Toward a Global Coral Reef Observatory

Kickoff Talk

Coral Reef Environmental Observatory Network (CREON) Meeting

Kenting, Taiwan

March 14, 2008

Dr. Larry Smarr

Director, California Institute for Telecommunications and Information Technology

Harry E. Gruber Professor,

Dept. of Computer Science and Engineering

Jacobs School of Engineering, UCSD

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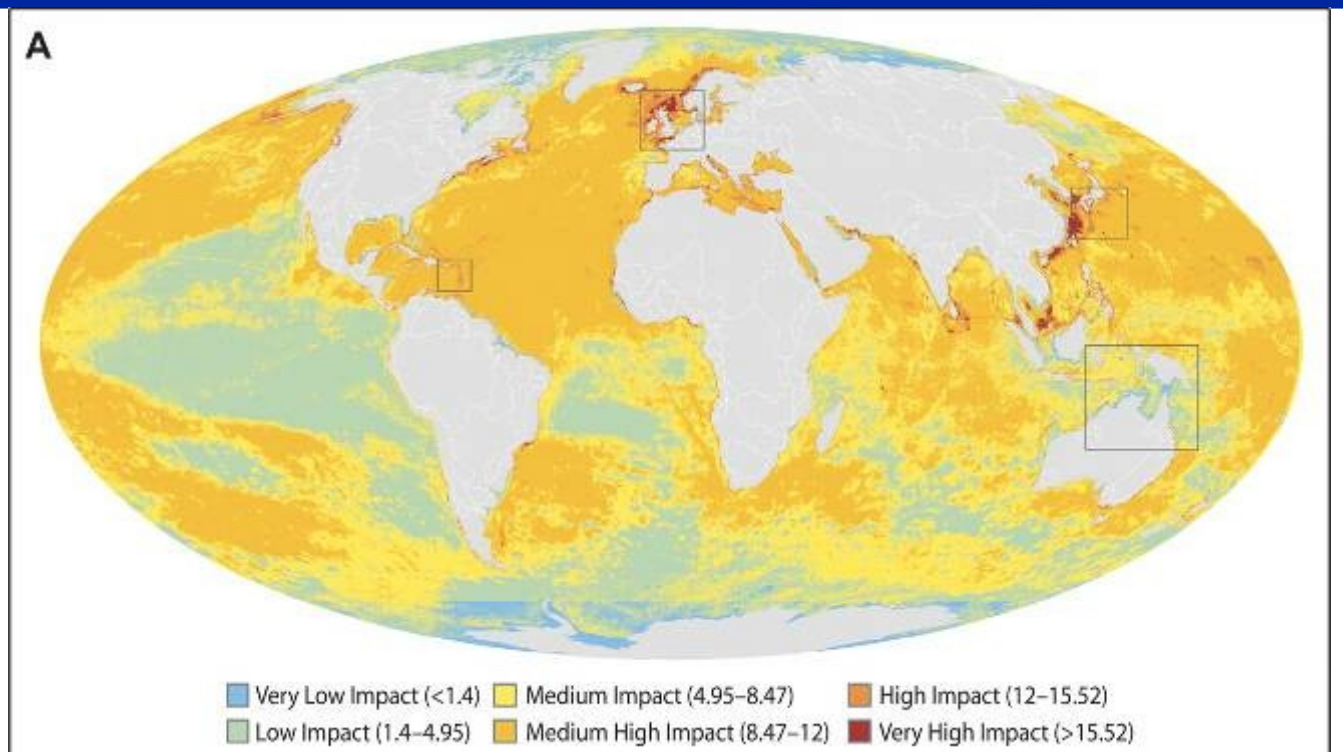
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International Threats to Coral Reefs and Ocean Biology -- Urgent Need for SensorNets



Science December 14, 2007



A Global Map of Human Impact on Marine Ecosystems
Science February 15, 2008



Science May 14, 2007

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Global Access to SensorNets via Internet Creates Environmental Observatories



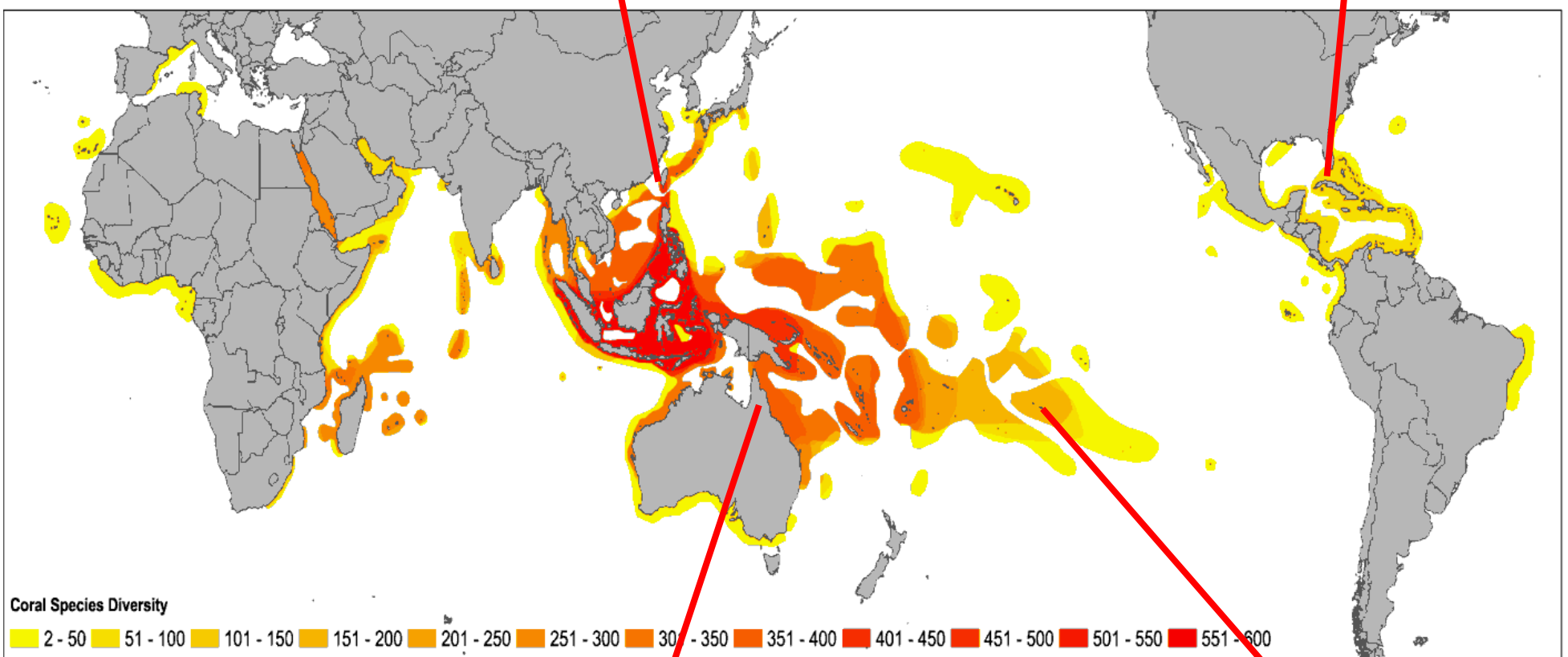
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Coral Reef Environmental Observatory Network (CREON)

www.coralreefeon.org/

Taiwan

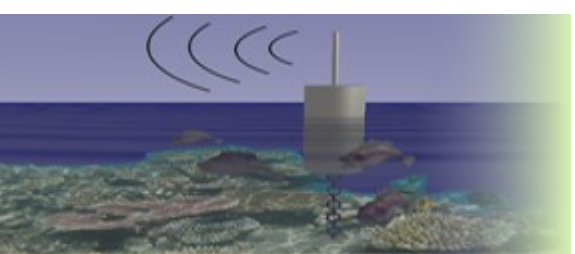
NOAA



NSF Collaboration:
UCSB and AS/NMMBA

GBR

UCSB



Source: Stuart Kininmonth, AIMS

Source : Fang-Pang Lin, NCHC

Taiwan's Kenting's Underwater Observatory

- **Deployed off Southern Taiwan 2004**
  - **Features 10 Underwater Cameras**
    - **Setup To Monitor Different Habitats on The Coral Reef**
  - **Currently Used by Taiwan's Academia Sinica and NMMBA**
- **On-Shore Video Servers are Used to Convert Analog Signals to Digital MJPEG Video Streams**
  - **Remote Observatory, Low Bandwidth (~1 Mbps)**
  - **Video Resolution: 320x240 Pixels**
  - **Effective Transfer Rate: 1 Frame/sec**

OPEN SOURCE DATA TURBINE INITIATIVE
Empowering the Scientific Community with Streaming Data Middleware



CREON



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Source: Ebbe Strandell, NCHC

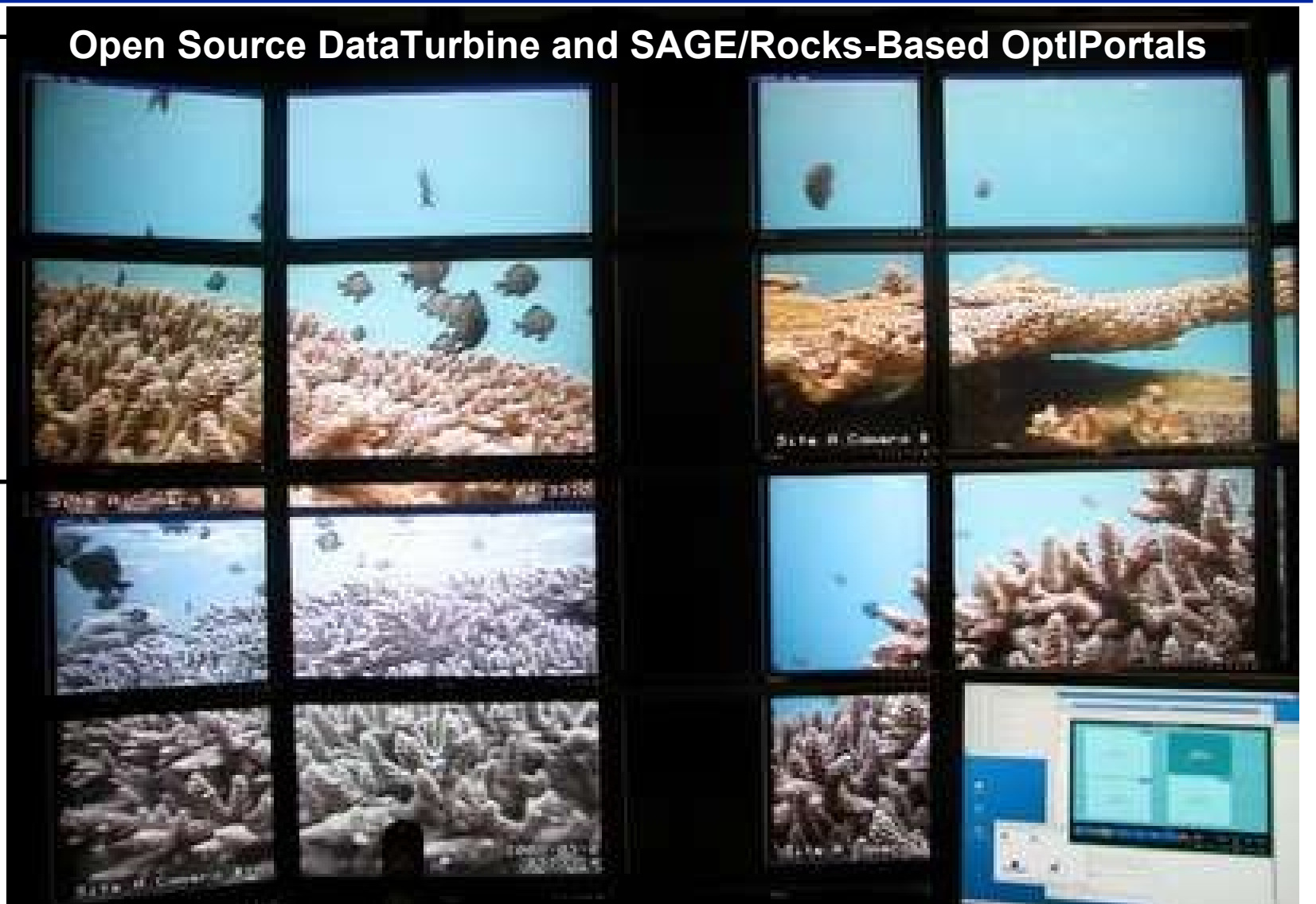
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New Year's Challenge: Streaming Underwater Video From Taiwan's Kenting Reef to Calit2's OptIPortal

My next plan is to stream stable and quality underwater images to Calit2, hopefully by PRAGMA 14. -- Fang-Pang to LS Jan. 1, 2008

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March 6, 2008 Plan Accomplished!



ROCKS

OptIPuter

OPEN SOURCE DATA TURBINE INITIATIVE

Empowering the Scientific Community with Streaming Data Middleware

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UCSD: Rajvikram Singh, Sameer Tilak, Jurgen Schulze, Tony Fountain, Peter Arzberger
NCHC : Ebbe Strandell, Sun-In Lin, Yao-Tsung Wang, Fang-Pang Lin

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Using SAGE to Control Kenting Coral Reef Video Streams Within Taichung 4k Projection

CREON





Source:
Ebbe Strandell, NCHC

Raj Singh, UCSD

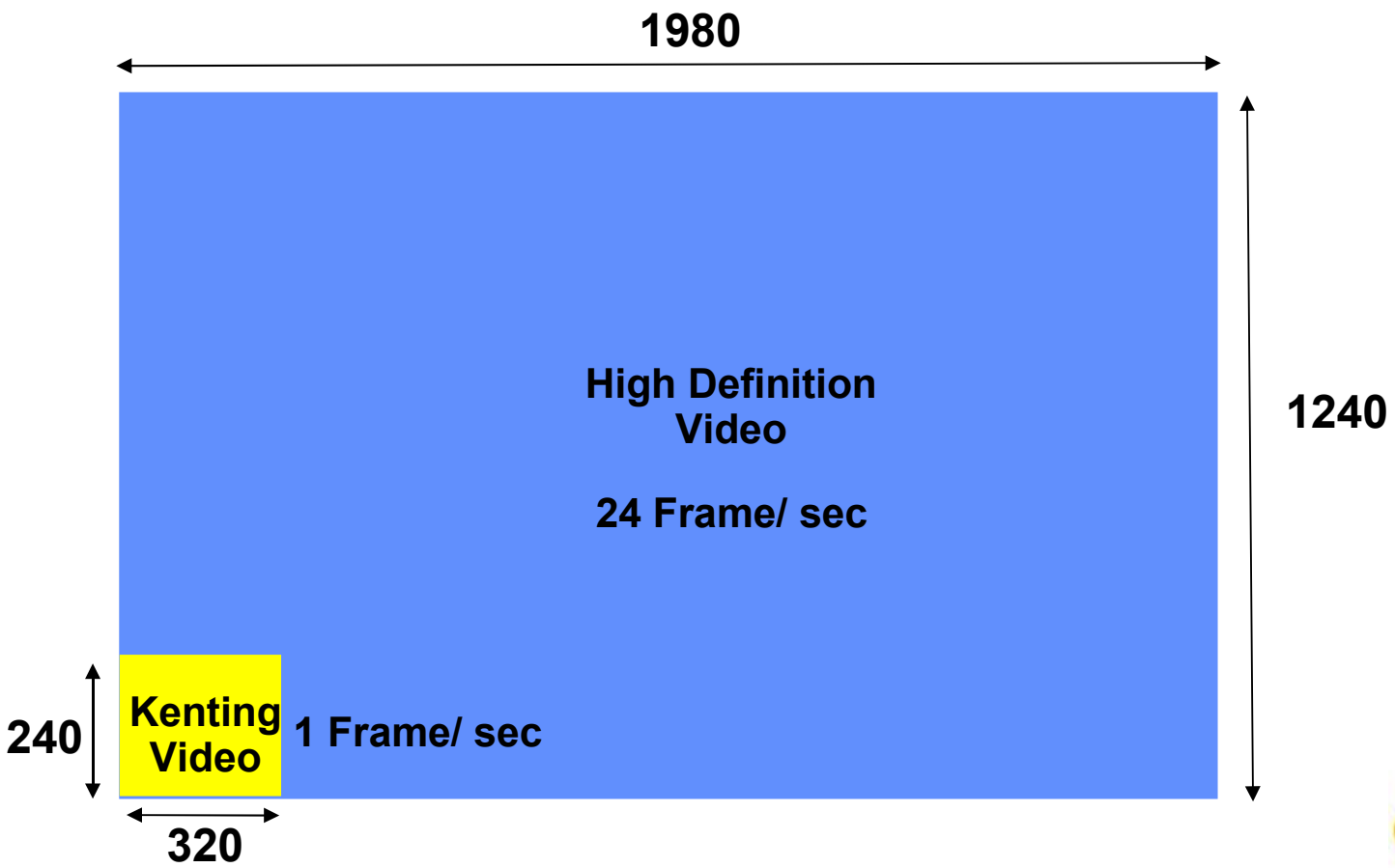
"View the Reef" Experience in Kenting Aquarium?

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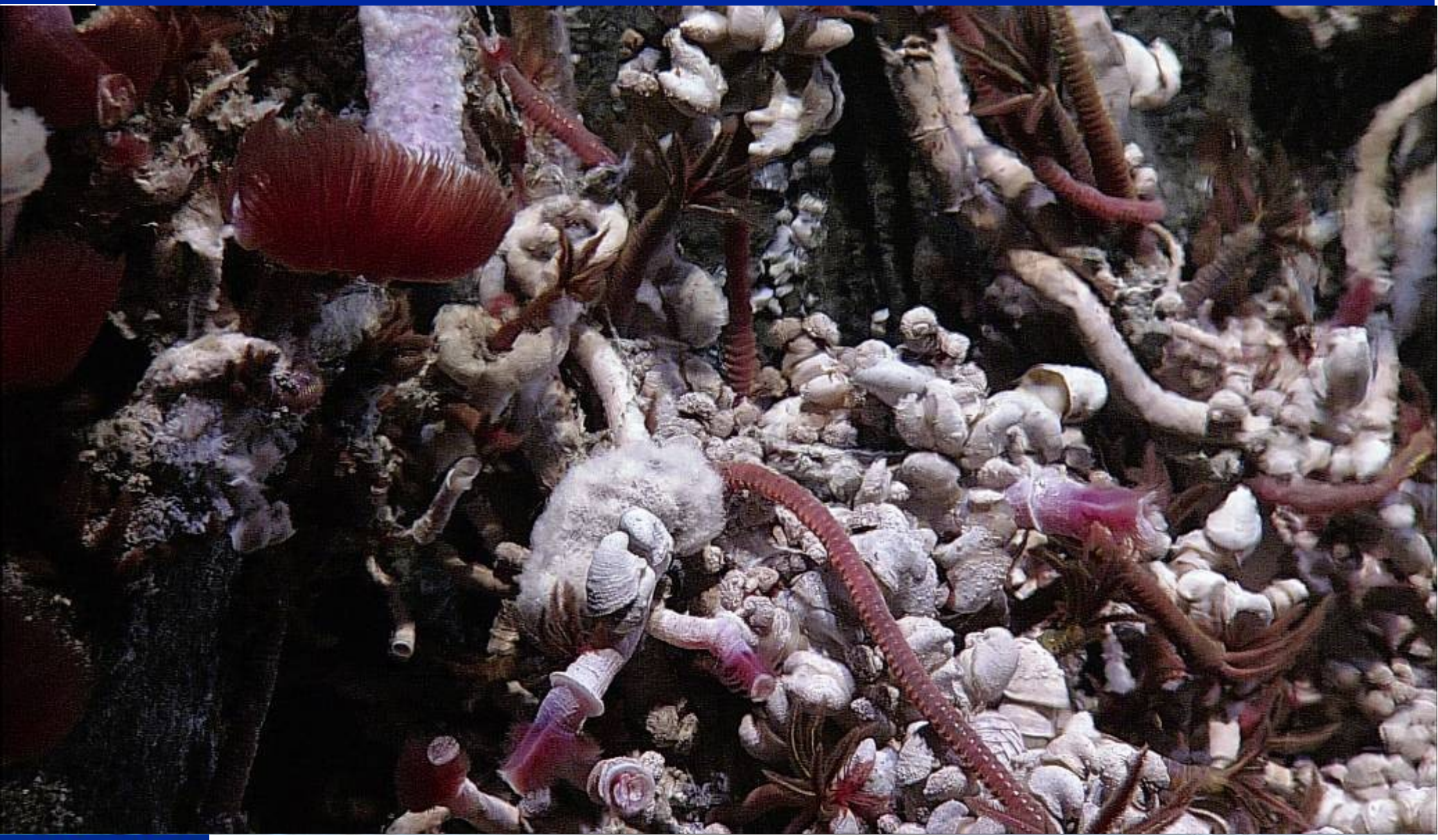
The Kenting "Bandwidth Bottleneck"

- Currently Limited Bandwidth Access to Underwater Cameras
  - Two ADSL Cables
- Bandwidth Less Than a Megabit/ Sec
  - Severely Limits Video Resolution and Frame Rate
- Kenting Would Benefit From Much Higher Bandwidth



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Electro/Fiber Optic Cable Enables Remote Interactive HD Imaging of Deep Sea Vent



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Source John Delaney & Deborah Kelley, UWash

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A Near Future 3D Stereo Fiber Optic-Enabled Ocean Observatory



Source John Delaney, UWash

Towards a Total Knowledge Integration System for the Coastal Zone—SensorNets Linked to Fiber Cable

- Moorings
- Ships
- Autonomous Vehicles
- Satellite Remote Sensing
- Drifters
- Long Range HF Radar
- Near-Shore Waves/Currents
- COAMPS Wind Model
- Nested ROMS Models
- Data Assimilation and Modeling
- Data Systems

Atul Nayak
Frank Vernon



Yellow—Proposed Initial OptIPuter Backbone

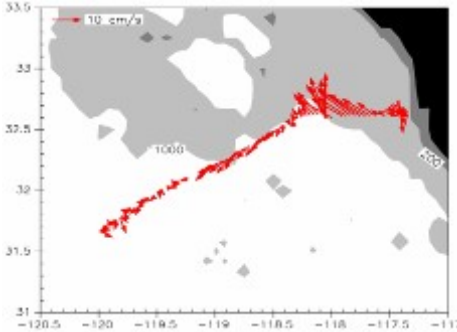
SOUTHERN CALIFORNIA COASTAL OCEAN OBSERVING SYSTEM

ROADNet

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www.sccoos.org/

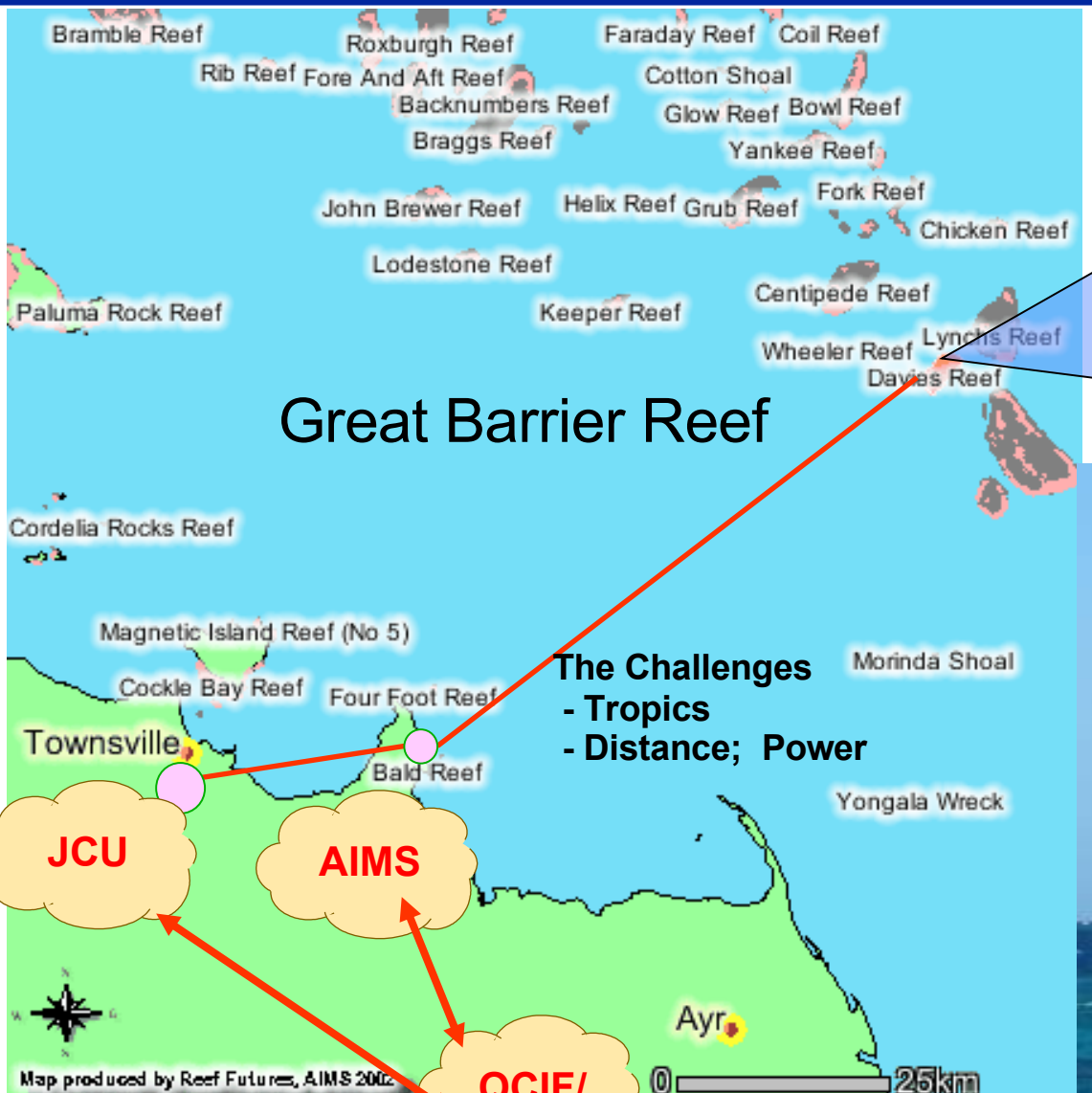
COCMP
Coastal Ocean Currents Monitoring Program





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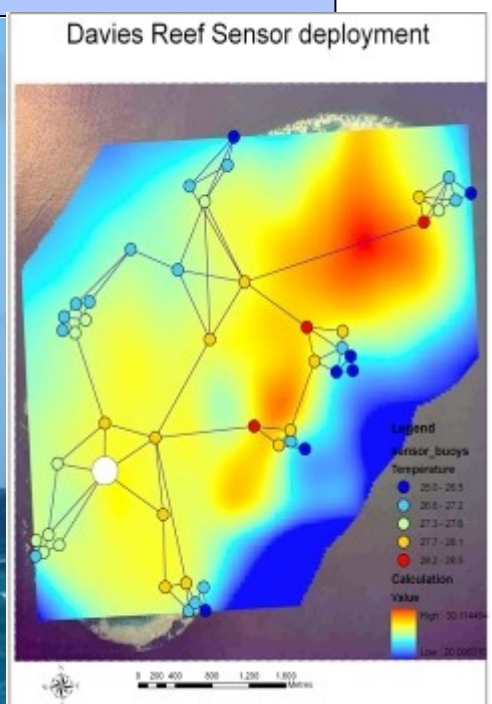
Realtime Sensornets on the Davis Reef Australia With High Speed Wireless Link to Shore



The Challenges
- **Tropics**
- **Distance; Power**







~20Mbps on 10.5 GHz Carrier
~ 70km over Water

CREON

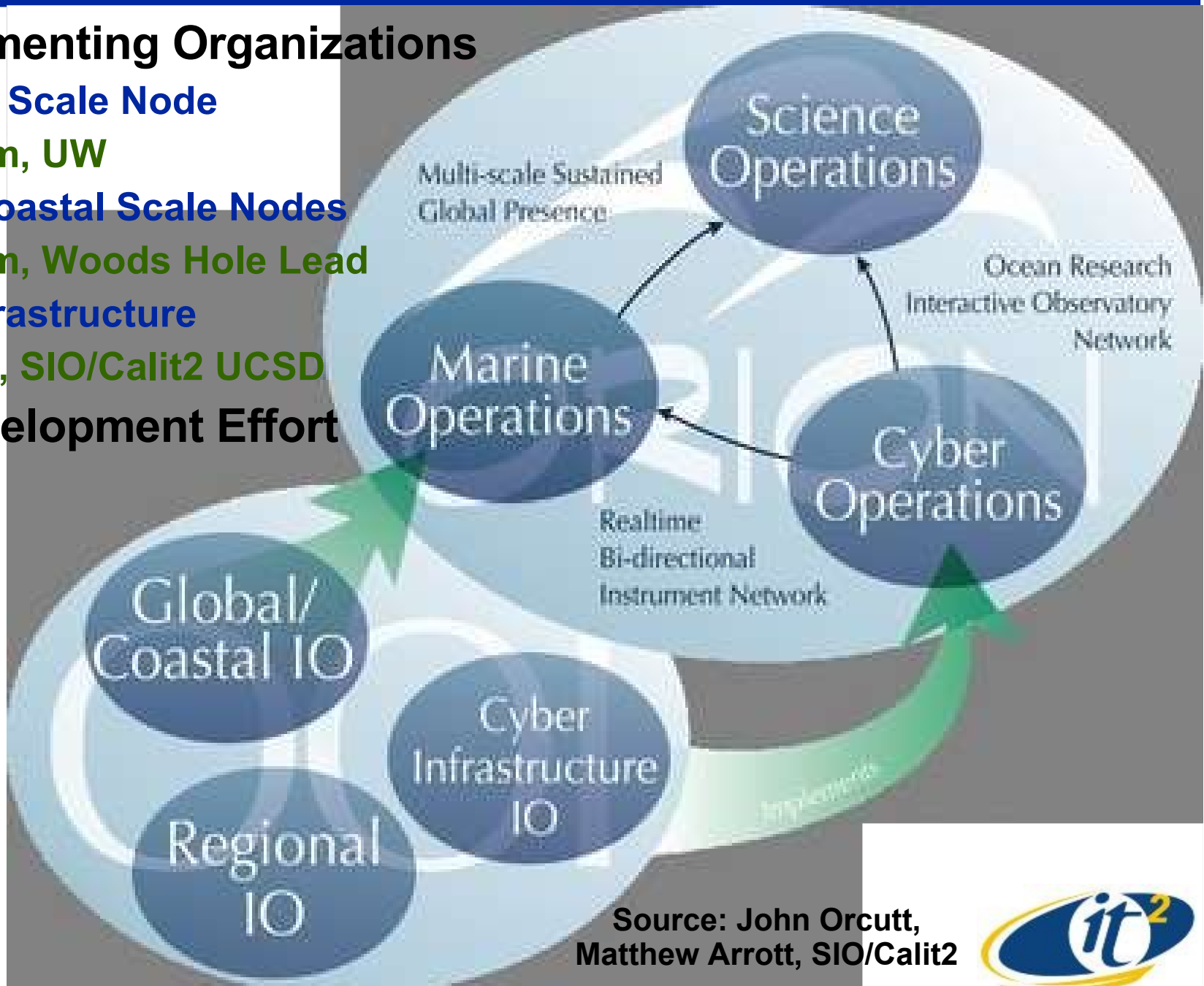
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Source: Stuart Kininmonth, Scott Bainbridge, AIMS Australia.

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Ocean Observatory Initiative -- Initial Stages

- **OOI Implementing Organizations**
  - **Regional Scale Node**
    - **$150m, UW**
  - **Global/Coastal Scale Nodes**
    - **$120m, Woods Hole Lead**
  - **Cyberinfrastructure**
    - **$30m, SIO/Calit2 UCSD**
- **6 Year Development Effort**



Source: John Orcutt, Matthew Arrott, SIO/Calit2

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Marine Sanctuary Conservation: Protecting the Integrity of Tropical Marine Ecosystems

- Continuous Data Collection of Natural Conditions
- Long-Term Digital Imaging Records
- Maintain Fish Counts
- Detection and Tracking of Pollutants
- Marine Sanctuary Patrol
  - Locate and Identify Intruders
  - Detect Poaching and Over-harvesting
  - Sentry Duties via 2-way Communications

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UCSB Ecological Research Programs: CREON Partner to Kenting Coral Reef

Santa Barbara Channel Long Term Ecological Research (SBC LTER) Program



- Goals
  - Focuses on understanding the nearshore ecosystems of the west coast
  - Time/space variation of individual organisms, populations, and ecological communities

Moorea Long Term Ecological Research (Moorea LTER) Program

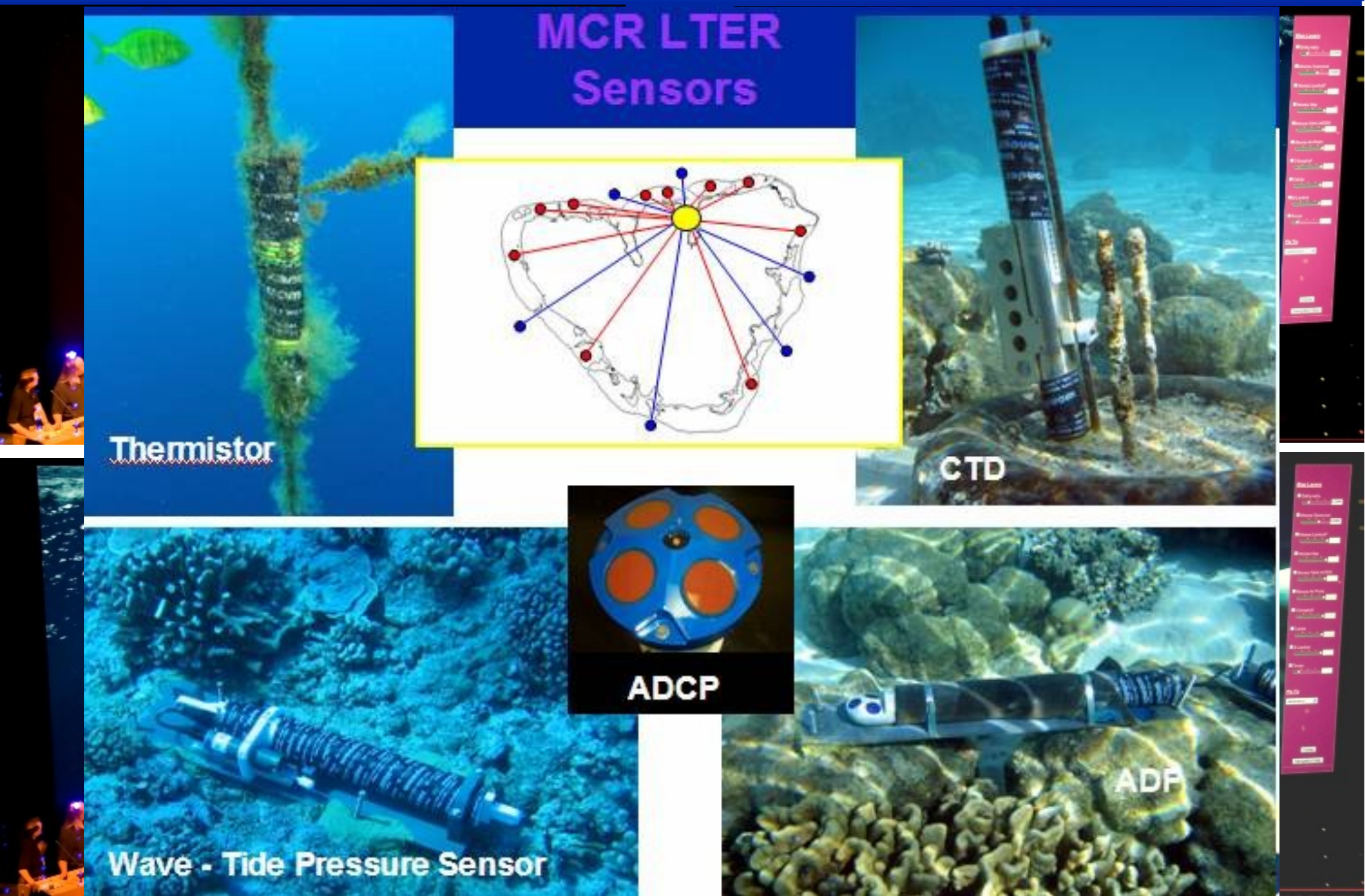


- Goals
  - Understanding processing in coral reef, lagoons and forereef
  - Nature of animal and plant community structure and diversity
  - Responses to environmental change induced either by human activities or natural cycles

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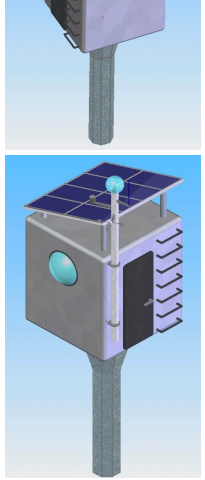
Source: Russell Schmitt, Sally Holbrook, UCSB

Creating a Digital Moorea
Calit2 Collaboration with UC Gump Station (UCB, UCSB)



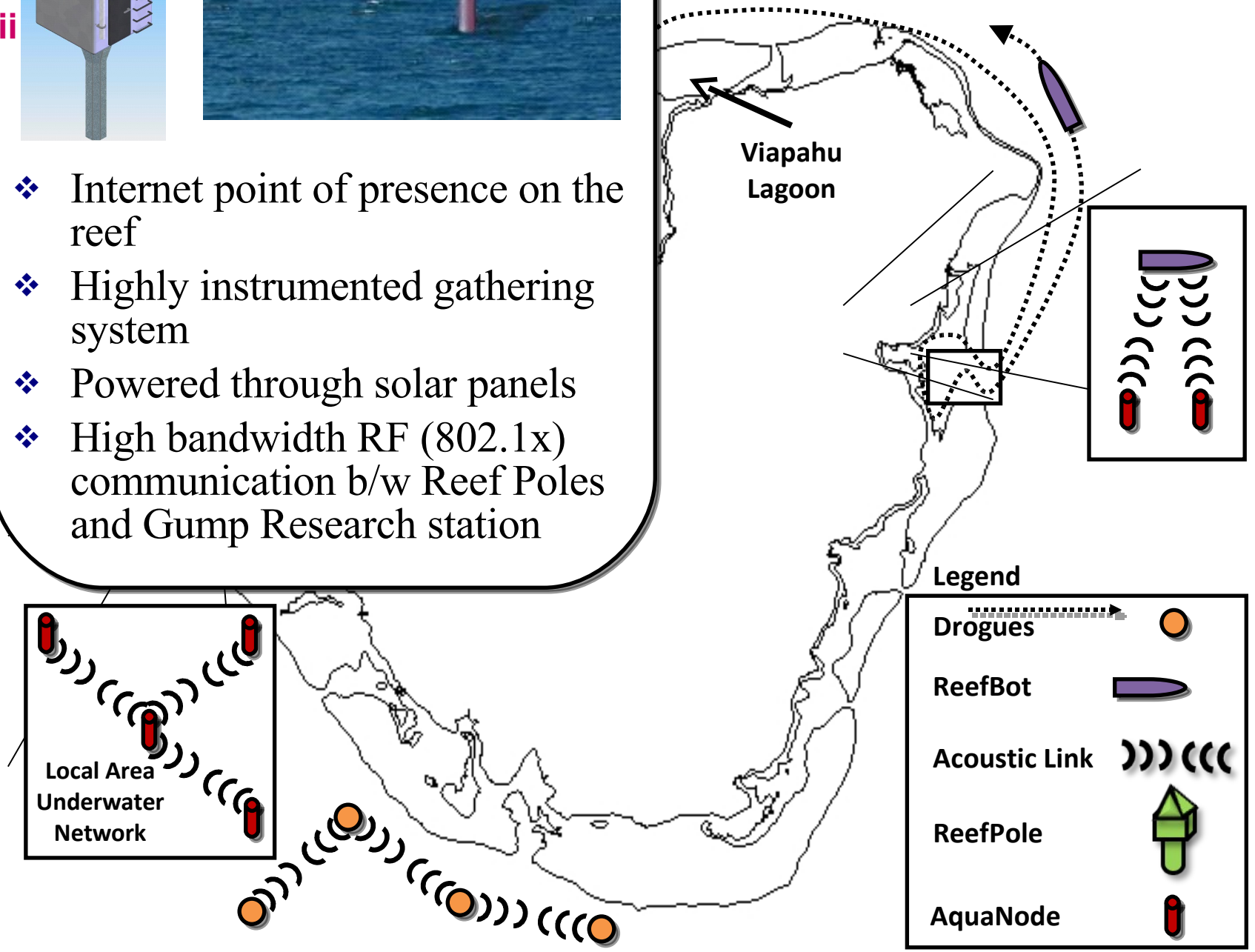
SensorNets

Fiber Cable From Hawaii to Moorea by 2010

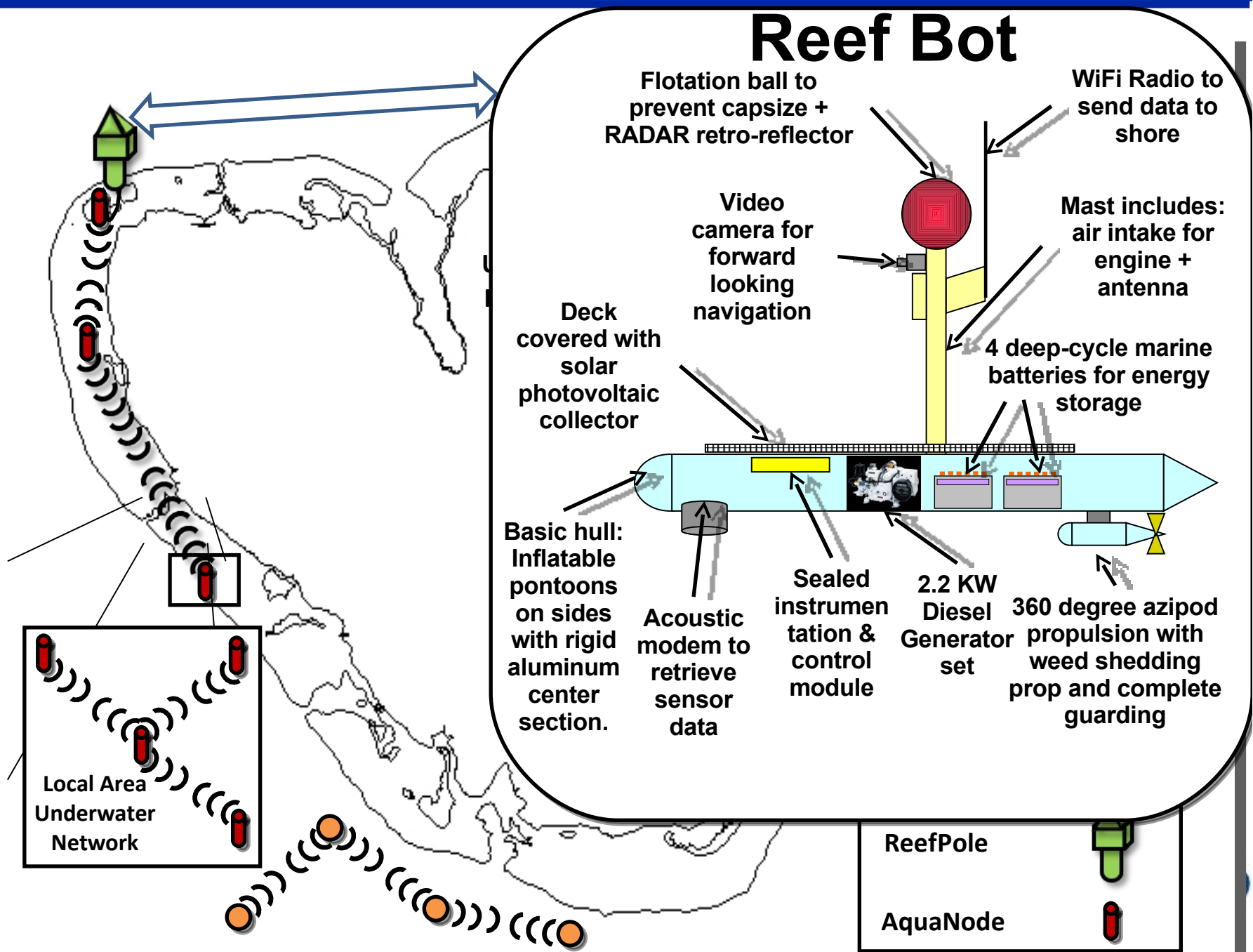




- Internet point of presence on the reef
- Highly instrumented gathering system
- Powered through solar panels
- High bandwidth RF (802.1x) communication b/w Reef Poles and Gump Research station



Vision of Moorea Networked SensorNets



ReefBot Is a Mobile Networked Sensor platform

- **Potential Reef Sensor Suite**
  - Water sampling
  - Computed currents
  - Temperature, turbidity
  - Digital photographic mapping
  - Wave/surf conditions
  - Accurate bathymetry
  - Acoustic monitoring
- **Collected data can be used for multiple studies**
  - Population studies (fish, corals etc)
  - Bleaching, crown of thorns monitoring
  - Growth/destruction profiling
  - Post event assessment
  - Profiling for current/turbidity/siltatation

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Calit2 ReefBot Design for Digital Reef Mapping

Explore Every Square Meter of the Moorea Coral Reef from a Remote Desktop

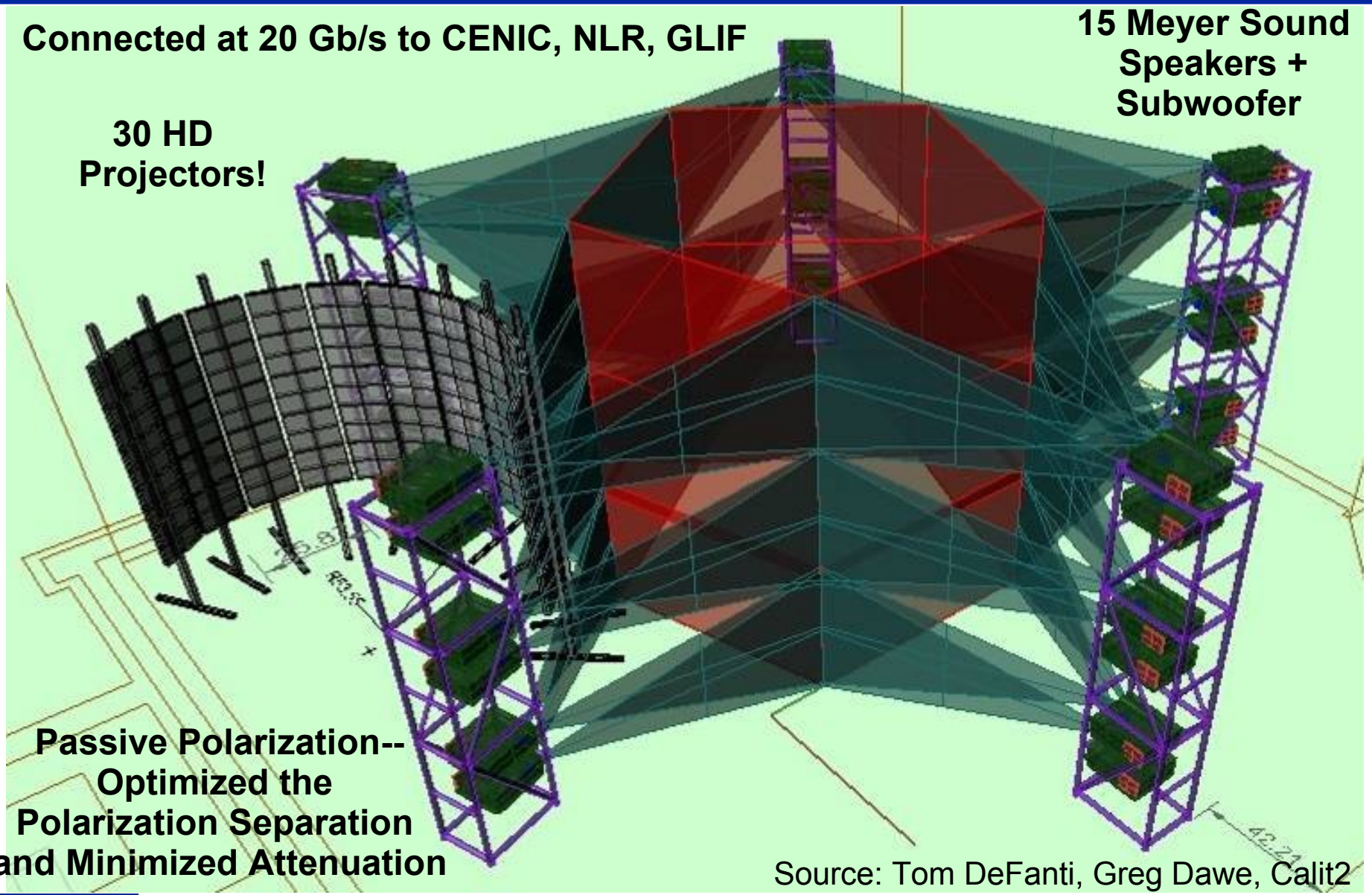






Use The Reef GIS
to Zoom Into
Any Portion
of the Shallow Reef
to View Details Down
to ~ Centimeter

3D OptIPortals: Calit2 StarCAVE and Varrier: Enables Exploration of Virtual Worlds



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Cluster with 30 Nvidia 5600 cards-60 GB Texture Memory

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The StarCAVE as a “ Browser” for the NASA’s “Blue Marble” Earth Dataset



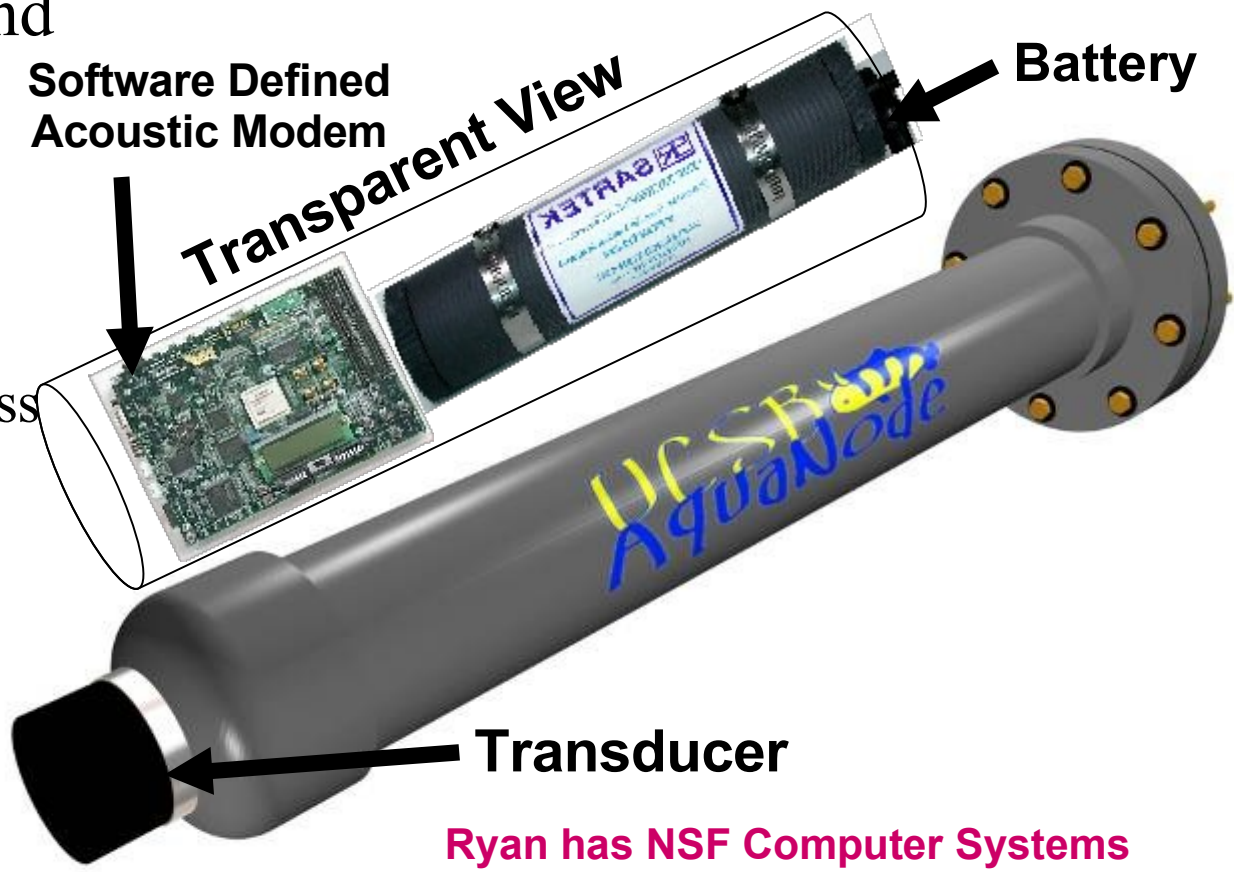
UCSD UCIrvine

Source: Tom DeFanti, Jurgen Schulze, Bob Kooima, Calit2/EVL

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AquaNode:
Proposed System Under Development at UCSD/UCSB

- Deploy ad hoc wireless underwater networks around island
- Transmit data to/from underwater sensors
- Aquanode requirements:
  - Low cost, low power wireless modems
  - Associated networking functionality
  - Plug and play interface with variety of sensors
  - Near real-time data and adaptive sampling



Ryan has NSF Computer Systems Research Grant to Develop a Software Defined Acoustic Modem (SDAM)

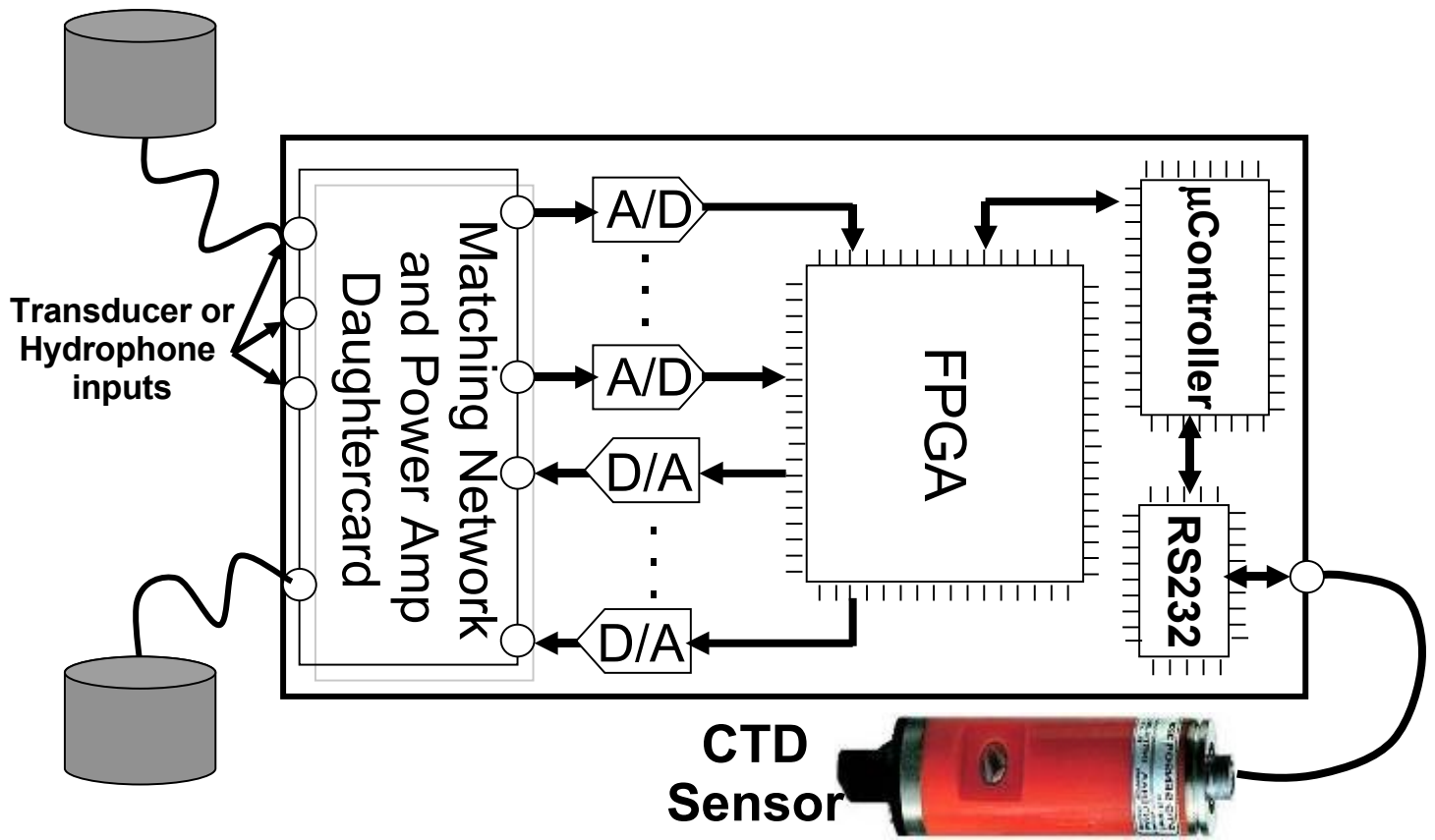
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Source: Ronald Iltis, Hua Lee, Grace Chang, UCSB
Ryan Kastner, Douglas Palmer, UCSD

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AquaNode Hardware Platform: Proposed Design

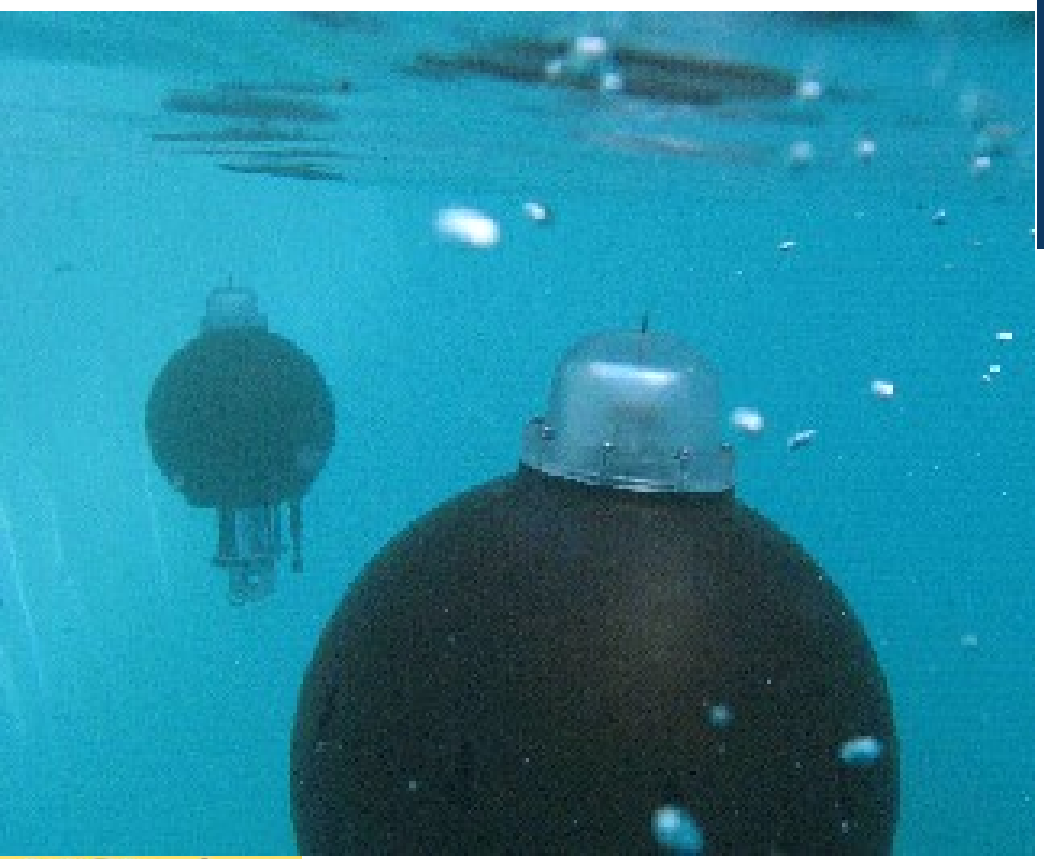
- **Ideal: One Piece of Hardware for any Sensor and Scenario**
- **Hardware is Wirelessly Updatable:**
  - **No Need to Retrieve Equipment to Update Hardware for Changing Communication Protocols, Sampling, Sensing Strategies**

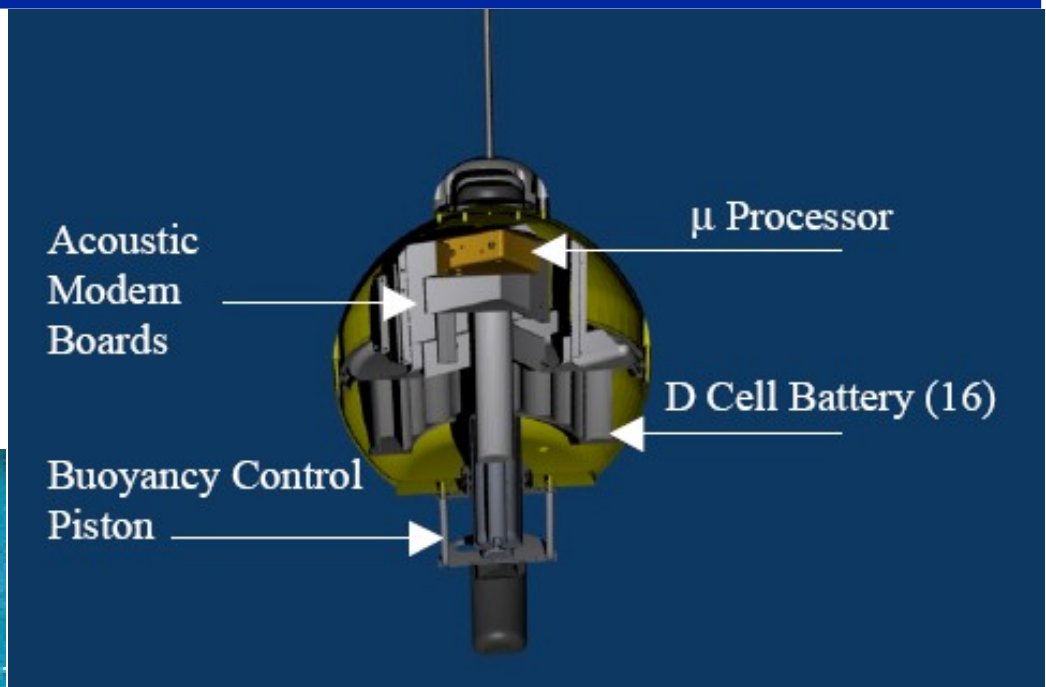


Source: Ronald Iltis, Hua Lee, Grace Chang, UCSB
Ryan Kastner, Douglas Palmer, UCSD

Underwater Array of Autonomous Drogues Coupled by Aqua Modem to Sense 3D Ocean Dynamics

- Autonomous Underwater Explorers: Self Organizing Drifters
- Dynamic, Spatiotemporal 3D Sampling
- Track Water Motions or Mimic Migration Behavior of Organisms





- Buoyancy Control Can Follow Ocean Surface
- Acoustic Modem For 3D Localization Amongst Drifters
- 25 cm Diameter
- Under Development by Curt Schurgers (ECE), Jules Jaffe (SIO), Raymond de Callafon (MAE), UCSD

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