



NOAA
CORAL REEF
CONSERVATION PROGRAM



NOAA Coral Reef Conservation Program Ecosystem Science Evaluation

***Coral Disease & Health Consortium
(CDHC)
Capacity Building & Tool Development***

Topical Area
Organism Responses and Biodiversity Metrics

Presenter
Cheryl M. Woodley
NOS NCCOS



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Overview

The Coral Disease and Health Consortium (CDHC)

- Created in 2002, in response to the U.S. Coral Reef Task Force's (USCRTF) National Action Plan to Conserve Coral Reefs.
- Goal: To provide coastal and ocean managers with scientific understanding and tools to help protect healthy coral reef ecosystems and restore degraded ones.
- The CDHC is a highly collaborative and completely voluntary network of field and laboratory scientists, coral reef managers, and agency representatives devoted to understanding and addressing coral health and disease issues.
- Guiding principles and methods of public health and wildlife medicine used to support coral reef conservation



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Overview

CDHC Partners

NOAA

AOML
Coral Reef Conservation Program
EPP
National Marine Sanctuaries
National Ocean Service
NOAA Fisheries

Other Federal

NIST

National Park Service

VINP, Buck Is NM, Salt River Bay NP,
SE Region, BNP

USGS Labs

WV, HI, USVI

Dept. of Defense

SERDP, Navy, Army, UACE

Non-Federal

Coral Reef Task Force

State Agencies

FL, HI, SC

Universities

CofC, MUSC, UH, UCF, Penn State, George
Mason, UVI, Tel Aviv Univ. Ben-Gurion Univ,
Univ Guelph

Not-for Profit

Haereticus Environmental Laboratory
Living Oceans Foundation

Commercial

Chroma Technology Corp.





Objectives

- **Innovation & Discovery**
 - Developing tools and technologies to identify, diagnose and treat coral health conditions
- **Community Capacity Building**
 - Providing educational opportunities and technology transfer for students, stakeholders and managers
 - Convening consensus building workshops to unify the coral reef community and set direction
 - Providing research community resources
- **Strategic Research for Decision Making**
 - Uses an integrated, investigative approach to identify stressors and establish causal relationships through mechanistic studies to support mitigation, restoration and recovery of our coral reef resources.



Overview

Ecosystem

Community

Species

Population

Individual

Organ

Tissue

Cell

Early and
direct effects
of stressors



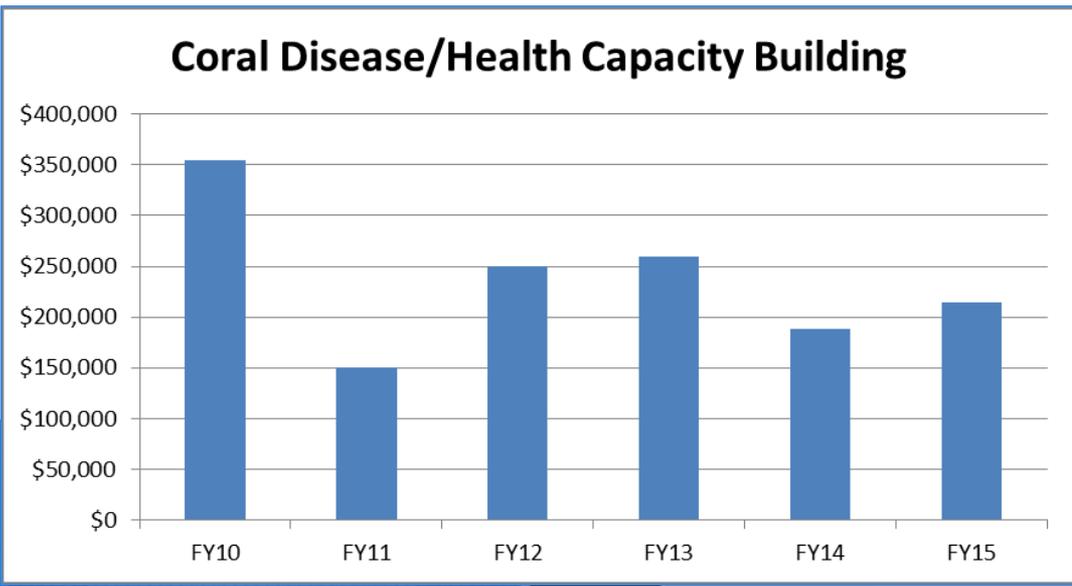


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Funding support 2010-2015

| Project Title | Project Mgr | LO | Funding Yrs | Total Yrs | Amount |
|--|--------------|------|-------------|-----------|--------------------|
| Incidence and characterization of coral diseases in the U.S. Pacific Is. | Vargas-Angel | NMFS | 2010 | 1 | \$129,000 |
| Coral reef ecosystem monitoring training and capacity building to support improved resource management in American Samoa | Vargas-Angel | NMFS | 2014-2015 | 2 | \$143,700 |
| Environmental investigation into impacts of LBSP on coral health in West Maui, HI | Woodley | NOS | 2012-2013 | 2 | \$230,000 |
| Coral Disease and Health Consortium (CDHC): Diagnostic metrics, epidemiology and capacity building | Woodley | NOS | 2010-2015 | 6 | \$915,000 |
| TOTAL | | | | | \$1,417,000 |





Funding Support Needed

Amount needed to conduct this work

\$300-400K/yr per lab

Ex. Contract labor costs \$70K-110K/person

Other leveraged resources

- NOS NCCOS base funds for FTE salaries
- NOS NCCOS Discretionary funds for related project
- DOD – SERDP – stressor-related project (2011-2013)
- Volunteer time



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Information - Products - Tools

- CDHC Website – www.cdhc.noaa.gov
- Coral Culture & Research Facility (Charleston SC)
- CoRIS database archive products
- Direct communication with Managers (local, state & federal)
- Distance Learning – Virtual Slide Technology
- Instructional Videos
- Peer-reviewed publications
- Technical Memoranda
- Training Workshops
- Technology Transfer
- Reference Books – *Diseases of Coral*



Drivers for this work

▶ ESA Coral Recovery Action Plans

• Objective 1. **Population Viability**

- Action 3. Conduct Strategic Research of Elkhorn and Staghorn Coral Biology
- Action 6. Conduct Active Population Enhancement

• Objective 2. **Eliminate or sufficiently abate, global, regional and local threats**

- Action 11: Research and develop mechanisms to enhance adaptation/acclimation of Elkhorn and Staghorn corals to increases in climate stress
- Action 16: Study organismal response to nutrients and contaminants and implement appropriate remedies

▶ CRCP LBSP & Climate Change Priorities



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Objectives

• Innovation & Discovery

- Custom design & fabrication of toxicity testing systems
- Coral disease therapeutics and drug delivery
- Tissue-based Assays
- Cell-based Assays
- Biochemical Assays
- Microscale assay modifications for ammonia, nitrate, nitrite, phosphate & sulfide
- Assays in development to address aging, immune status, reproductive status, stressor-specific biomarkers

• Community Capacity Building

- Providing educational opportunities and technology transfer for students, stakeholders and managers
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• Strategic Research for Decision Making

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Innovation & Discovery Science

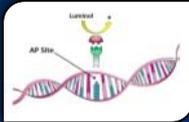
2010

Porphyrin
Quantification



2011

DNA AP site assay



Custom fabricated glass-
Teflon culture & dosing
systems



2012

Other DNA Damage
Assays as Indicators of
Reproductive Impacts



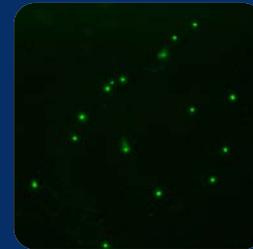
2013

Sea Urchin Embryo
Fertilization &
Development Bioassays



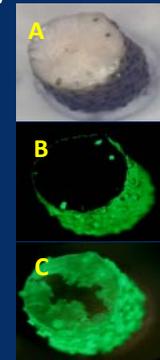
2014

Sperm viability &
damage Assays



2015

Wound Healing
Assays



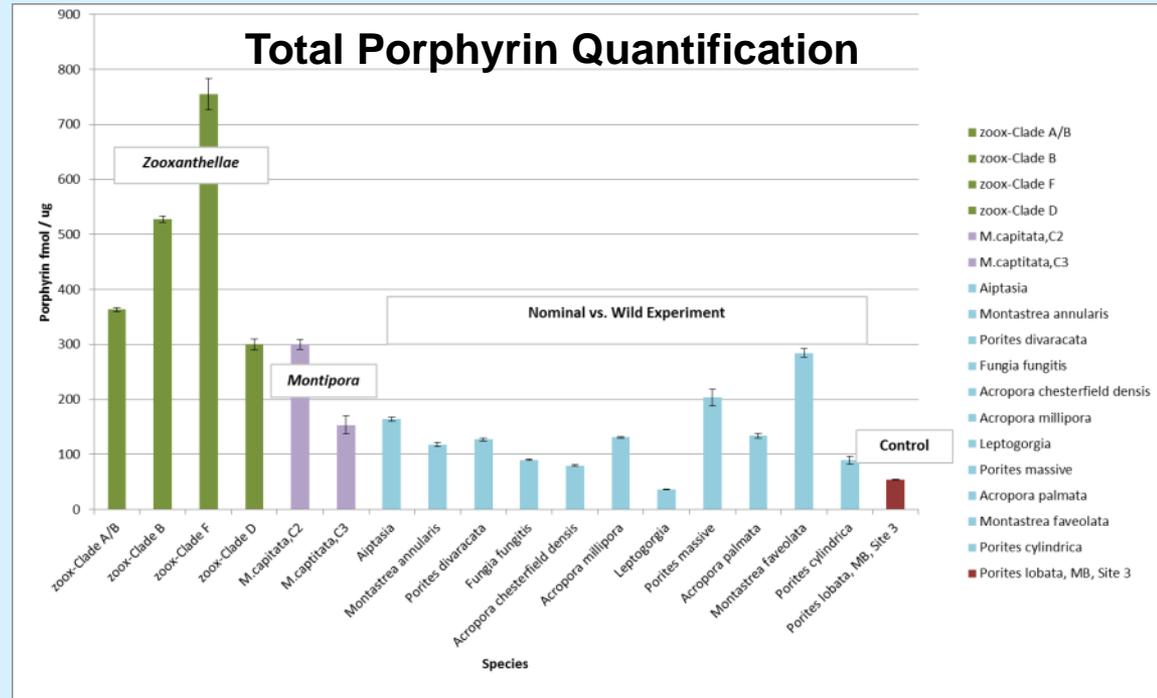
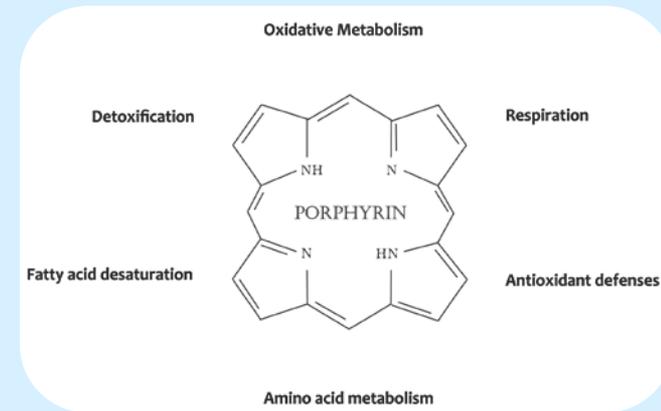
2016

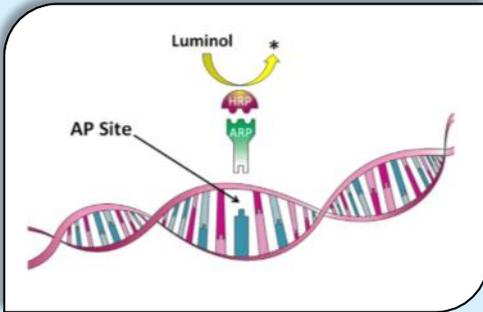
Telomerase Activity
qPCR

Protein Assays

Porphyryns:

- Biochemical intermediates in the heme biosynthetic pathway
- Porphyria – disruption of heme pathway
- Bioindicator of general metabolic suppression
- Acquired porphyrias indicators of toxic exposures
 - Heavy metals
 - Organic contaminants

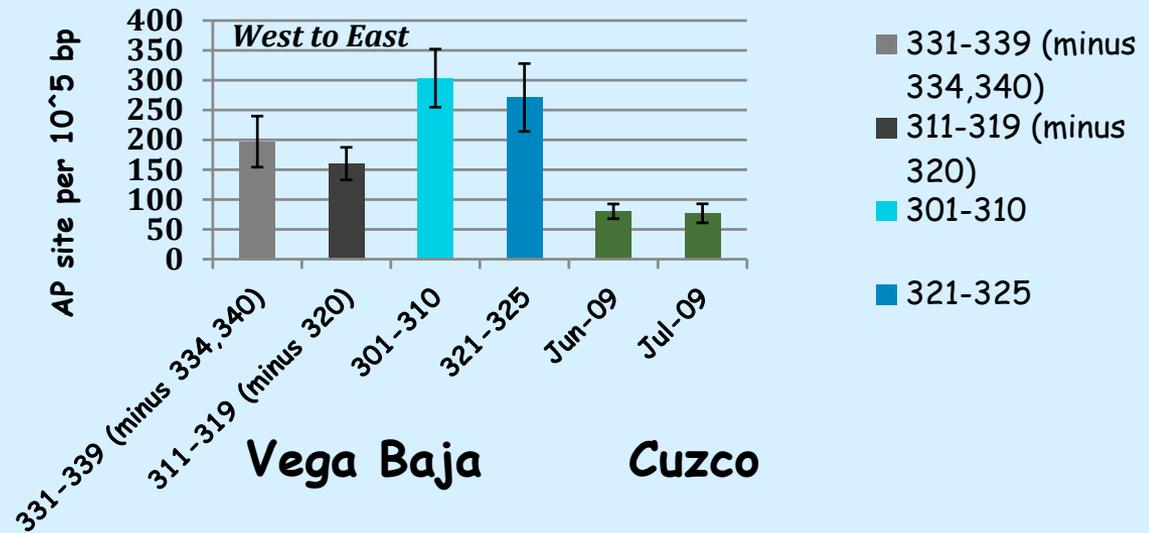




DNA Damage Assays

- Accumulation of high levels of DNA damage is indicative of exposure to genotoxic contaminants
- Indicator of possible reduced reproductive fitness affecting gamete viability
- For surviving offspring may give rise to mutations that can reduce fitness of the species/population

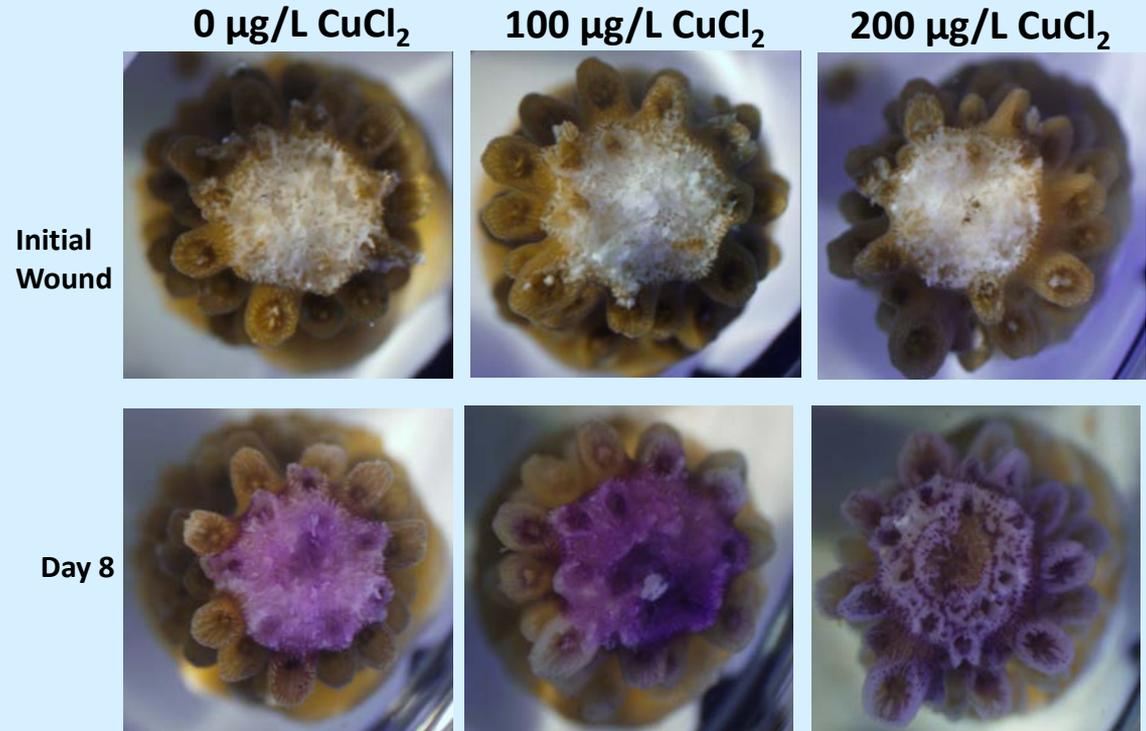
A. palamata: Vega Baja, PR DNA AP Site Assay



Tissue-based Assays

- Regeneration rates reflect ability of colonies to recover/repair physical damage
- Useful indicator of physiological or environmental conditions
- Provides information on the effect of stress on the overall fitness and function of the organism
- Instructional video of this assay for lab or field application can be found at www.cdhc.noaa.gov

Wound Healing Assay





How is this information useful?

- **NO** single metric is adequate to understand or assess the complex and inherently variable effects of environmental change on coral reef ecosystems. The tools being developed as part of this project are critical, fundamental steps to enable
 - Investigations to determine causal links for reef degradation and collapse
 - Mitigation for targeted threat-reduction actions
 - Restoration to recover coral species, habitats and ecosystems for reefs in the future
- The Innovations and Discoveries of this project are targeted assays to assess the status or condition of specific biological systems/function. They address:
 - Exposure – provides evidence the organism is or has been exposed to xenobiotics or adverse environmental conditions
 - Effect – provides evidence of alterations in molecular and cellular processes
 - Susceptibility – reflects the risk that an organism may acquire an adverse condition (PROGNOSIS)



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 - Protein Biomarker Assays
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- Community Capacity Building
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Community Capacity Building

Monitoring & Capacity Building in American Samoa

2010 2011 2012 2013 2014 2015 2016

Cayman Islands
Outbreak
Training

Acropora Surveillance
Network Workshop



Threat Assessment
Training for Hawaii
Resource Managers



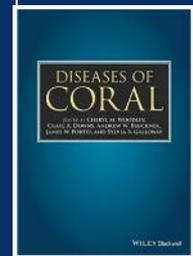
Instructional Video:
Sediment Sampling for
Toxicology



CDHC Website
Content Updates



2016



Threat Assessment
Training for Caribbean
Resource Managers

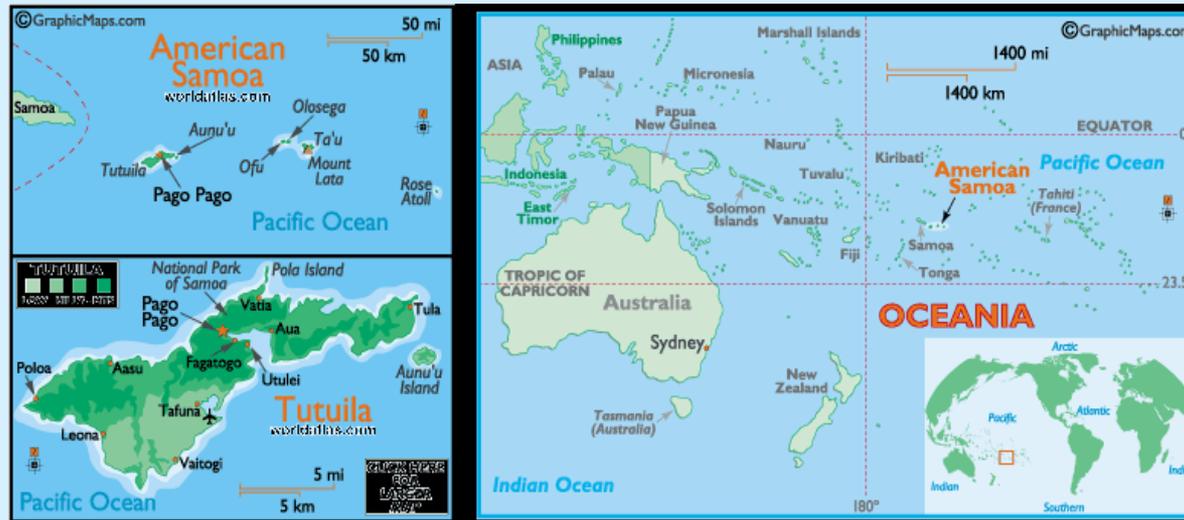


Instructional Video:
Laceration Regeneration
Assay



St. Vincent and
the Grenadines

Monitoring & Capacity Building in American Samoa



- Training workshop on coral reef benthic monitoring design and methods, especially stratified random designs
- Baseline characterization for the benthic communities in the Fagamalo Village no-take MPA, along with other priority management sites (Vatia Bay and Faga'alu Bay)
- Outputs: training materials, metadata, and baseline data distributed as technical life Resources

(Vargas-Angel PIFSC)



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How is this information useful?

- Local capacity for rigorous monitoring improved in Am. Samoa
- Resource managers from 11 Caribbean nations now have new tools to prioritize potential impacts from human activities, and generate their own data to justify management actions for protecting the resource when finances, expertise or time are limited
- These efforts can increase the quality and comparability of data collected by our partners, so datasets can be more effectively leveraged.
- Instructional videos aid in improving the quality of sample collections and standardization of assays and ultimately quality of data used in decision-making



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Strategic Research in Support of Management

2010 2011 2012 2013 2014 2015 2016

Field Trials for Dive Suits
as Vectors of Coral
Disease



Laboratory
studies to ask
Can Dive Suits
Vector
Disease?



Environ. Investigation into Impacts
of LBSP on Coral Health in W. Maui



Disease
Characterization in
US Pacific



Field Testing
COMET assay
with urchin
sperm



St. Croix USVI
Sediment Tox.
Survey



Examining Acropora
Genotype Vigor

Disease Characterization in US Pacific

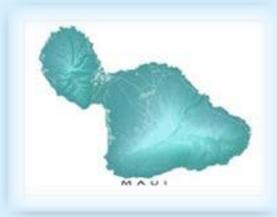
(Vargas-Angel PIFSC)

- Crucial baseline and reference point to compare levels of coral disease for many of the US Pacific Territories (nonexistent prior)
- Nomenclature for coral diseases that is congruent with efforts conducted by colleagues throughout the Pacific.
- Basis for ongoing disease data collection in CREP surveys



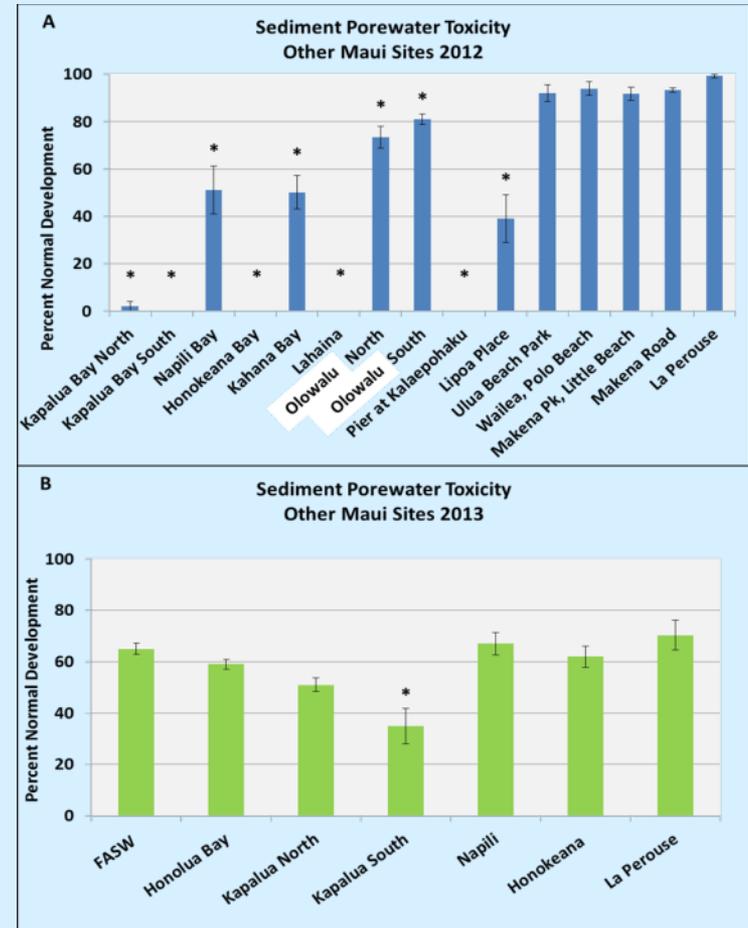
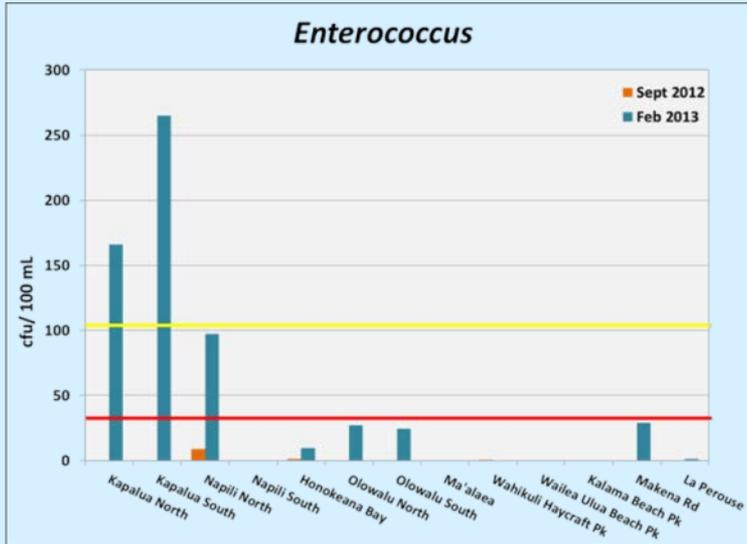
Investigation

West Maui, HI



Sediment Porewater Toxicity

Bacterial Water Quality



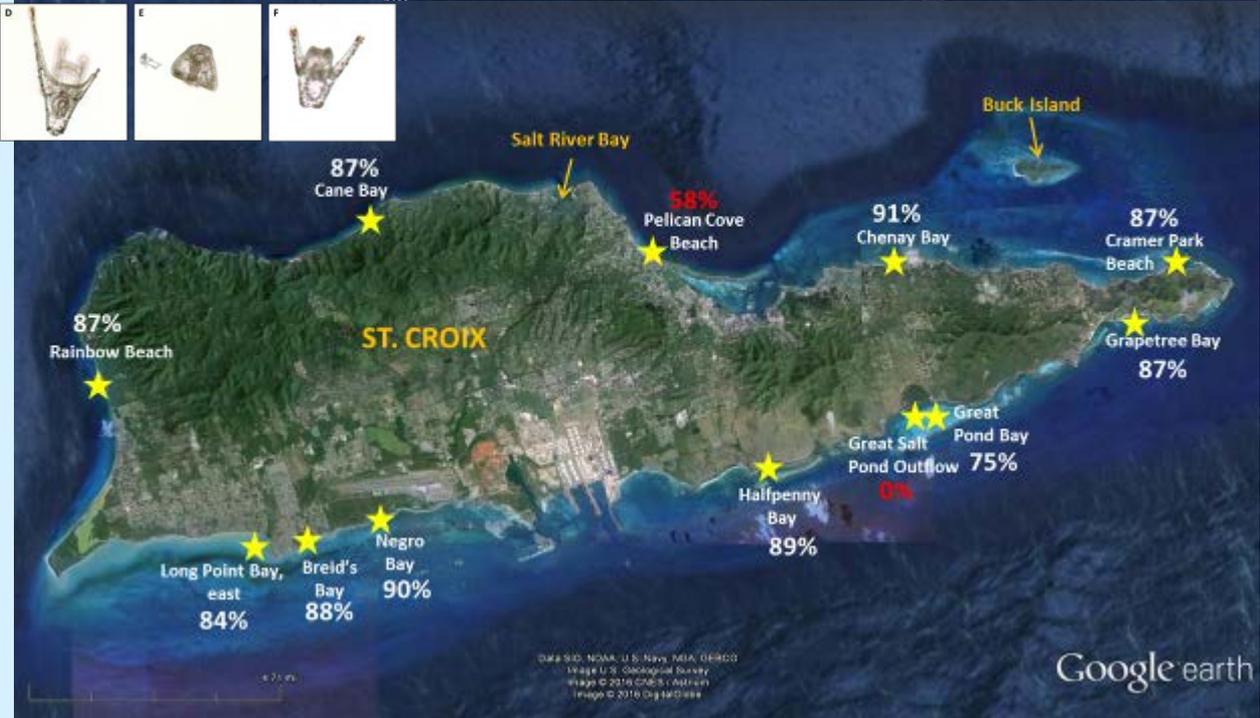
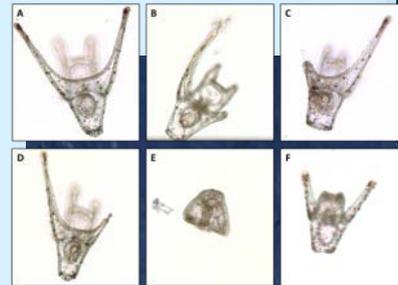
➤ The sites with high *Enterococcus* levels did not have elevated fecal coliforms arguing against stormwater runoff, which is often the source of fecal coliforms. These two opposing pieces of data suggest the fecal contamination was more likely human origin, such as sewage leakage or increased numbers of swimmers.

➤ Multiple locations found toxic to marine life, fecal indicators also at Kapalua & Napili suggest sewage leaks

Investigation

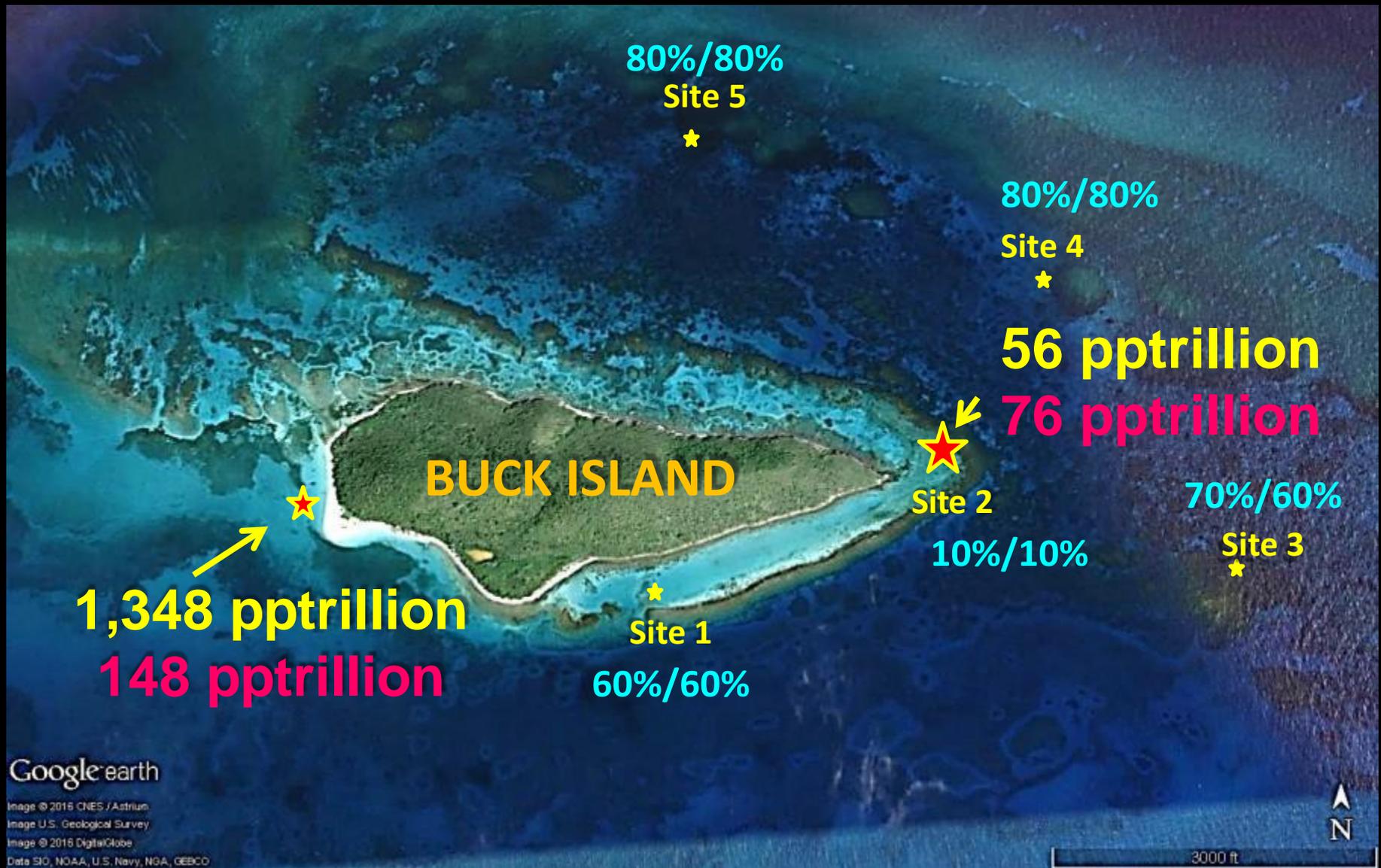
St. Croix, USVI

- Sea urchin development bioassay used to survey for toxicity along coast of St. Croix & Buck Is. 8 sites showed less than 80% normally developing embryos
- Toxicity reduction assays significantly increased normal development at BI underwater trail
- This site also had high incidence (90%) of coral zombies and elevated levels of oxybenzone and ethylhexyl-methoxy-cinnamate



Oxybenzone Contamination

EHMcinnamate Contamination



***Acropora palmata* % oval / % spermaries**



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How is this information useful?

- Targeted monitoring provide ability to establish baselines, detect basic trends in reef processes, and enable evaluation of management actions
- Data on levels of recruitment or coral disease is provided to partners and co-workers for documentation and comparative analysis.
- West Maui project data provided to Maui County which began sewer repairs and budgeting for sewer upgrades in West Maui
- National Park Service is seeking more information to support management actions for mitigating toxicity and coral zombies at Buck Island and Salt River Bay
- Exposure and/or effect data gives resource agencies evidence to take action where otherwise lack of public support or political will means no action and coral reef resources suffer



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Key Contributions and Strengths

We investigate emerging threats that have management-potential and threat-reduction options to support decisions for mitigation, restoration and conservation of coral reefs for the future.

Our research provides diagnostic-based information on issues impacting coral health, potential causes and their action levels, for environmental protection and to support informed choices by decision makers, managers, politicians and the public.



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Challenges

- ▶ Qualified human capital to conduct work & continuity of workforce
- ▶ Difficulty communicating to managers those applications in our portfolio which may benefit future management actions
- ▶ Paucity of knowledge for developing nomenclature for Pacific coral disease and obtaining sufficient voucher samples
- ▶ Limitations of human resources and infrastructure in Am. Samoa to execute field work
- ▶ Limited resources for advancing new technologies for field applications (bridging lab to field)
- ▶ Having a 'triage' capability for managers



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Future Directions

- **Innovation & Development**
 - Aging – Reproductive senescence
 - Immune status
 - Reproductive status
 - Stressor-specific biomarkers
 - New technologies for easier, faster, reporting for coral health assessment (e.g., Reporter-genes, coralspeQ, chemical sniffers)
- **Capacity Building**
 - Develop virtual protocols for the web with accompanying instructional videos as new assays are available
 - Provide training and technology transfer to international resource managers
 - Mentor students and young professionals to help equip the next generation of scientists



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Future Directions

- **Strategic Research**
 - Conduct targeted investigations to understand whether a coral zombie can recover –and live/reproduce normally again
 - Determine the root cause of toxicity at Buck Island’s underwater trail in St. Croix USVI to support management actions
 - Conduct epidemiological survey for reproductive status of *Orbicella* spp. in the U. S. Caribbean
 - West Maui - further investigation to determine the identity of pollutants present in waters and sediments, their source and potential control mechanisms



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- Downs, C.A., Kramarsky-Winter, E., Segal, R., Fauth, F., Bronstein, O., Jeger, R., Lichtenfeld, Y., Woodley, C.M., Pennington, P., Al-Horani, F., Kushmaro, A., Loya Y. (2014) Toxicological effects of the sunscreen UV filter, benzophenone-2, on planula and in vitro cells of the coral, *Stylophora pistillata*. Ecotoxicology. 23: 175-191. DOI: 10.1007/s10646-013-1161-y
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Publications

- May, L. A., A. R. Avadanei, et al. (2010). Community Analysis of *Acropora palmata* Mucus Swabs, Water and Sediment Samples from Hawksnest Bay, St. John, U.S. Virgin Islands. NOAA TM NOS NCCOS 123 & CRCP 14. Silver Spring, National Oceanic and Atmospheric Administration: 7p.
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