Coral Reef Watch activities in Australia:
An Overview of Collaborators and Collaborations

William J. Skirving & Scott F. Heron

NOAA/NESDIS – Coral Reef Watch

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william.skirving@noaa.gov
http://coralreefwatch.noaa.gov

What Does CRW Do?

- **Coral Reef Watch (CRW) aims to assist in the management, study and assessment of impacts of environmental change on coral reef ecosystems.**
- **NESDIS Coral Reef Watch mostly uses basic environmental satellite products often developed by STAR.**

The Coral Reef Watch Team

Coordinator:

Mark Eakin

Team members:

Tyler Christensen
Dwight Gledhill
Scott Heron*
Gang Liu
Jessica Morgan
Britt Parker
William Skirving*
Al Strong

* CRW in Australia

What is Aussie CRW Doing?

- Current operational and experimental satellite products
- Satellite algorithm development
  - High resolution coral bleaching algorithms
  - Coral disease algorithms
  - New light/temp bleaching product
  - MPA design inputs from satellites
  - Environmental effects of algal blooms
  - Ocean acidification
- Improved understanding of current products
  - Within-pixel variations of temperature
  - Within-reef variation of thermal thresholds
- Algorithm validation
- Outreach and Education

Why Australia?

- Access to complementary knowledge-base
- Access to and influence of other research efforts
- Easy access to Pacific coral reefs
- Free access to instrumentation and ship time
- Access to in-water biological data
- Similarities to US reef water parameters
- Access to new sources of funding (leveraging)
- Expanding CRW research effort at low cost
- Kudos we didn't expect

Collaborators

UQ

AIMS

GBRMPA

JCU

BoM

CSIRO

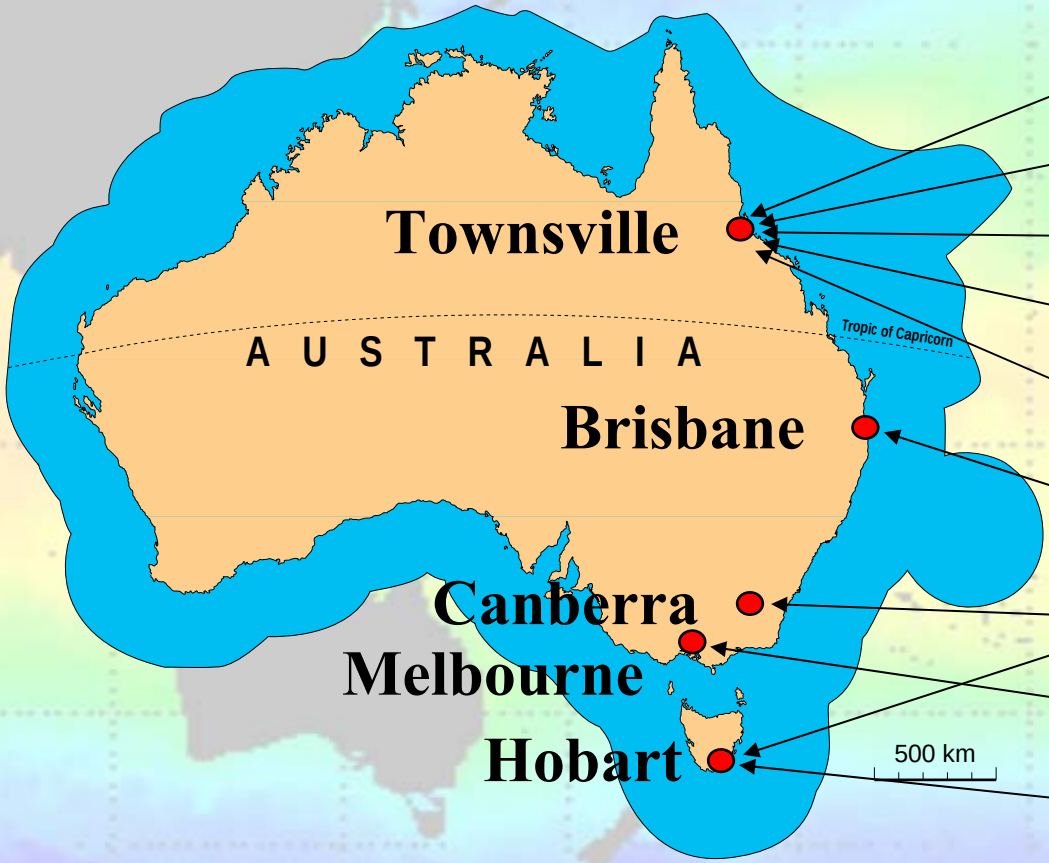
UTas

RRRC

Projects

ARC Linkage
Ocean Acidification
World Bank - GEF
Light/temp Project
Bio-Discovery
Algal Blooms
SST-based products
Ocean Colour
GBROOS
Coral Disease Outbreak
Hydrodynamic Modelling
MTSRF
Radar Oceanography

Where is everyone?



CRW Australia

AIMS

JCU

GBRMPA

RRRC

UQ

CSIRO

BoM

UTas

Australian Institute of Marine Science

RV Cape Ferguson 24m





RV Solander 35m



Australian Government | Australian Institute of Marine Science

AIMS Overview:

95 scientific staff
69 non-scientific staff
$35 million per year revenue
$90 million assets

Facilities:

2 x 24/7 ships
Daily boats
Various laboratories
Various workshops
Computing and data centre
Library

NOAA CORAL REEF WATCH

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

University of Queensland

- 5661 staff (2408 academic)
- 38000 students (10000 postgraduate)
- Revenue – $1 billion
- Research income – $215 million

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Centre for Marine Studies

- Study various ecosystems including coral reefs, rugged rocky shores, clean beaches, salt-marshes, mangroves and seagrasses
- Heron Island Research Station, the largest and best equipped research station on the Great Barrier Reef







NOAA CORAL REEF WATCH

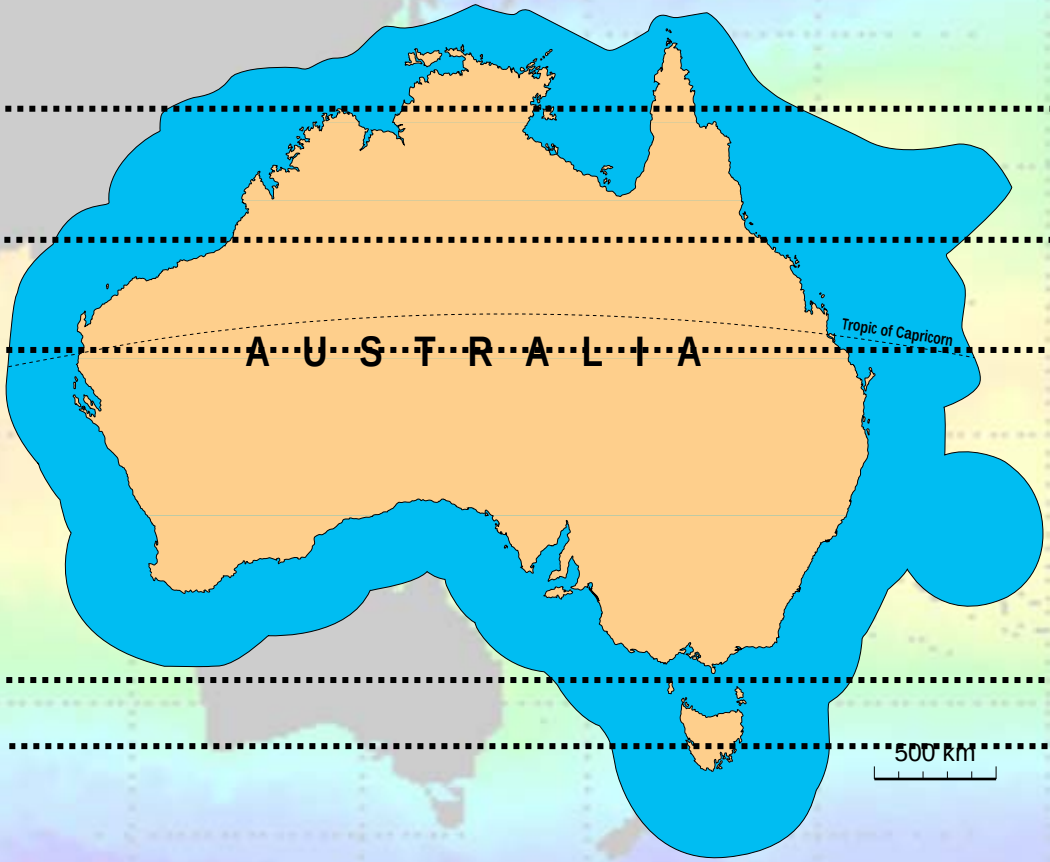
NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

Where do we do work?

- US Coral Reefs
- Australian Coral Reefs
- Global Coral Reefs

Australia

Latitude comparison with America



Southern tip of Mexico

Mexico City

Miami

Washington DC

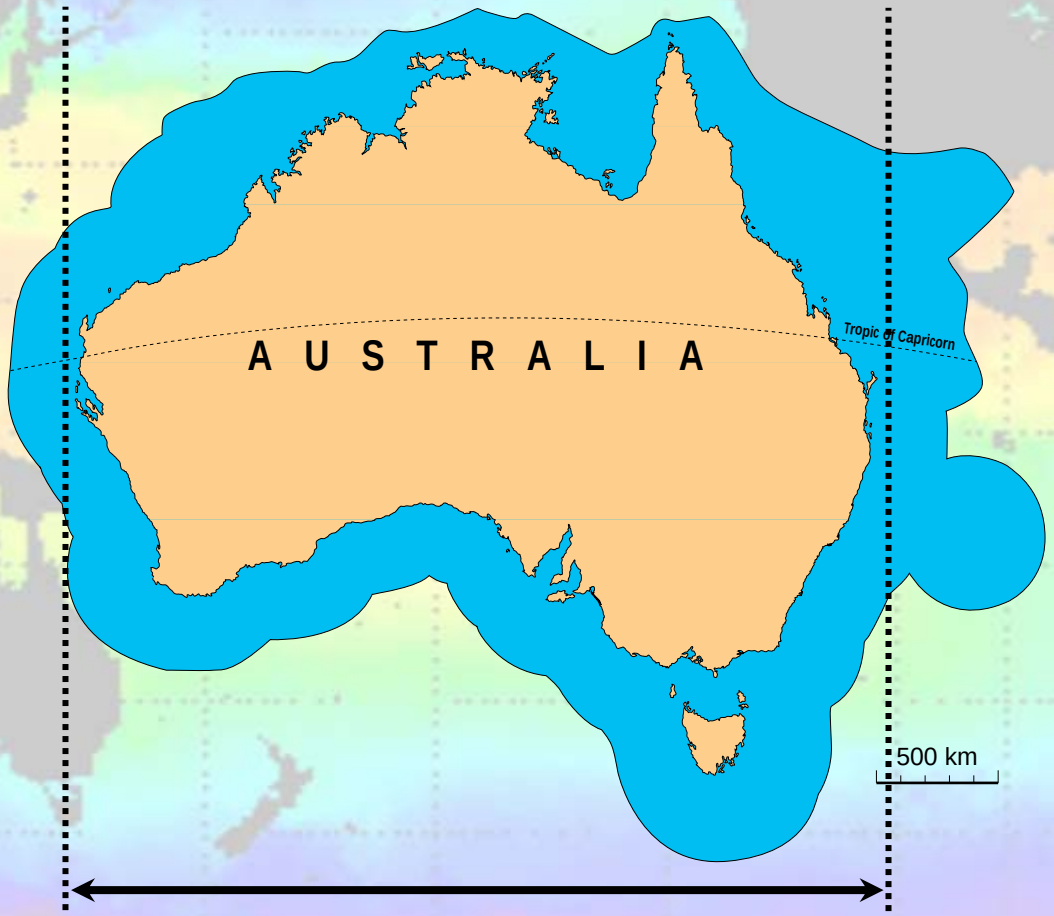
Boston

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Australia

Longitude comparison with America

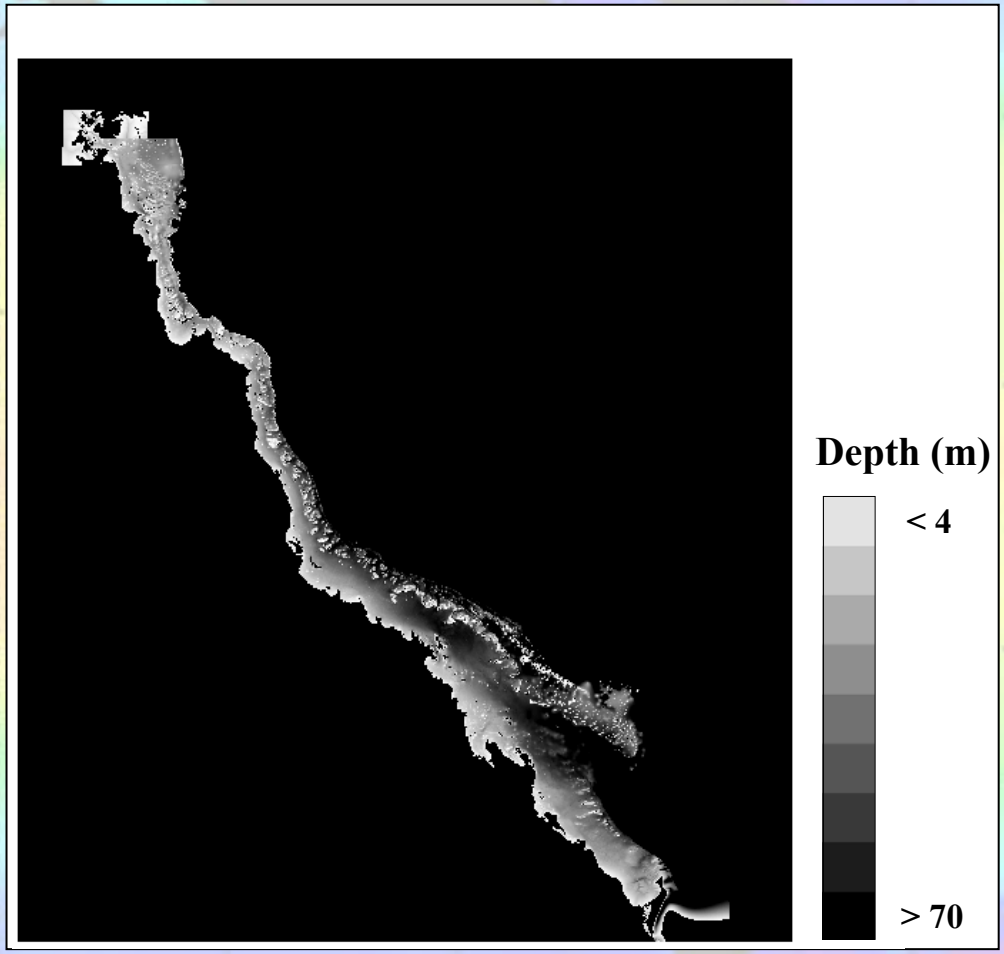


LA to Washington DC

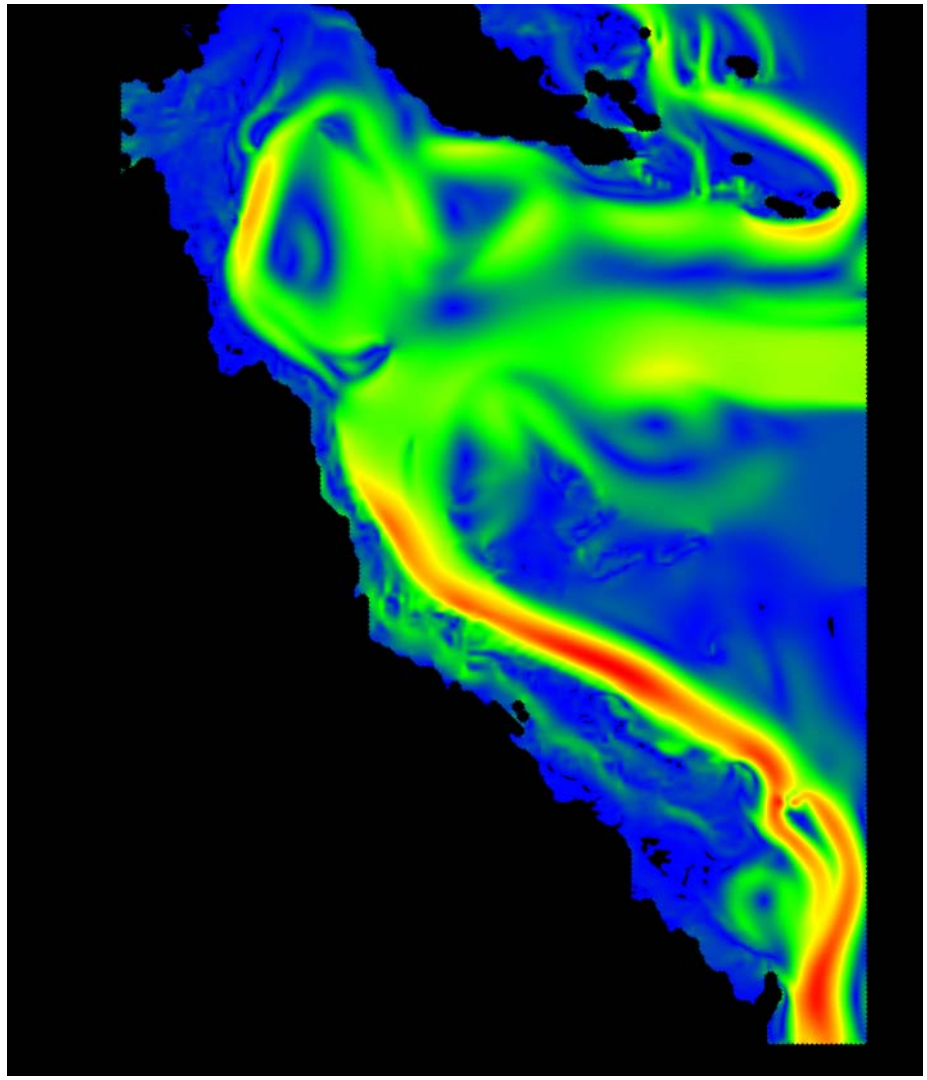
The Great Barrier Reef



Bathymetry



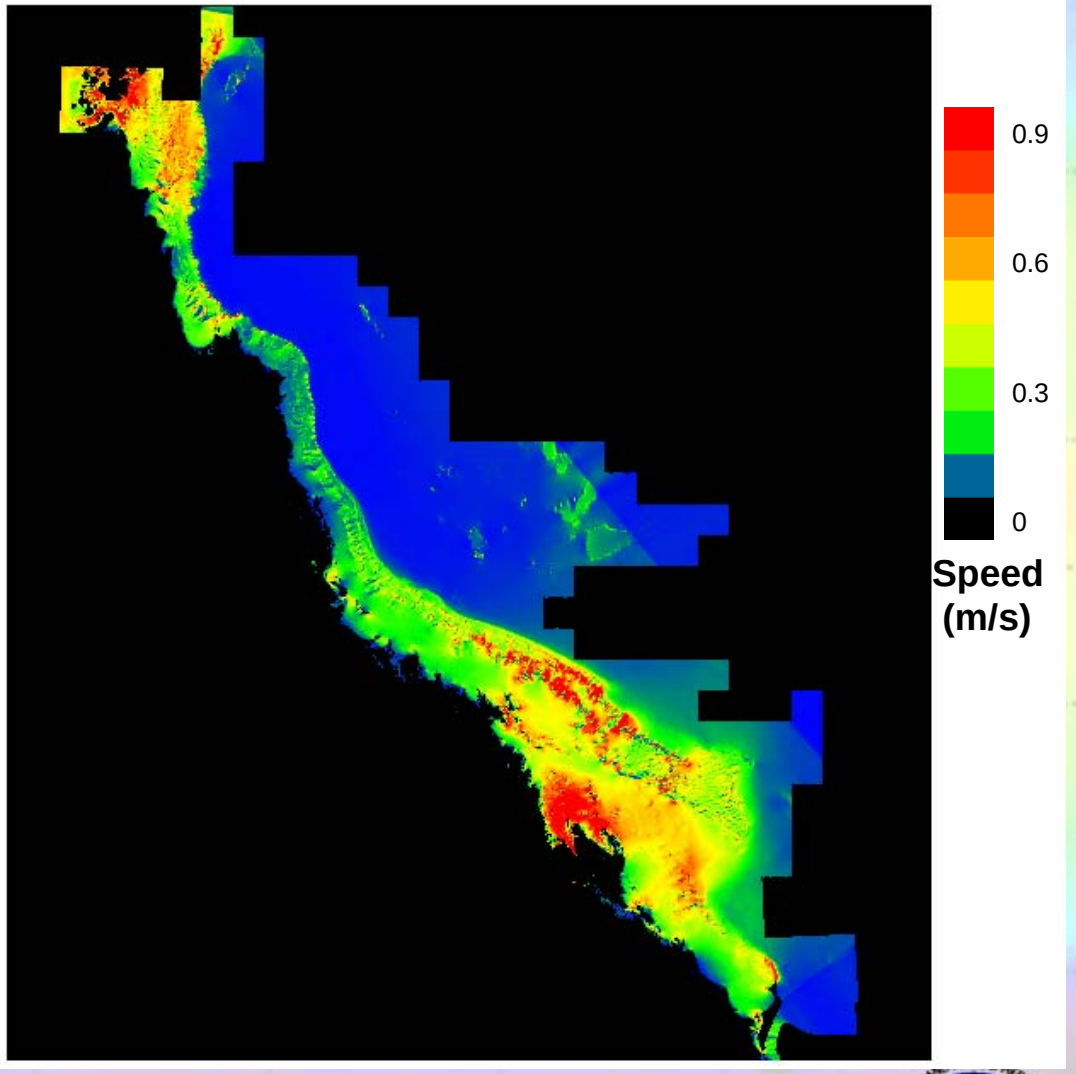
Low Frequency Currents



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NOAA U.S. DEPARTMENT OF COMMERCE

Tidal Currents



Collaborators

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Algal Blooms

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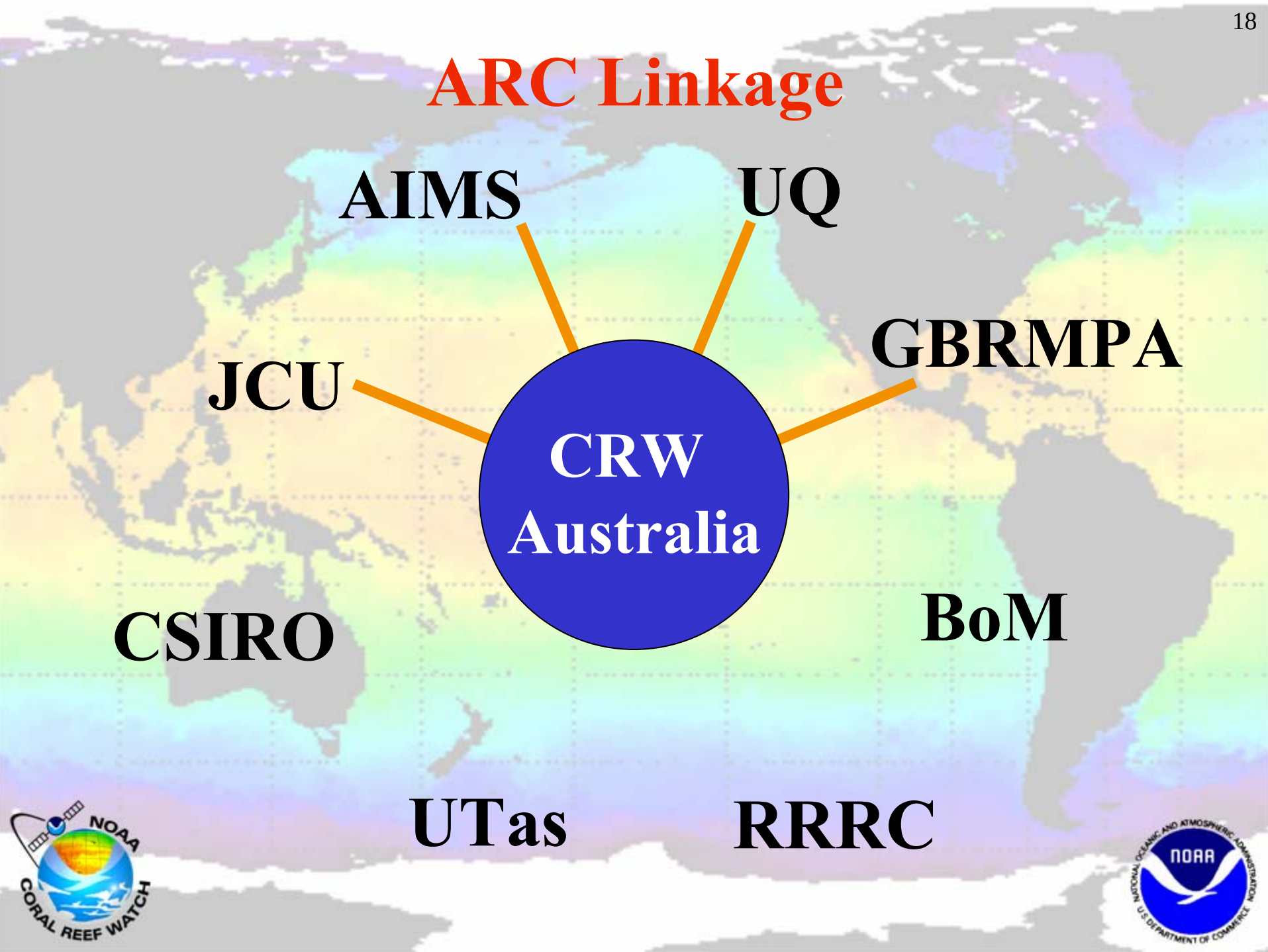
Coral Disease Outbreak

Hydrodynamic Modelling

MTSRF

Radar Oceanography

ARC Linkage



ARC Linkage

Effects of climate change on the Great Barrier Reef

CRW interest:

- **Within-reef variation of thermal thresholds**
- **Within-reef 3D variation of SST**
- **Within-reef 3D variation of light**
- **Development of simple methodologies for modelling/monitoring 3D reef temperature**
- **Development of Ocean Acidification algorithms**

$3.7 million over 5 years
(ARC Industry Linkage Grant)

Research centred on Heron Island

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA



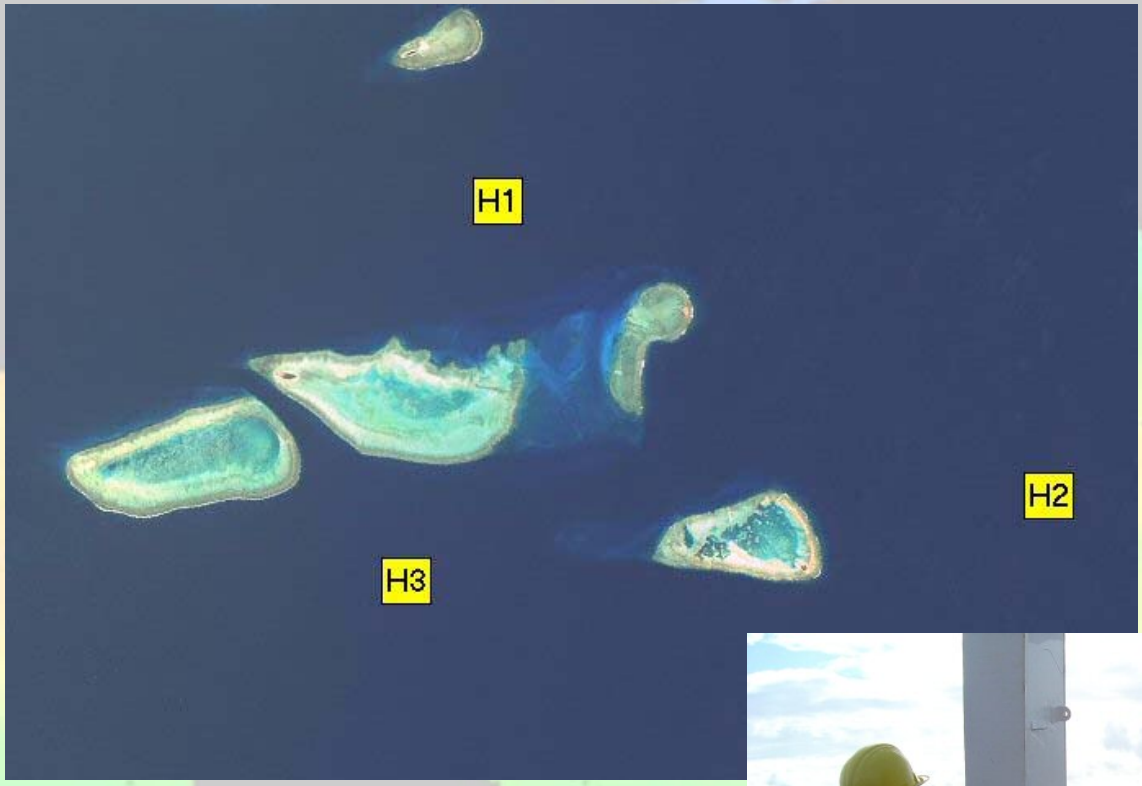
Heron Island







Heron Island Instrumentation



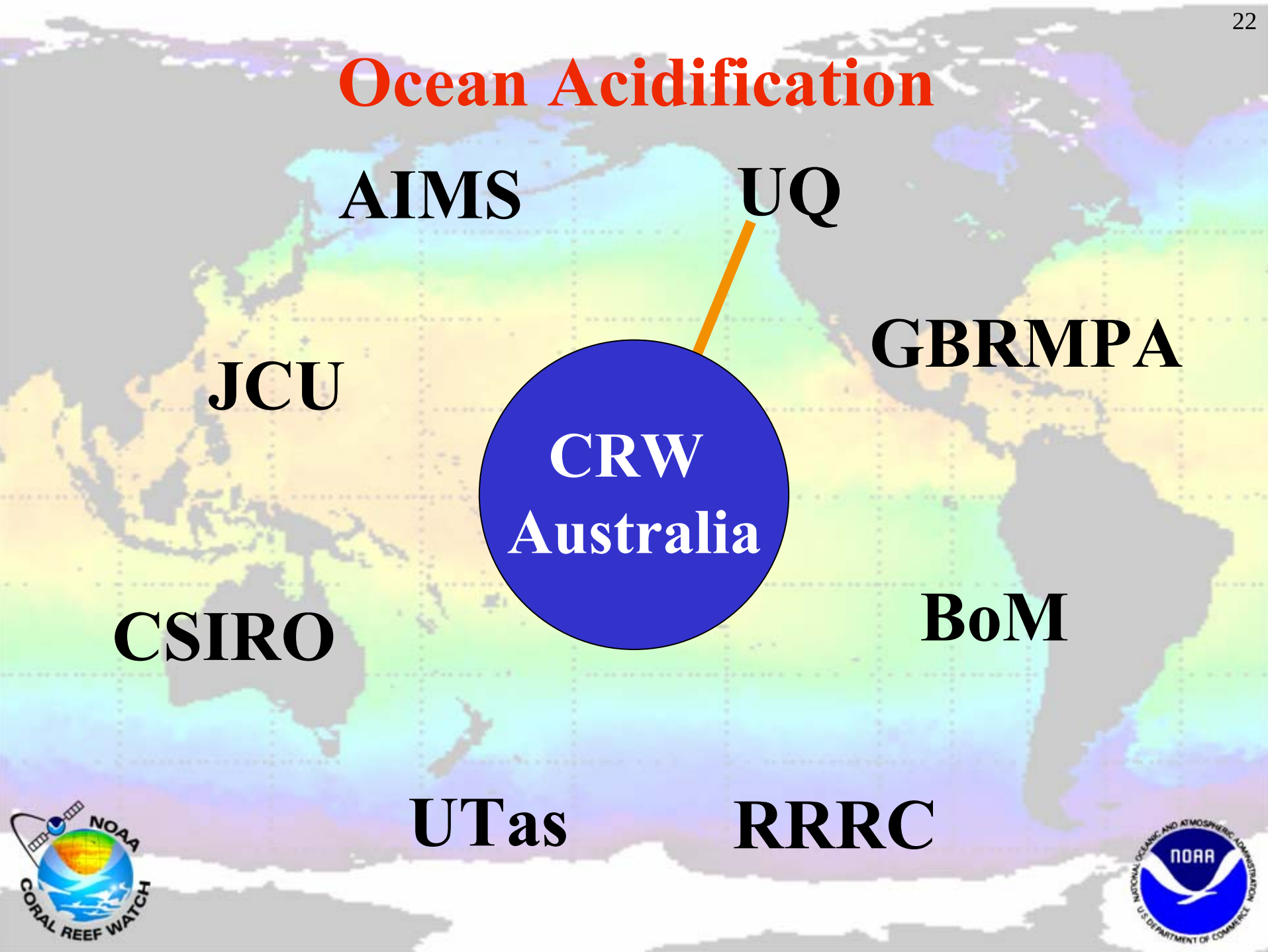




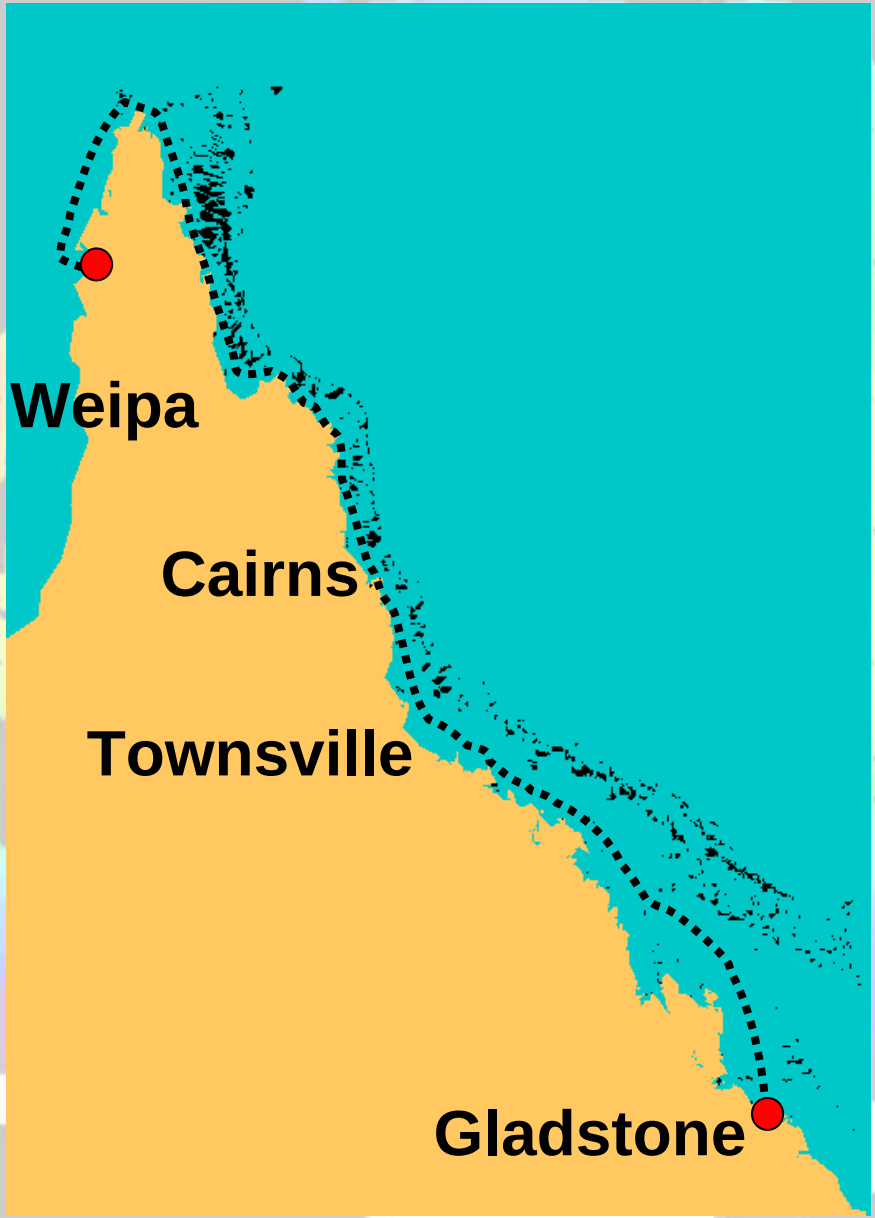
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NOAA

Ocean Acidification

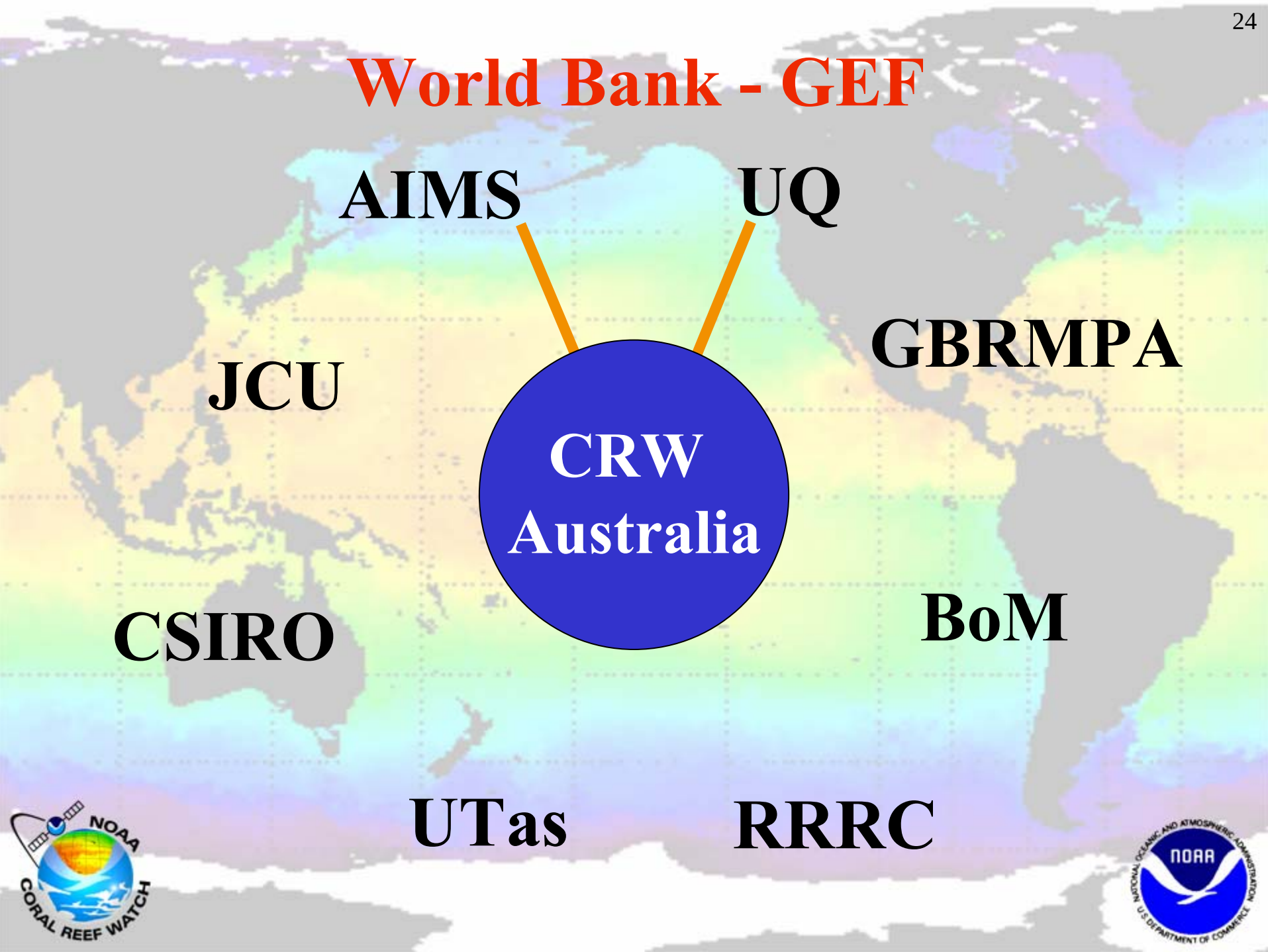


Ocean Acidification



UQ / Rio Tinto negotiations to fund a pCO_2 sensor mounted on the bulk bauxite carrier that transits along the inside of the GBR from Weipa to Gladstone twice per week

World Bank - GEF



World Bank – GEF

6 Working Groups

- Bleaching *
- Disease *
- Connectivity
- Restoration
- Remote Sensing
- Modeling and Decision Support

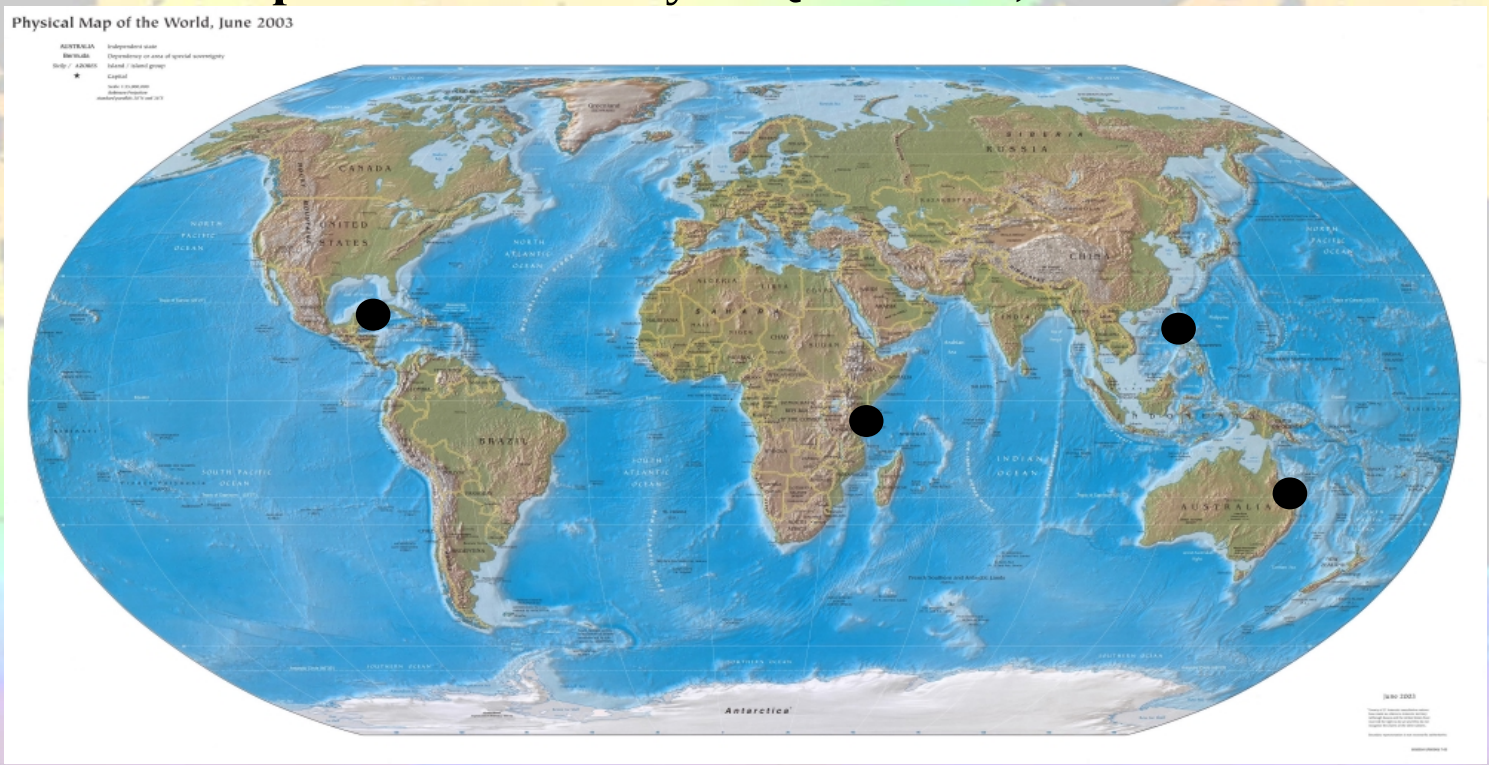
World Bank – GEF Regional Nodes

Western Caribbean - Universidad Autonoma Nacianal de Mexico

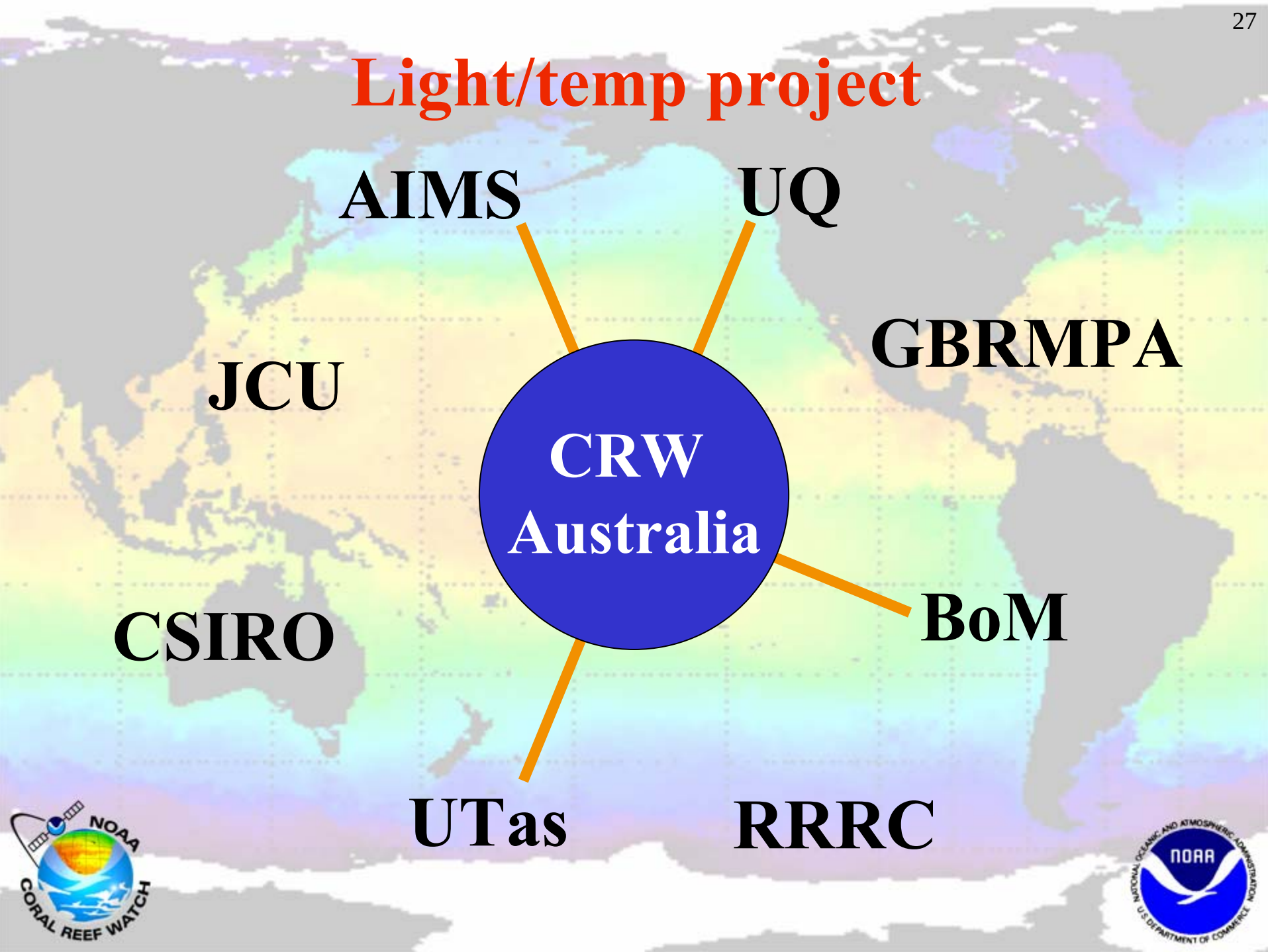
Eastern Africa - Marine Science Institute, Zanzibar, Tanzania

Southeast Asia - Marine Science Institute, University of the Philippines

Central south pacific - University of Queensland, Australia



Light/temp project



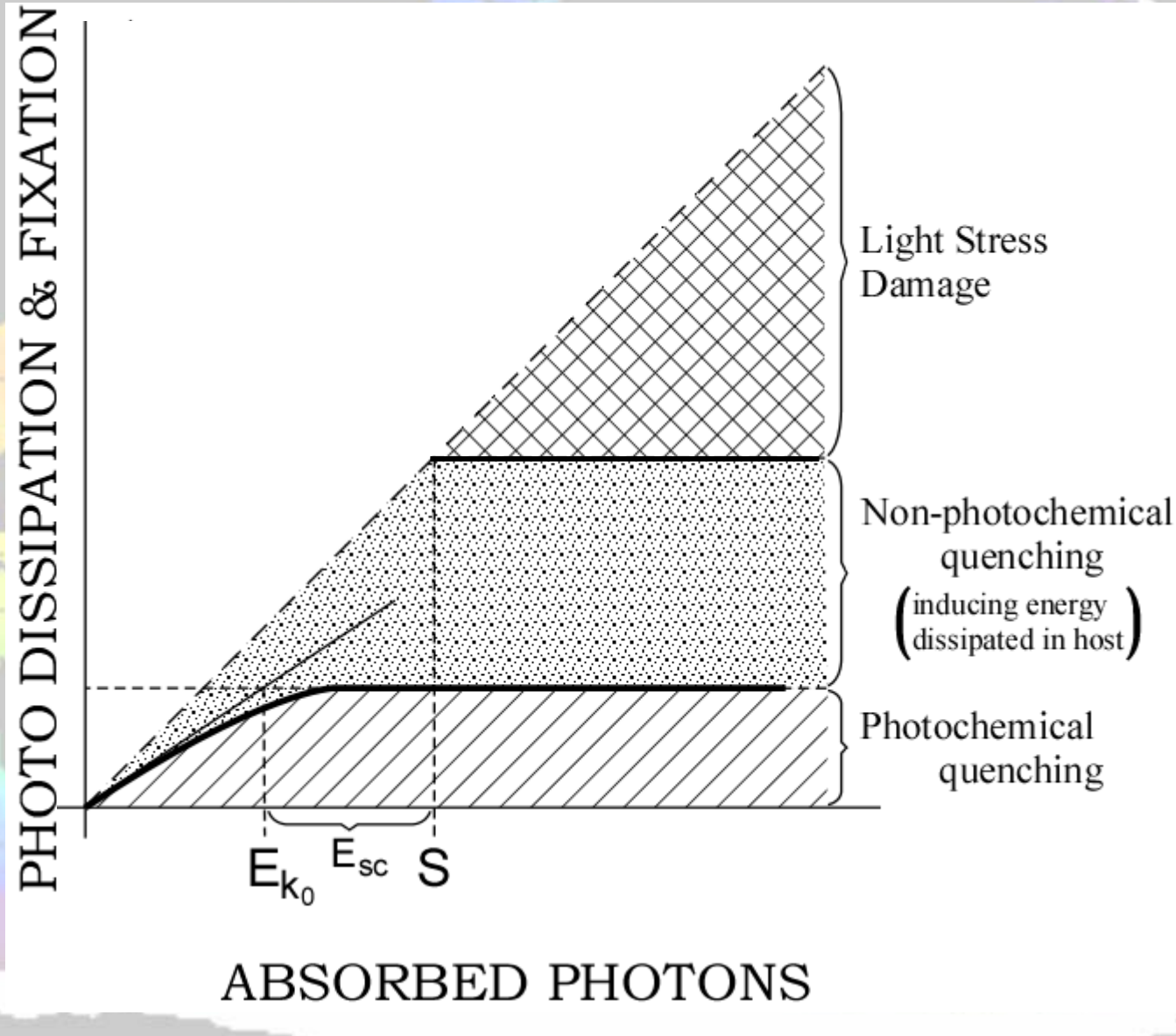
Light/temp project

NOAA CRW
World Bank (Remote Sensing and Bleaching WGs)
ARC Linkage

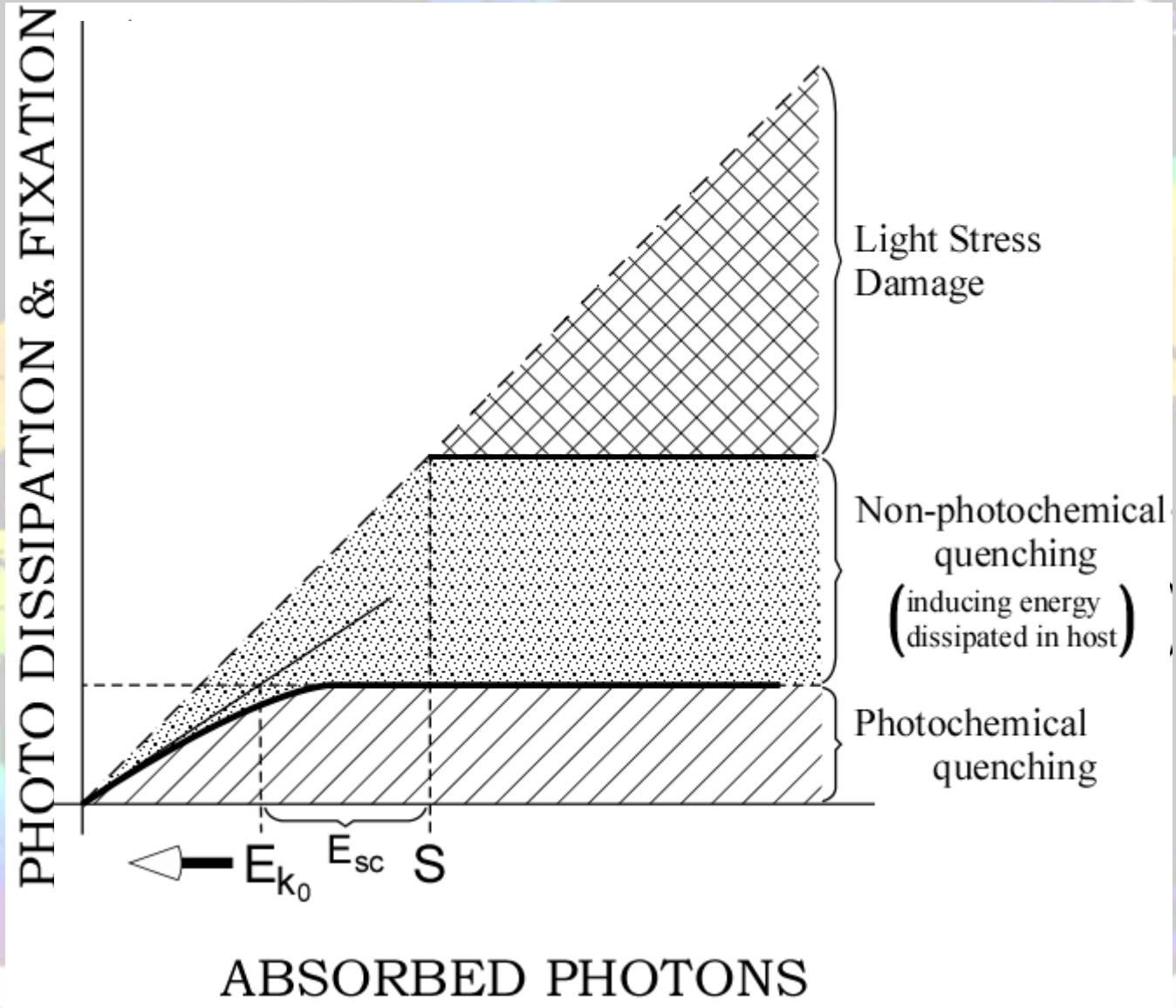
Team includes:

- **NOAA CRW/STAR**
- **Universidad Autonoma Nacianal de Mexico**
- **University of Exeter – UK**
- **University of Queensland – Australia**
- **University of Tasmania – Australia**

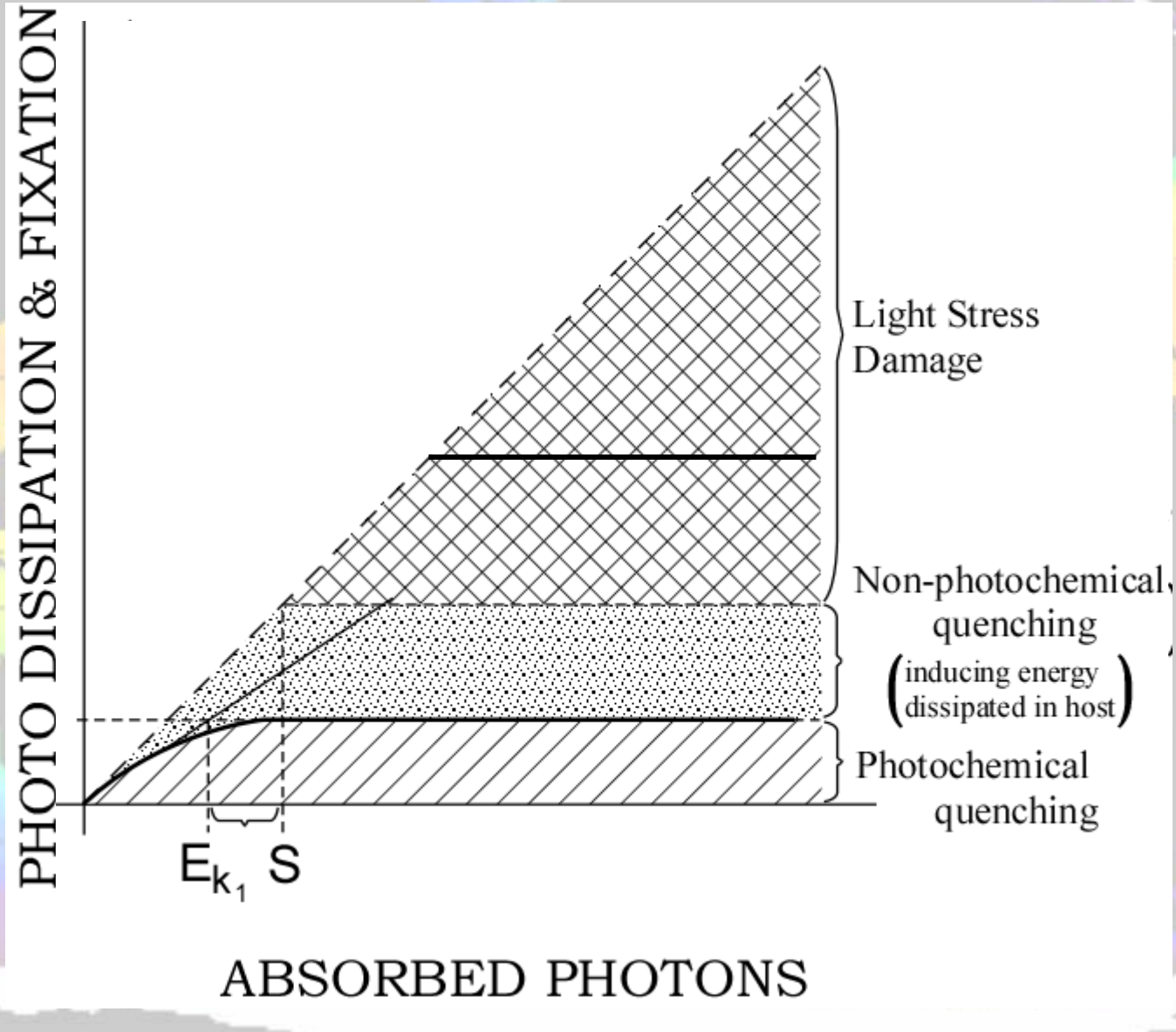
Light/temp project



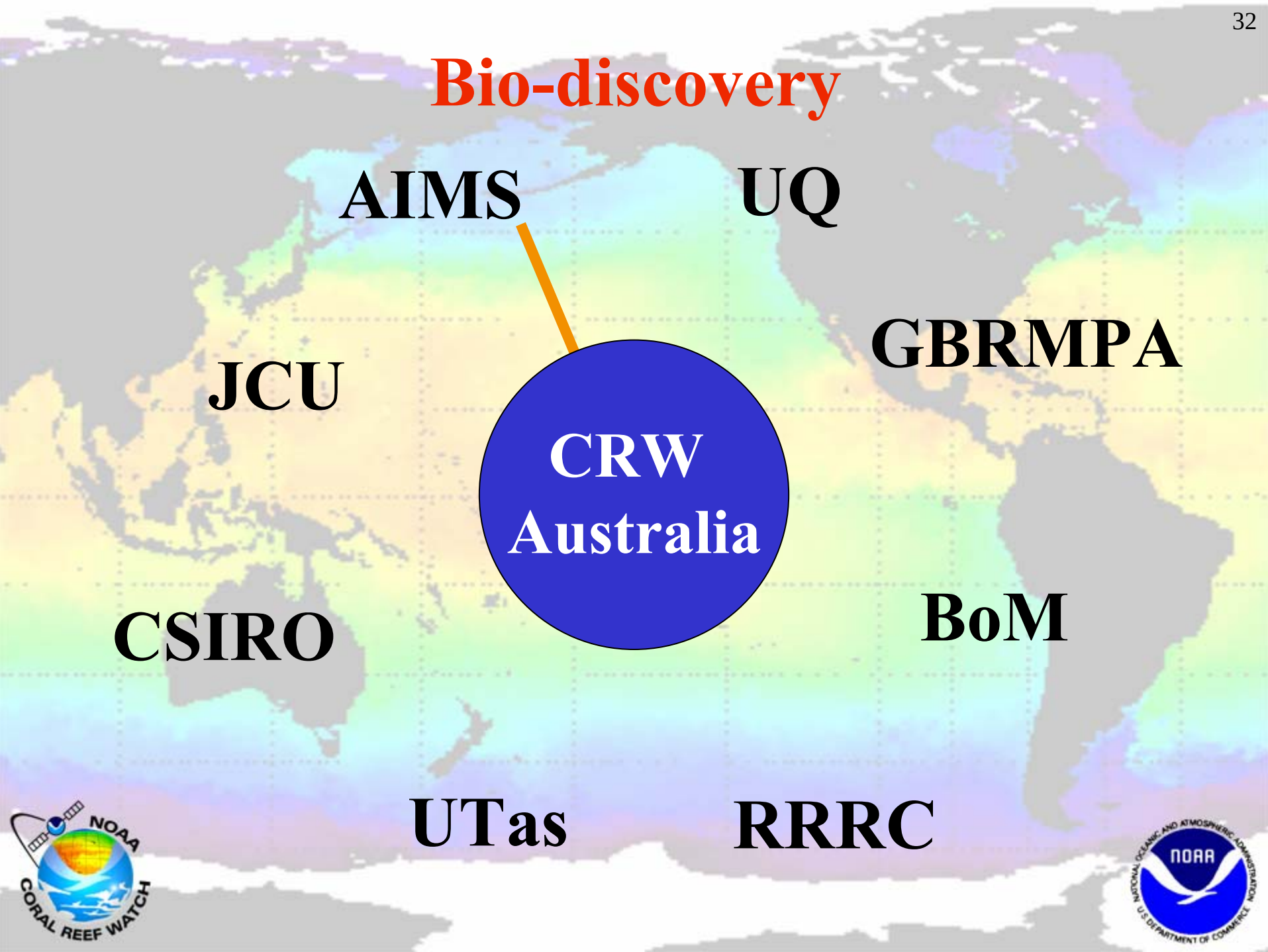
Light/temp project



Light/temp project



Bio-discovery



Bio-discovery

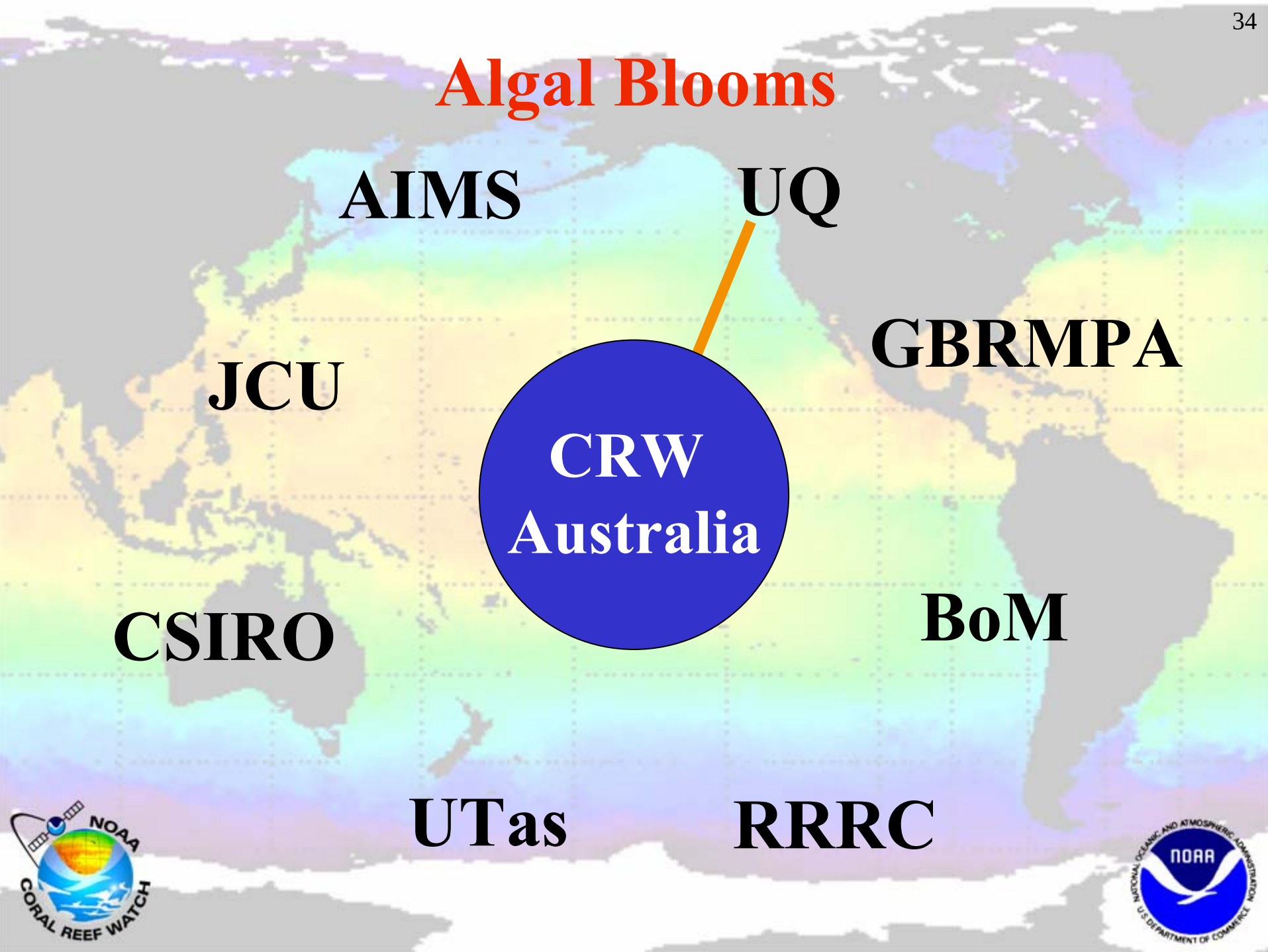
- Over 60% of modern drugs are derived directly or indirectly from nature
- Over 90% of known phyla are represented on the sea floor
- Extreme Biodiversity equals extreme chemical complexity

- Stress = production of interesting drugs

- One major sources of stress is environmental
  - can be mapped using satellite data

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Algal Blooms



Algal Blooms

- Emerging problem of blue-green algae in Morton Bay
- Same algae as in a number of US bays
- Effects Florida Keys region
- UQ researchers linking SST/climate change with bloom size
- NOAA CRW have been approached to provide IP and data to help derive a satellite-based prediction tool



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Coral Disease Outbreak

Hydrodynamic Modelling

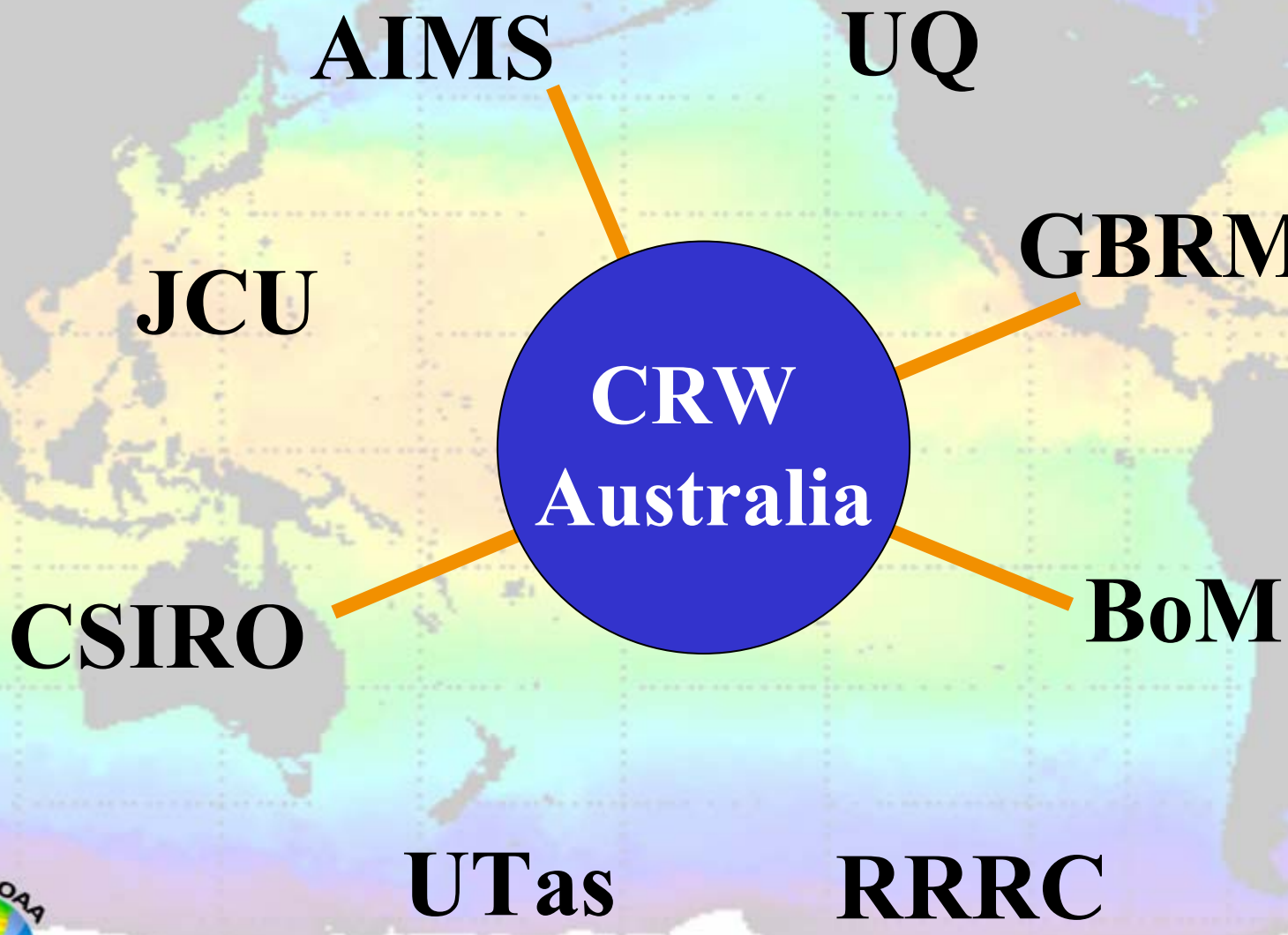
MTSRF

Radar Oceanography



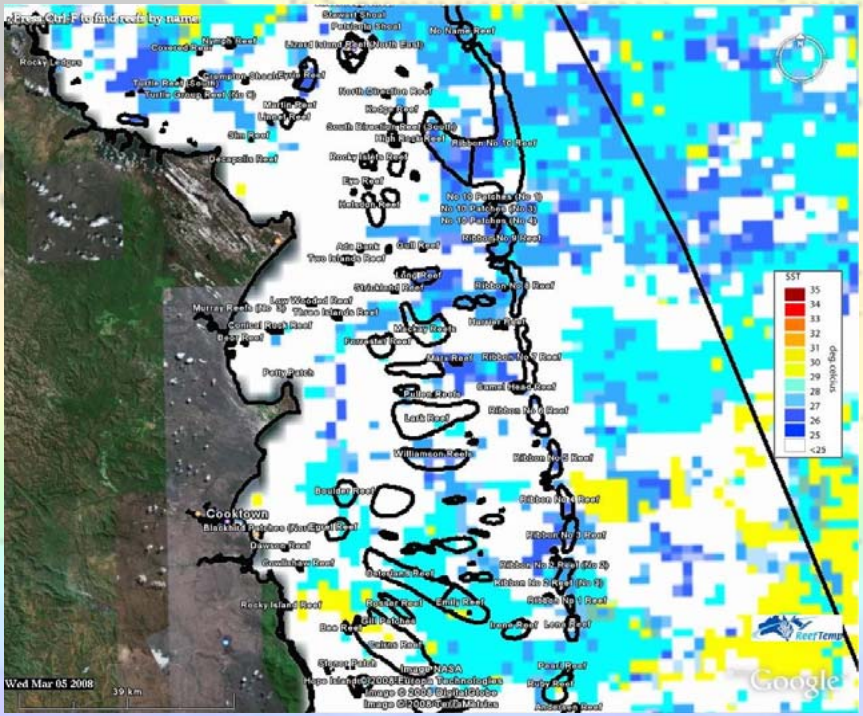


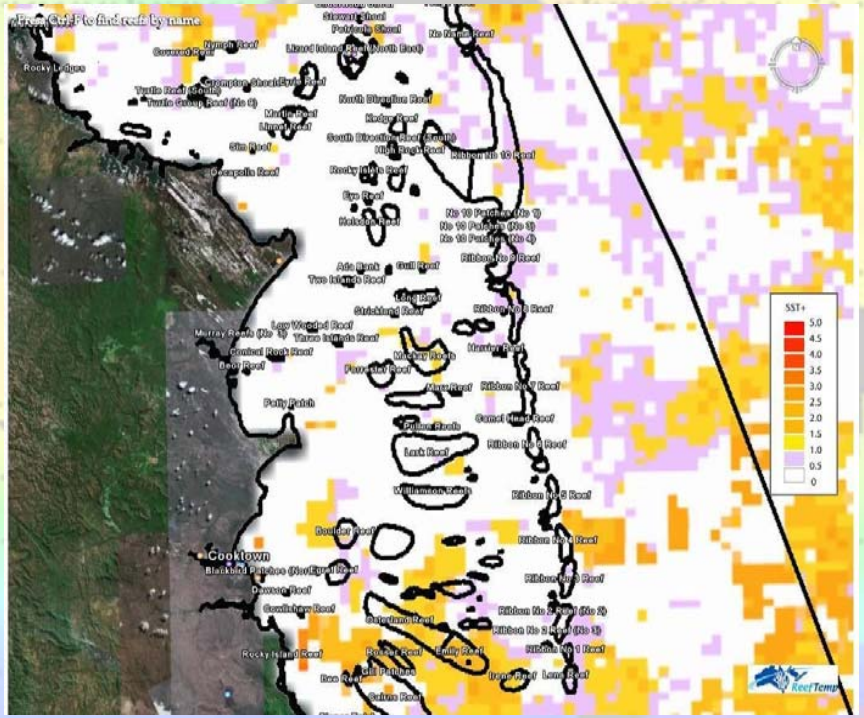
SST-based Products



GBR-specific product

ReefTemp





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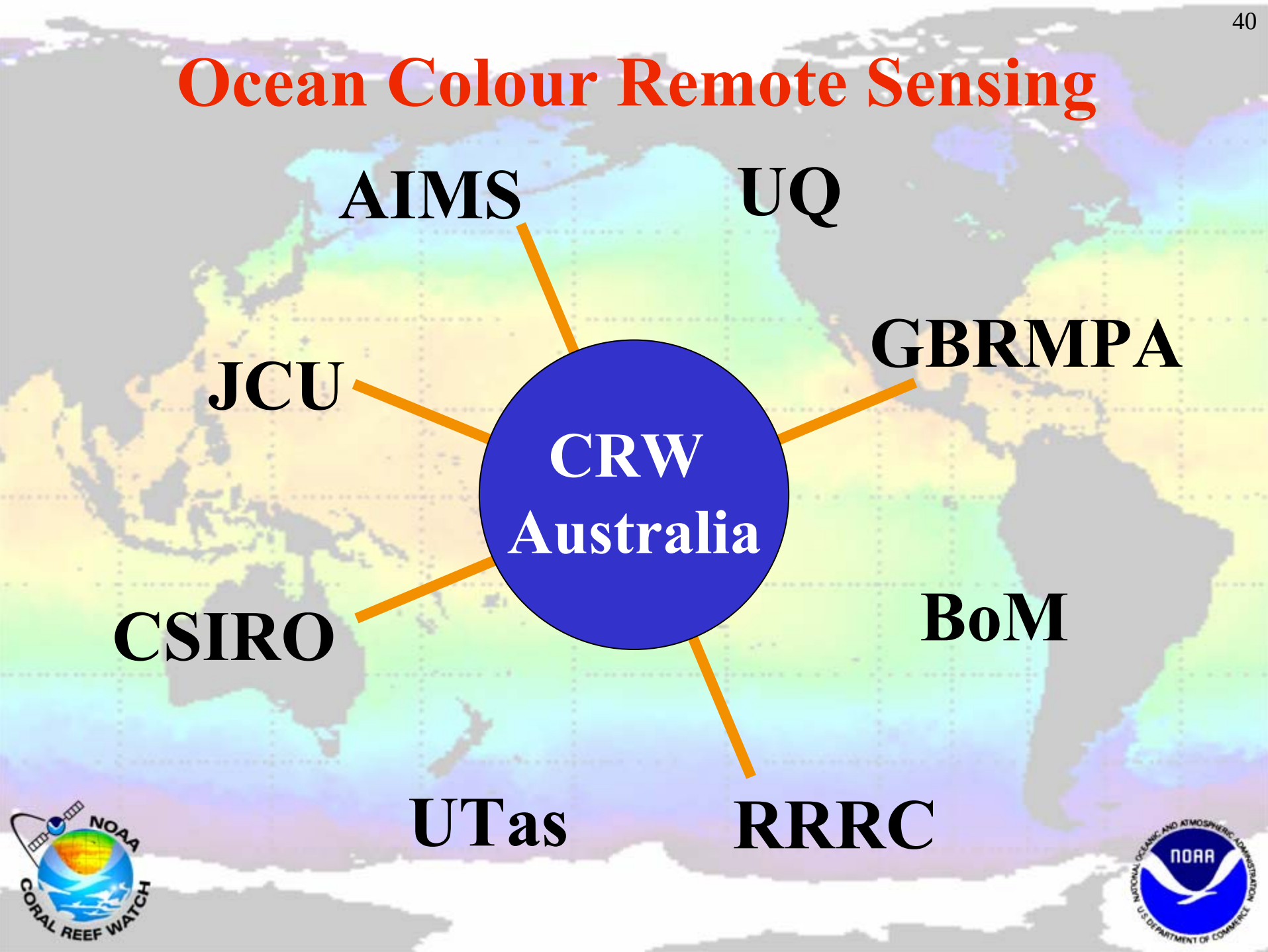
SST-based Products



- Static images with reef overlay
- Interactive GoogleEarth™
- 90 days archive
- Uses different gapfilling technique
- Uses different climatology definition
- Planning for comparison/validation initiated

www.cmar.csiro.au/remotesensing/gbrmpa/ReefTemp_application

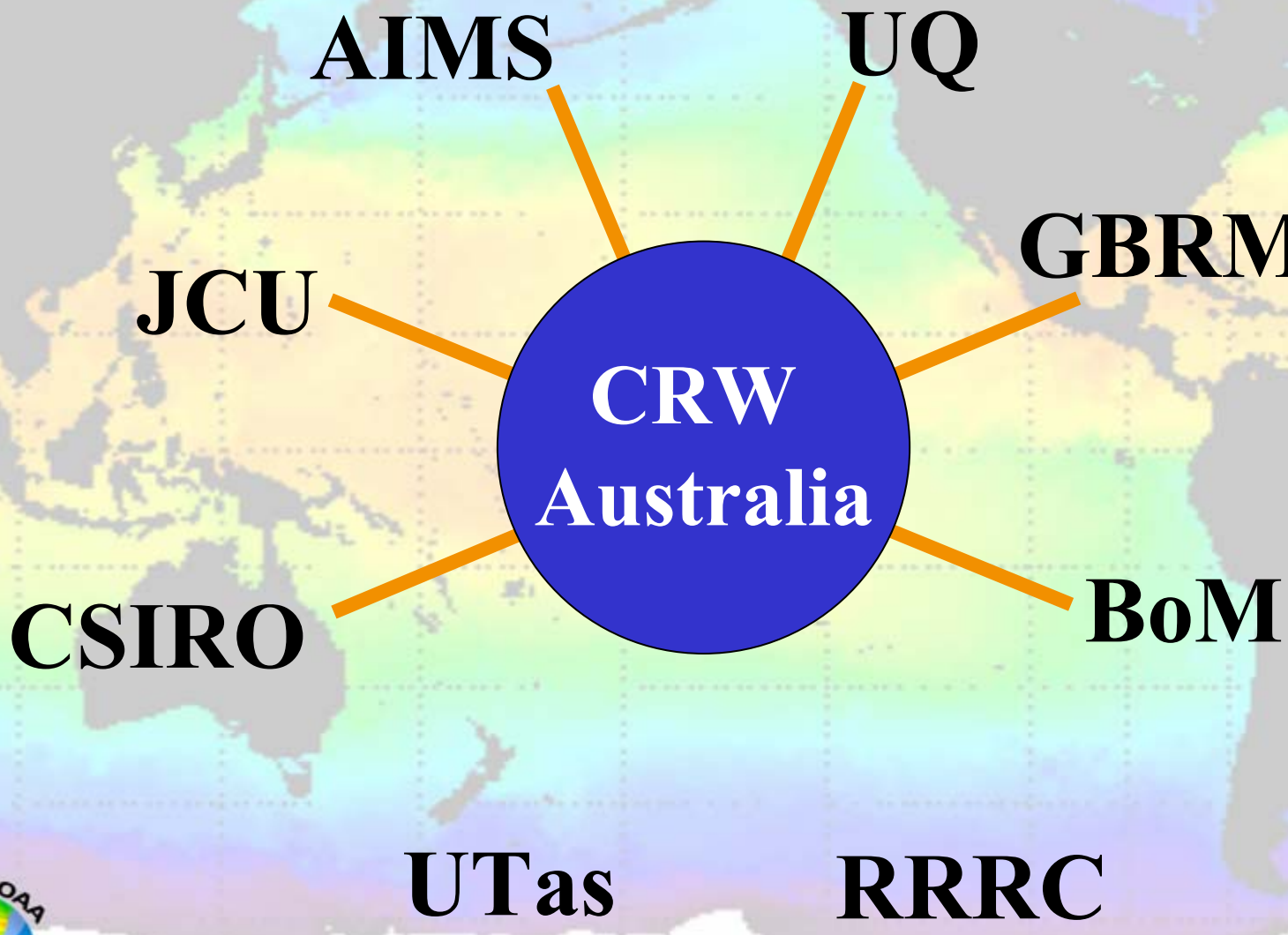
Ocean Colour Remote Sensing



Ocean Colour Remote Sensing

- A suite of 12 Inherent Optical Properties (IOP) that describe water types on the GBR
- These optical properties are a super set of those found in US and European waters (via published data)
- These are part of a coastal waters ocean colour algorithm that is being tested on the GBR
- Discussions are underway for testing in NYC adjacent waters

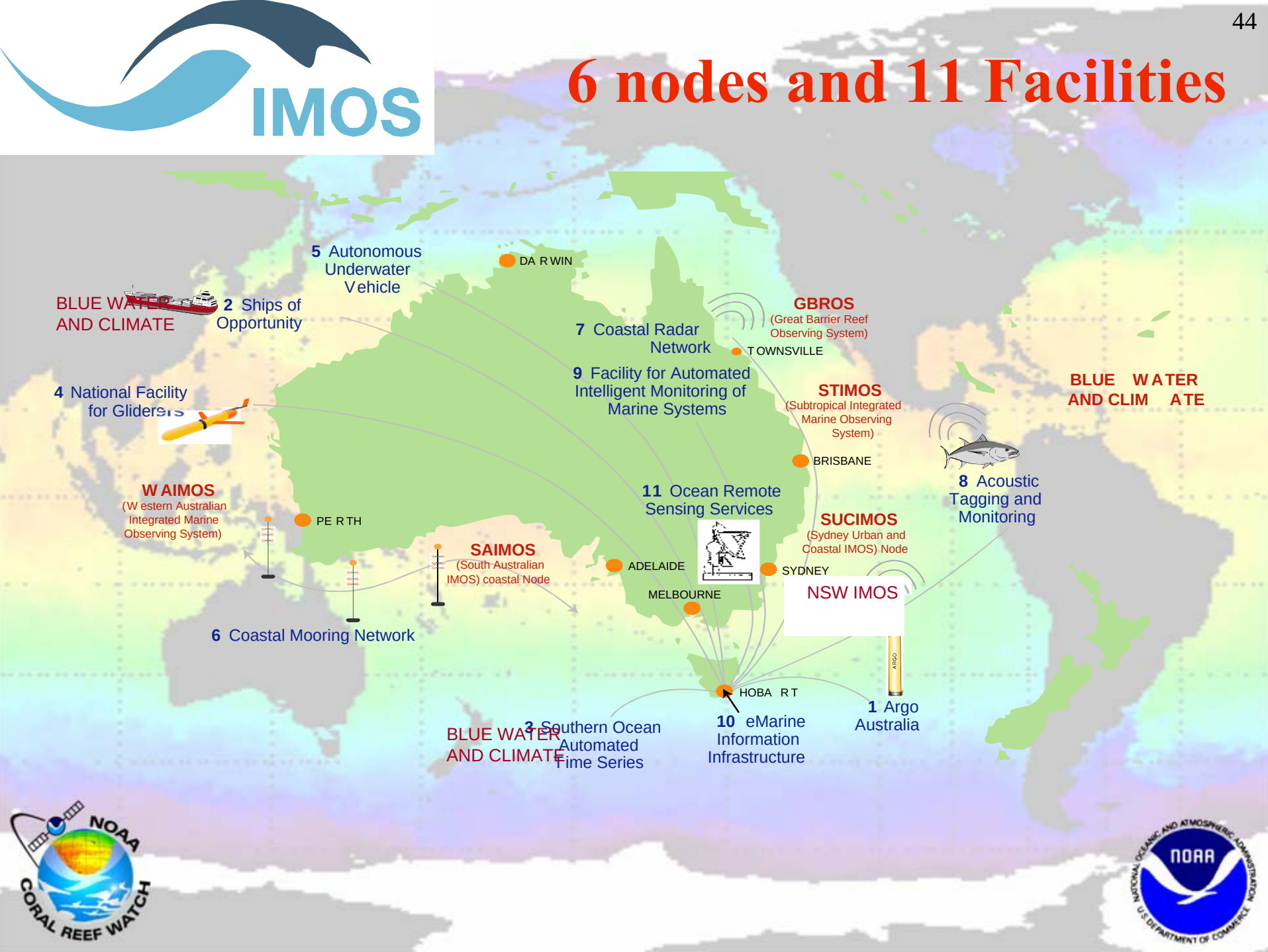
GBROOS



Integrated Marine Observing System

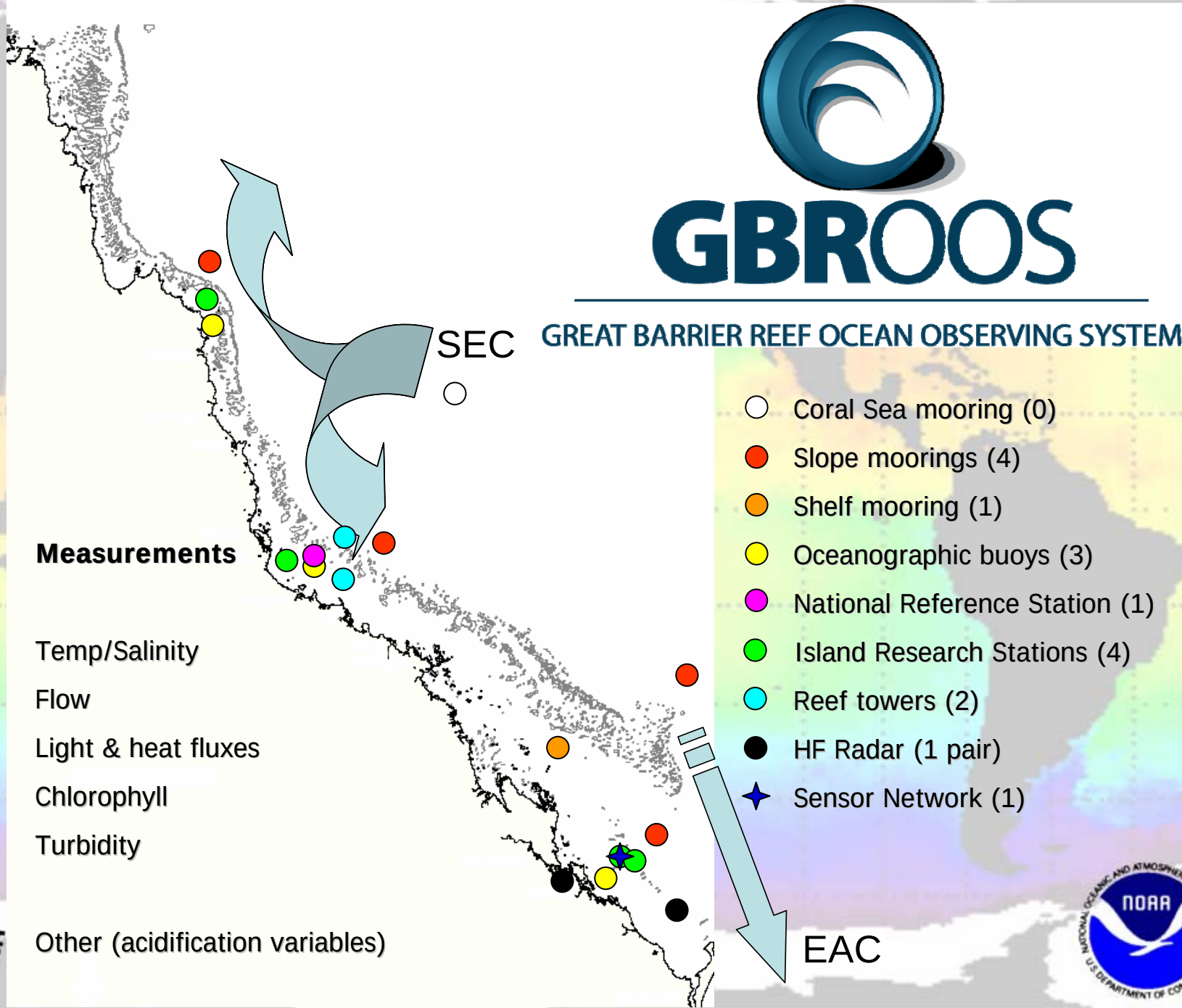
- Nation-wide collaborative program designed to observe the oceans around Australia
- $55M from July 2006 to June 2011 supplied by DEST under the National Collaborative Research Infrastructure Structure (+$40M in-kind)
- IMOS will provide data to support research on many of the critical marine issues facing Australia, including climate change and sustainability of ecosystems
- 28+ Australian institutions are involved
- See http://www.imos.org.au/

6 nodes and 11 Facilities



GBROOS

GREAT BARRIER REEF OCEAN OBSERVING SYSTEM



Measurements

Temp/Salinity

Flow

Light & heat fluxes

Chlorophyll

Turbidity

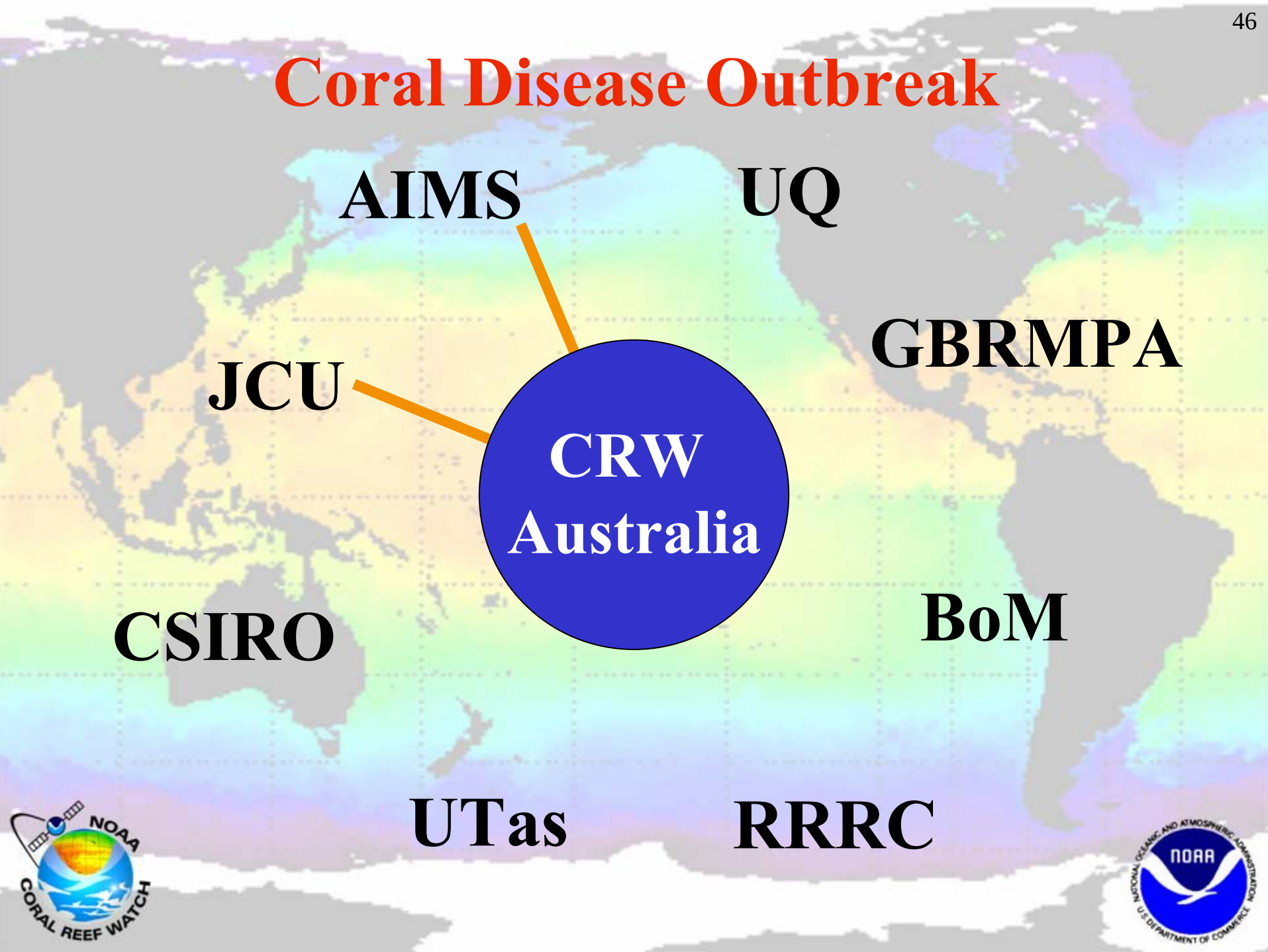
Other (acidification variables)

- Coral Sea mooring (0)
- Slope moorings (4)
- Shelf mooring (1)
- Oceanographic buoys (3)
- National Reference Station (1)
- Island Research Stations (4)
- Reef towers (2)
- HF Radar (1 pair)
- Sensor Network (1)

NOAA CORAL REEF WATCH

NOAA

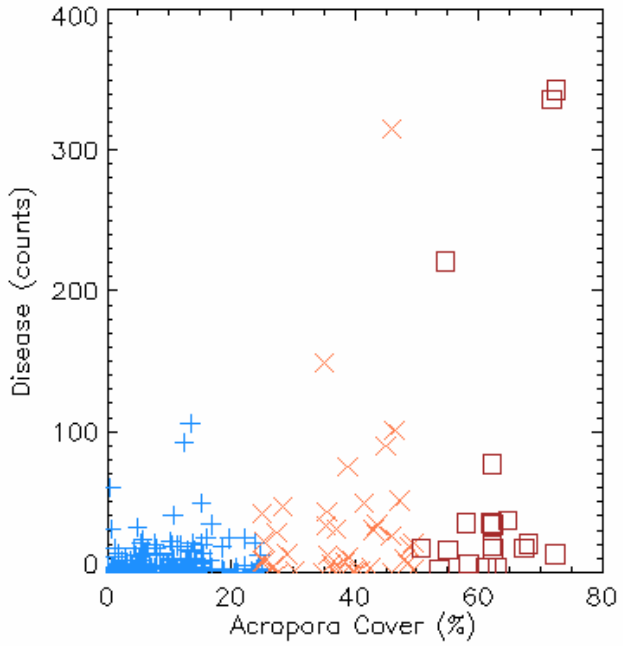
Coral Disease Outbreak



Coral Disease Factors

- Disease occurrence linked to high coral cover and warm temperatures
- New evidence suggests relationship with cold-winter followed by hot-summer
- These are being used to develop a satellite-based predictive model for risk of disease outbreak

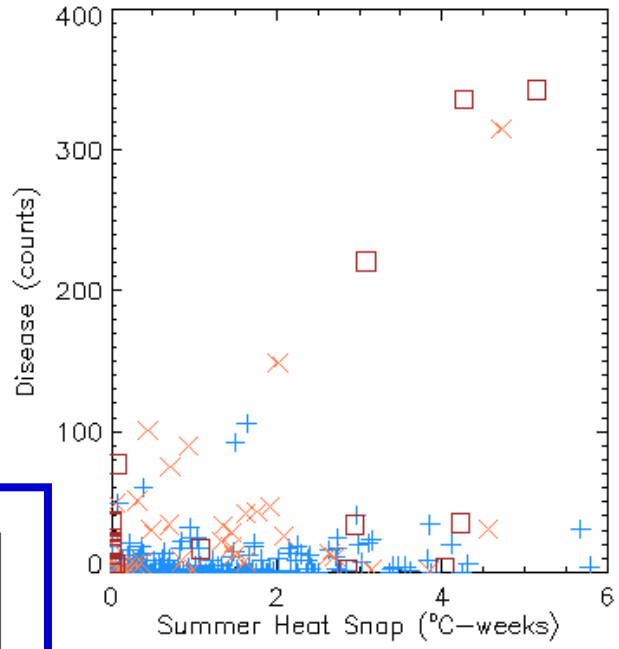
Coral Disease vs Metrics

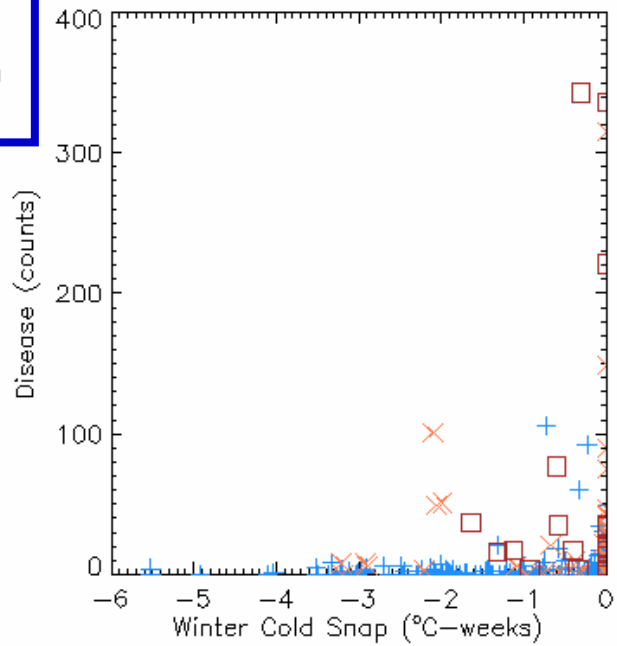


+ Cover < 25%

× 25% ≤ Cover < 50%

□ 50% ≤ Cover





NOAA CORAL REEF WATCH

NOAA

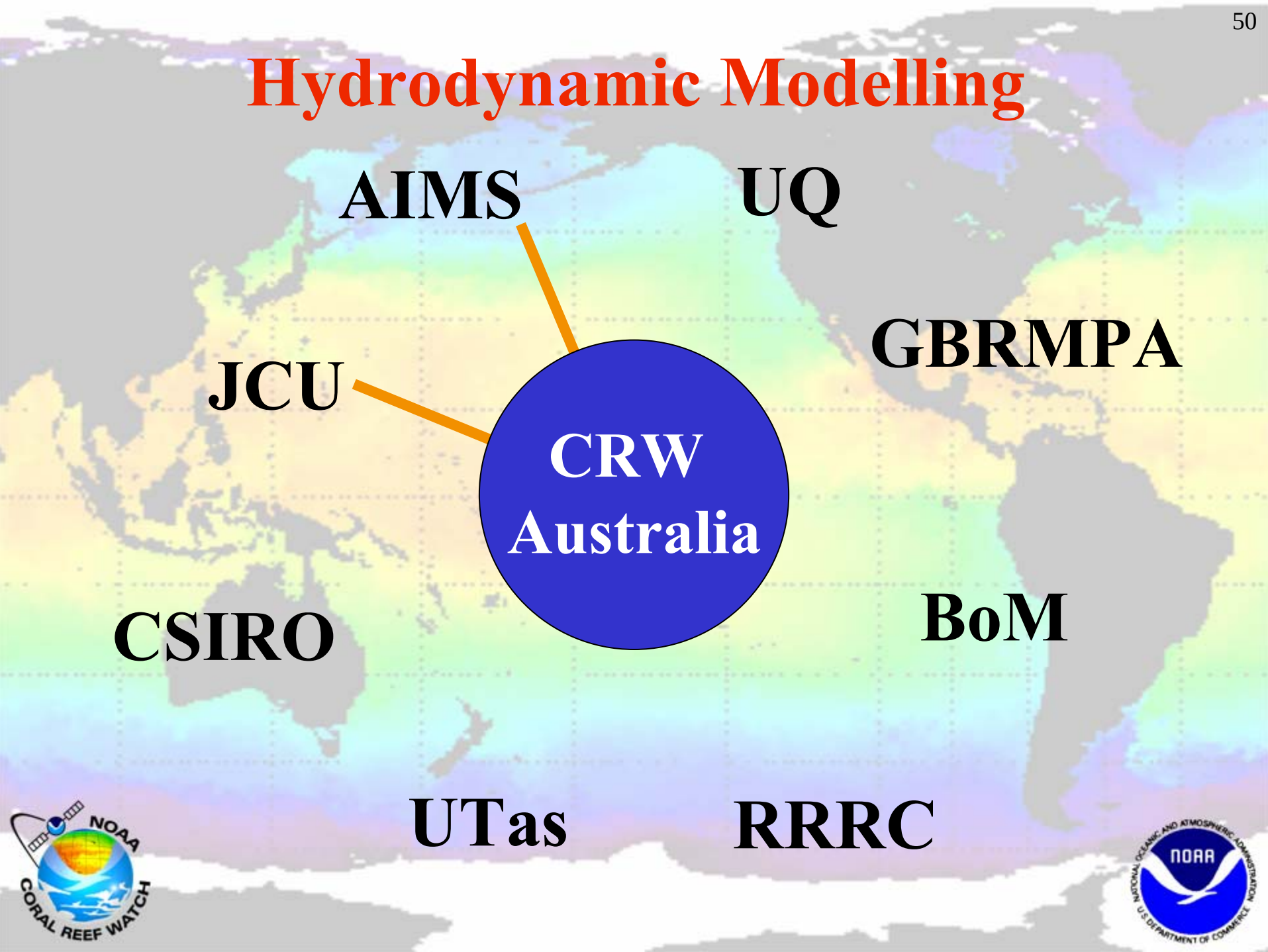
Coral Disease Outbreak Prediction

- **Positive (i.e., risk of outbreak) where disease count is at or above the 90th-percentile value of disease observations that have corresponding SST**

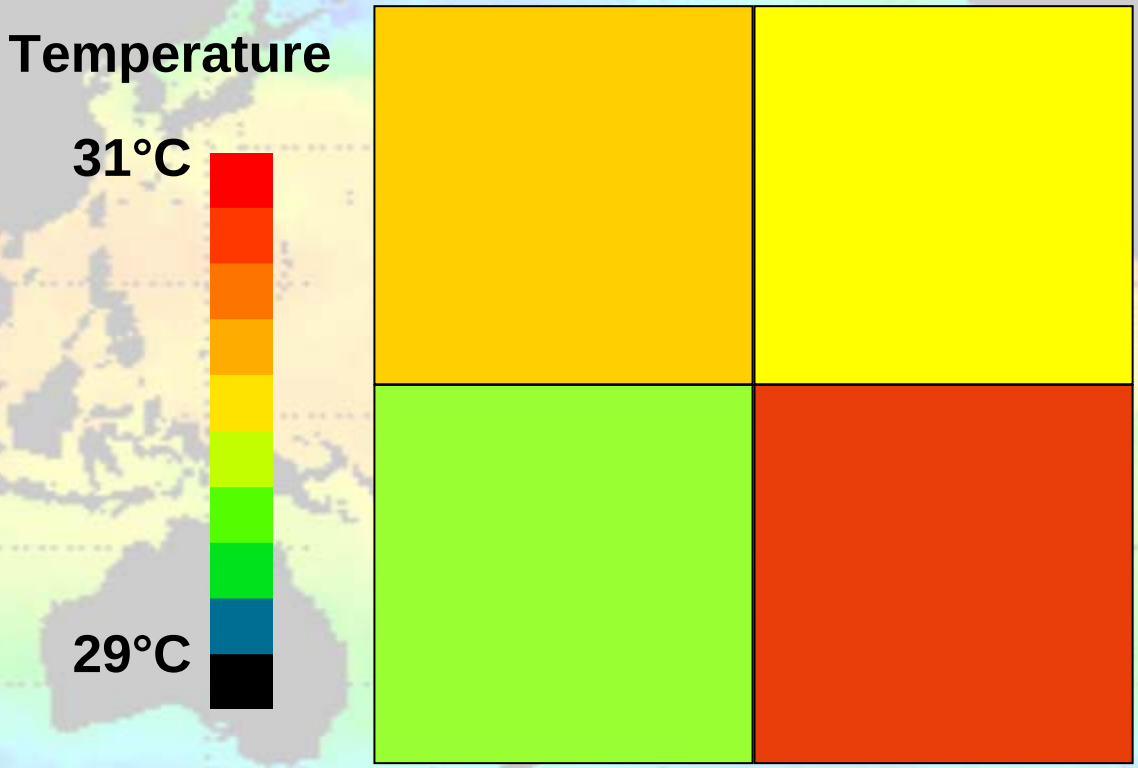
- **LowCover< 25%**

Bruno *et al.* (2007) model	coldprDW > -1.5 & summprDW >= 0.5	Prediction outcome
15	26	True Positive
203	185	True Negative
104	122	False Positive (total)
20	9	False Negative
13	11	False Positive with not-LowCover

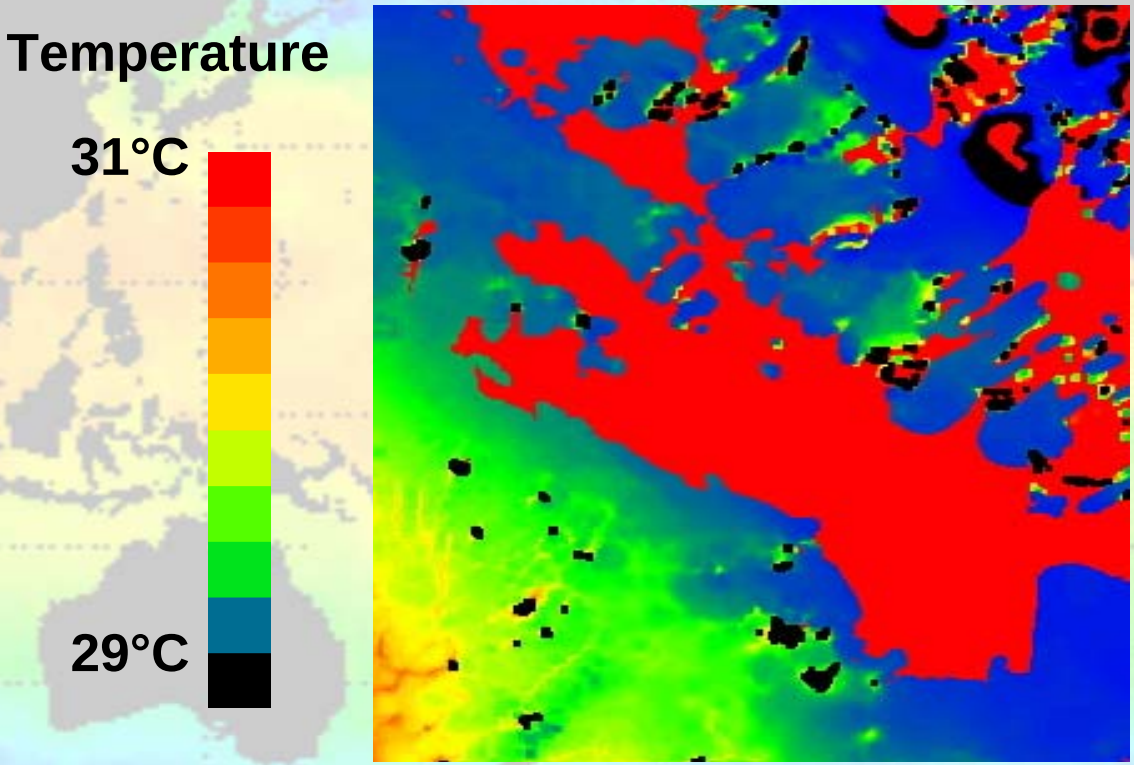
Hydrodynamic Modelling



Why Hydrodynamic Modelling?

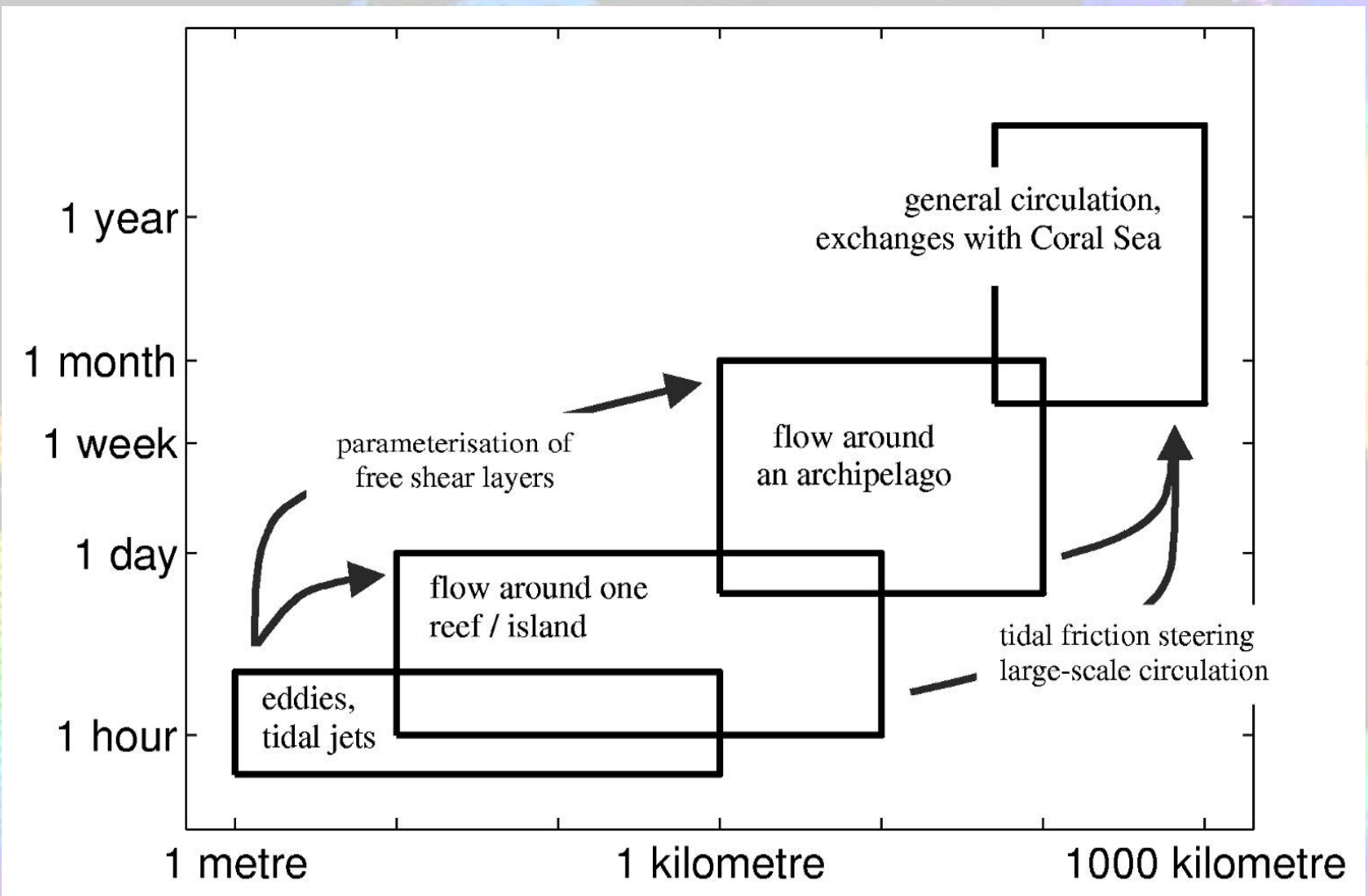


Why Hydrodynamic Modelling?

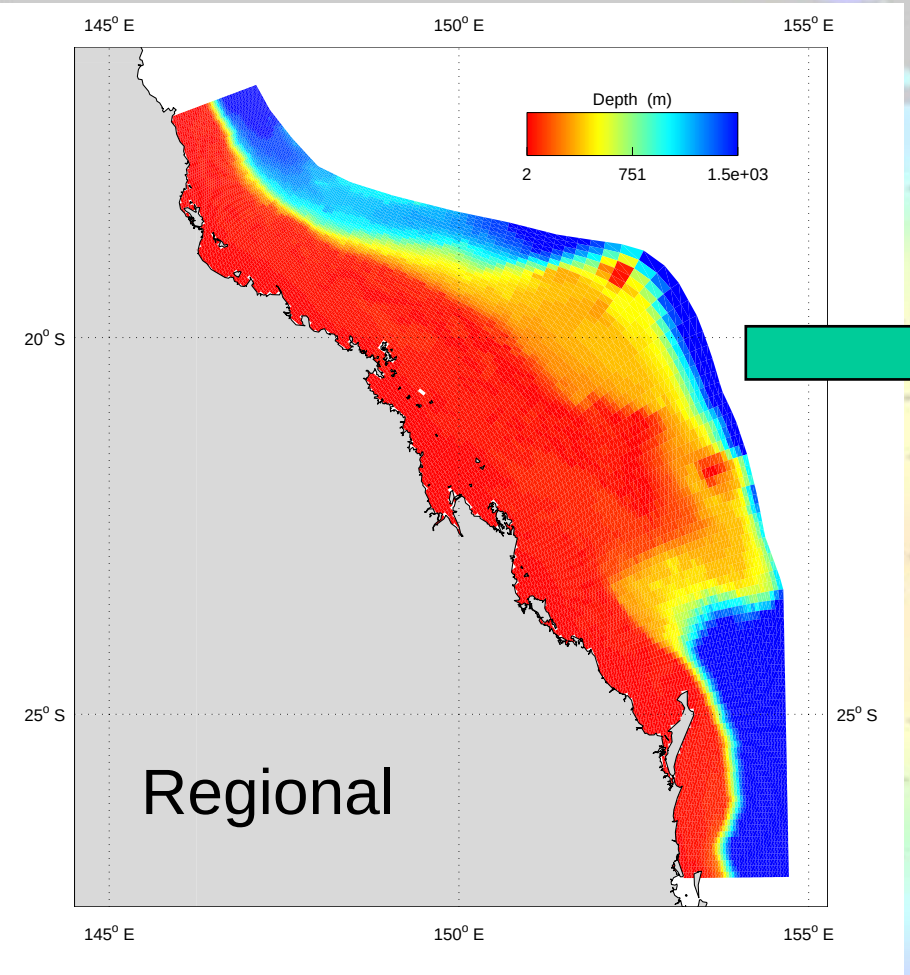


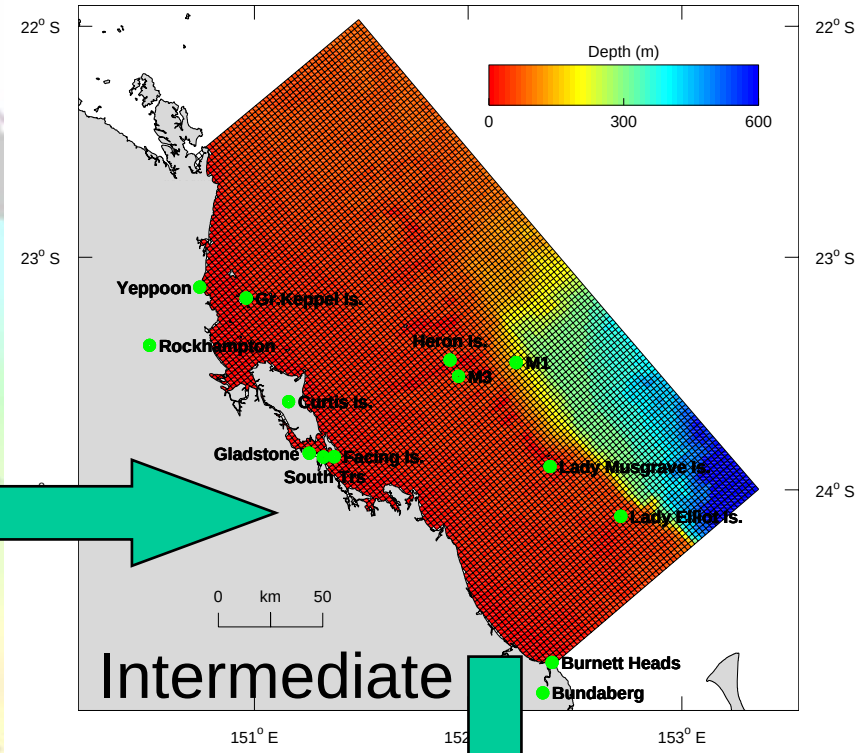
NOAA CORAL REEF WATCH
NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

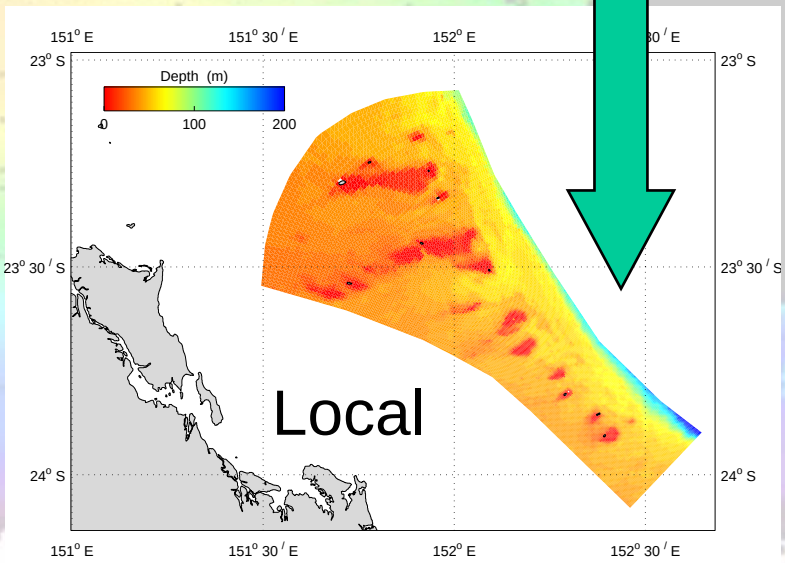
Scales of GBR Hydrodynamics



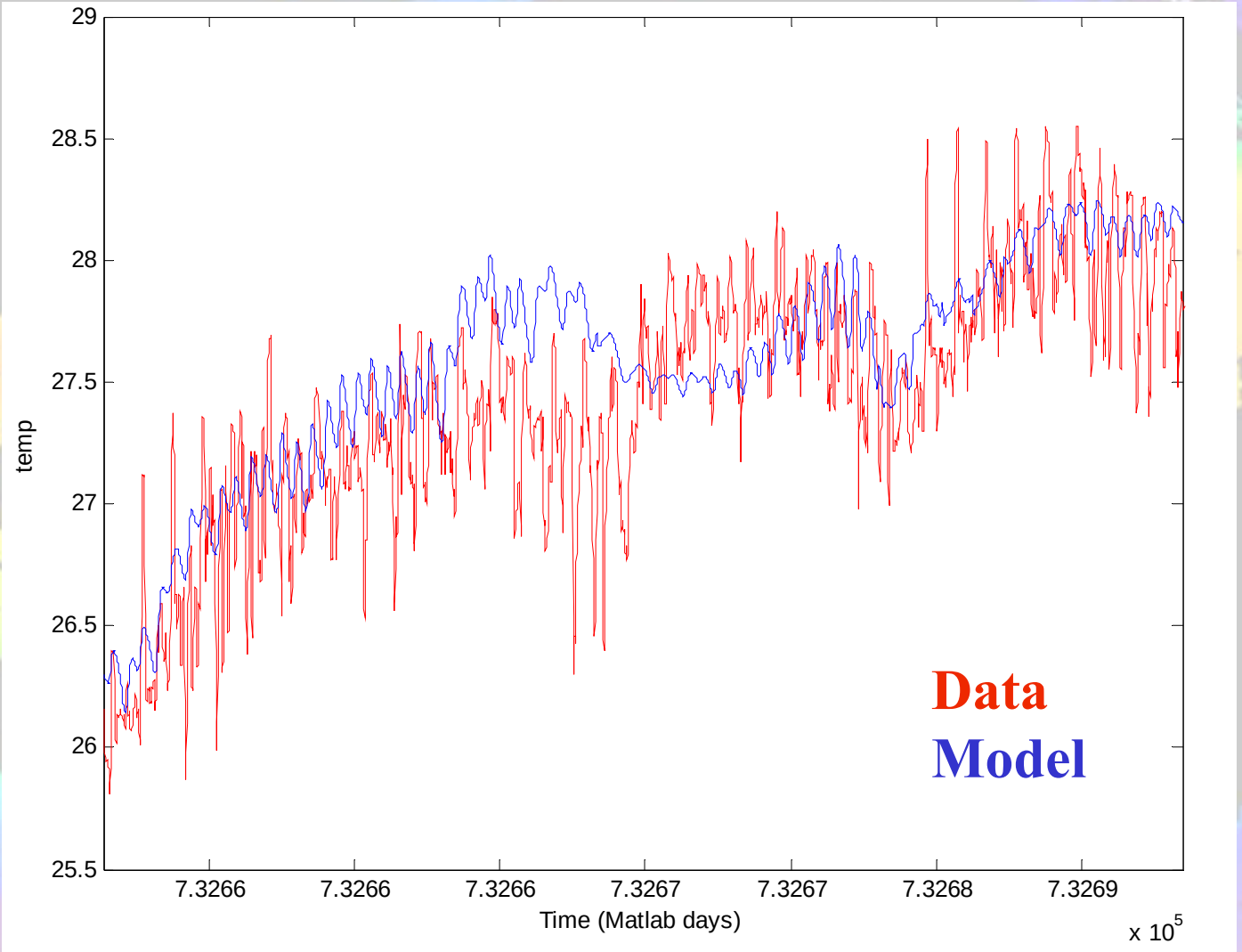
Nesting (1 way)



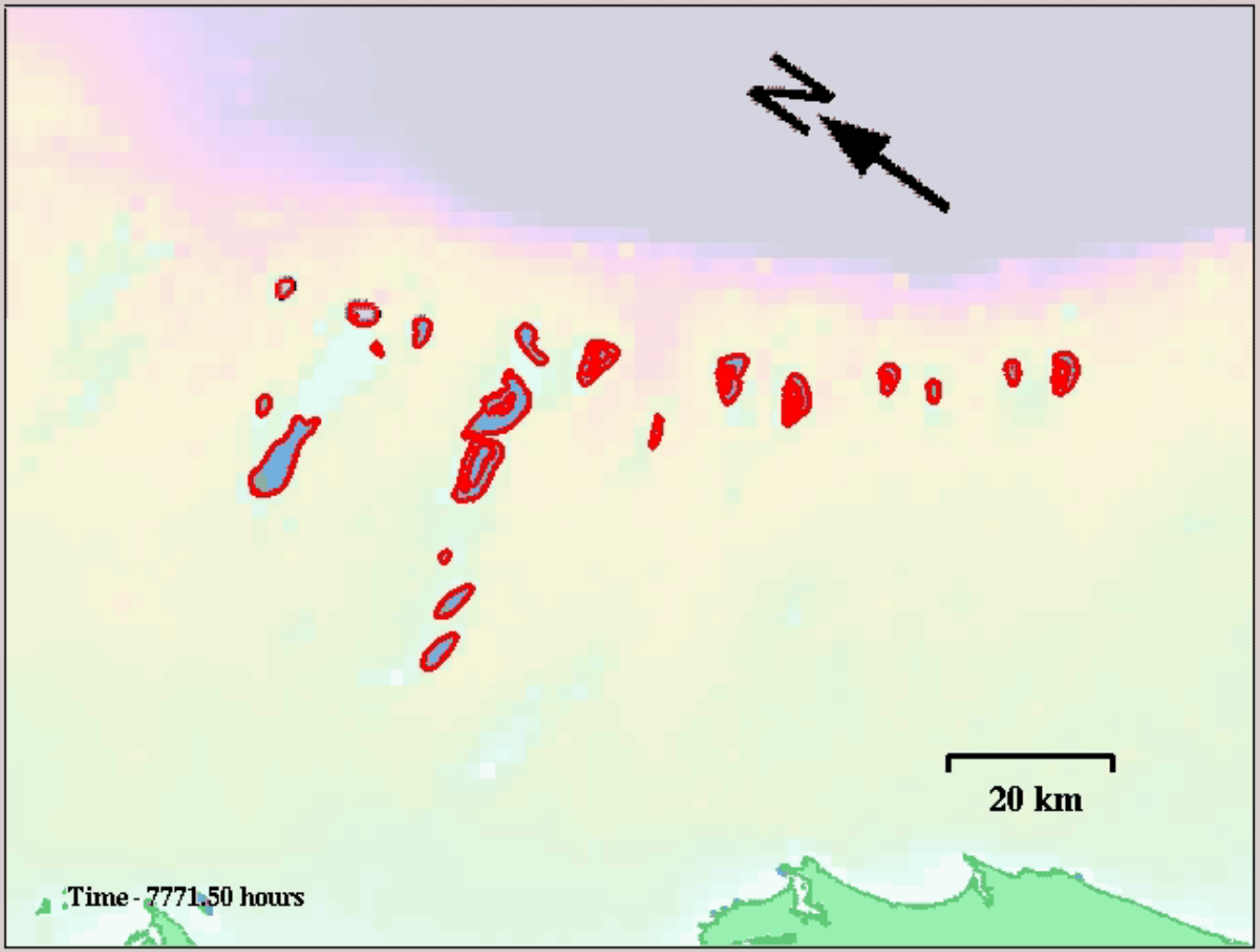




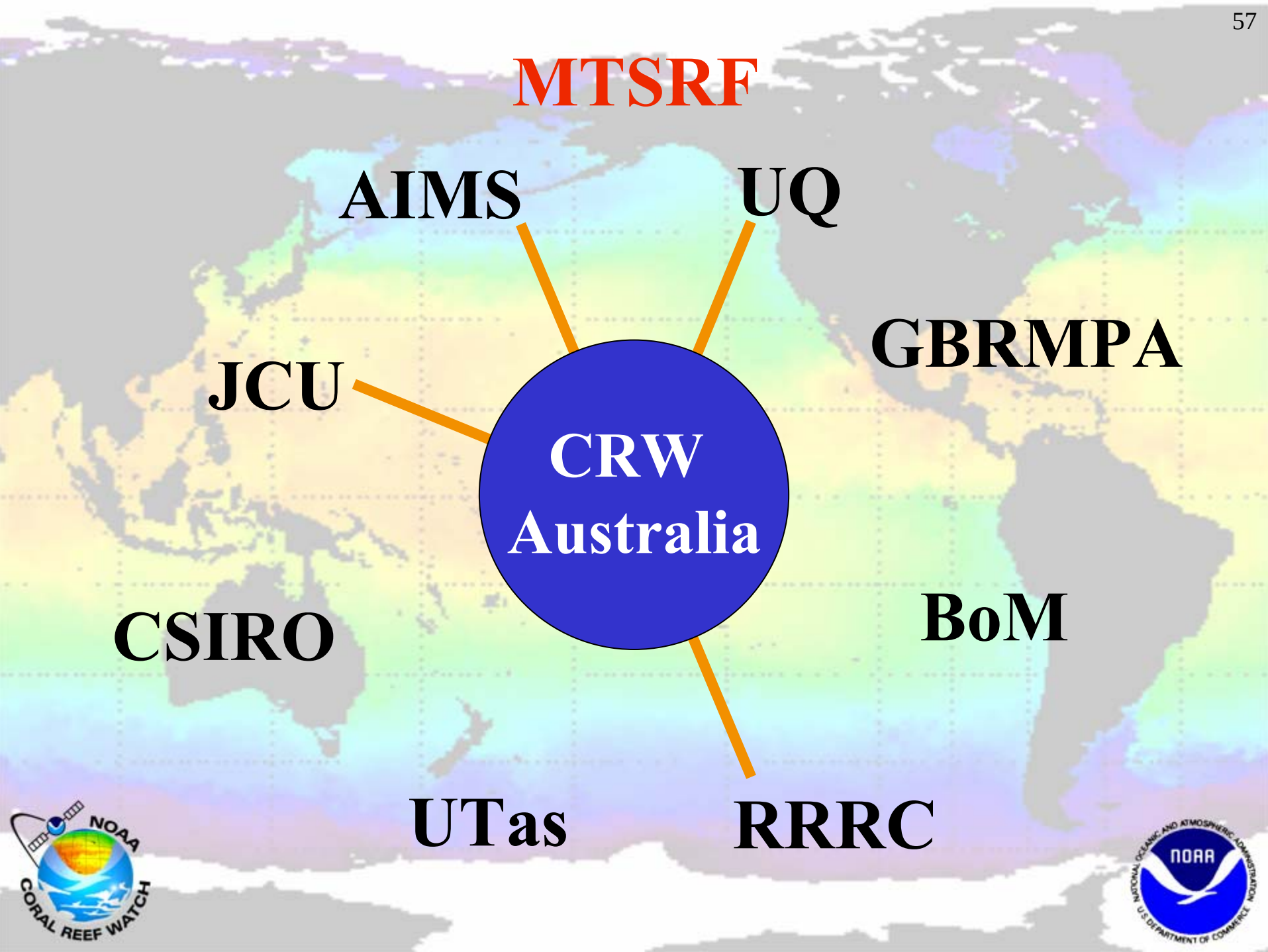
Model Validation



Application: Connectivity



MTSRF



MTSRF

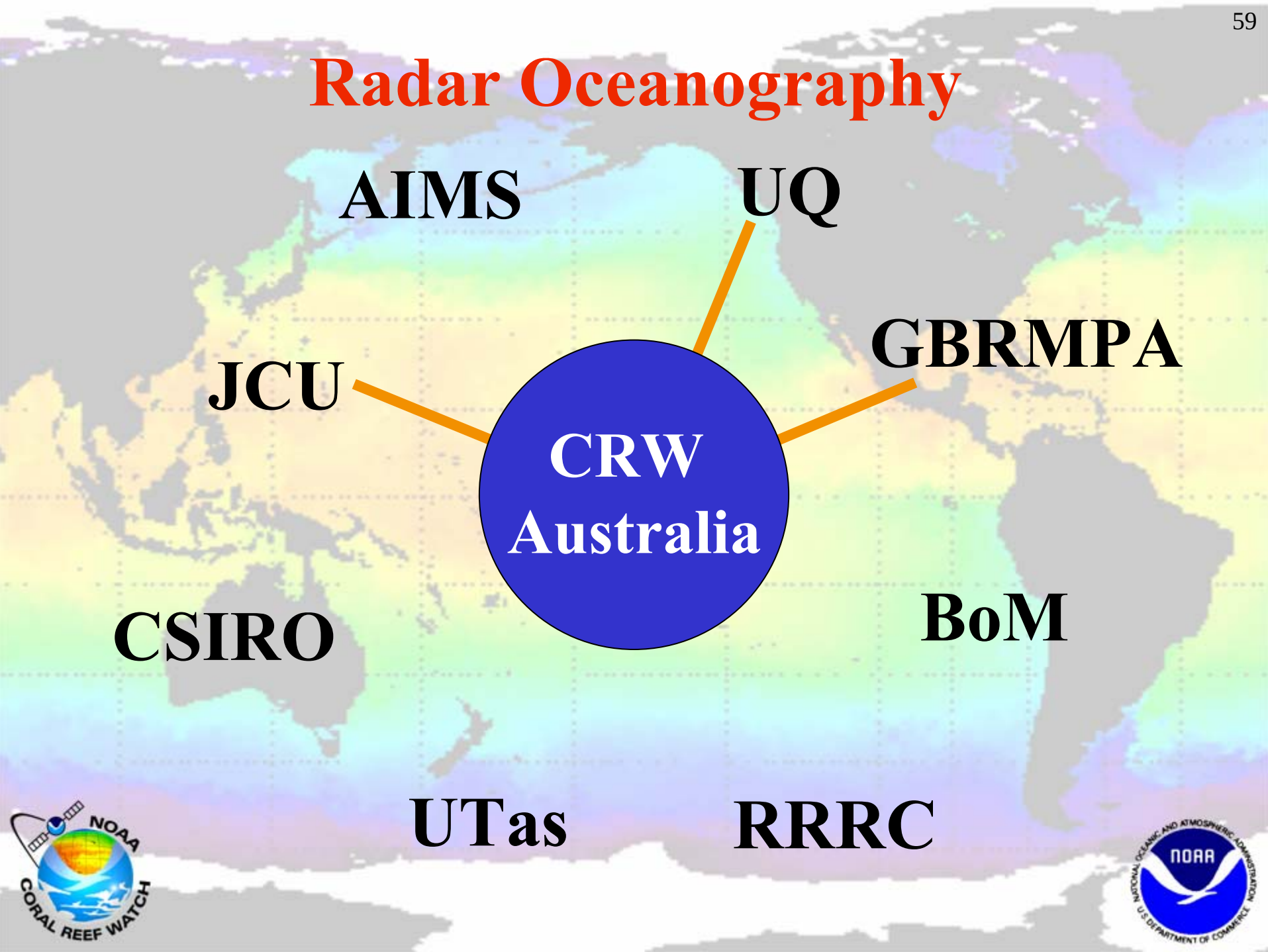
Climate-scale Hydrodynamic Modelling

- **Force the developed models with large-scale conditions forecast to 2050**
- **Examine the hi-res conditions around coral reefs**

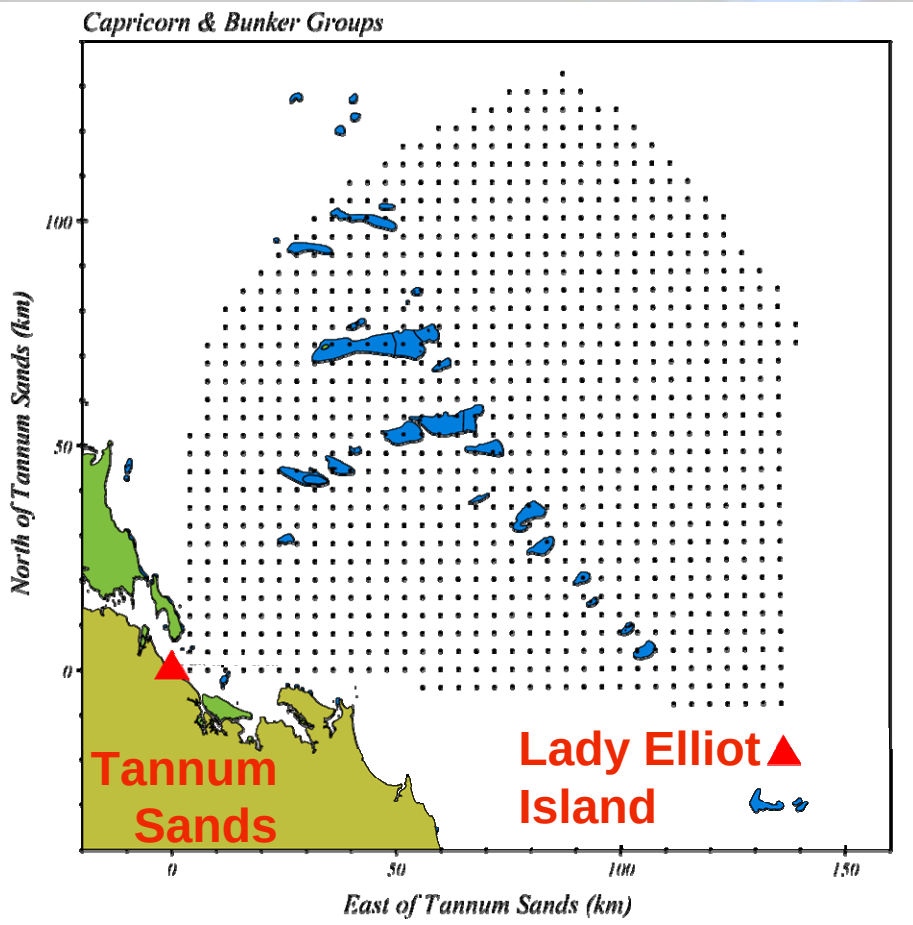
Disease

- **MTSRF supports additional field studies for the understanding and prediction of environmental conditions conducive to coral disease events**

Radar Oceanography



Radar Oceanography





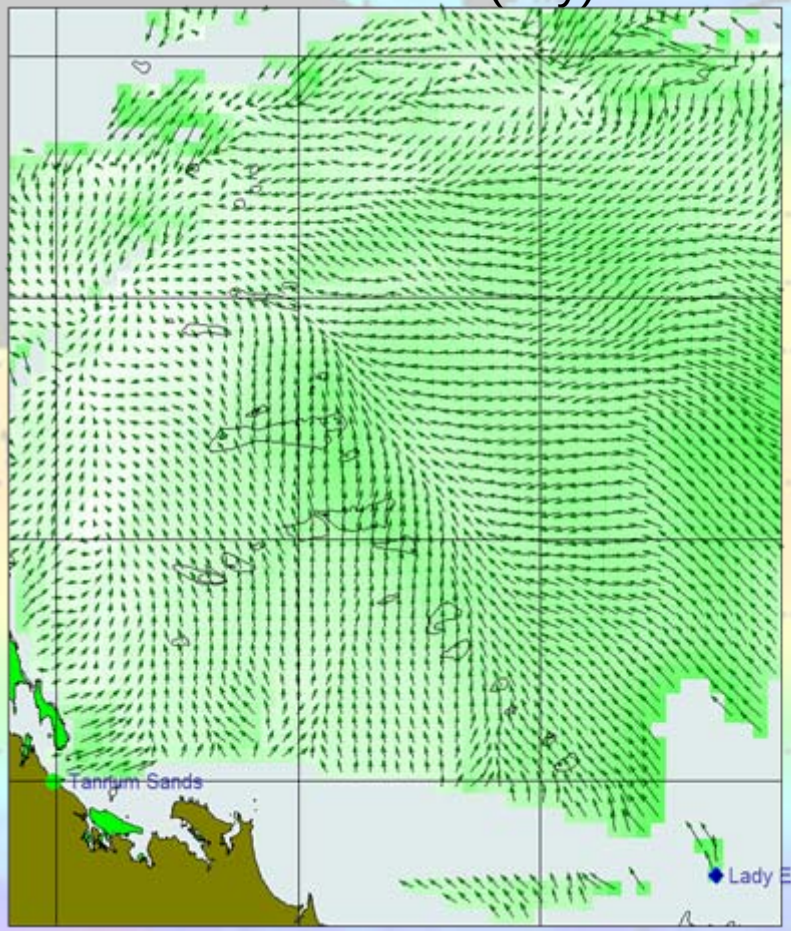






Radar Oceanography

28.11.2007 0305UTC (day)



SURFACE CURRENTS

Current: 10 cm/s

Scale: 100 km

Sampling time: 10 minutes

Time averaging: Nil

Space averaging: Nil

Coral Reefs:

Islands:

Mainland:

Radar Power: 30 Watt

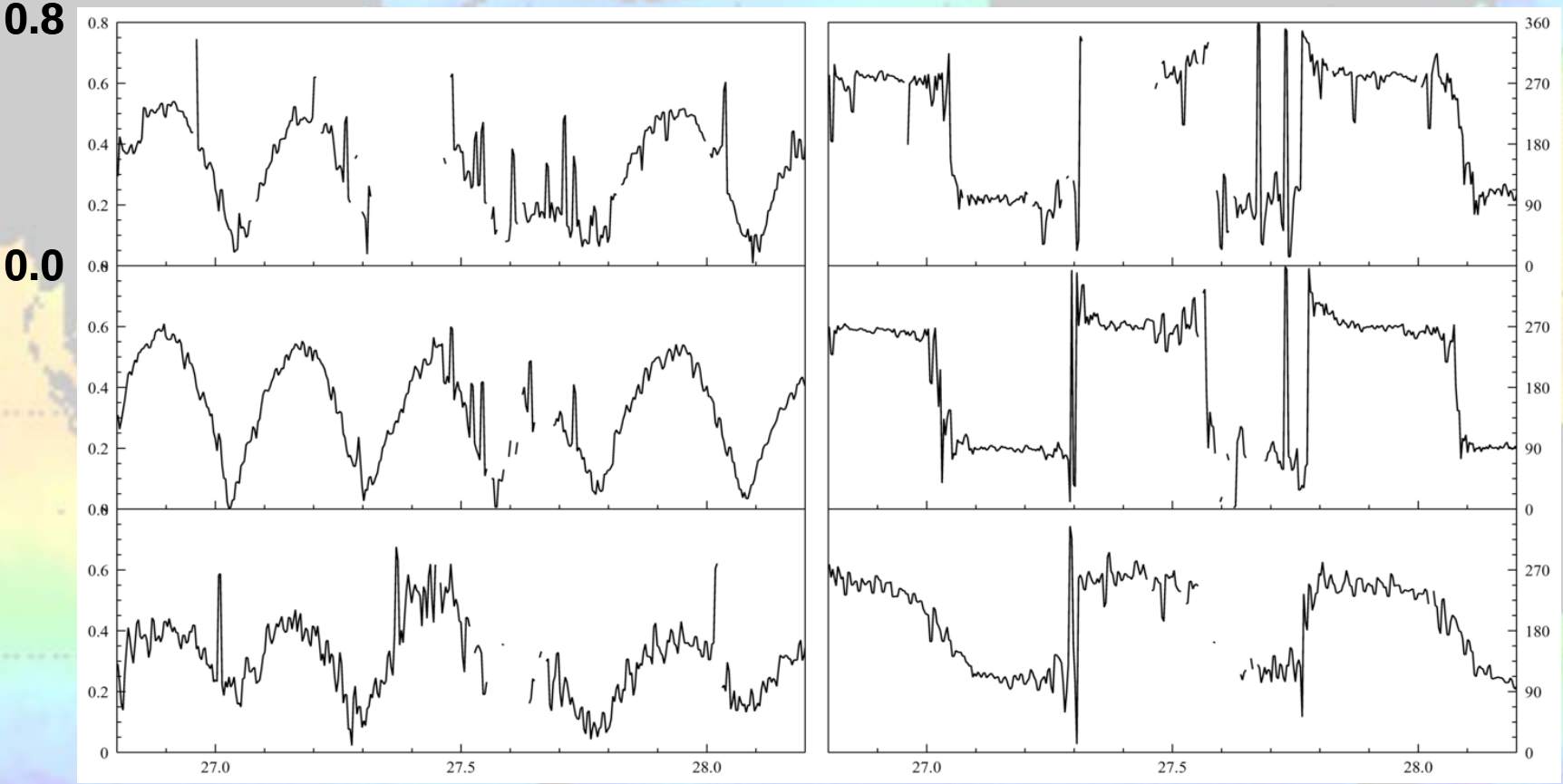
Frequency: 8.438 MHz

Radar Stations: Tannum Sands

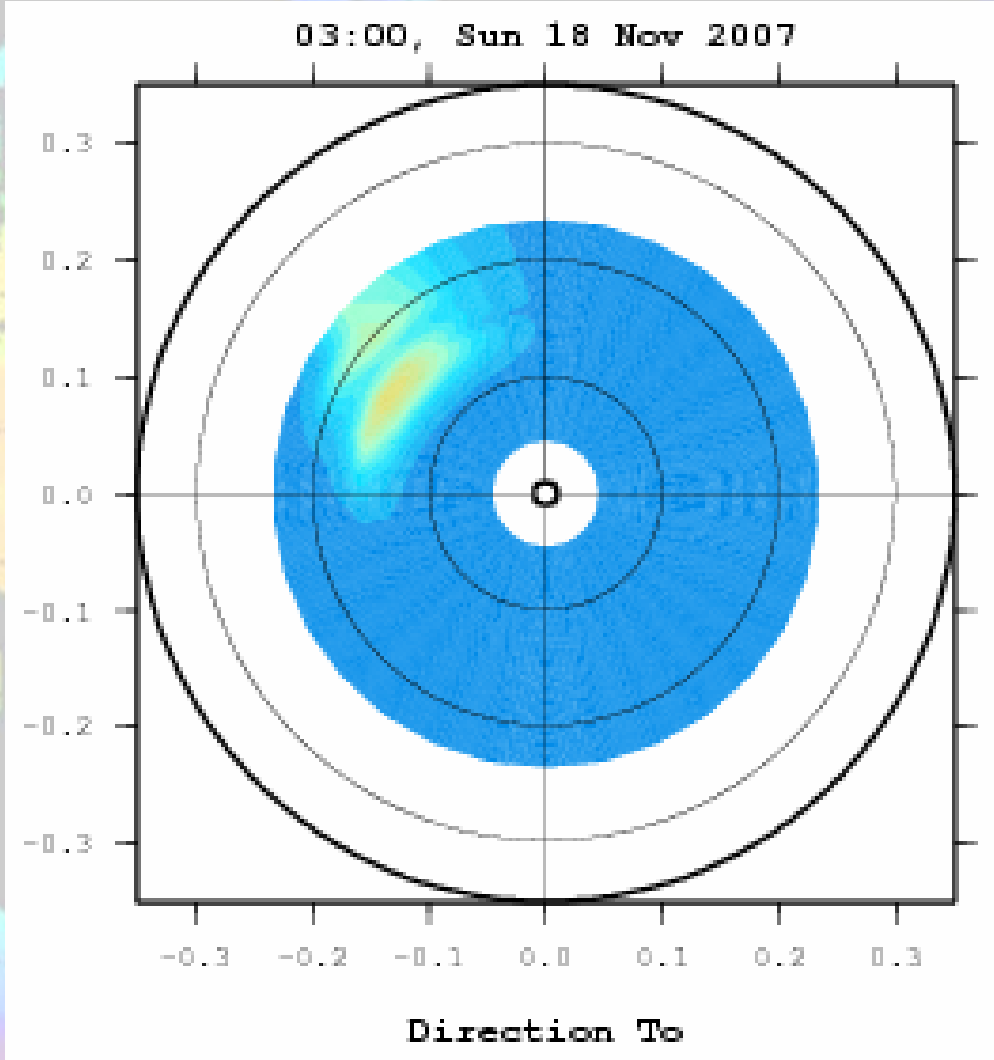
Lady Elliot Is.

Radar Time Series

Surface current speed (m/s) **Surface current direction (°)**



Radar Wave Spectrum



Collaborators

UQ

AIMS

GBRMPA

JCU

BoM

CSIRO

UTas

RRRC

Projects

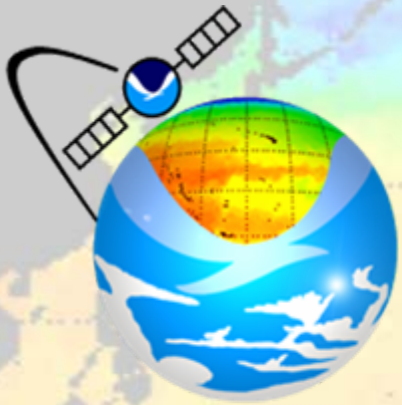
ARC Linkage
Ocean Acidification
World Bank - GEF
Light/temp Project
Bio-Discovery
Algal Blooms
SST-based products
Ocean Colour
GBROOS
Coral Disease Outbreak
Hydrodynamic Modelling
MTSRF
Radar Oceanography

Summary

- CRW began utilizing US research only
- US-Australian connection taps into the majority of global coral reef research
- Australian collaboration increased CRW research capacity and capability 10-fold
- This allows CRW to concentrate on coral-specific algorithms and applied products







Coral Reef Watch

NOAA coral reef
CONSERVATION PROGRAM

NOAA CORAL REEF WATCH

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE