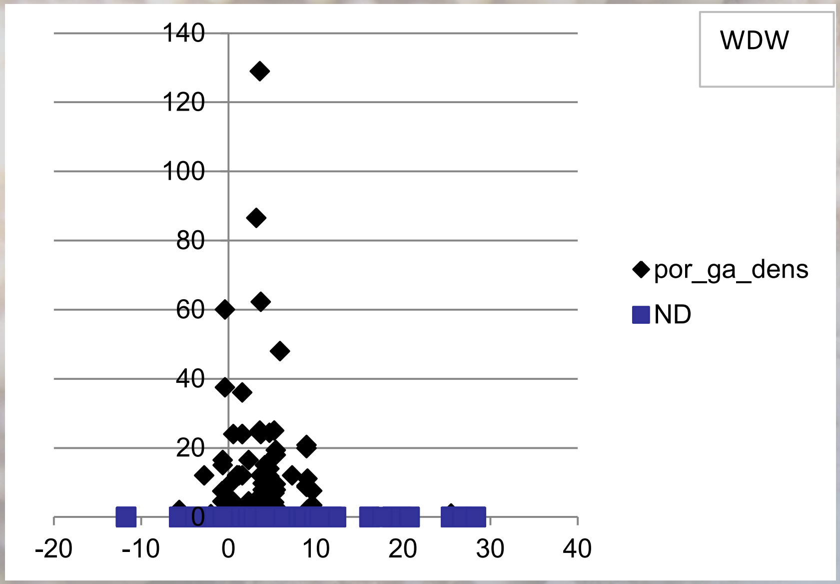


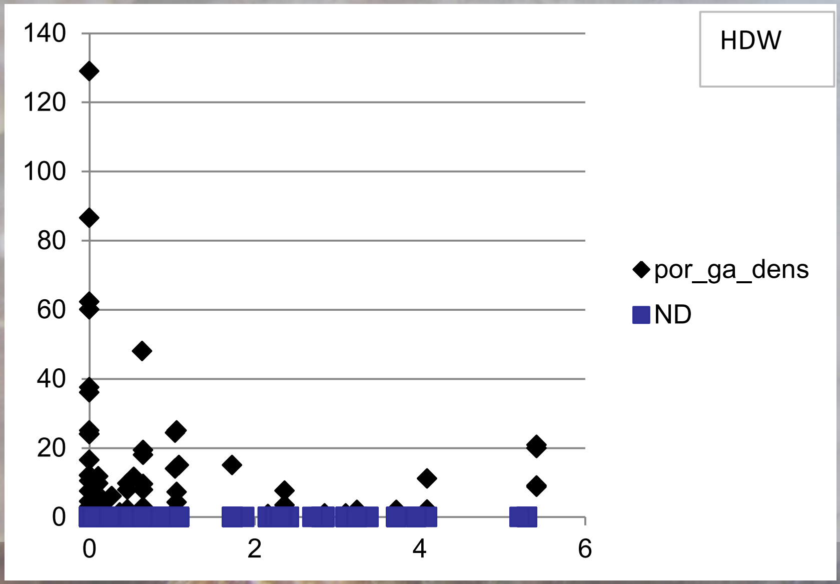
Retrospective Analysis: White Syndrome + Tissue Loss



- White syndrome and tissue losso were associated with the winter cold snap (50km resolution)

Retrospective Analysis: *Porites* Growth Anomalies





- *Porites* GA density was associated with Winter Condition (50km resolution
- *Porites* GA density was associated with zero summer HotSnap (50km resolution)

Summary and Conclusions

- Spatial disease patterns
  - High levels of spatial variability
  - Except for recurrent bleaching mainly in the NWHI, overall levels of disease are relatively low.
  - Presence of hotspots, some of which may be also linked to LBSP.
- Modeling tools
  - Retrospective analysis emphasizes that different diseases need to be treated separately and cannot all be clumped together and assumed to have the same drivers.
  - Retrospectively; winter temperatures appear to play an important role in disease outbreak.
  - Remote sensing tools may be more suited to monitor outbreaks rather than normal levels of disease.
  - Future direction: Look at algorithm performance comparing 4km vs. 50km resolution temperature data.
  - Upgrade algorithm using J Maynard’s work for ACWS in the GBR and apply it to localized outbreaks of disease such as those at KBay

Final Programmatic Report Narrative

1. Summary of Accomplishments

Key accomplishments of this project include: 1) determined broad-spatial temperature metrics (50 km) gives similarly reliable results for assessing disease risk when compared with 4 km metrics, 2) compared usefulness of the Host Snap (HDW) temperature metric developed by NOAA Coral Reef Watch with the mean positive summer anomaly (MPSA) metric developed by Maynard *et al* 2010, 3) tracked spatial and temporal trends of disease prevalence from 2004-2010 throughout the Hawai'ian Archipelago, and 4) enhanced the usability of the Hawai'i Coral Disease database (HICORDIS).

2. Project Activities & Outcomes

Activities

- Compared the decision tree model using 50 km temperature metrics and 4 km temperature metrics.
- Spatially and temporally mapped disease prevalence from 2004-2009 in the Hawai'ian Archipelago using ArcGIS.
- Determined mean winter and summer temperatures at each survey location.
- Compared the correlation between HDW with disease prevalence with the correlation between MSPA and disease prevalence.
- Performed a Moran's L.I.S.A. test of spatial clustering on each disease and overall disease prevalence.
- Calculated true positive rate (TPR), false positive rate (FRP) and overall accuracy (ACC) of original decision tree model with HICORDIS observational surveys.

Discrepancies between activities conducted from those that were proposed:

- Incorporated 2010 observational surveys from CRED (genus disease prevalence data).
- Standardized calculations for coral cover and disease prevalence for comparable observational data from the Hawai'i Institute of Marine Biology (HIMB), Hawa'i Department of Aquatic Resources (DAR) and NOAA Coral Reef Ecosystems Division (CRED).
- Created metadata for HICORDIS.
    - Discrepancies occurred because we were unaware of database errors prior to beginning work with the most recent version of HICORDIS. Errors included typos, miscalculations and differences in calculation/survey techniques by various sources contributing to the database.

Outcomes

- Determined 50 km satellite temperature metrics, which are gathered faster and more reliably than 4 km satellite temperature metrics, can be relied upon for this model, despite the broad-scale coverage for assessing fine scale ecological processes.
- Maps of disease prevalence focused our efforts on locations with the greatest disease occurrences.
- Temporal trends in disease occurrence supported the Great Barrier Reef findings that winter temperature conditions play a major role in disease prevalence.
- Results of moran's L.I.S.A. found *Porites* trematodiasis, *Porites* discolored tissue thinning syndrome and total prevalence to show significant spatial clustering.
- Overall accuracy of the decision tree model based on HICORDIS observational surveys were better than random (ACC between .60-.90), however, they also give a higher FPR and lower TPR than desired for operational use.
- We held a coral disease workshop to discuss model applicability and future goals of this research will all parties involved in the collection and compilation of HICORDIS.

- We anticipate publishing the enhanced HICORDIS database with metadata in the near future.

3. Lessons Learned

We learned that remote sensing tools used for coral disease risk assessment might be most useful for detecting outbreaks rather than monitoring normal levels of prevalence. We also determined that *Porites* trematodiasis might not be suitable for this decision tree model in the Hawai'ian Archipelago. In addition, the coral disease workshop and HICORDIS database errors brought to our attention gaps in scientific knowledge in the field that could enhance future versions of this model. Other conservation organizations would benefit from determining standardized methods of observation and data collection prior to fieldwork. This would greatly benefit data analysis.

4. Dissemination

Dissemination of this information will occur through: 1) an oral presentation of this project at the 12th International Coral Reef Symposium, July 9-13, 2012, 2) the HICORDIS database will be published for open use of collected data; 3) with follow up research we anticipate publishing a peer reviewed journal article and 4) NOAA will offer training for any future operational use of this product.