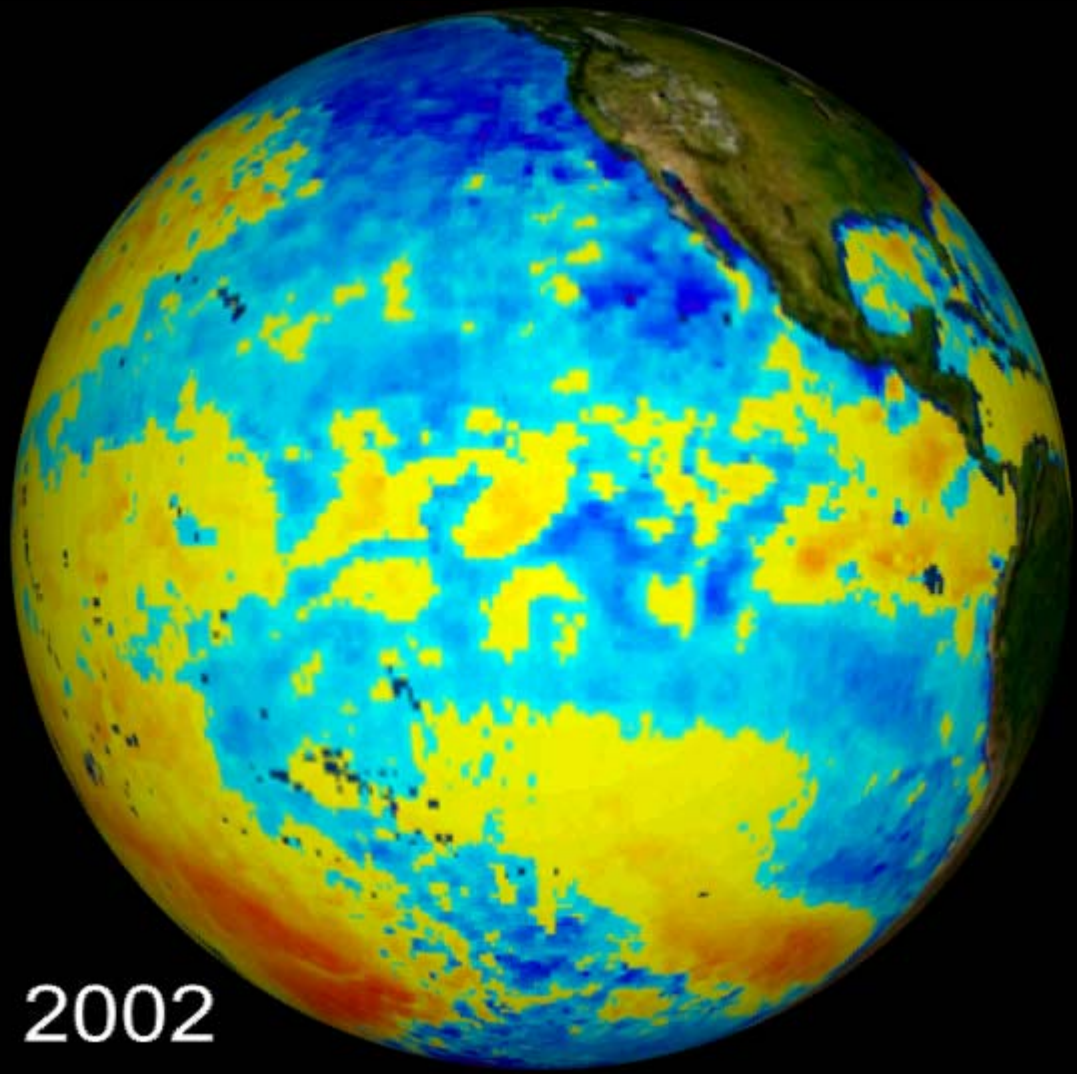
Coral Reef Watch – A Satellite View



AE
Strong

Satellite SST Anomalies

January 2002 – May 2003

Coral Reefs, Climate, and
Coral Bleaching Workshop
June 18-20, 2003
Turtle Bay, Oahu, HI

Coral Reef Watch

Program Leaders:

NOAA Satellite Information Service

-- Alan Strong

NOAA Research - *in situ*

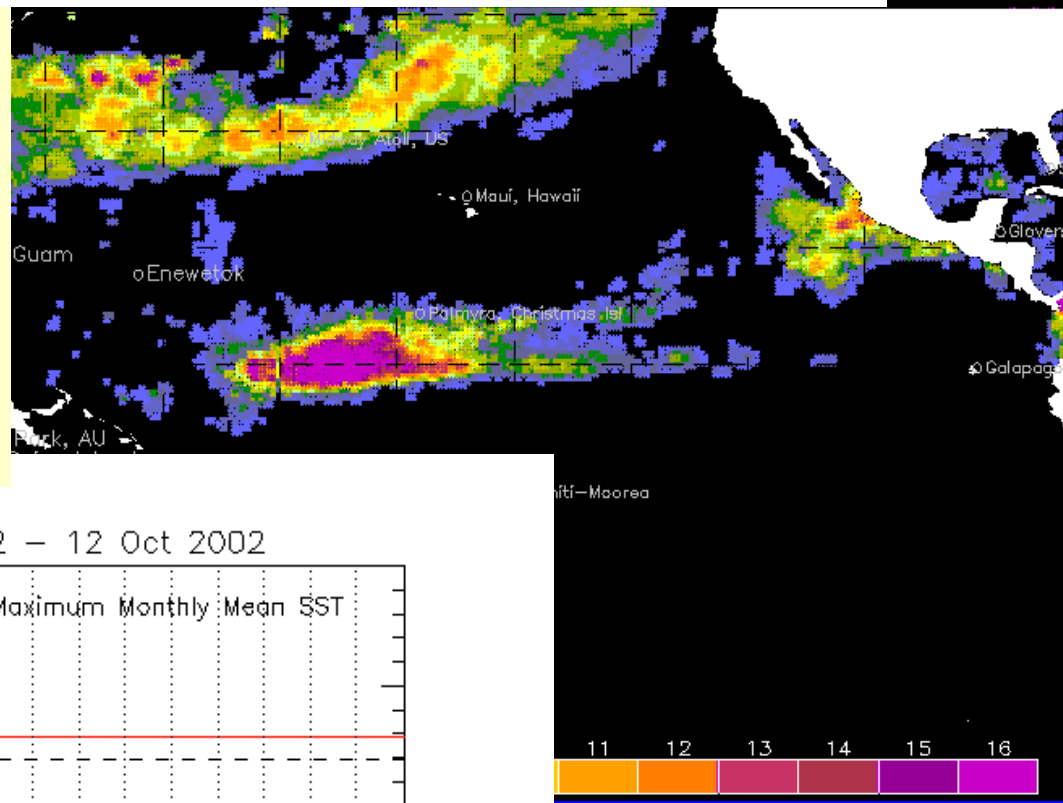
-- Jim Hendee

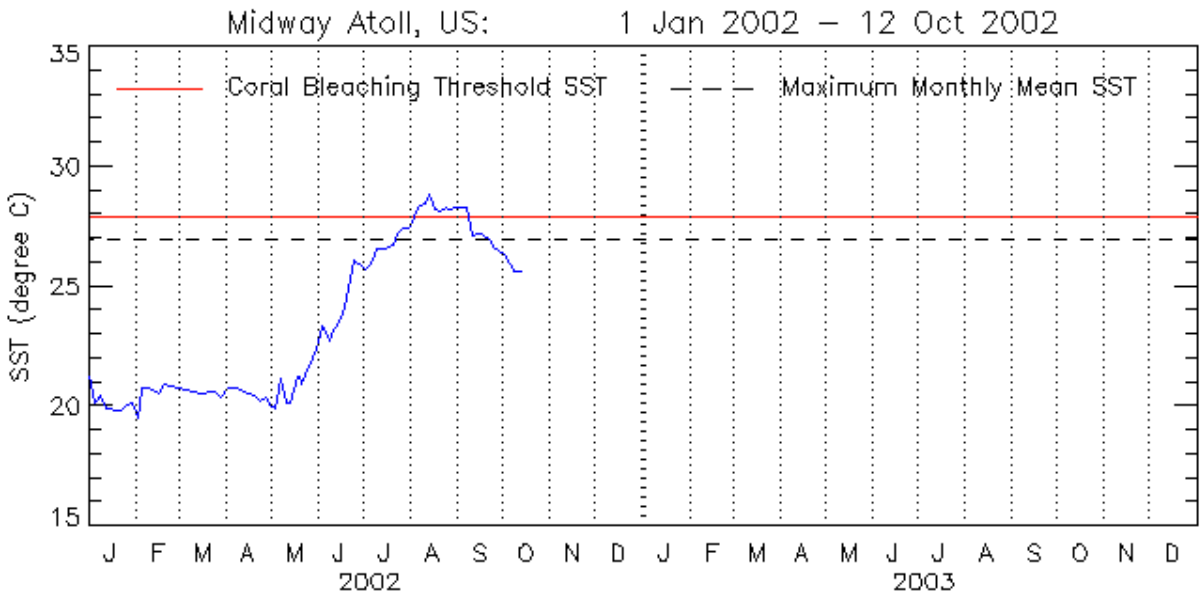
Coral Reef Watch

Degree Heating Weeks for 7 September, 2002

Thermal Stress at Midway
Started 1st August
Stopped 7th September

NESDIS Bleaching Warning issued 7th August



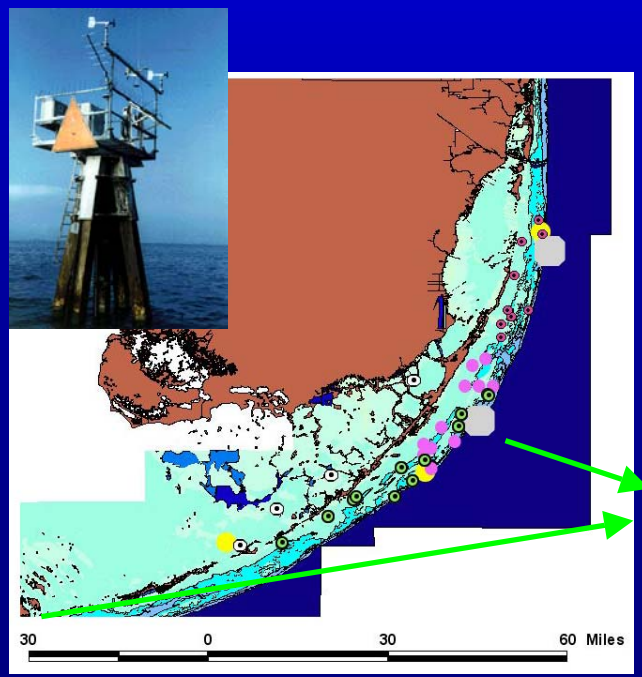


Coral Reef Watch

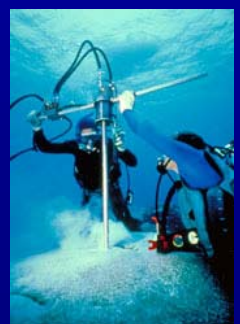
"Retrospective monitoring" using paleoclimate proxy records from reefs with NOAA Research buoy and tower *in situ* environmental monitoring stations

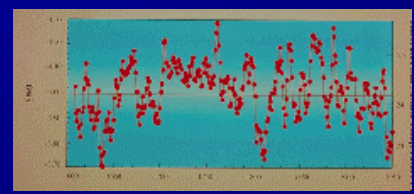
Target #1: Florida Keys National Marine Sanctuary

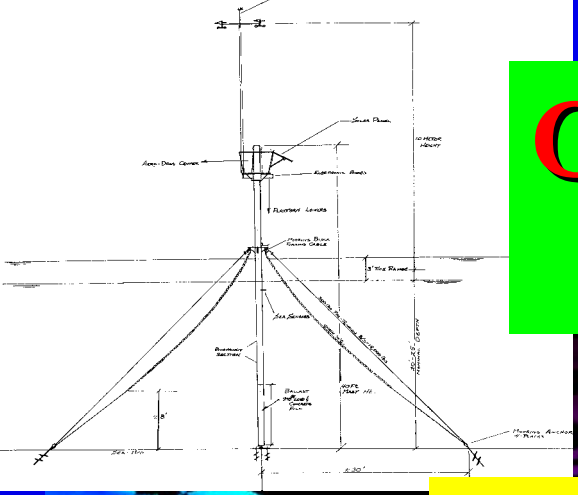
NOAA's Paleoclimatology Program
University of Miami
University of South Florida
(with U.S. Geological Survey)
Nova University



Cores from Molasses Reef, Looe Key now being analyzed



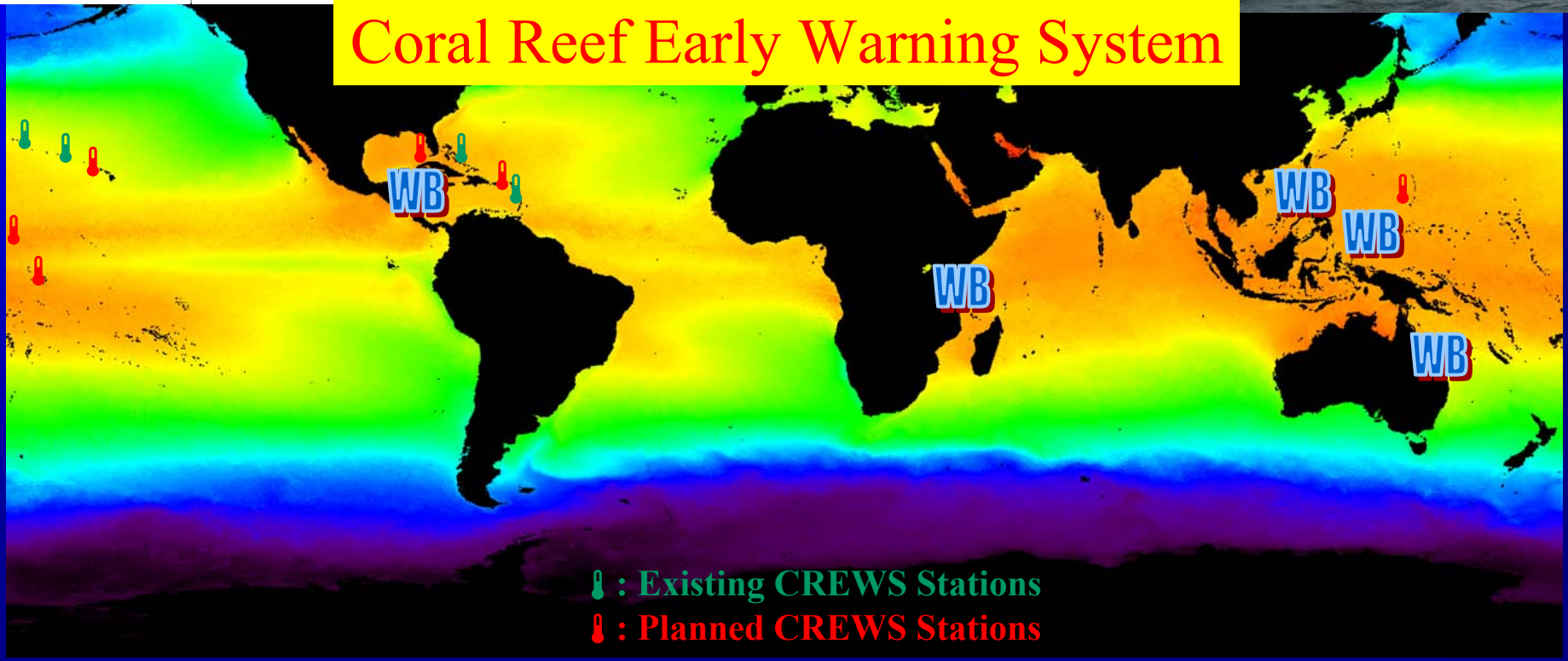




Coral Reef Watch

in situ monitoring

Coral Reef Early Warning System



- Use of expert systems to provide a real-time bleaching warning
- Enhance long-term site data / marry with paleo data

- **IGOS Coral Sub-Theme Report**

  Integrated Global Observing Strategy

  Just Approved

- **USCRTF – Coral Reefs & Climate Change**

  US Coral Reef Task Force

Workshop – June 2003

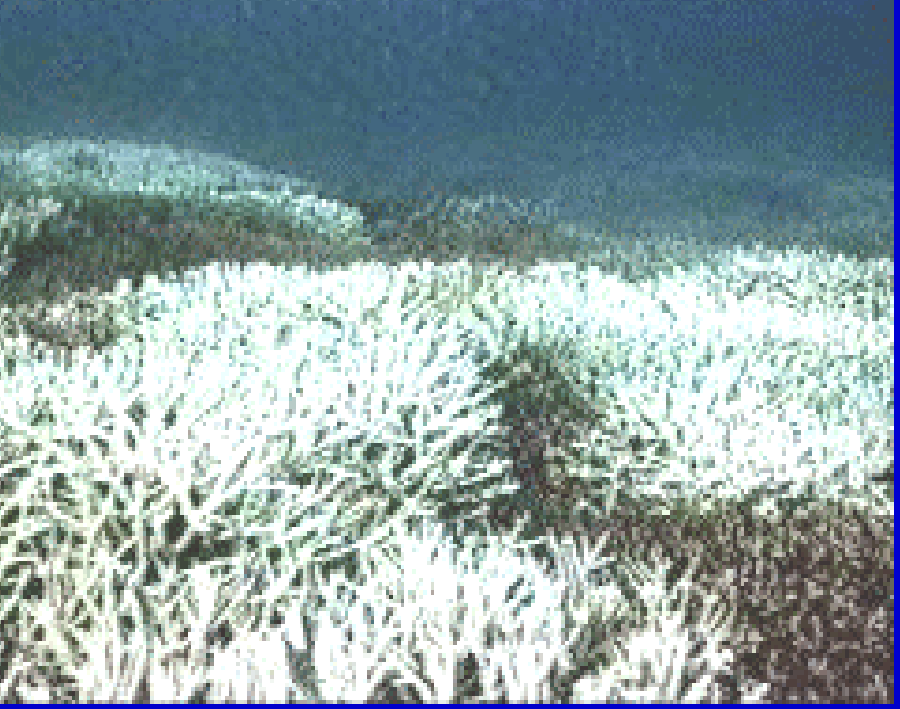
Recently released IGOS Ocean Theme Report

IGOS
Coral Sub Theme

- **Report accepted June 2003**
- **Integrates satellite and *in situ* systems to**
  - provide early warnings and watches
  - monitor
  - provide long term trends of indices

"Coral reefs appear to be the first major ecosystem type to show rapid degradation at a global scale due to human impacts."

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



Bleaching: El Niño or Climate Change?

- Cannot be explained by localized stressors, natural variability, or El Niño alone
- Likely accentuated by an underlying global rising baseline of marine temperatures
- Other natural variability: PDO, NAO, etc

State Dept. Report to USCRTF 1999

Changing SST Tendencies?

- Recent Pacific Reversal? -

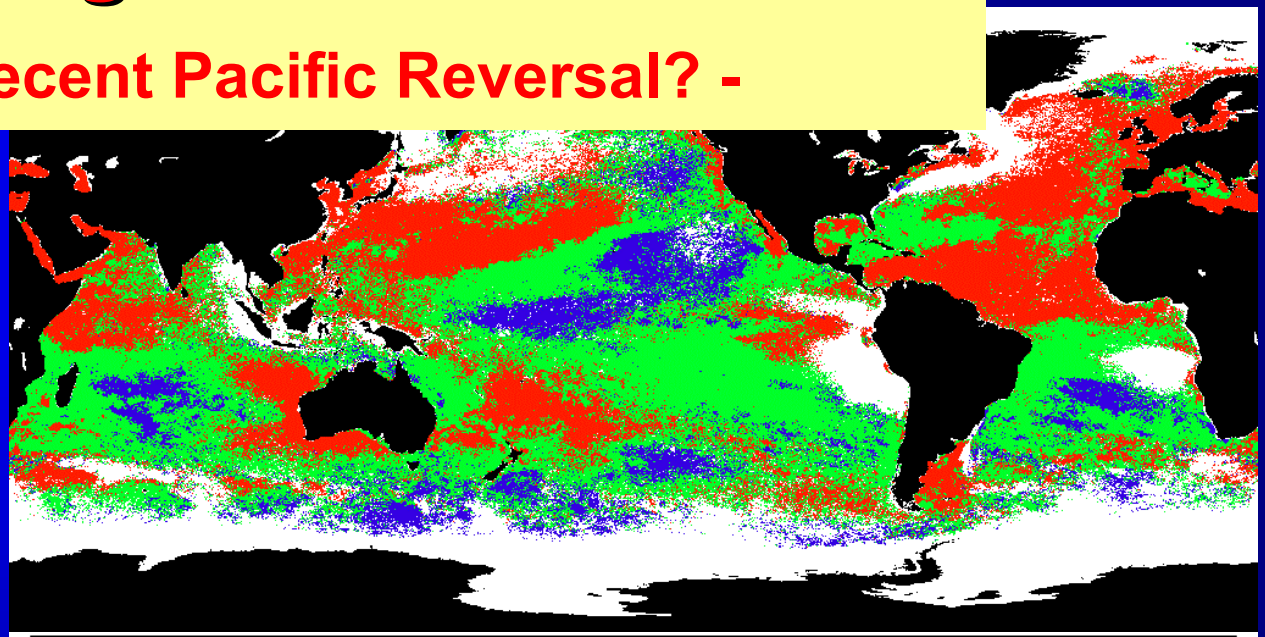
1985 - 2000

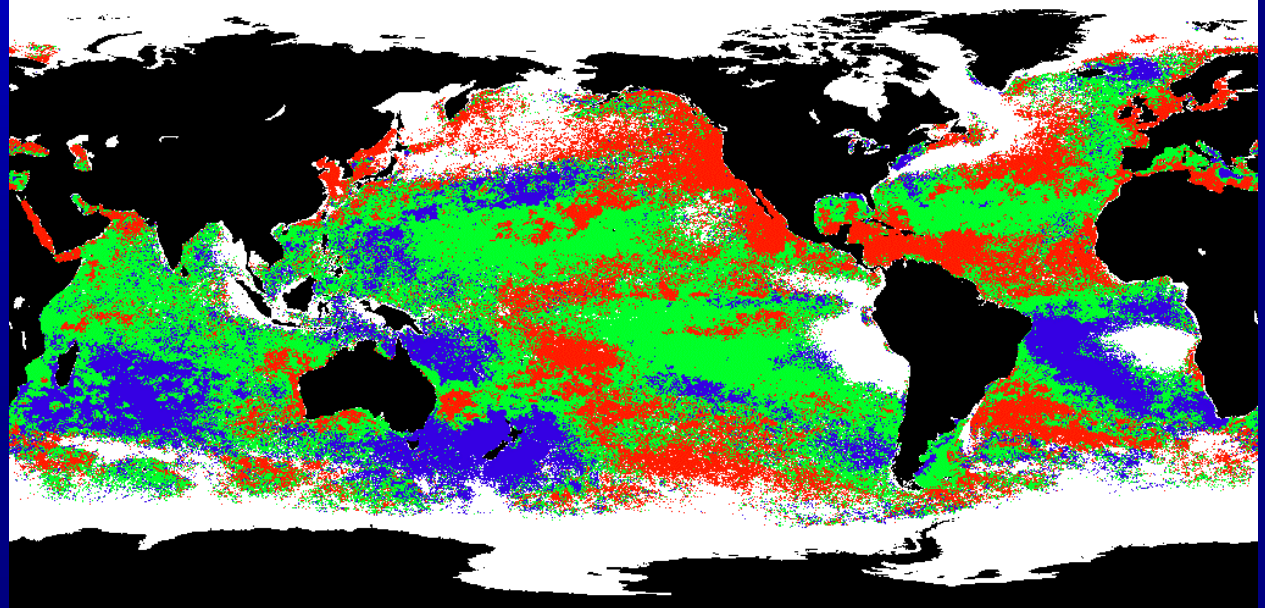
after 1998

El Niño

(16 years)

Tendency = °C/decade





1985 - 1996

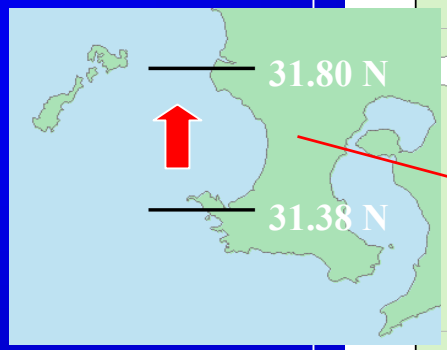
before 1998

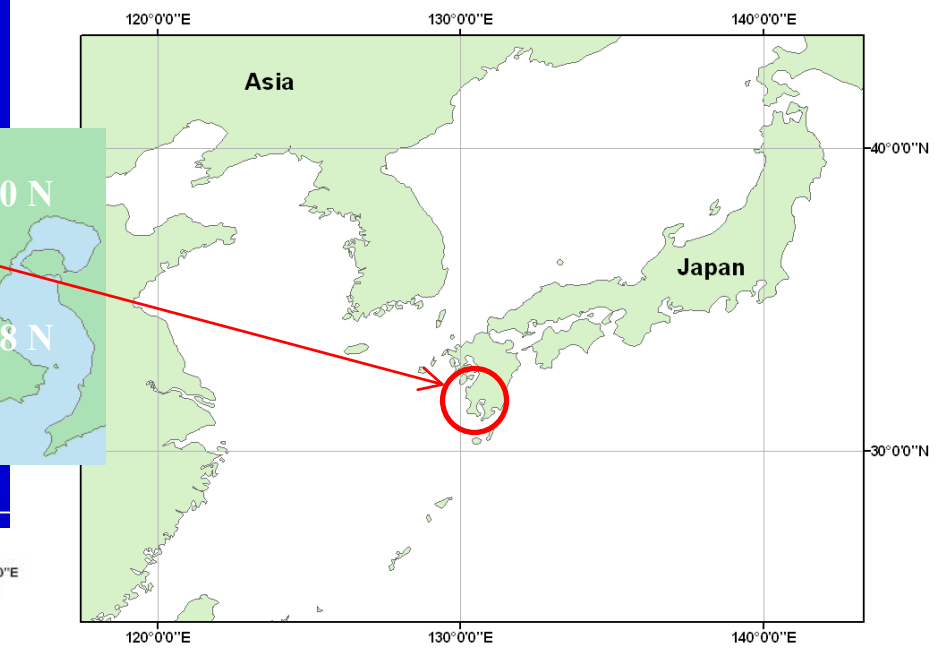
El Niño

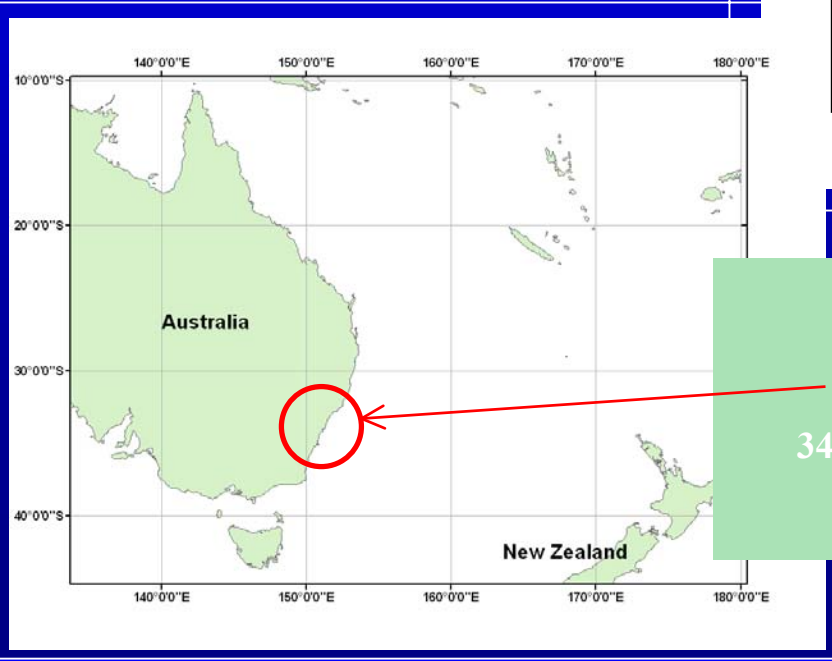
(12 years)

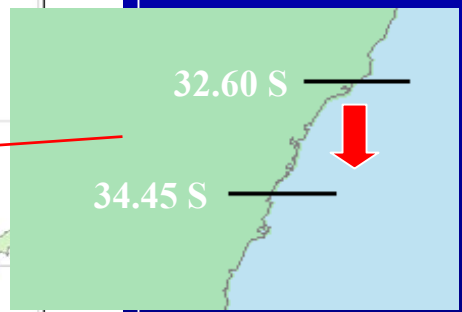
17-year Poleward Movement of Annual minimum monthly mean 18° isotherm

1985-2001
0.03° latitude/year





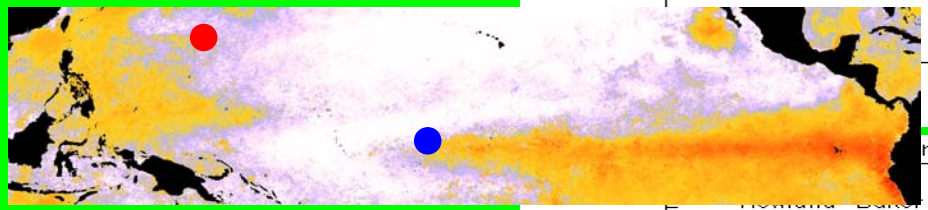




1985-2001
0.12° latitude/year

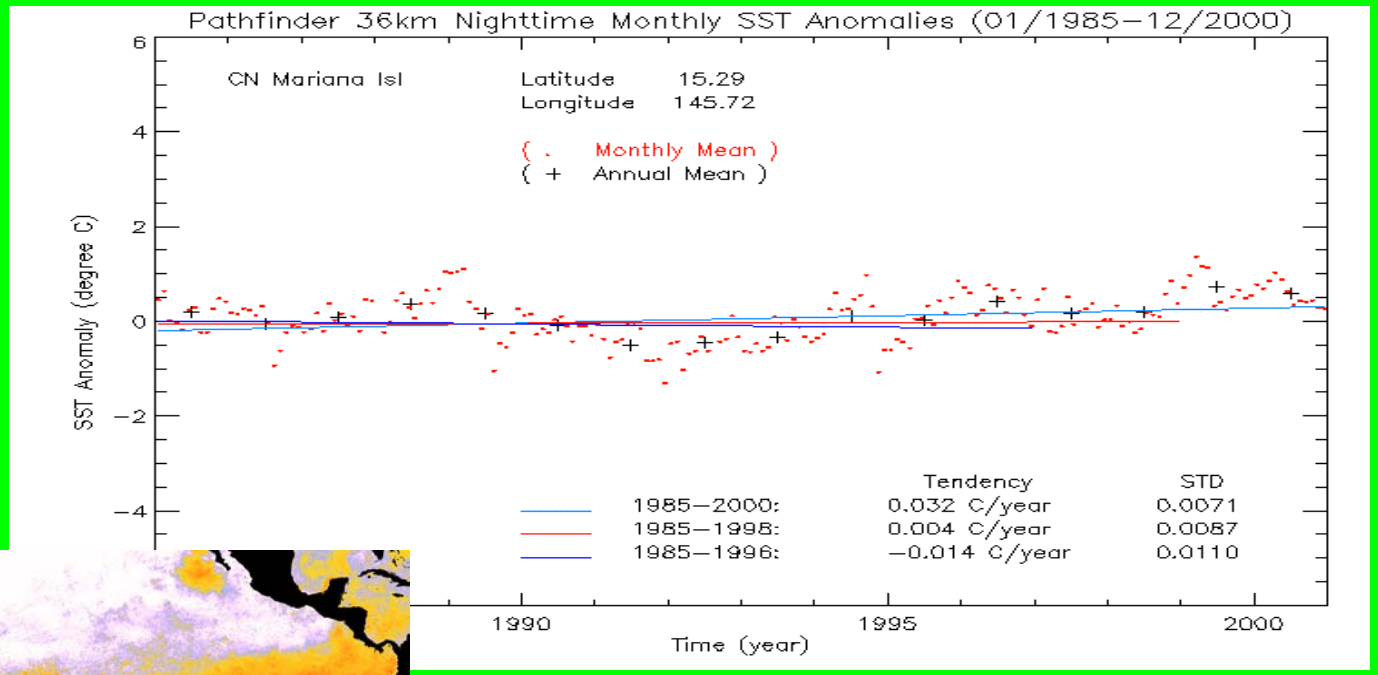
CNMI

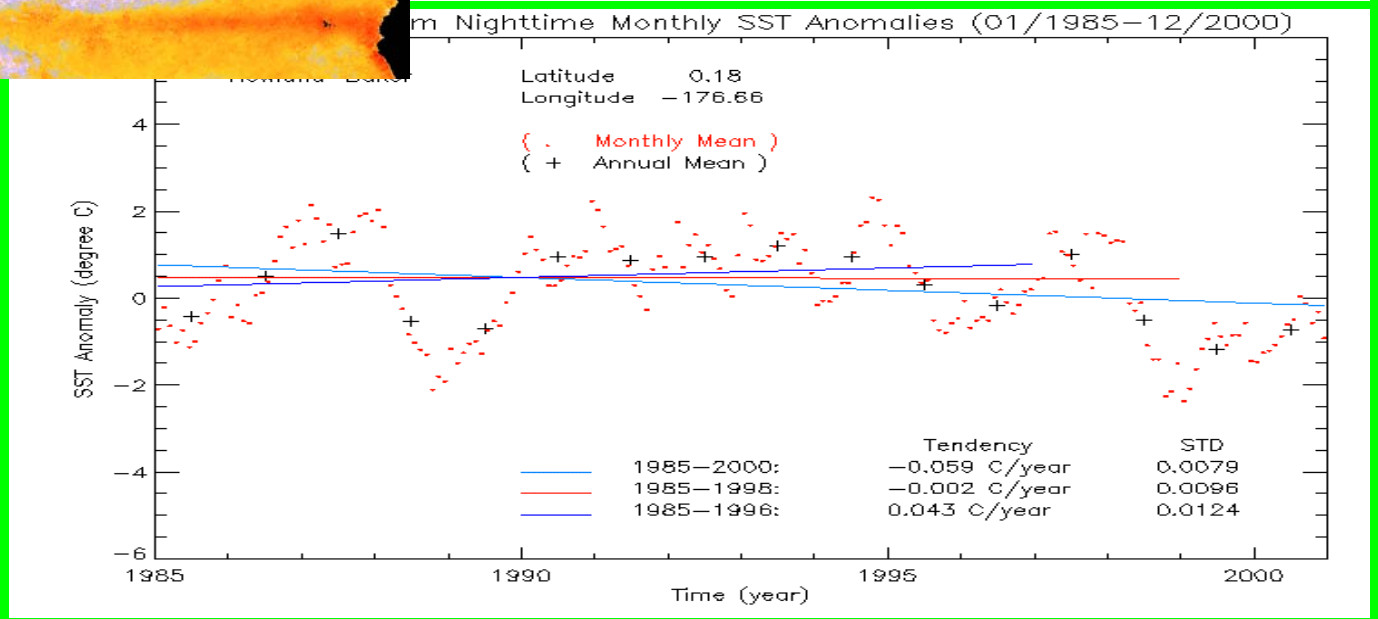
+0.32°C/decade



Howland / Baker

-0.59°C/decade





Satellite Annual Coral Bleaching HotSpot Charts (1985 - 2000)

Operational Sep 02

Satellite retrospective annual composite monthly mean coral bleaching "HotSpot" charts document the spatial distribution, pattern and magnitude of the thermal stresses that may have contributed to coral bleaching mortality in the past. A coral bleaching HotSpot is defined as the sea surface temperature (SST) anomaly, above a "static" coral bleaching threshold SST climatology. These HotSpot charts were derived from the NOAA/NASA 9-km satellite AVHRR (Advanced Very High Resolution Radiometer) Oceans Pathfinder SST dataset, the most refined available. HotSpot charts are proving to be highly successful in providing early warnings of coral bleaching over large spatial scales.

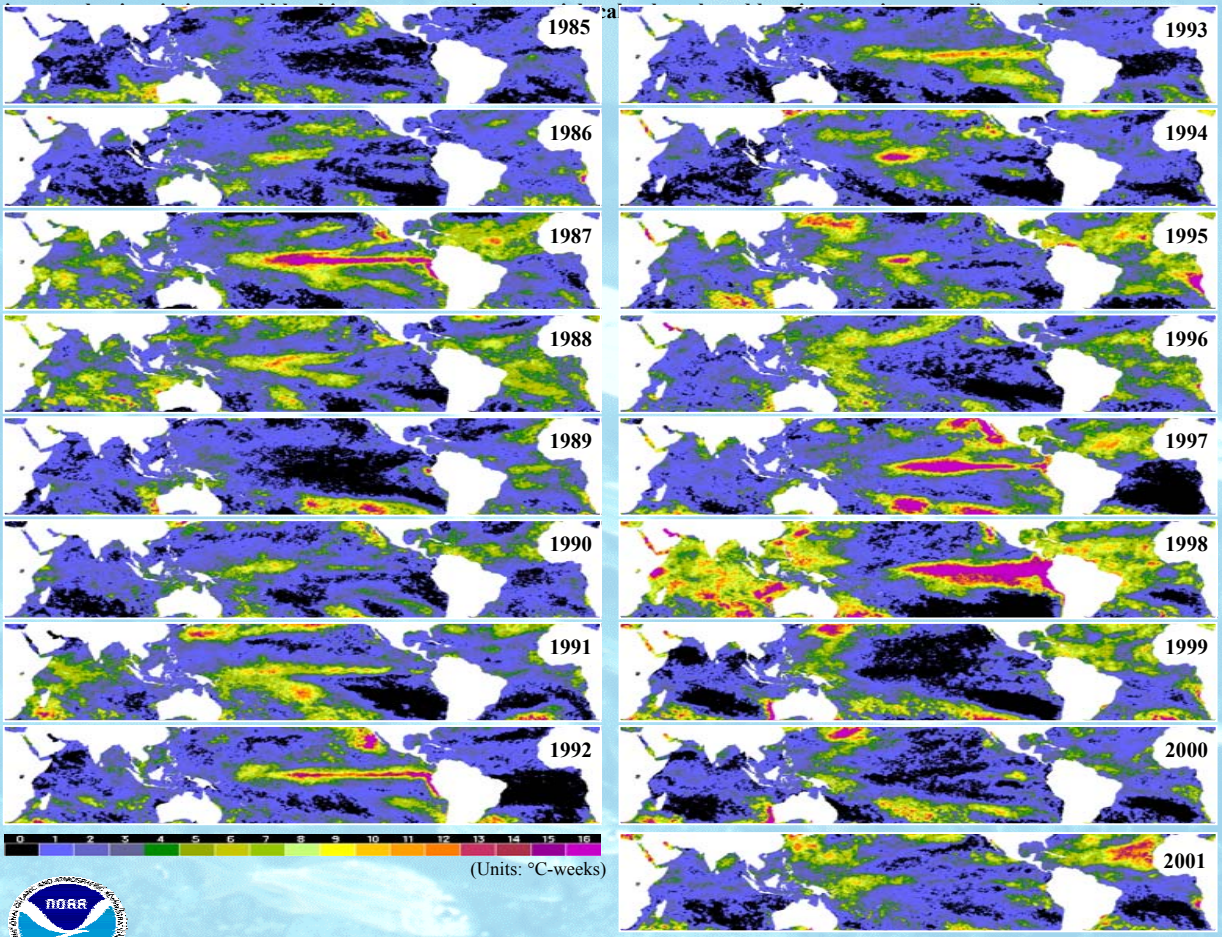
Incidences of coral bleaching were influenced by unprecedented SST anomalies during 1998, due to a severe El Niño event as shown by the HotSpot chart (see below). This bleaching event was the most extensive event recorded in the modern record.

http://orbit-net.nesdis.noaa.gov/orad/coral_bleaching_index.html

NOAA/NESDIS – AE Strong, G Liu, KS Casey, LF Arzayus, WJ Skirving
Background photo courtesy R Berkelmans - Great Barrier Reef Marine Park Authority

Satellite Annual Coral Bleaching
Degree Heating Weeks Charts
(1985 - 2001)

Satellite retrospective annual composite maximum twice-weekly coral bleaching Degree Heating Weeks (DHW) charts document the spatial distribution, pattern and magnitude of the accumulated thermal stresses that may have contributed to coral bleaching in the past. DHW represents the accumulation of NOAA's satellite coral bleaching HotSpots for a given location, over a rolling 12-week time period. A coral bleaching HotSpot is defined as the sea surface temperature (SST) anomaly, above a "static" coral bleaching threshold SST climatology. These DHW charts were derived from the NOAA/NASA 9-km satellite AVHRR (Advanced Very High Resolution Radiometer) Oceans Pathfinder SST dataset, the most refined available. DHW charts are proving to be highly successful



Operational Feb 03

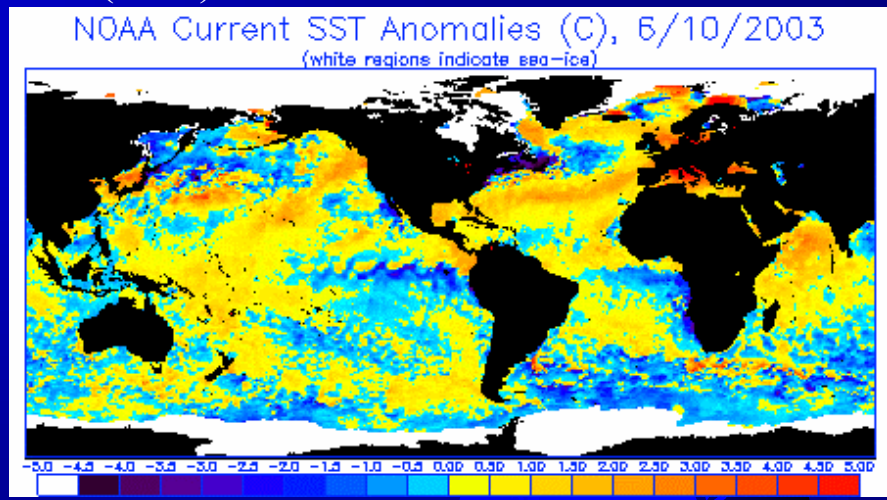
http://orbit-net.nesdis.noaa.gov/orad/coral_bleaching_index.html

NOAA Coral Reef Watch Program

Coral Reef Watch

External Collaborators/projects:

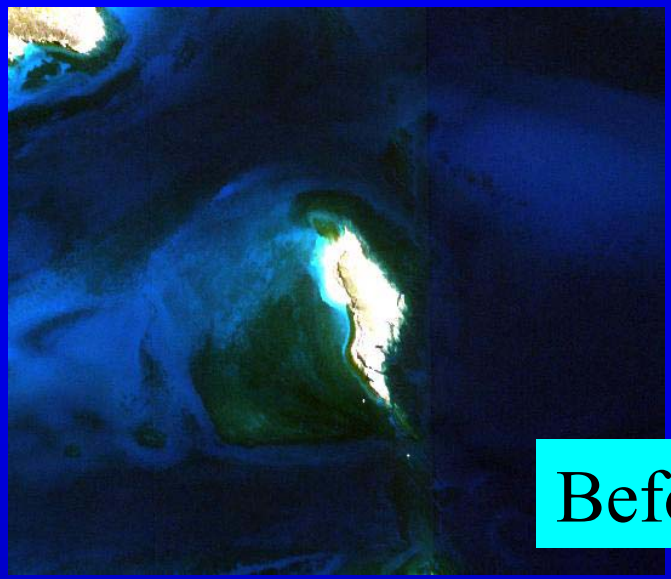
- Australian Agreement
  - Australian Institute of Marine Science (AIMS)
  - Great Barrier Reef Marine Park Authority (GBRMPA)
  - University of Queensland ('03?)
- The Nature Conservancy
- The World Bank / GEF



Future directions:

- Improved spatial resolution for satellite products
- Satellite based trend analysis
- Inclusion of other satellite data such as wind
- Improved product delivery via web
  - including better regional focus & GIS
- Development of bleaching predictive tools

IKONOS Catches GBR Bleaching Event

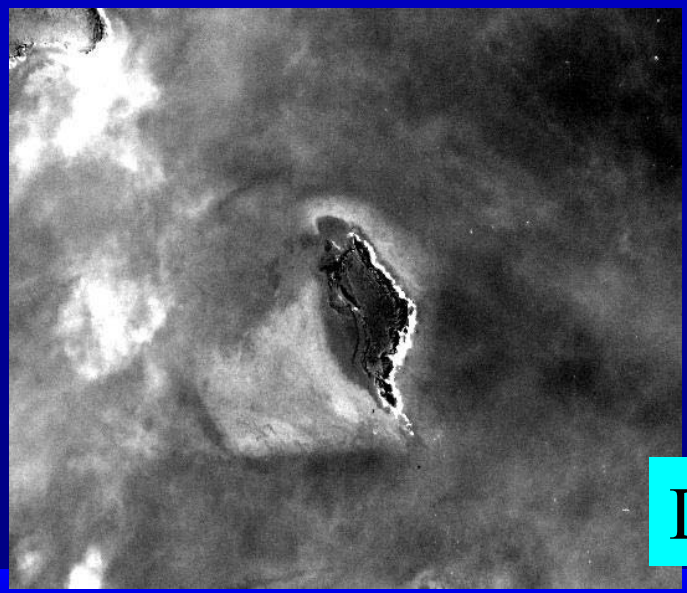


8/22/01

Before

4/15/02

After



Halfway Island

Band 1 of 8/22/01 scene subtracted from band 1 of 4/15/02 scene.

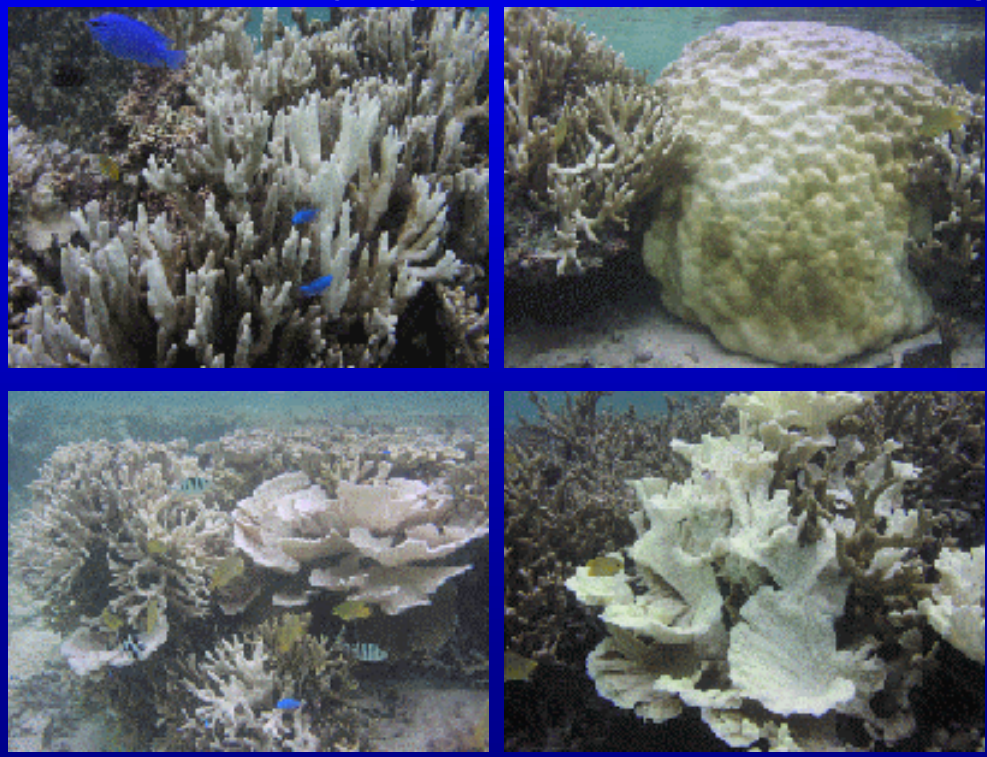
Difference

CRW Near Real-time Satellite Monitoring Products

Samples of successful detection of large-scale bleaching events

a) Midway 2002

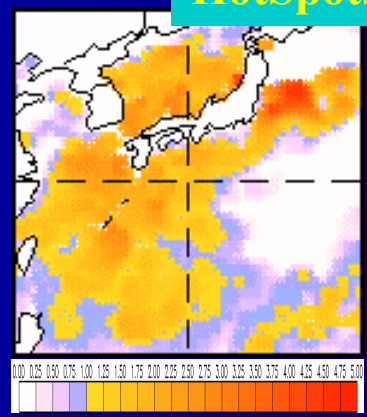
b) 2001 Summer Ryukyu Islands, Japan Bleaching Event



(Photos by Dr. Michio Hidaka of University of the Ryukyus, Japan)

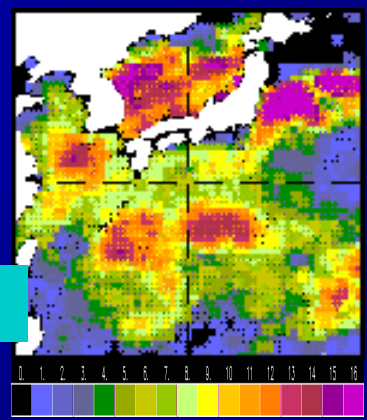
HotSpots

Aug. 11-13 Maximum



July-Sept 2001

DHWs



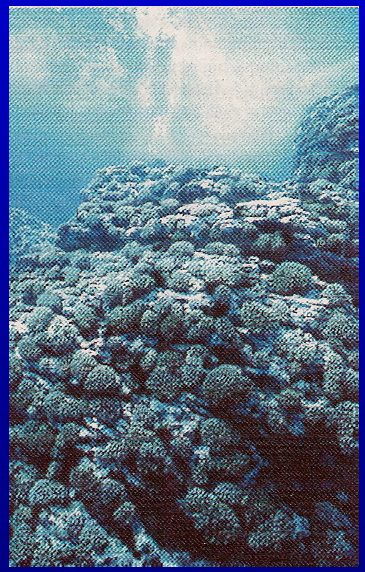
CRW Near Real-time Satellite Monitoring Products

Samples of successful delectation of large-scale bleaching events

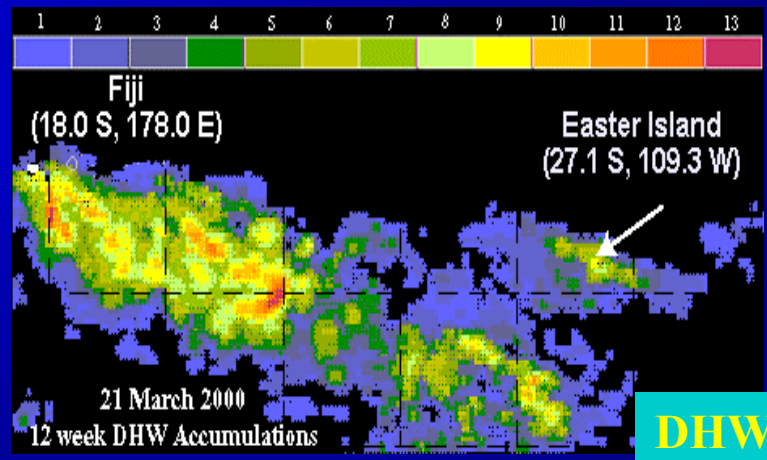
c) 2000 Easter Island Bleaching Event

Colonies of Pocillopora verrucosa at 10-m depth near Hanga Roa. Easter Island (Rapi Nui) were healthy in early 1999, but, at the same location a year later, were totally bleached [8].

March 18, 1999
Healthy Colonies



March 14, 2000
Bleached Colonies



DHWs

CRW satellite derived SST DHW Indices identified and predicted this bleaching event clearly. By March 21, 2000, Degree Heating Weeks (DHW) reached "9" at Easter Island .

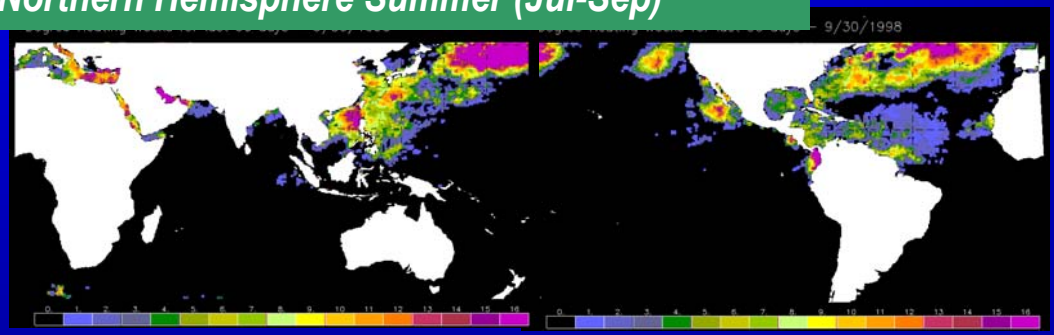
CRW Near Real-time Satellite Monitoring Products

Samples of successful delectation of large-scale bleaching events

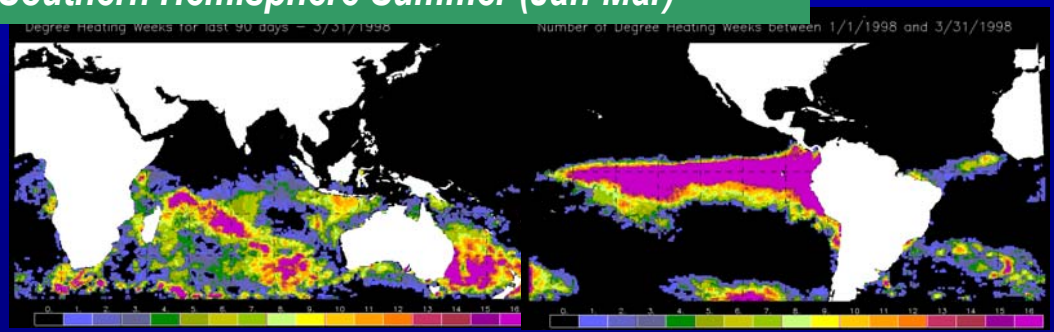
d) 1998 Global Bleaching Event (during a strong El Niño event)

1998 Summer Seasonal Degree Heating Weeks

Northern Hemisphere Summer (Jul-Sep)



Southern Hemisphere Summer (Jan-Mar)

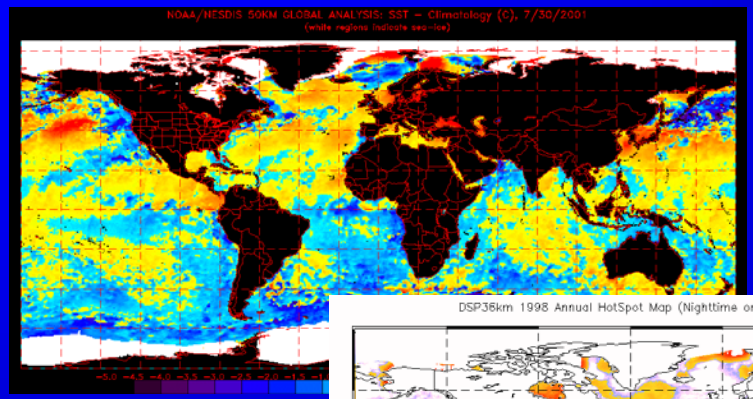


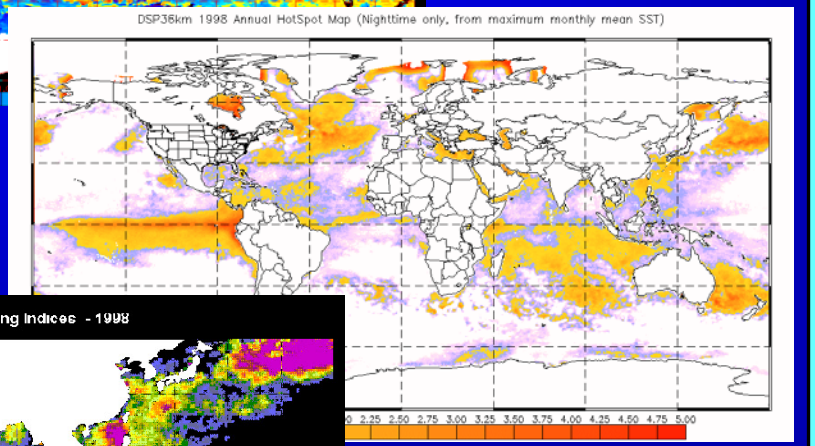
Globally the most extensive bleaching event in the modern record for most of the affected regions.

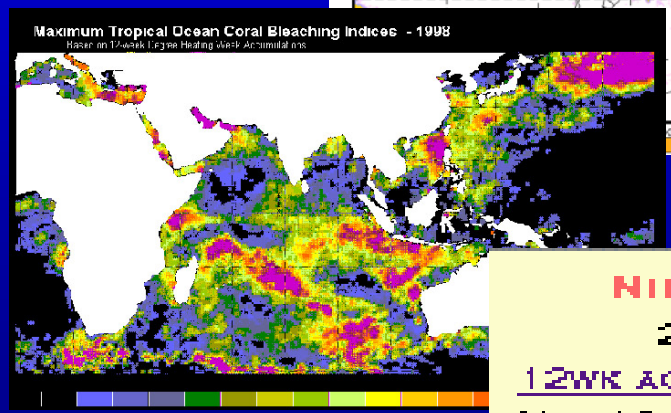
Bleaching / mortality hit

- *Indian Ocean*
- *West Pacific Ocean*
- *East Pacific Ocean*
- *The Caribbean*
- *The Greater Atlantic Ocean*

ORA PRODUCTS







NINGALOO, AU

21.5S, 114E

12WK ACCUM TODAY	3.9
MAX 12WK*	6 (99)
CURRENT TEMP (C)	29.7
EXP. MAX TEMP**	28.3

"Early Warning System"

↓

SST anomalies

↓

HotSpot Charts

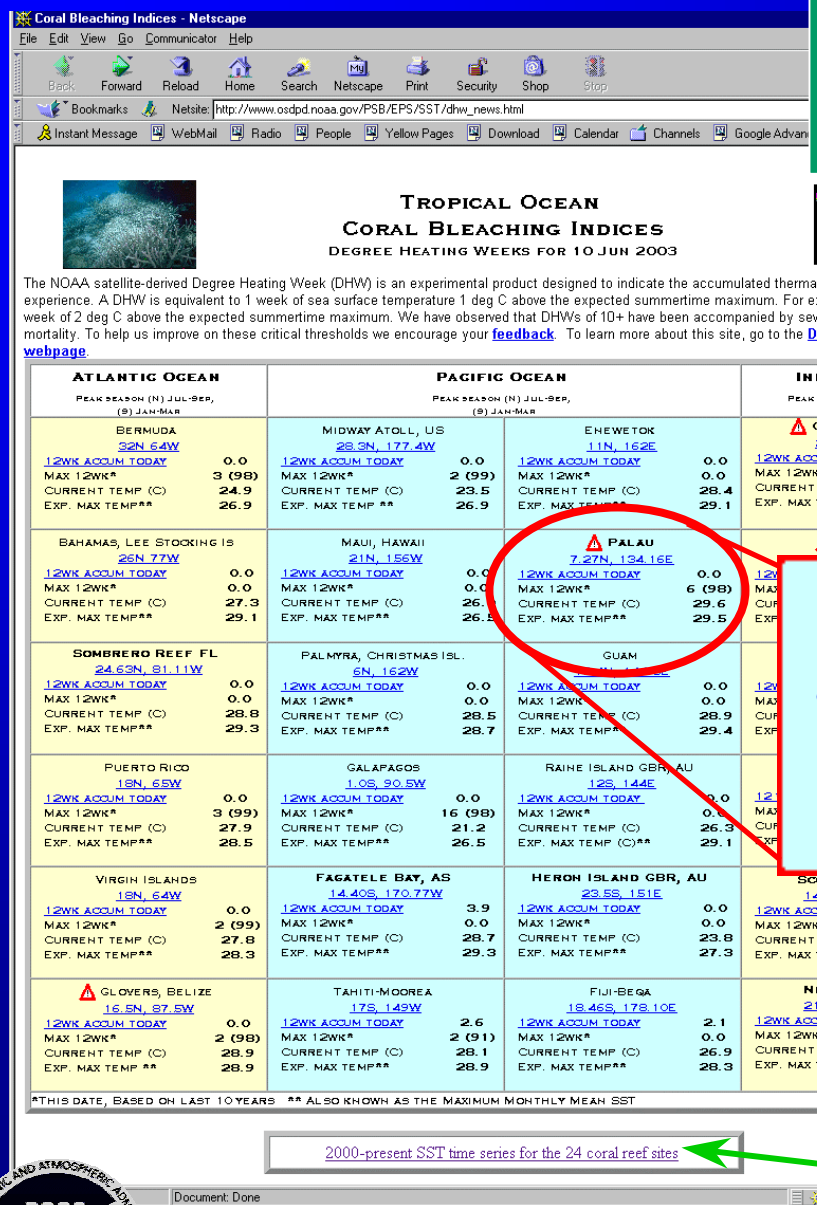
↓

Degree Heating Weeks

Indices Page

Added in FY 02-03

SST Field, SST time series, Animations, ReefBase maps, links to wind and *in situ* data.



Reef site name

Red Triangle : SST > MMM SST;

Red Name+triangle : SST > (MMM SST+1 ℃).

Reef geographic location

(linked to a reef map)

Current DHW Index

(linked to DHW Indices map)

Historical maximum DHW Index & the year of the occurrence

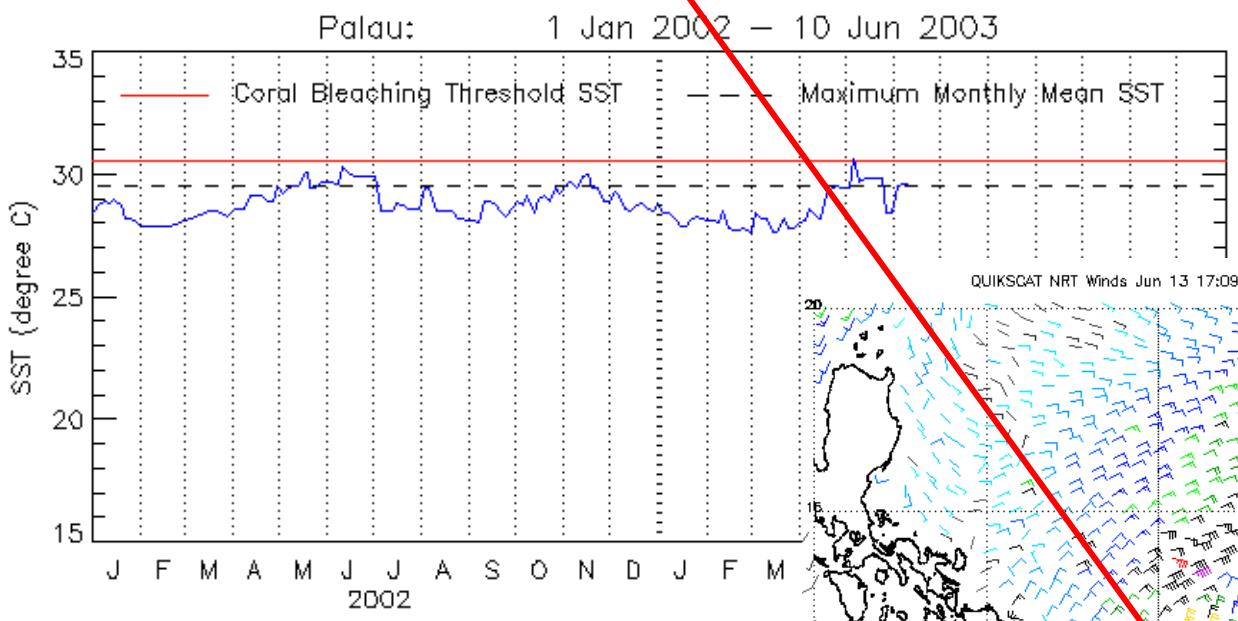
Current SST

MMM SST at the site

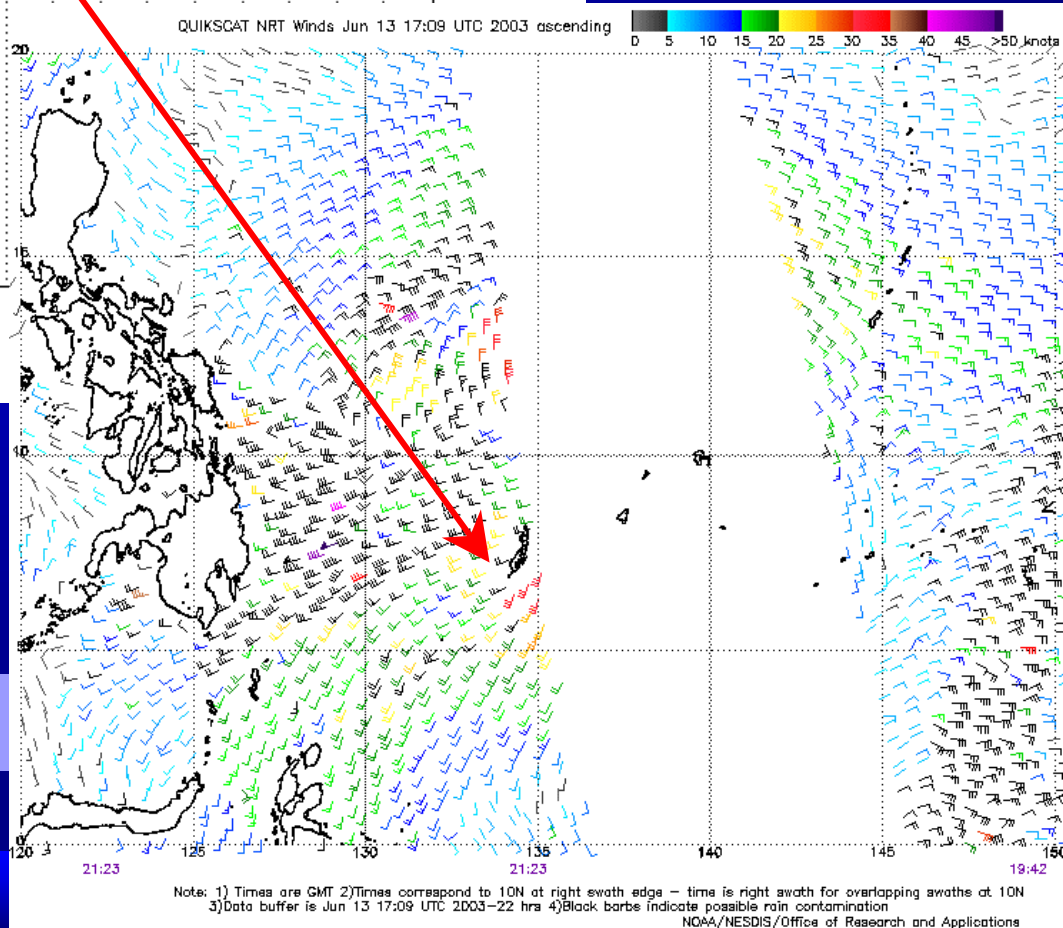
Link to SST time series

Palau

SST Time-series



QuickSCAT Winds

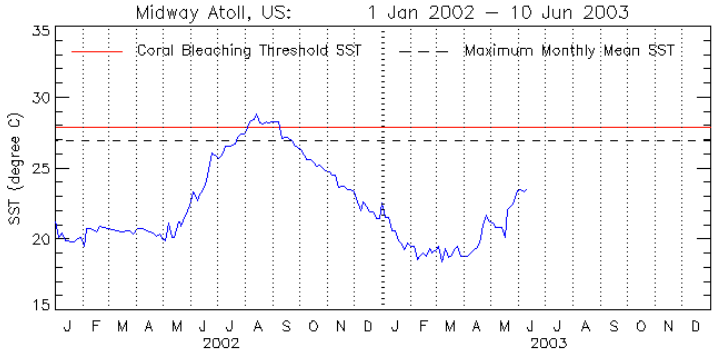


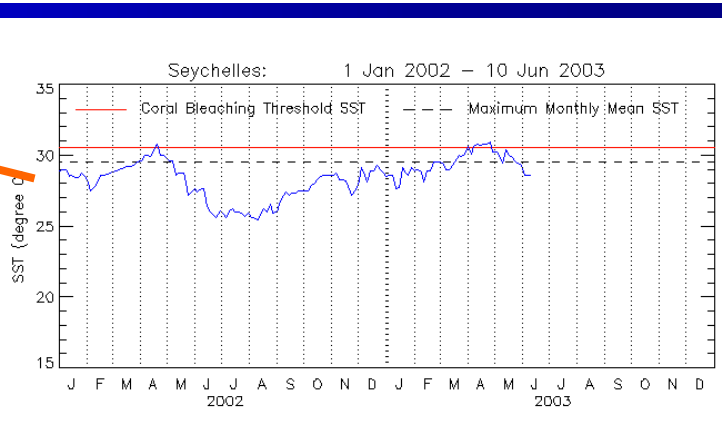
SST Time Series

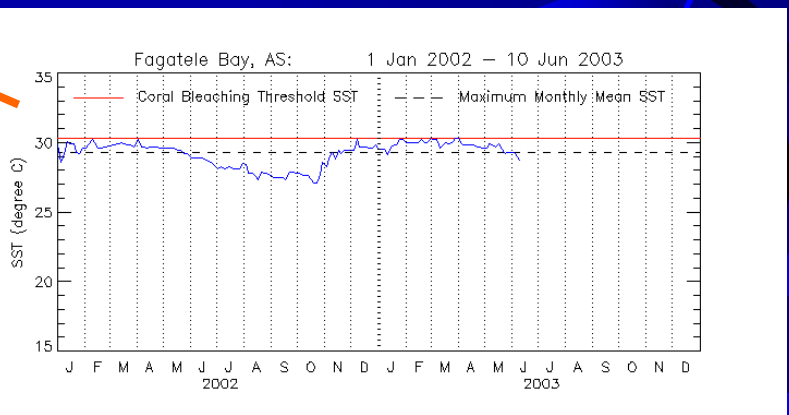
The time series for the 24 coral reef locations linked from the table below are the time series derived from satellite, nighttime only sea surface temperature (SST) at 50 km Resolution

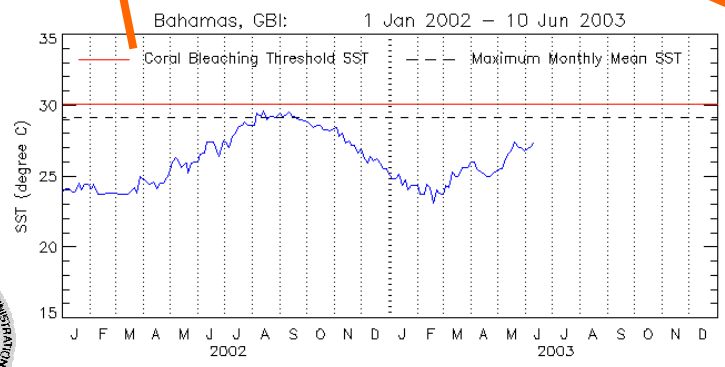
Click on a location name to see the SST time series at that location.

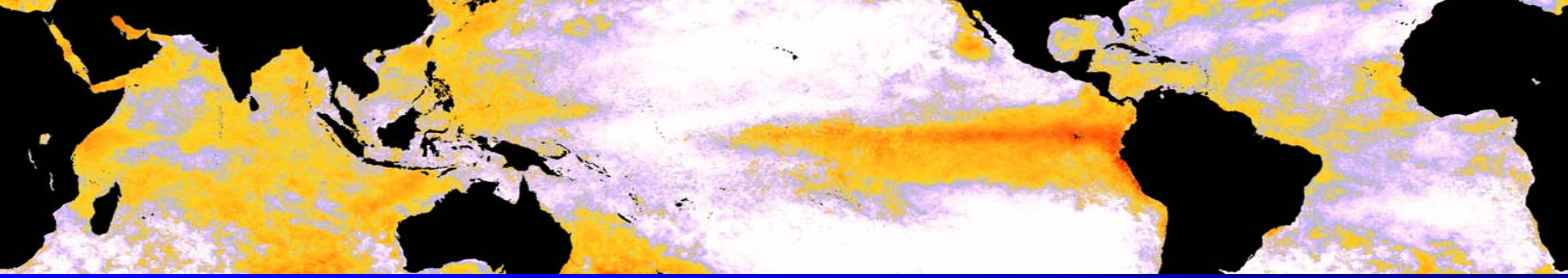
Atlantic Ocean Peak Season (N) Jul-Sep (S) Jan-Mar	Pacific Ocean Peak Season (N) Jul-Sep (S) Jan-Mar		Indian Ocean Peak Season (N) Apr-Jun (S) Jan-Apr
Bermuda 32N 64W	Midway Atoll, US 28.3N, 177.4W	Enewetok 11N, 162E	Oman - Muscat 23.7N, 58.6E
Bahamas, GBI 26N 77W	Maui, Hawaii 21N, 156W	Palau 7.27N, 134.16E	Maldives 4N, 72E
Sombrero Reef FL 24.63N, 81.11W	Palmyra, Christmas Isl. 6N, 162W	Guam 13.4N, 144.8E	Seychelles 4S, 55E
Puerto Rico 18N, 65W	Galapagos 1.0S, 90.5W	Raine Island GBR, AU 12S, 144E	Cobourg Park, AU 11.26S, 132.29E
Virgin Islands 18N, 64W	Fagatele Bay, AS 14.40S, 170.77W	Heron Island GBR, AU 23.5S, 151E	Scott Reef, AU 14.02S, 121.85E
Glovers, Belize 16.5N, 87.5W	Tahiti-Moorea 17S, 149W	Fiji-Beqa 18.46S, 178.10E	Ningaloo, AU 21.88S, 113.97E







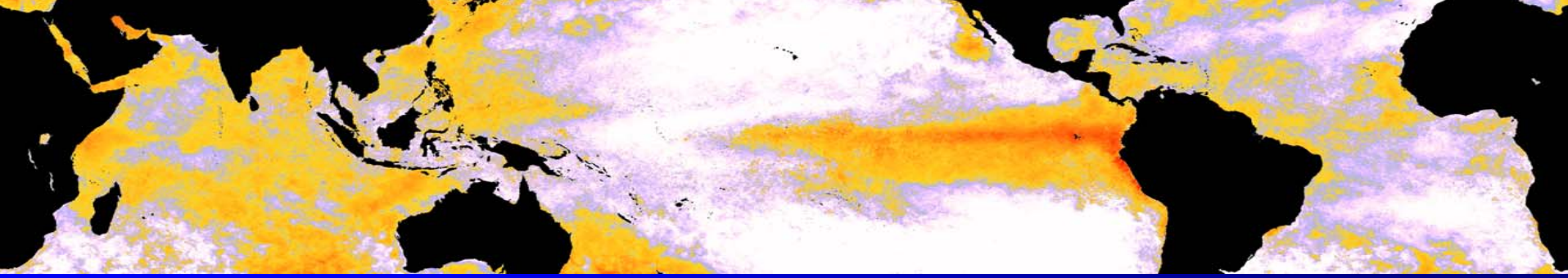




1998 NOAA SST HotSpot Composite - Pathfinder

Conclusions

- Climate change is likely to significantly alter existing reefs worldwide - with predictions of negative impacts on fisheries and food security
- The first impacts have already been seen in the 1998 bleaching and are likely to be more severe in the coming decade
- There is a need to monitor environmental indices, ecosystems, impacts, recovery, and adaptation



1998 NOAA SST HotSpot Composite - Pathfinder

Conclusions – cont'd

- There are practical steps that managers can take
  - But…to be effective… **Managers need timely information**
  - Improved management can reduce stress

Remote Sensing ⇒ Products ⇒ Answers

Knowledge ⇒ Credibility ⇒ Empowerment