NOAA NESDIS

Oceanic Research and Applications Division

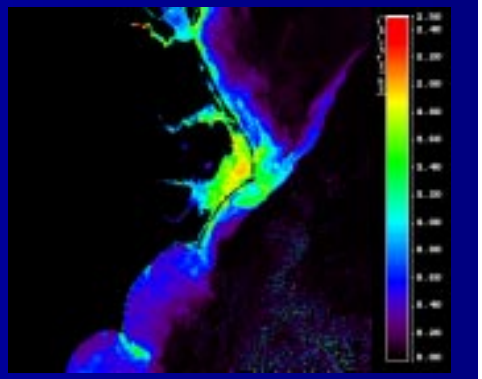
Dr. Marie Colton, Acting Chief

NWHI Coral Reef Watch Review

February 12, 2001

Al Strong – Asst. to the Chief

ORA's Goals for Oceans

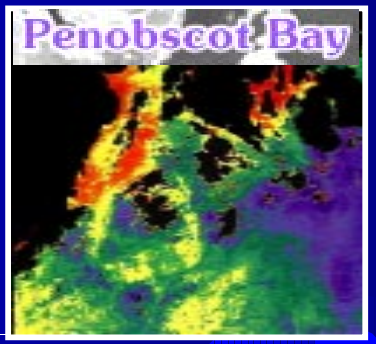


Realize the Full Potential of Environmental Satellites in Coastal and Ocean Applications

CoastWatch

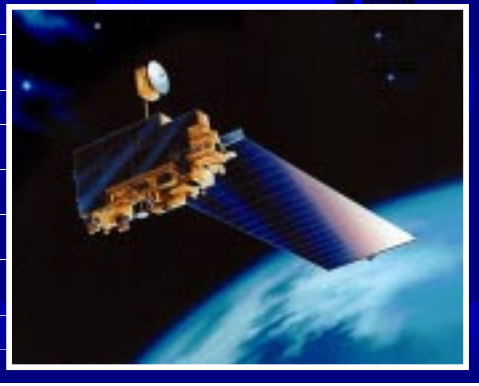
Imagery Data Services

Improve User Access



Increase Users' Capacity

Expand Our Services to Users



Prepare for Future Systems

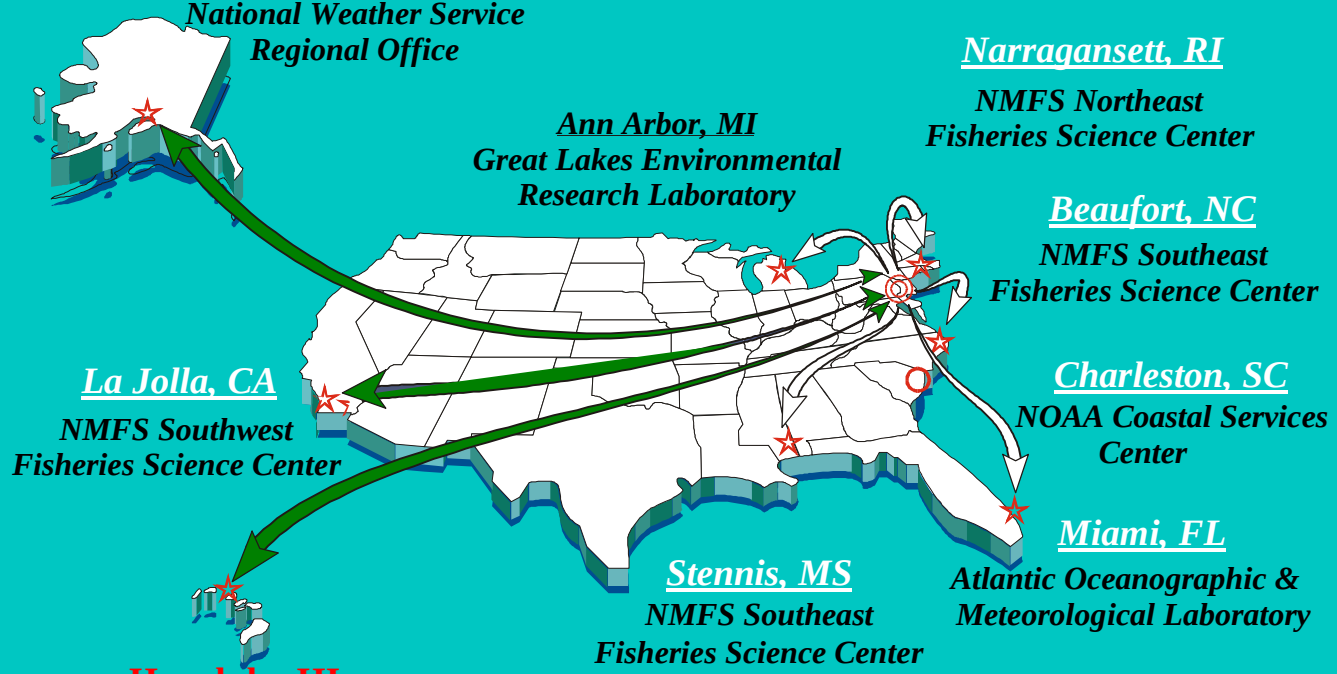
ORAD

Our Major Activities

- **CoastWatch**
- **Ocean Surface Winds**
- **Sea Surface Topography**
- **Ocean Color Physics and Biology**
- **Sea Surface Temperature**
- **Synthetic Aperture Radar**
- **Sea Ice and Polar Oceans**
- **Oceanic Rainfall**

CoastWatch

- Fisheries
- Coastal Habitat
- Resource Management
- Harmful Algal Blooms
- Coastal Currents
- Water Quality
- Marine Ice
- Pollution



Anchorage, AK
National Weather Service
Regional Office

Ann Arbor, MI
Great Lakes Environmental
Research Laboratory

Narragansett, RI
NMFS Northeast
Fisheries Science Center

Beaufort, NC
NMFS Southeast
Fisheries Science Center

La Jolla, CA
NMFS Southwest
Fisheries Science Center

Charleston, SC
NOAA Coastal Services
Center

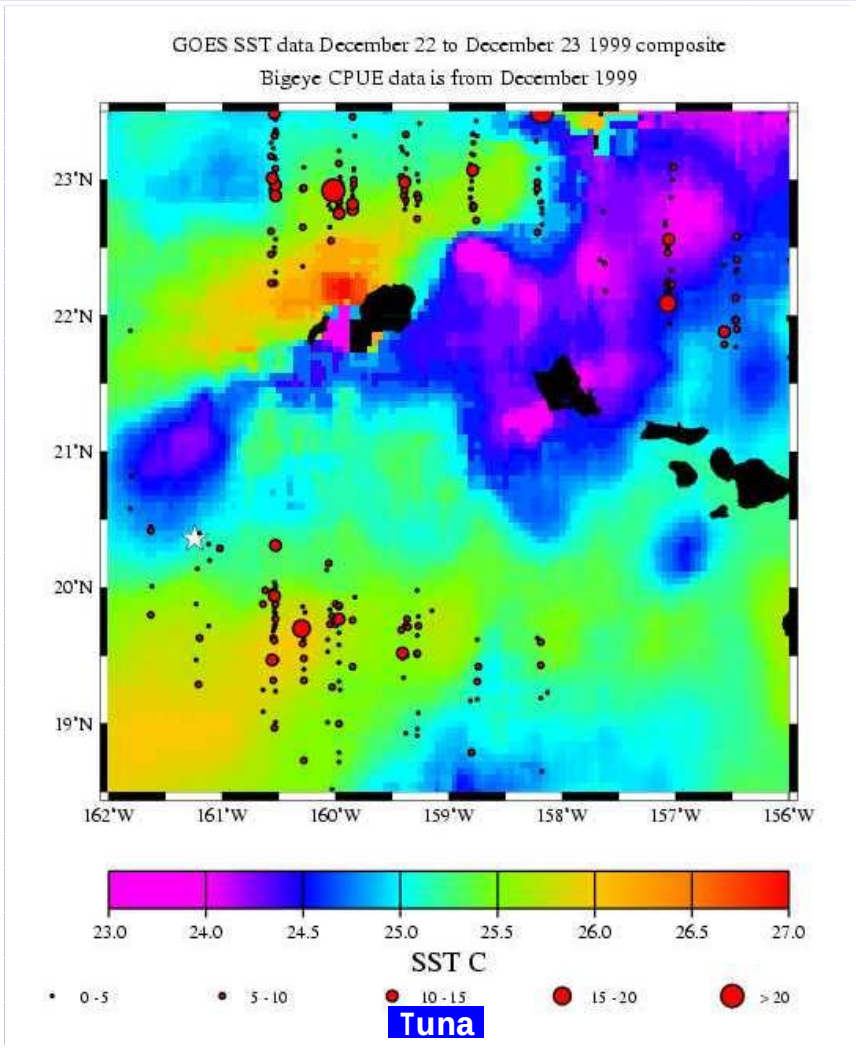
Miami, FL
Atlantic Oceanographic &
Meteorological Laboratory

Stennis, MS
NMFS Southeast
Fisheries Science Center
Mississippi Laboratories

Honolulu, HI
NMFS Southwest
Fisheries Science Center
Honolulu Laboratory

CoastWatch

Improving Fisheries Management Decisions



Catch Per Unit Effort An Essential Fisheries Management Statistic

CPUE Influenced by Environment

- Fish Aggregation / Dispersal
- Gear Performance

Ocean Conditions Under-Represented

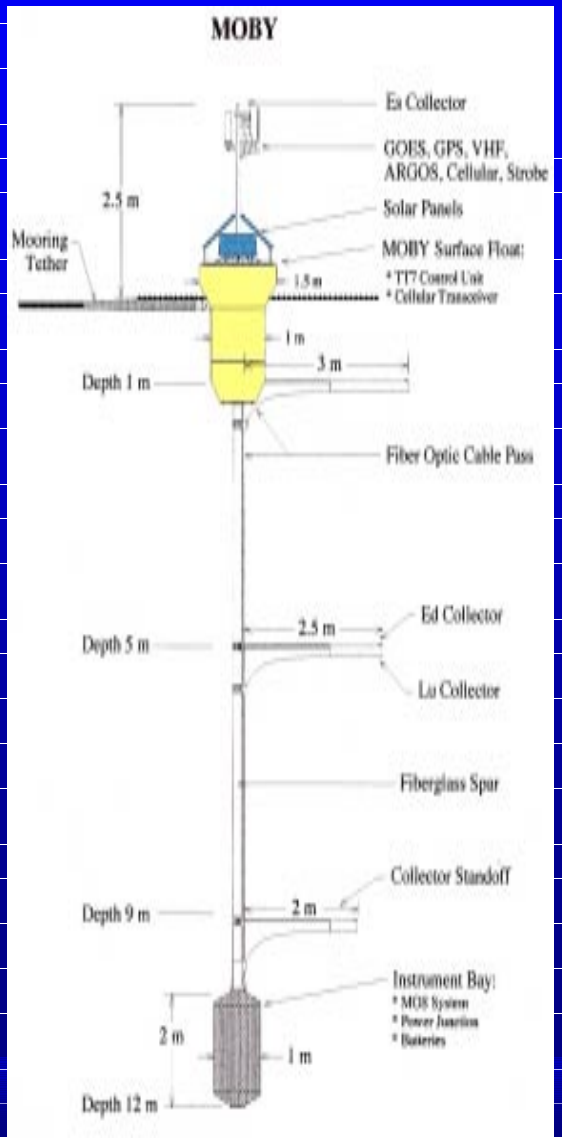
- Mesoscale Eddies
- Physical / Biological Fronts
- Surface Winds

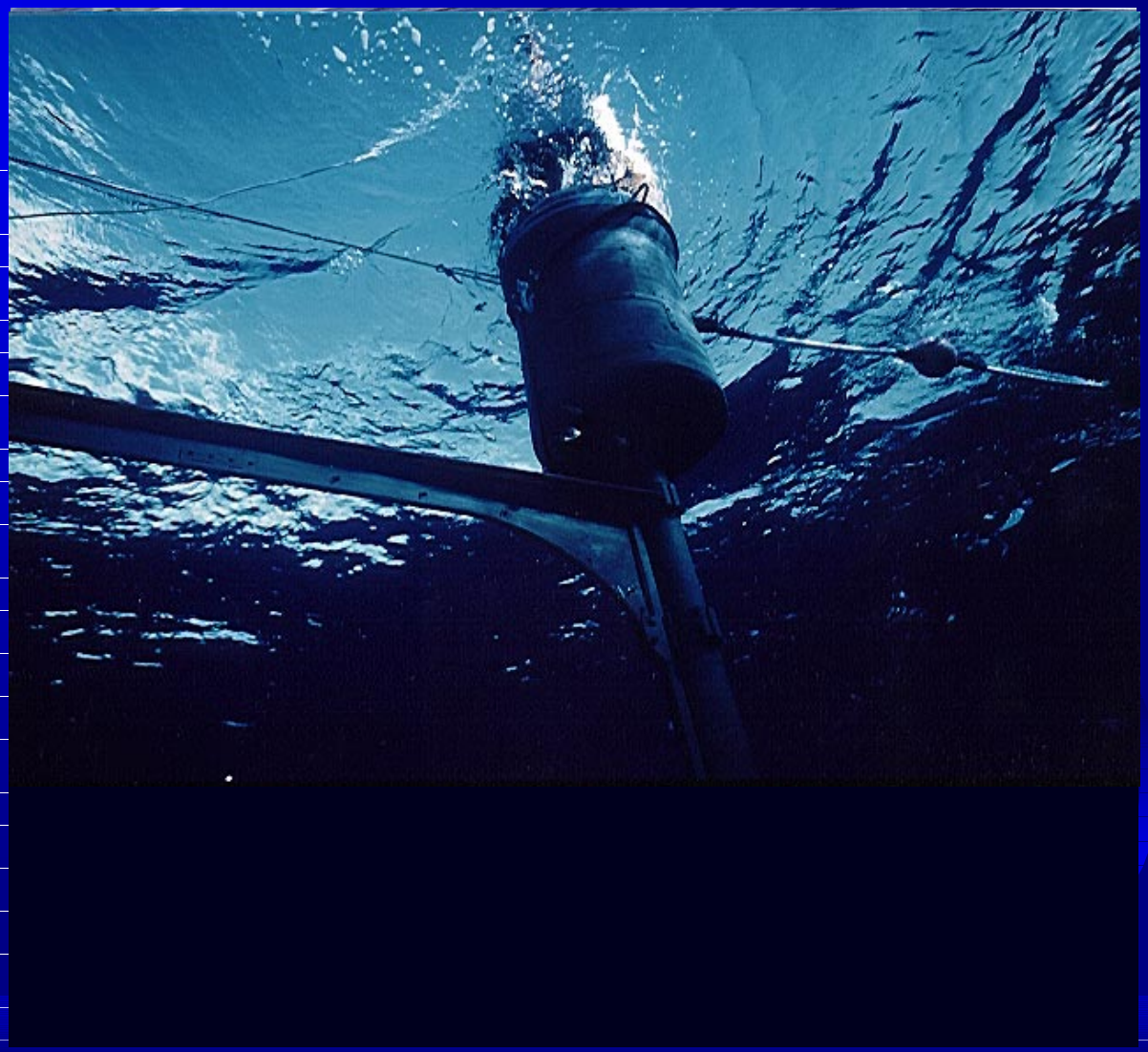
Transitioning Satellite Data to NMFS

- SST (**GOES**) for Physical Fronts/Eddies
- Sea Surface height (**TOPEX**) for Currents/Eddies
- Ocean Color (**SeaWiFS**) for Biological Fronts/Eddies
- Surface Winds/Seas (**QuikSCAT**) for Convergence / Divergence

Marine Optics

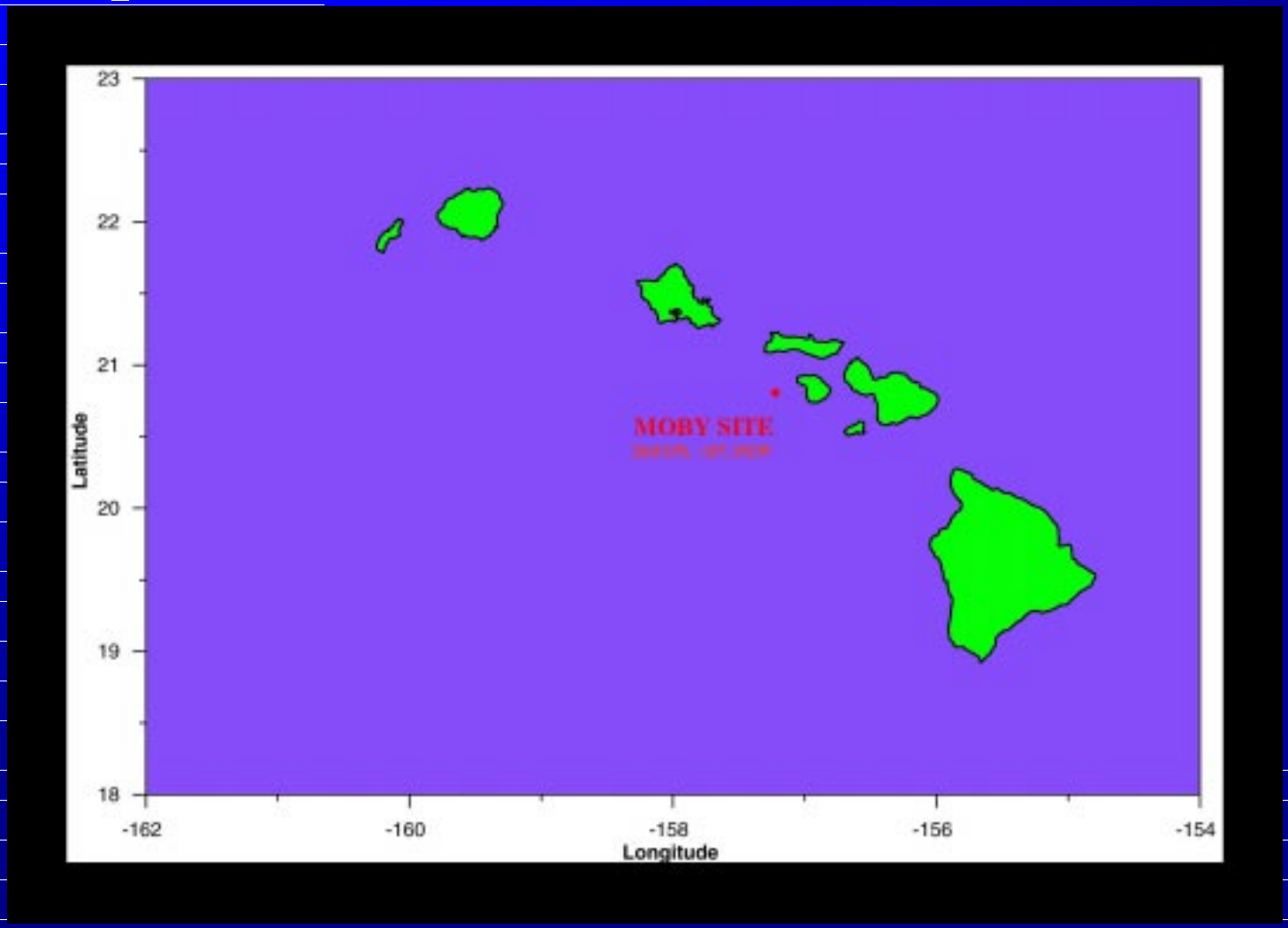
Marine Optical Buoy (MOBY)





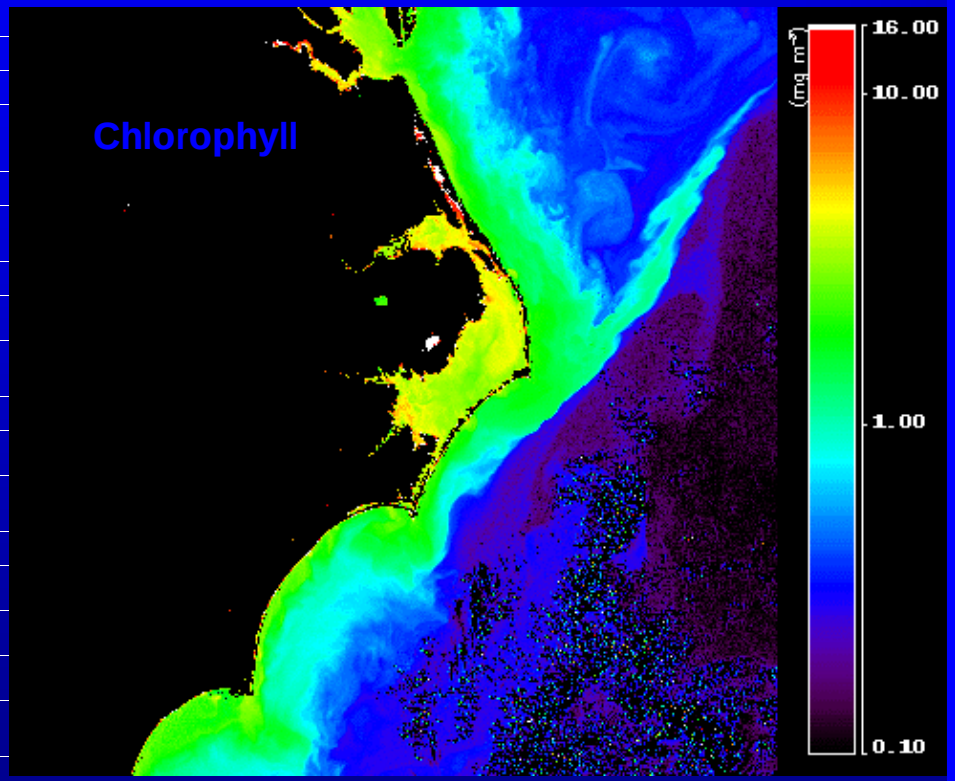
Marine Optics

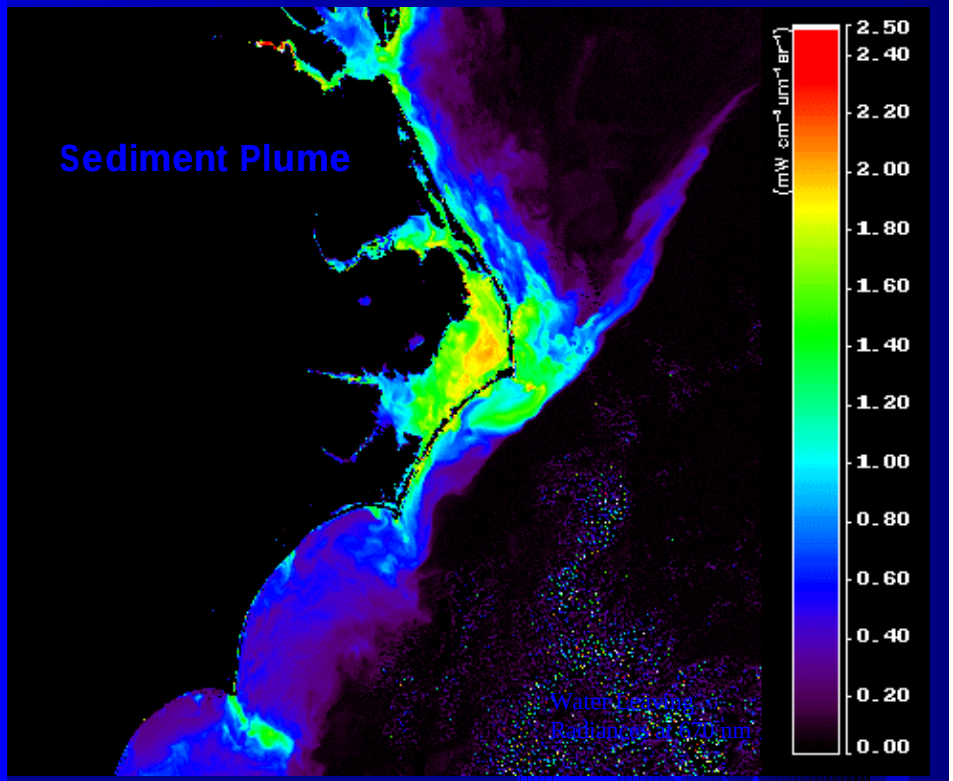
Marine Optical Buoy (MOBY)



Marine Optics

Extreme Case II Waters





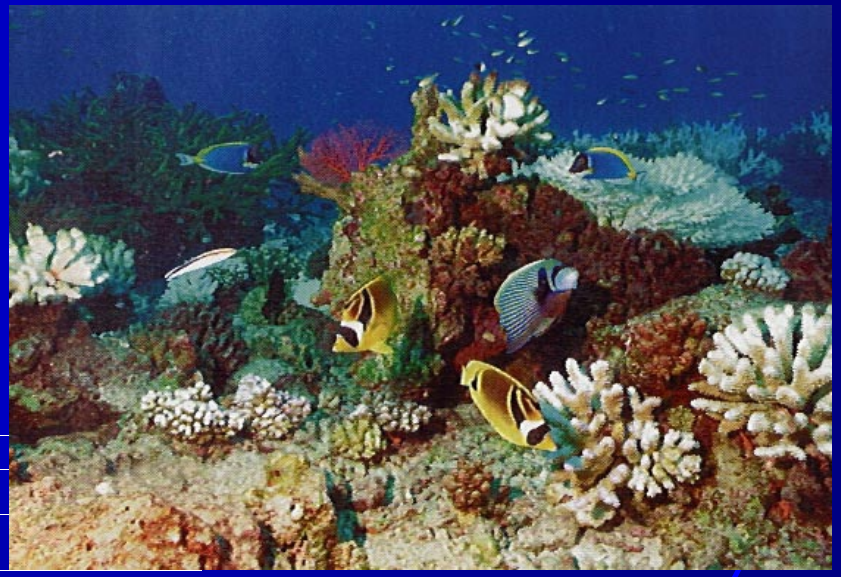
Hurricane Floyd Coastal Flooding Emergency Response 23 Sep 1999

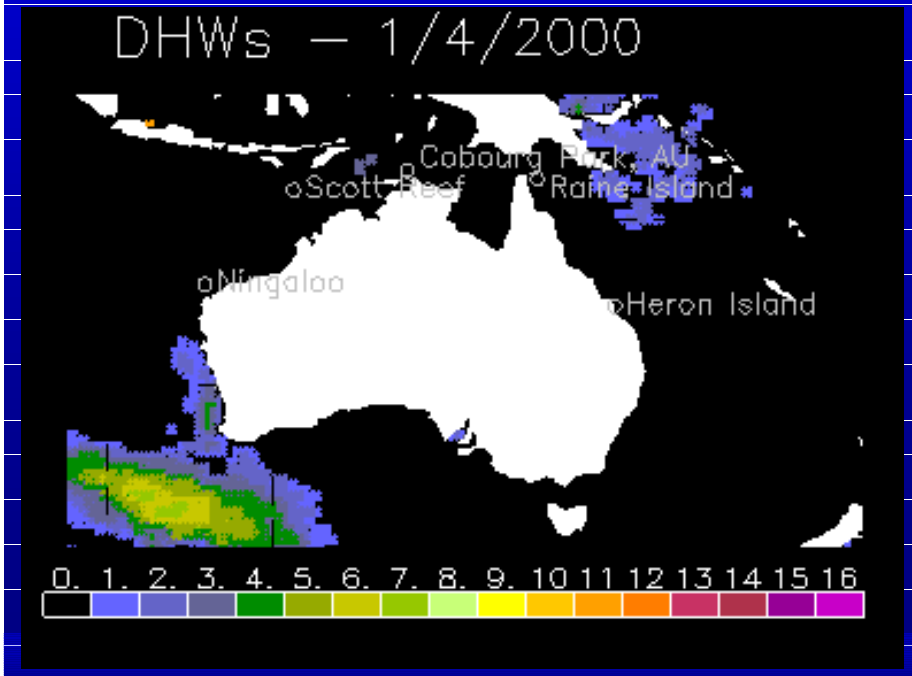
Extreme Case II Waters NOS/NCCOS Algorithm From Multi-Spectral SeaWiFS Data. NOAA Data Through OrbImage, Inc.

Sea Surface Temperature

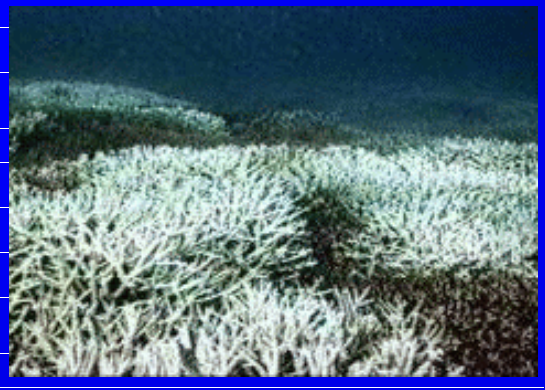
Global Coral Reef Bleaching

- **High Visibility Effort**
  - Presidential Coral Reef Task Force
  - NOAA-Australia “Virtual Laboratory”
  - NESDIS ORA Leadership Role





- **Internationally Recognized**
  - Satellite Bleaching Hot Spots Monitoring
  - Degree Heating Weeks Analysis
  - Coral Reef Bleaching Indices
  - Global User Collaboration

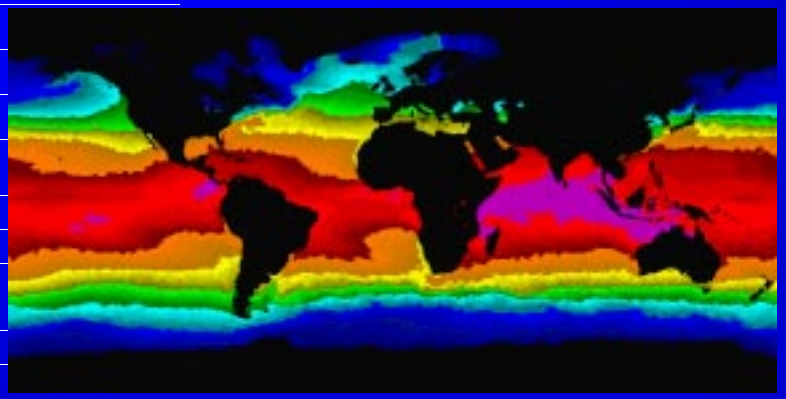


CORAL REEF WATCH

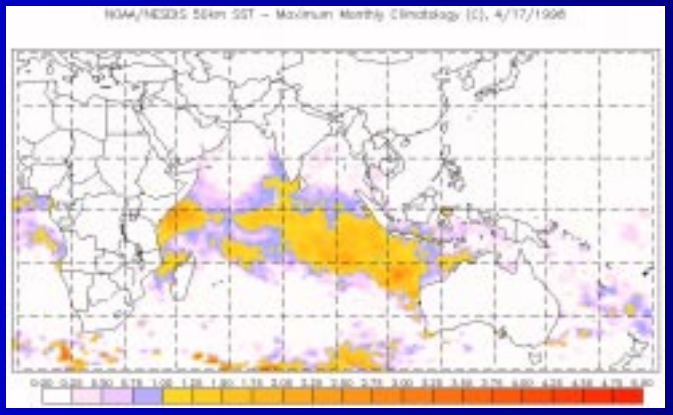
Project Coordinators:
Dr. Al Strong – NESDIS/ORA
Dr. Jim Hendee – OAR/AOML

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

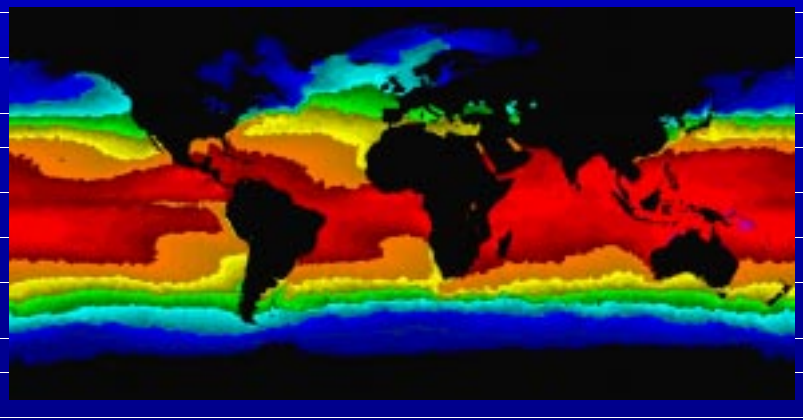
NOAA HotSpots & SSTs



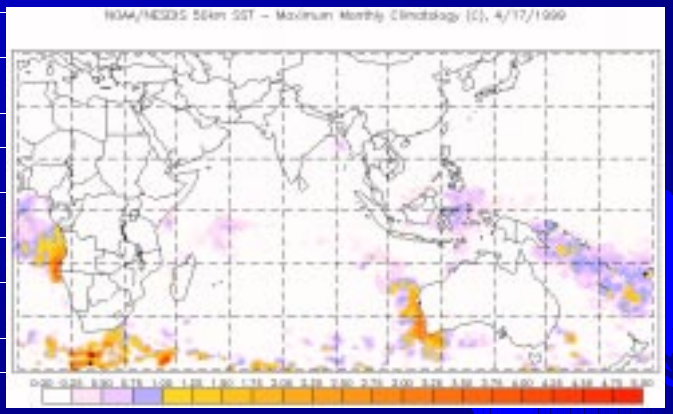
Apr 98 - SSTs



Apr 98 - HotSpots

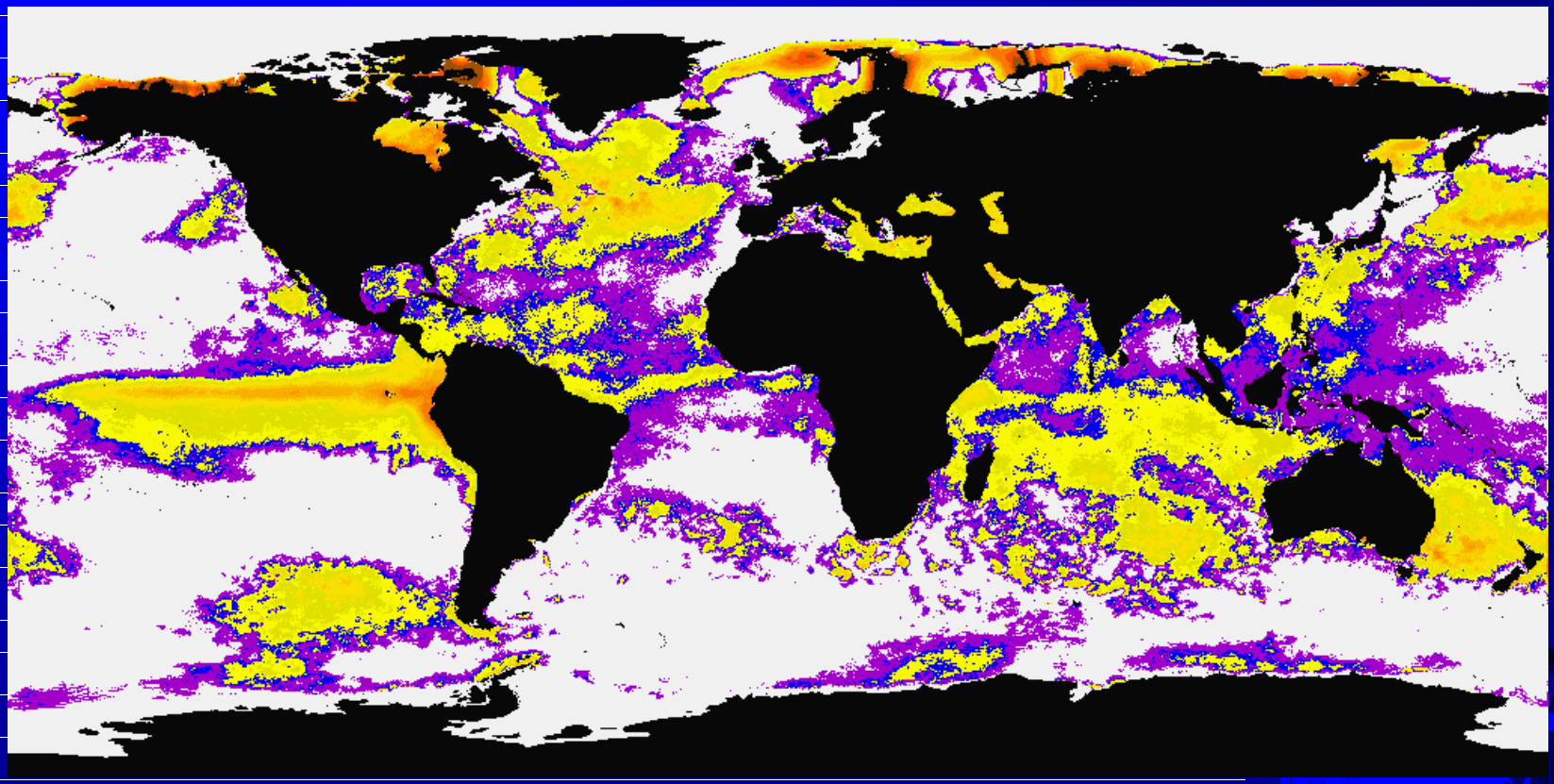


Apr 99 - SSTs



Apr 99 - HotSpots

Coral Reef Bleaching HotSpots



1998 HotSpots
Composite
50-km

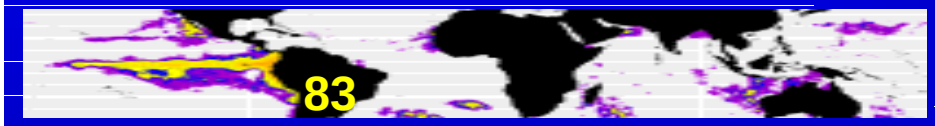
Coral Reef Bleaching Hindcasts

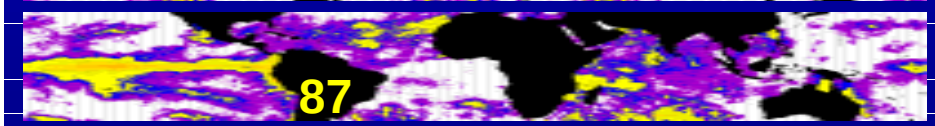
- **HotSpot Index: SST greater than normal annual "summer" maximum SST**

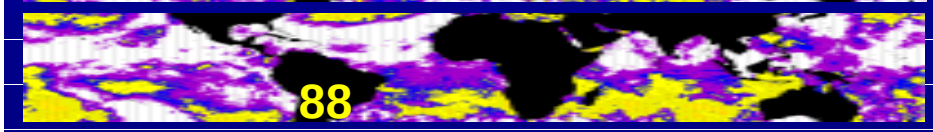
Coral bleaching is associated with HotSpots equal to or greater than 1 deg C (yellow areas)

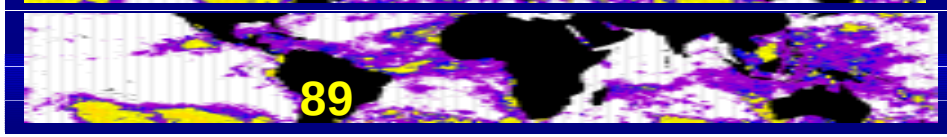
Elevation in Deg C above the annual maximum SST

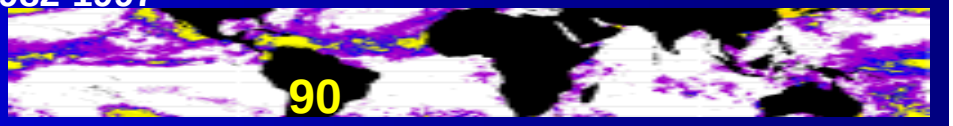
Annual HotSpot Composites: 1982-1997

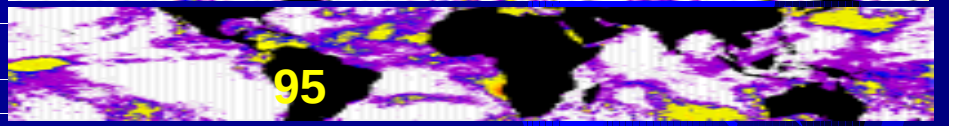


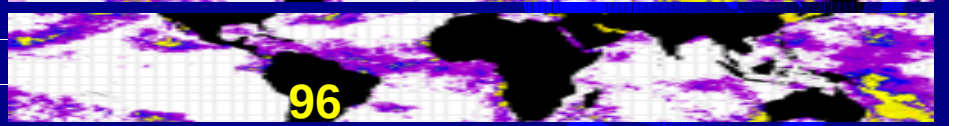




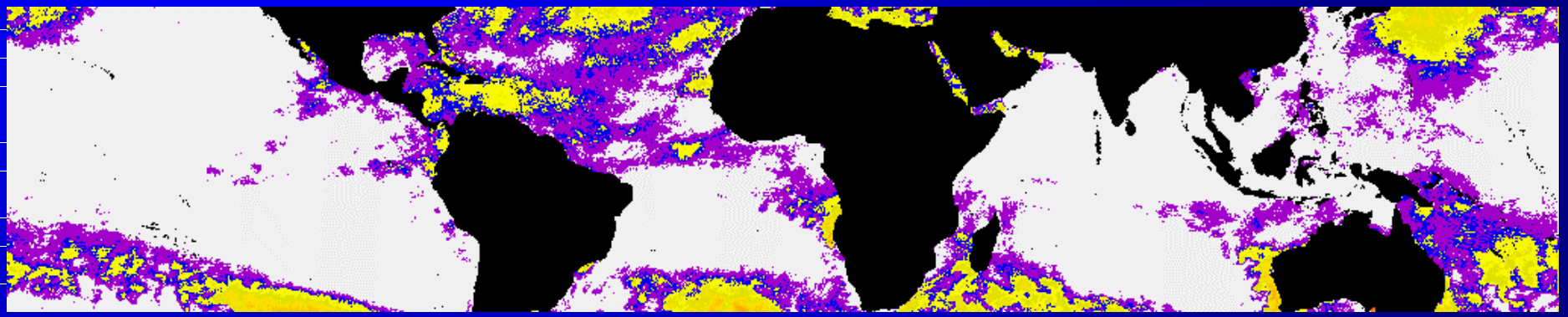








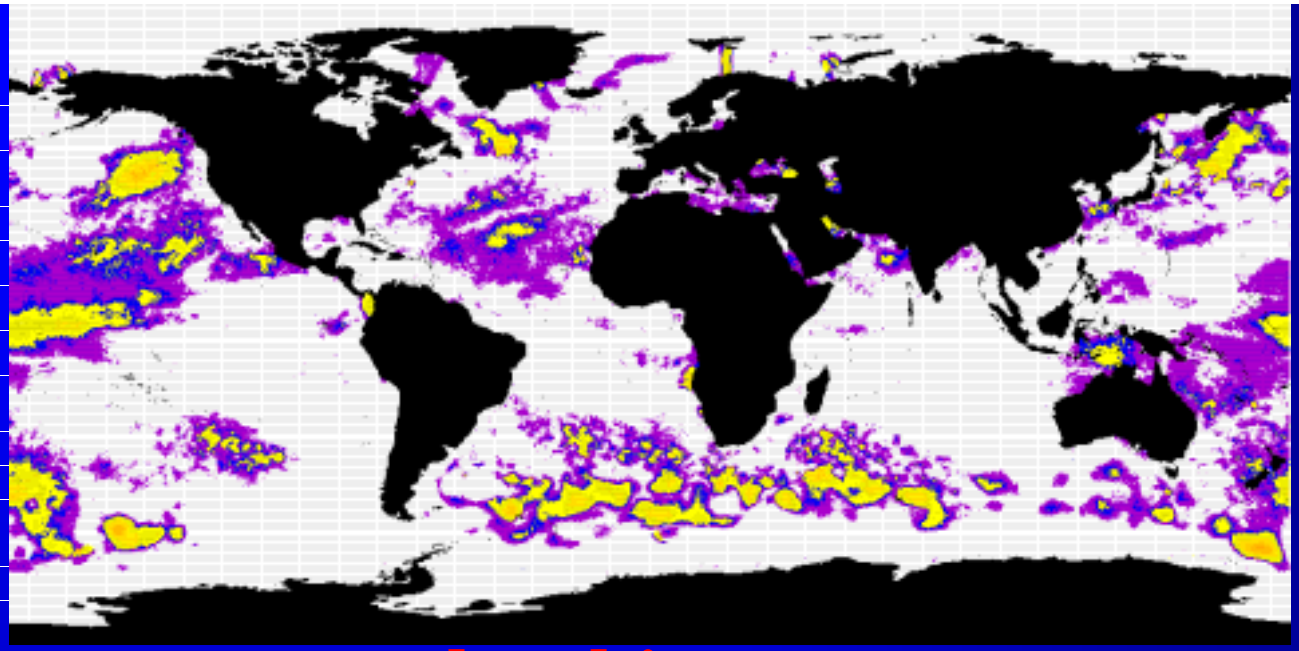
HotSpot Composite - 1999



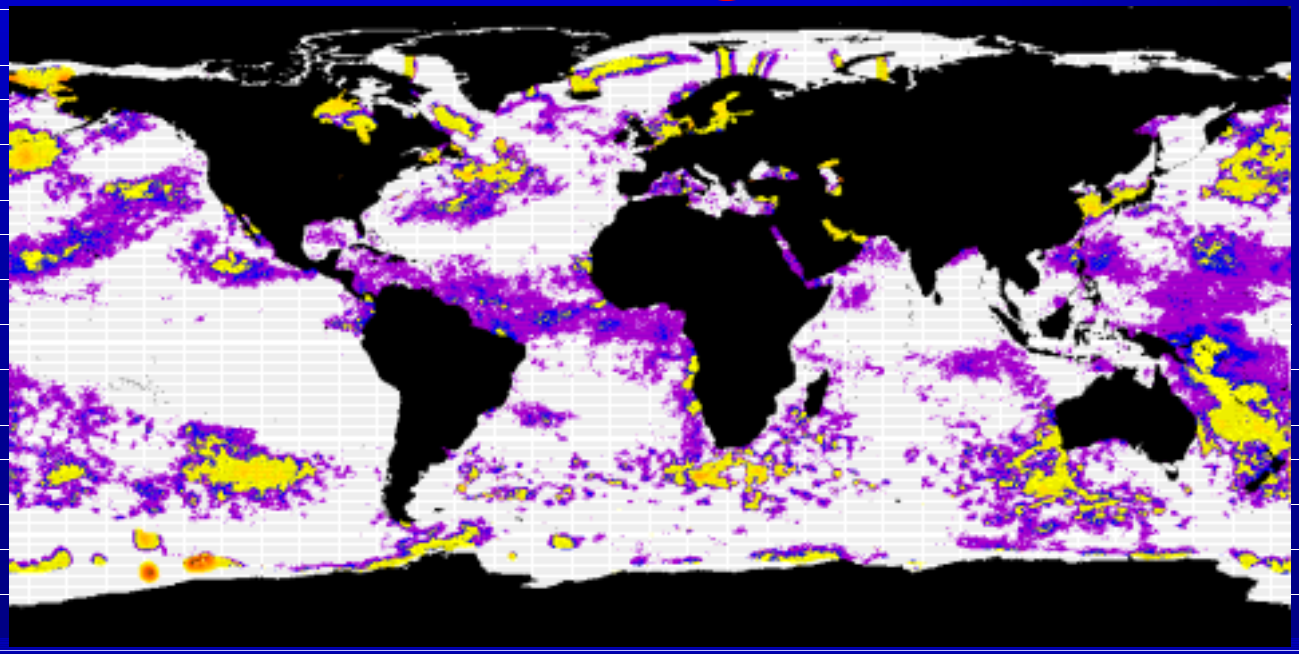
- La NiZa slows coral reef bleaching
- 2nd lowest levels of the decade

(Jan-Oct data only)

NWHI Bleaching Events

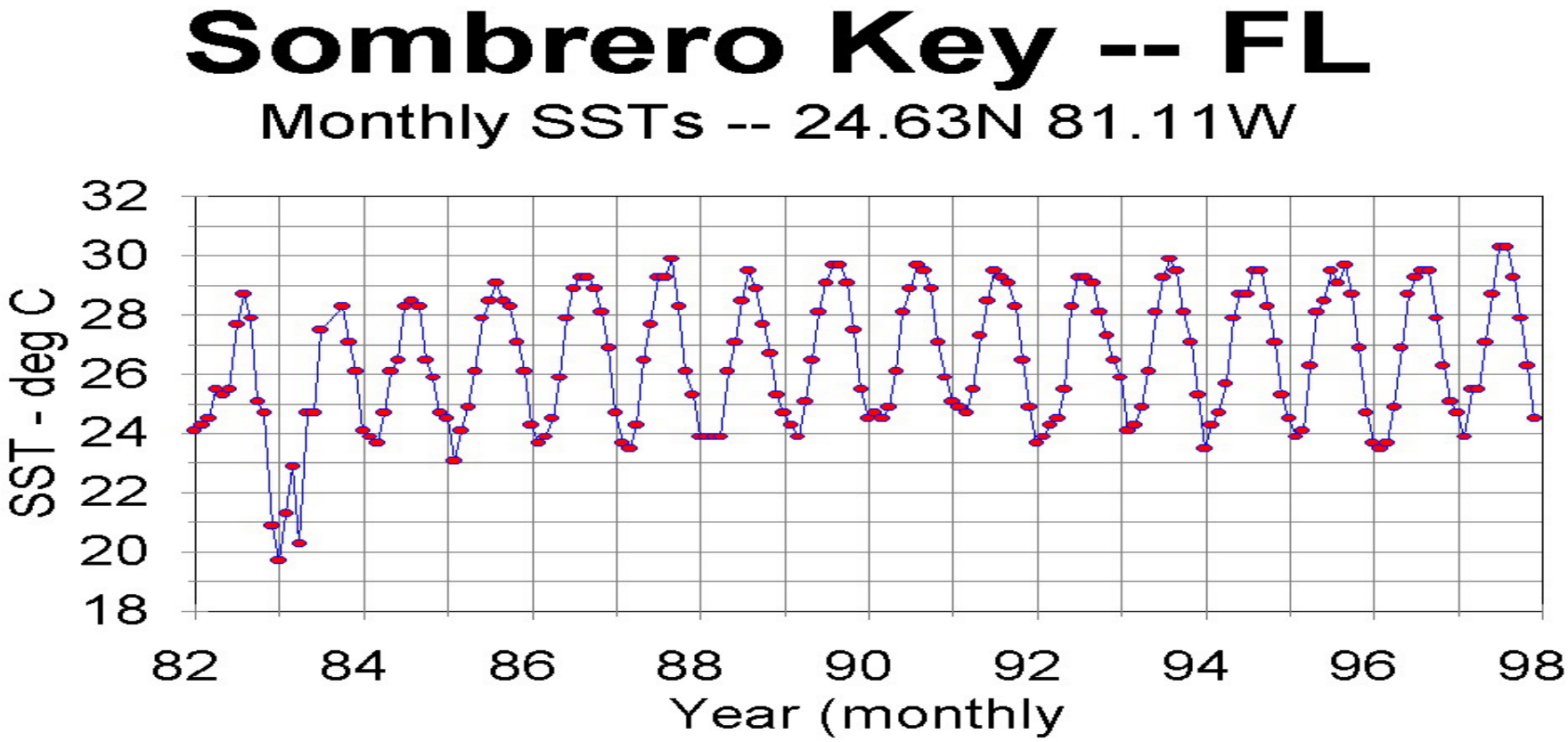


1986



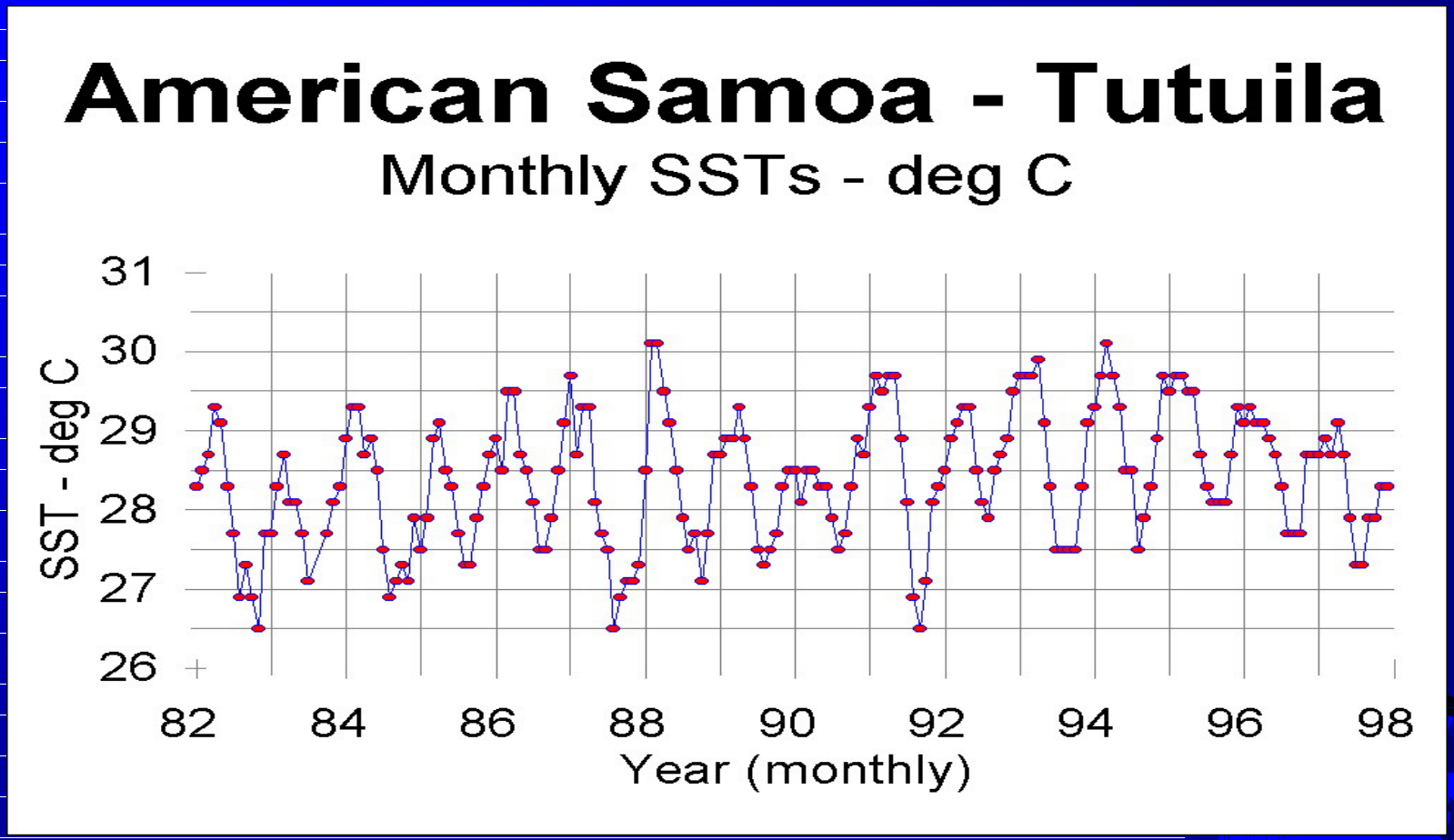
1996

Satellite SSTs



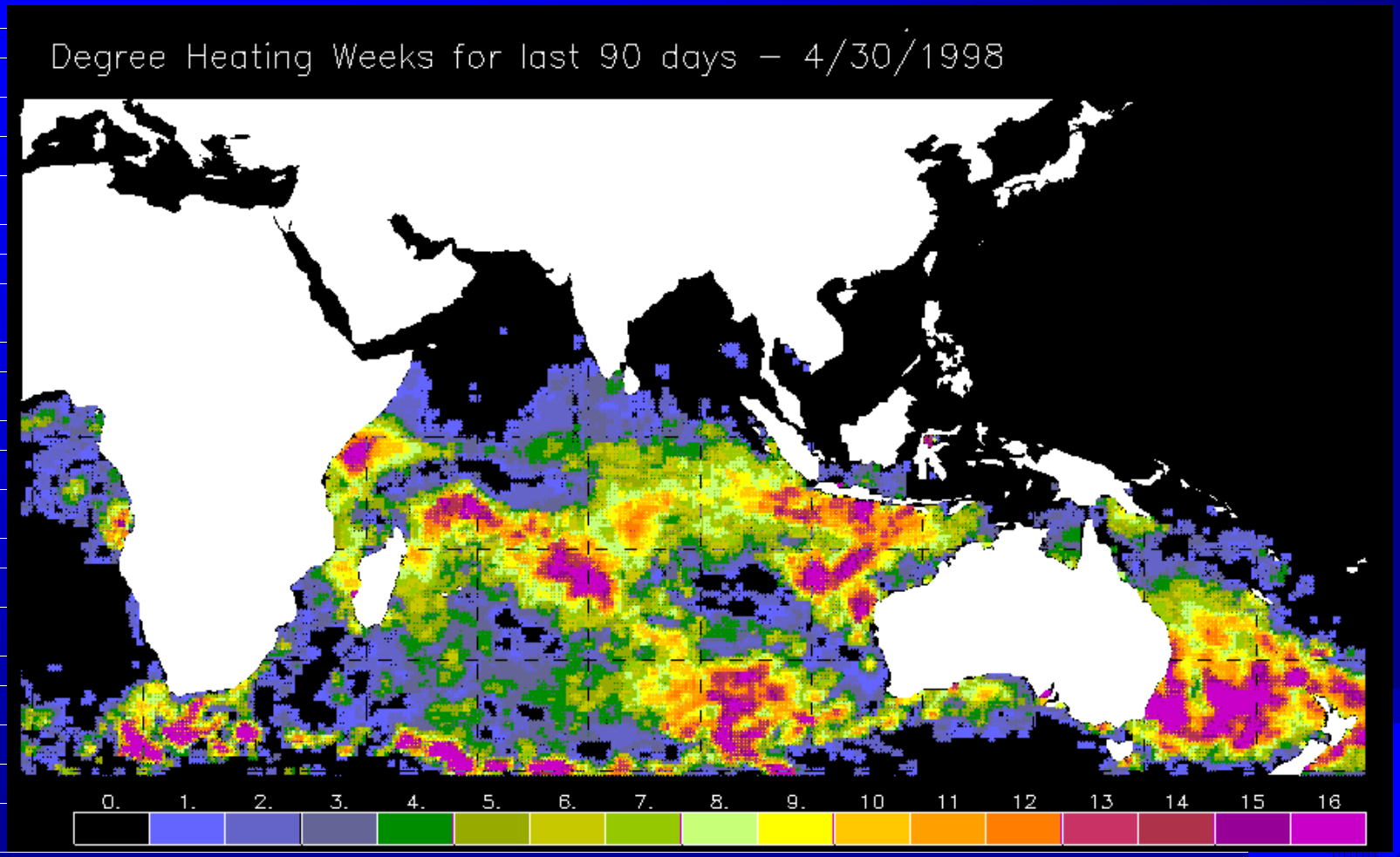
– **Bleaching Threshold = 30.3°C**

Satellite SSTs



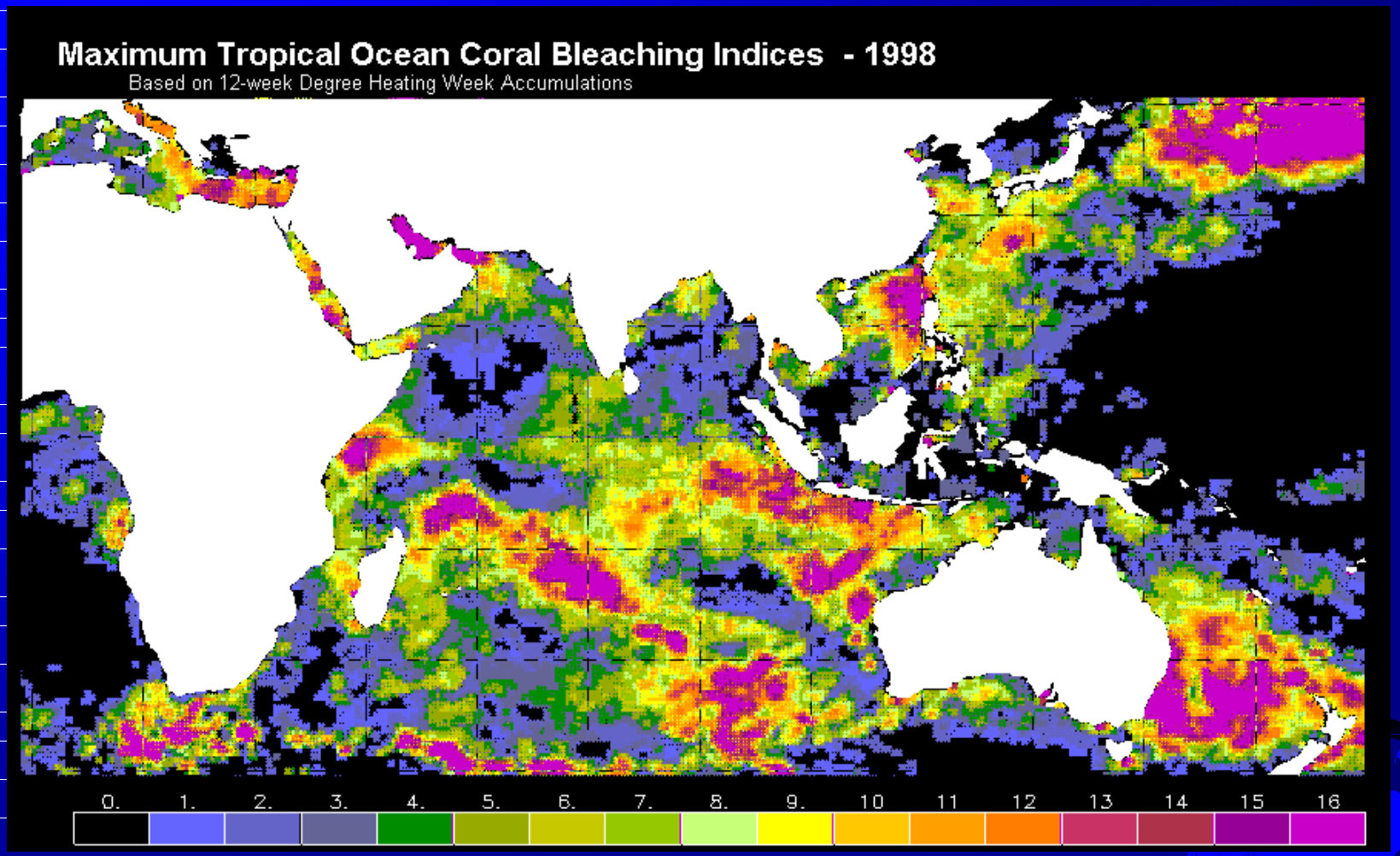
- **Bleaching Threshold - 30.3°C**

Degree Heating Weeks

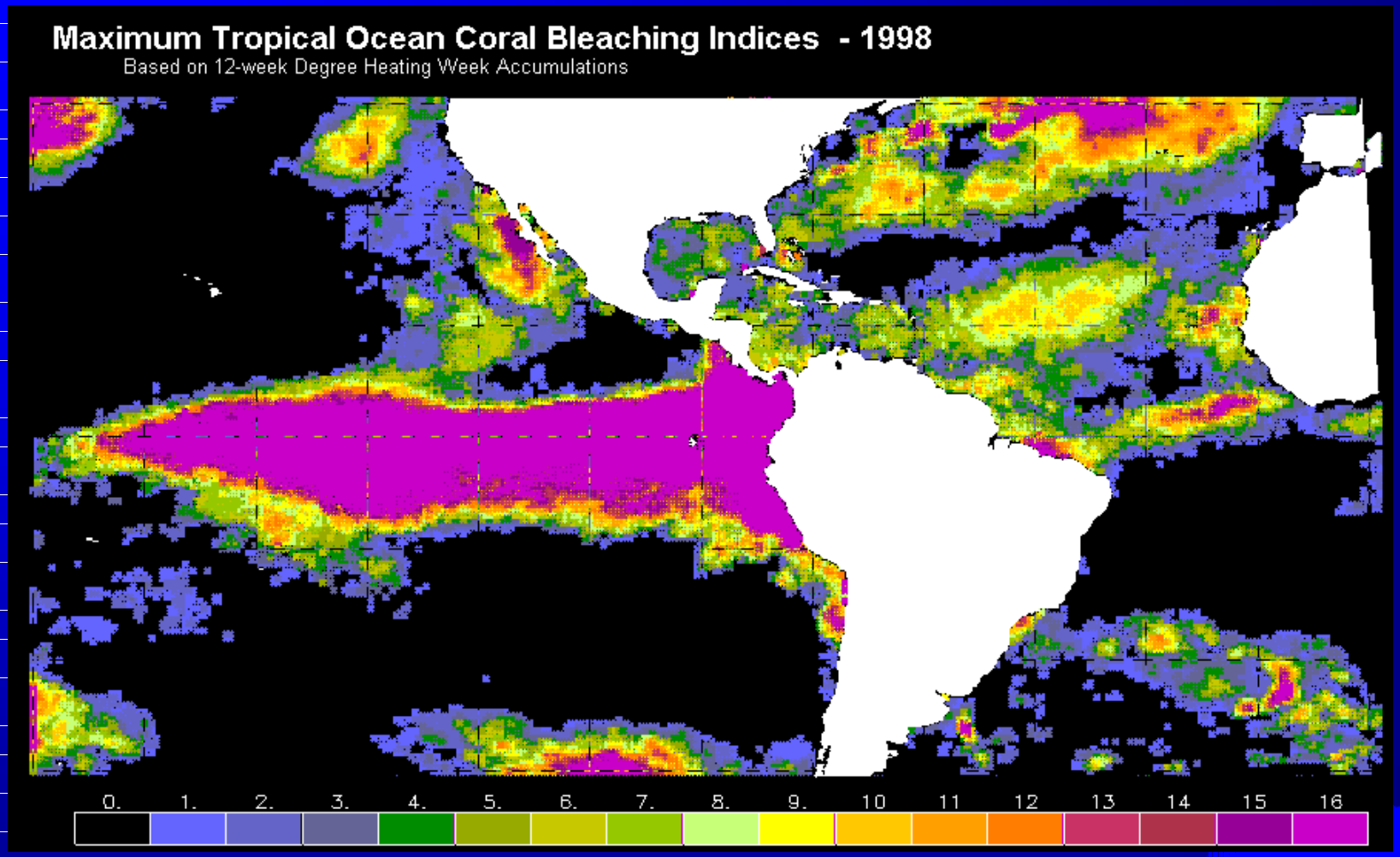


- **Accumulative Heat Stress points to coral reef mortality**
- **Thermal Stress accumulations > 10 = high mortality**

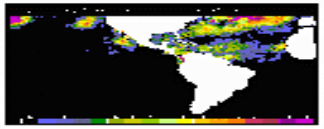

1998 DEGREE HEATING WEEKS
(EASTERN HEMISPHERE)


Maximum Tropical Ocean Coral Bleaching Indices - 1998
Based on 12-week Degree Heating Week Accumulations
0. 1. 2. 3. 4. 5. 6. 7. 8. 9. 10 11 12 13 14 15 16


1998 DEGREE HEATING WEEKS
(WESTERN HEMISPHERE)


Maximum Tropical Ocean Coral Bleaching Indices - 1998
Based on 12-week Degree Heating Week Accumulations
0. 1. 2. 3. 4. 5. 6. 7. 8. 9. 10 11 12 13 14 15 16

Tropical Ocean
Coral Bleaching Indices
Degree Heating Weeks for 22 Feb 2000



The NOAA satellite-derived Degree Heating Week (DHW) is an experimental product designed to indicate the accumulated thermal stress that coral reefs experience. A DHW is equivalent to 1 week of sea surface temperature 1 deg C above the expected summertime maximum. For example, 2 DHWs indicate 1 week of 2 deg C above the expected summertime maximum. We have observed that DHWs of 10+ have been accompanied by severe bleaching and often mortality. To help us improve on these critical thresholds we encourage your feedback. Blinking regions indicate the temperature is equal to or exceeds the expected summertime maximum.

Atlantic Ocean

Peak season (N) Jul-Sep, (S) Jan-Mar

Bermuda
32N 64W

12WK ACCUM TODAY	0.0
MAX 12WK*	0.0
CURRENT TEMP (C)	19.8
EXP. MAX TEMP**	26.9

Bahamas, GBI
26N 77W

12WK ACCUM TODAY	0.0
MAX 12WK*	0.0
CURRENT TEMP (C)	23.4
EXP. MAX TEMP**	29.1

Dry Totrtugas FL
24.64N, 82.86W

12WK ACCUM TODAY	0.0
MAX 12WK*	0.0
CURRENT TEMP (C)	24.1
EXP. MAX TEMP**	29.3

Puerto Rico
18N, 65W

12WK ACCUM TODAY	0.0
MAX 12WK*	0.0
CURRENT TEMP (C)	25.2
EXP. MAX TEMP**	28.5

Virgin Islands
18N, 64W

12WK ACCUM TODAY	0.0
MAX 12WK*	0.0
CURRENT TEMP (C)	25.1
EXP. MAX TEMP**	28.3

Glovers, Belize
16.5N, 87.5W

12WK ACCUM TODAY	0.0
MAX 12WK*	0.0
CURRENT TEMP (C)	25.9
EXP. MAX TEMP **	28.9

Pacific Ocean

Peak season (N) Jul-Sep, (S) Jan-Mar

Midway Atoll, US
28.3N, 177.4W

12WK ACCUM TODAY	0.0
MAX 12WK*	0.0
CURRENT TEMP (C)	22.0
EXP. MAX TEMP **	26.9

Maui, Hawaii
21N, 156W

12WK ACCUM TODAY	0.0
MAX 12WK*	0.0
CURRENT TEMP (C)	23.6
EXP. MAX TEMP**	26.5

Palmyra, Christmas Isl.
6N, 162W

12WK ACCUM TODAY	0.0
MAX 12WK*	0.0
CURRENT TEMP (C)	26.4
EXP. MAX TEMP**	28.7

Galapagos
1.0S, 90.5W

12WK ACCUM TODAY	0.0
MAX 12WK*	16 (98)
CURRENT TEMP (C)	25.1
EXP. MAX TEMP**	26.5

Tutuila, Amer. Samoa
14.1S, 170.7W

12WK ACCUM TODAY	0.0
MAX 12WK*	0.0
CURRENT TEMP (C)	29.4
EXP. MAX TEMP**	29.3

Tahiti-Moorea
17S, 149W

12WK ACCUM TODAY	0.0
MAX 12WK*	3 (99)
CURRENT TEMP (C)	28.7
EXP. MAX TEMP**	28.9

Enewetok
11N, 162E

12WK ACCUM TODAY	0.0
MAX 12WK*	0.0
CURRENT TEMP (C)	27.3
EXP. MAX TEMP**	29.1

Palau
7.27N, 134.16E

12WK ACCUM TODAY	0.0
MAX 12WK*	0.0
CURRENT TEMP (C)	28.7
EXP. MAX TEMP**	29.5

Guam
13.4N, 144.8E

12WK ACCUM TODAY	0.0
MAX 12WK*	0.0
CURRENT TEMP (C)	28.0
EXP. MAX TEMP**	29.4

Raine Island GBR, AU
12S, 144E

12WK ACCUM TODAY	0.0
MAX 12WK*	2 (98)
CURRENT TEMP (C)	29.6
EXP. MAX TEMP (C)**	29.1

Heron Island GBR, AU
23.5S, 151E

12WK ACCUM TODAY	0.0
MAX 12WK*	7 (98)
CURRENT TEMP (C)	25.7
EXP. MAX TEMP**	27.3

Fiji-Nandi
18S, 177W

12WK ACCUM TODAY	2.8
MAX 12WK*	0.0
CURRENT TEMP (C)	29.0
EXP. MAX TEMP**	28.6

Indian Ocean

Peak season (N) Apr-Jun, (S) Jan-Apr

Oman - Muscat
23.7N, 58.6E

12WK ACCUM TODAY	0.0
MAX 12WK*	0.0
CURRENT TEMP (C)	23.0
EXP. MAX TEMP**	30.1

Maldives
4N, 72E

12WK ACCUM TODAY	0.0
MAX 12WK*	0.0
CURRENT TEMP (C)	28.3
EXP. MAX TEMP**	29.9

Seychelles
4S, 55E

12WK ACCUM TODAY	0.0
MAX 12WK*	0.0
CURRENT TEMP (C)	27.8
EXP. MAX TEMP **	29.5

Chagos Islands
6S, 71E

12 WK ACCUM TODAY	0.0
MAX 12WK*	1 (98)
CURRENT TEMP (C)	27.5
EXP. MAX TEMP**	29.3

Scott Reef, AU
13S, 122E

12WK ACCUM TODAY	0.0
MAX 12WK*	7 (98)
CURRENT TEMP (C)	29.0
EXP. MAX TEMP**	29.7

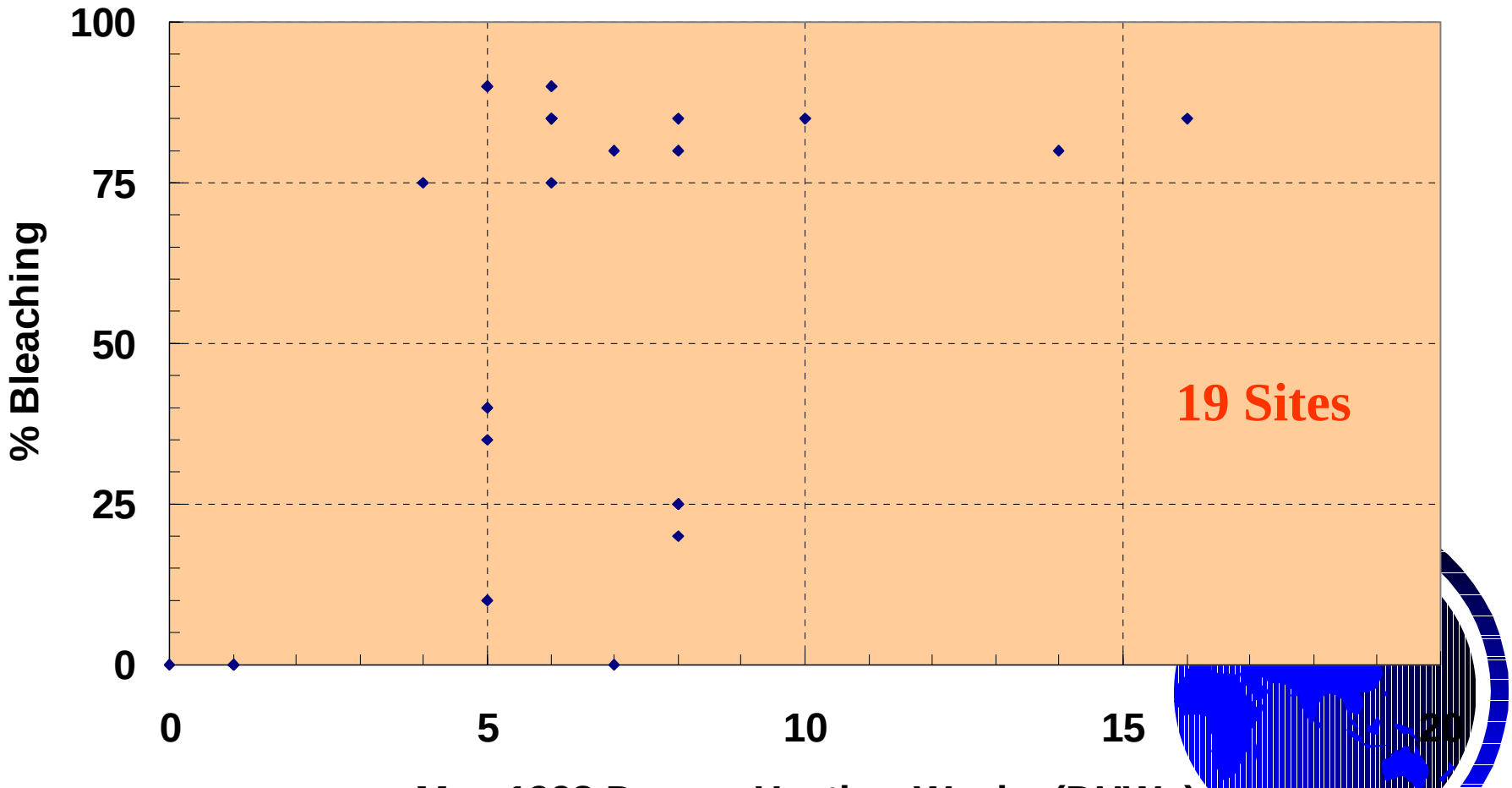
Ningaloo, AU
21.5S, 114E

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

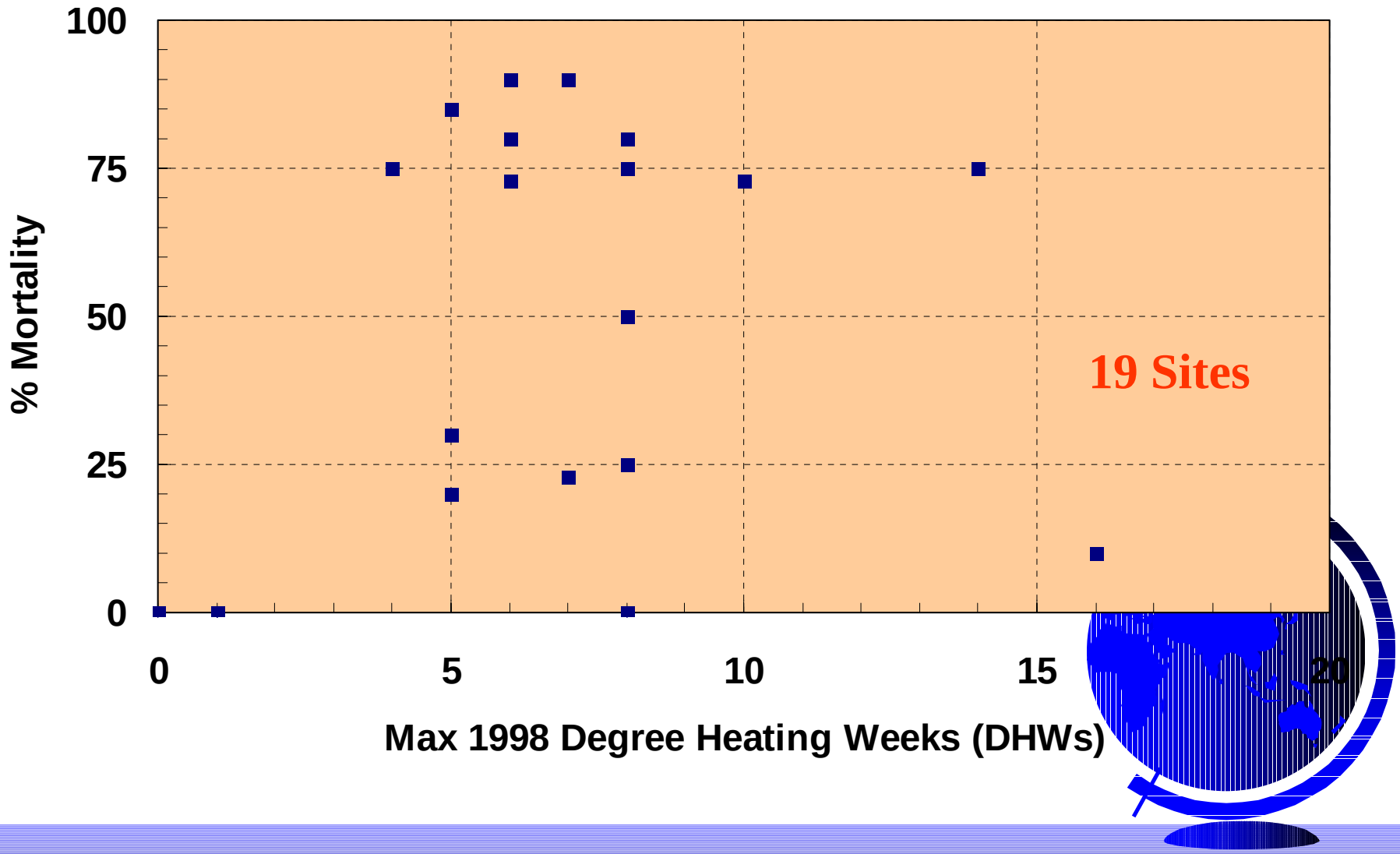
*THIS DATE BASED ON LAST 10 YEARS ** ALSO KNOWN AS THE MAXIMUM MONTHLY MEAN SST

Reef	% Bleach	% Mortality	DHW
Raine, AU	NA	NA	2
Heron Island, AU	80	23	7
Oman, Arabian Gulf	85	10	16
Maldives	90	85	5
Seychelles	75	75	4
Scott Reef, AU	85	80	8
Ningaloo, AU	NA	NA	8
Chagos	90	85	5
Lakshadweep Islands	NA	90	7
Andamans	75	80	6
Gulf of Mannar	85	73	6
Kenya	80	75	14
Madagascar - Tulear	25	25	8
Mauritius	10	20	5
Mayotte	80	75	8
Reunion	40	20	5
Sri Lanka - NE	0	0	1
Sri Lanka - SW	85	80	6
Tanzania - south	20	50	8
Zanzibar	35	30	5
Tanya	25	NA	8
Mafia Island	90	90	6
Okinawa	85	73	10
Palau	NA	NA	9
Fiji	0	0	1
Easter Island	0	0	0

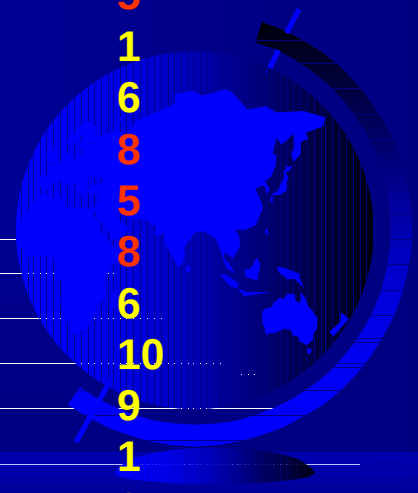
1998 Degree Heating Weeks vs Bleaching



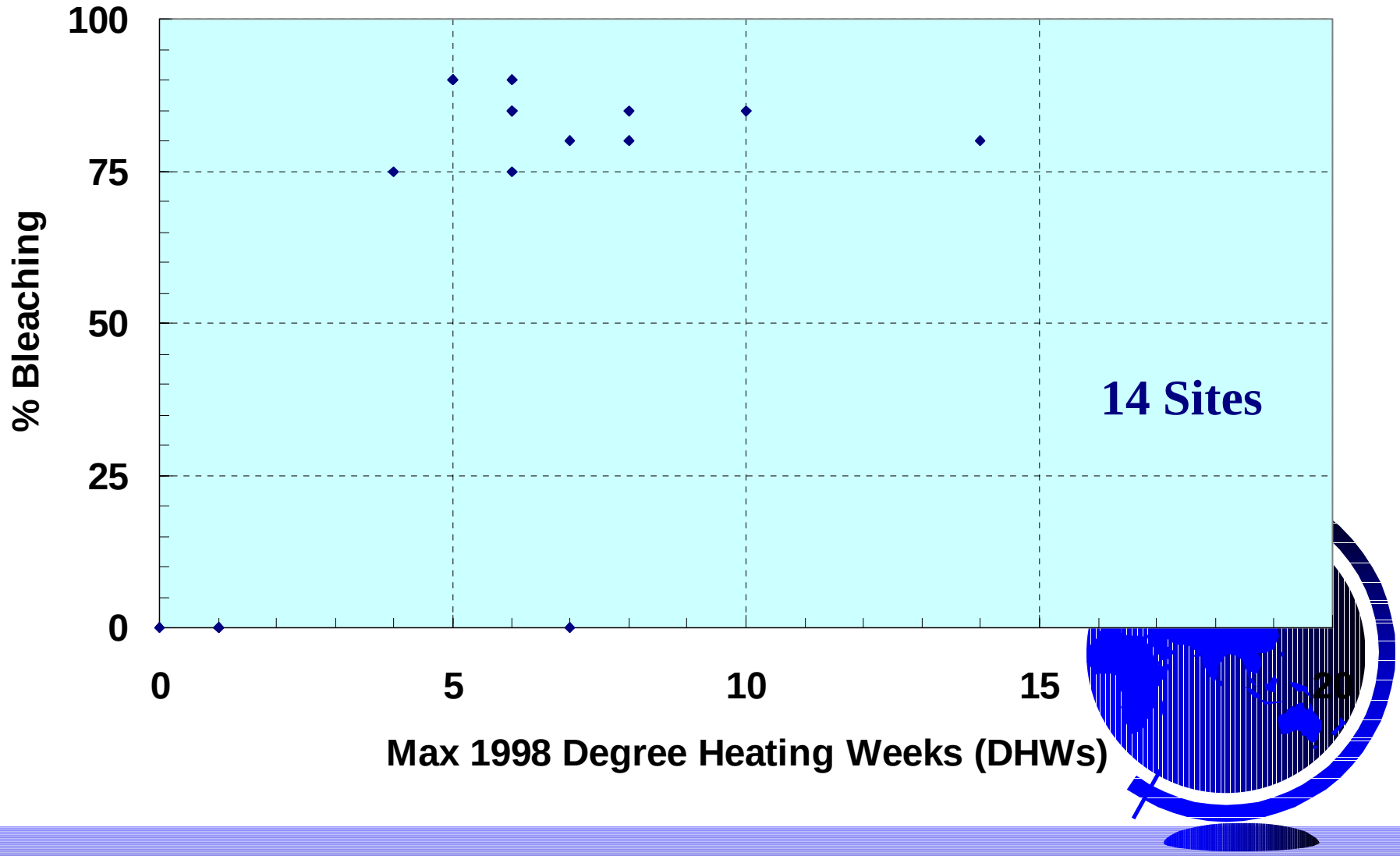
1998 Degree Heating Weeks vs Mortality



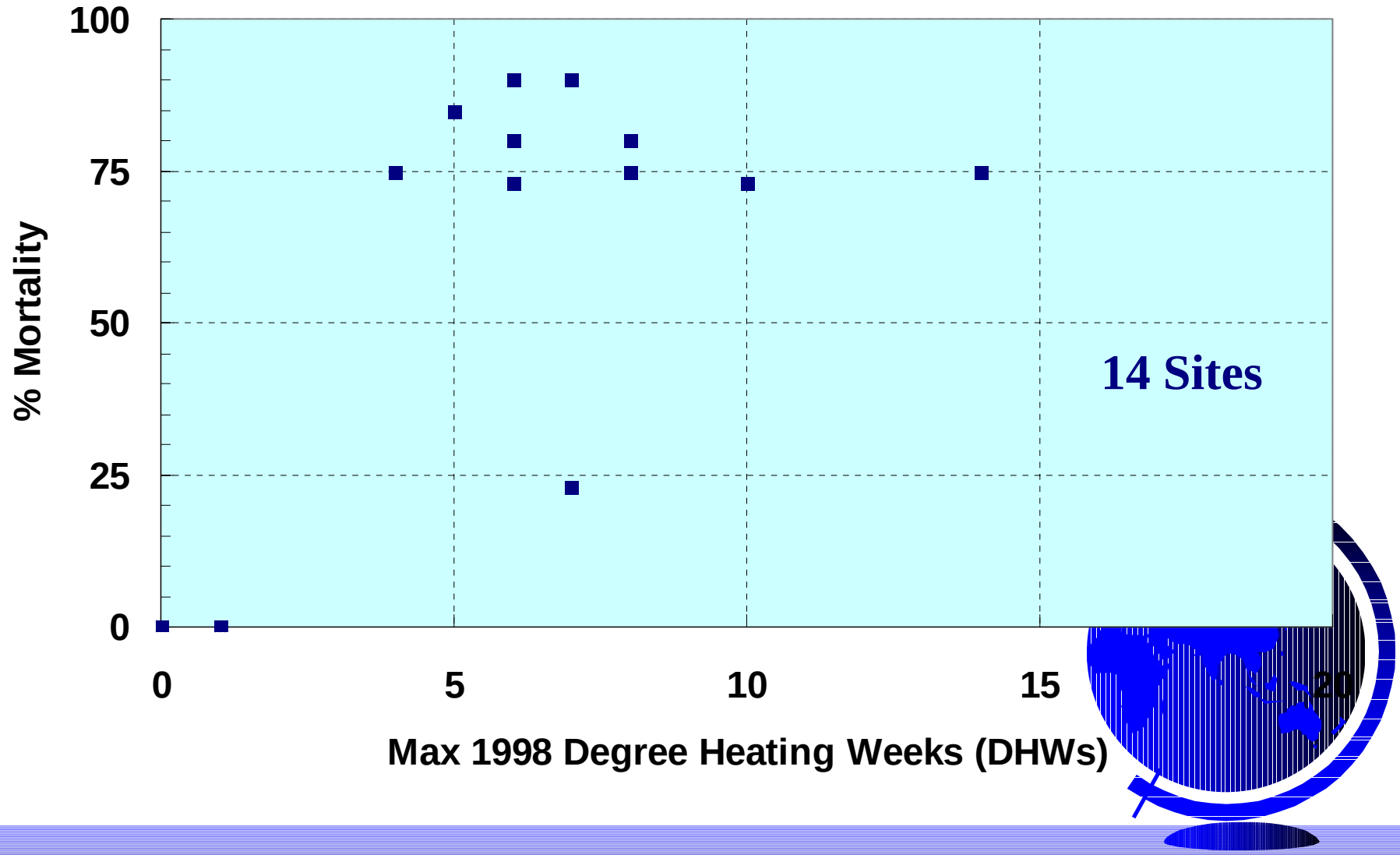
Revised Reefs	%Bleach	% Mortal	DHW
Raine, AU	NA	NA	2
Heron Island, AU	80	23	7
Oman, Arabian Gulf	85	10	16
Maldives	90	85	5
Seychelles	75	75	4
Scott Reef, AU	85	80	8
Ningaloo, AU	NA	NA	8
Chagos	90	85	5
Lakshadweep Islands	NA	90	7
Andamans	75	80	6
Gulf of Mannar	85	73	6
Kenya	80	75	14
Madagascar - Tulear	25	25	8
Mauritius	10	20	5
Mayotte	80	75	8
Reunion	40	20	5
Sri Lanka - NE	0	0	1
Sri Lanka - SW	85	80	6
Tanzania - south	20	50	8
Zanzibar	35	30	5
Tanya	25	NA	8
Mafia Island	90	90	6
Okinawa	85	73	10
Palau	NA	NA	9
Fiji	0	0	1
Easter Island	0	0	0



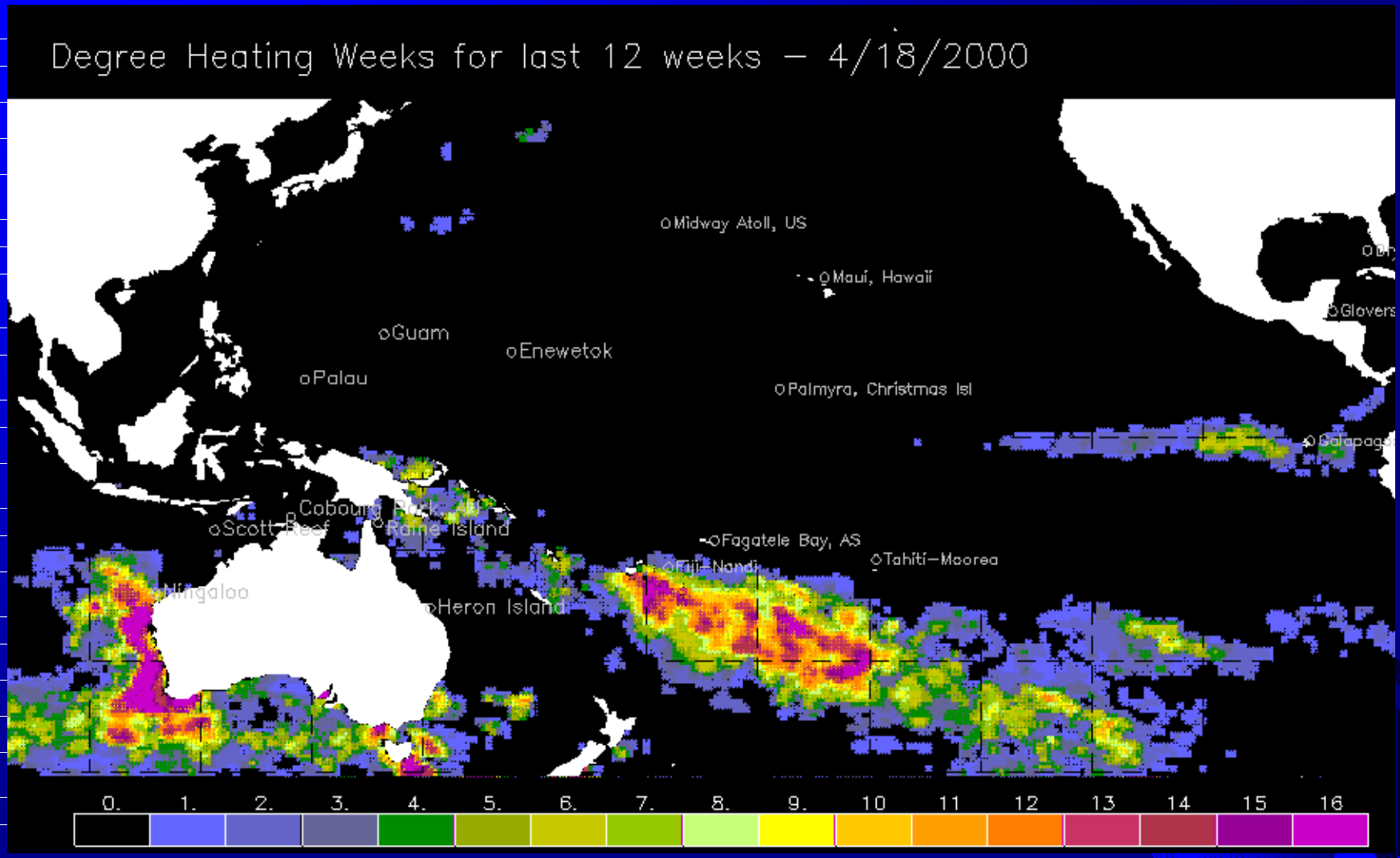
DHW - 1998 Bleaching (Outliers Removed)



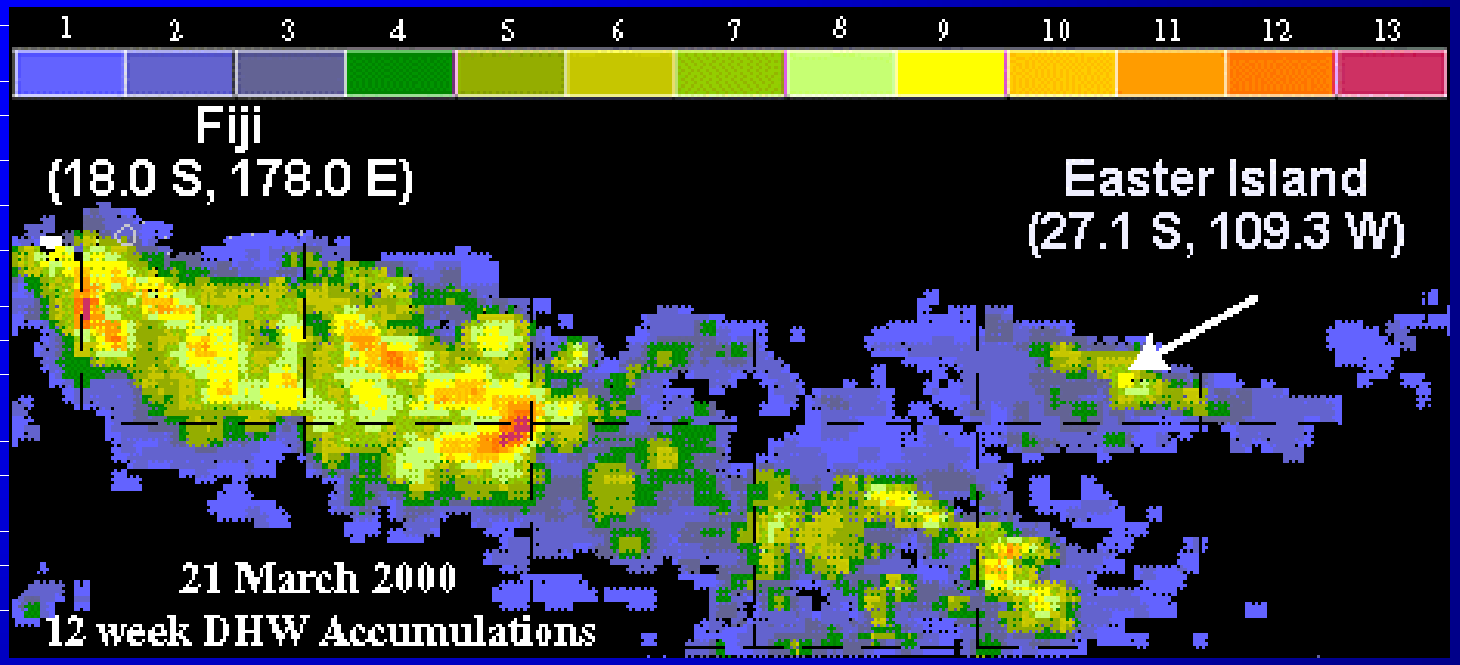
DHW - 1998 Mortality (Outliers Removed)



Degree Heating Weeks



- **Accumulative Heat Stress points to coral reef mortality**
- **Thermal Stress accumulations > 5 = high mortality**



Bleaching Events -- 2000

- Easter Island [unprecedented]
- Fiji

Easter Island

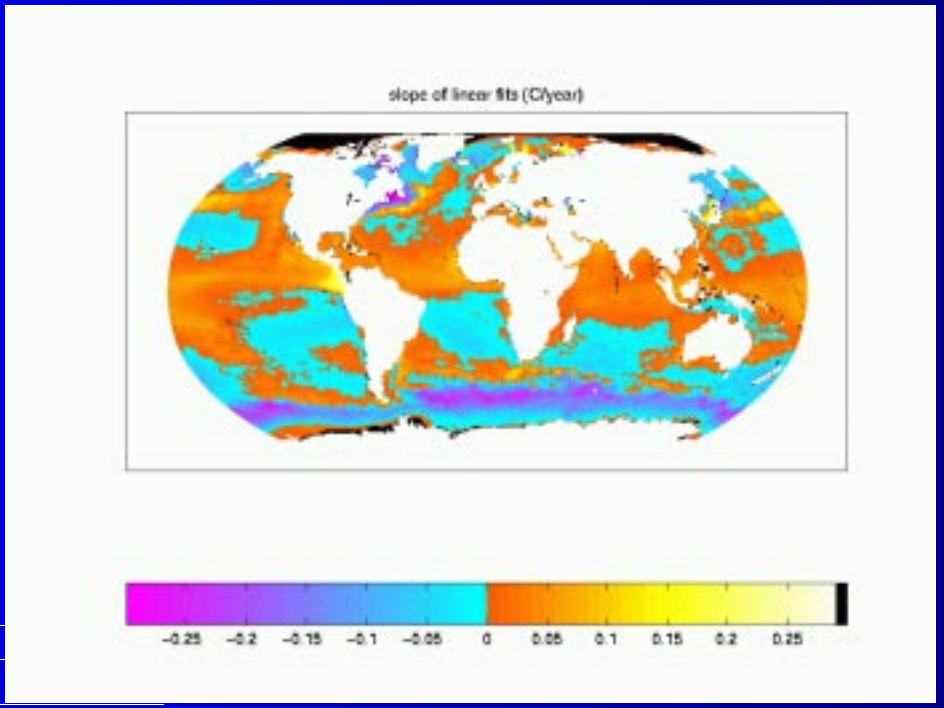
March 1999

March 2000

Paper in press: Wellington & Strong et al., 2000: ***EOS***

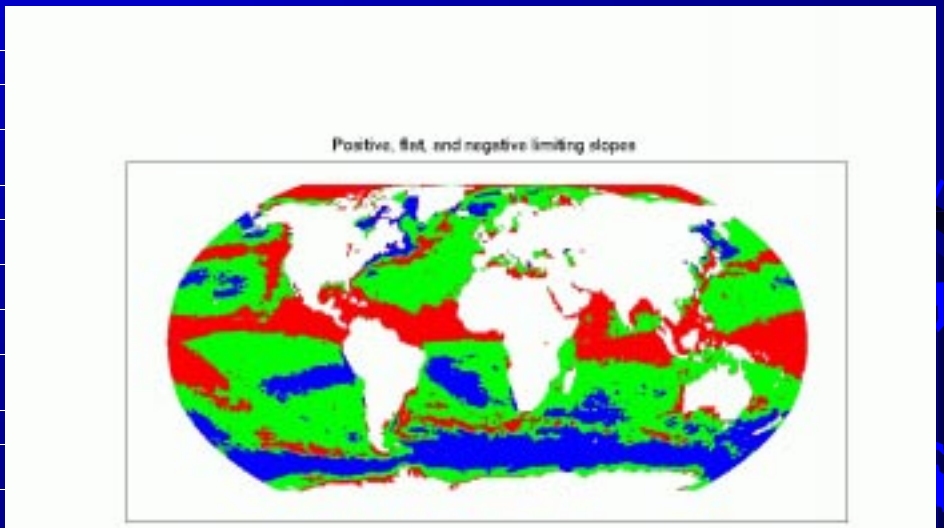
SST Trends 1984-1996

[deg C/yr]



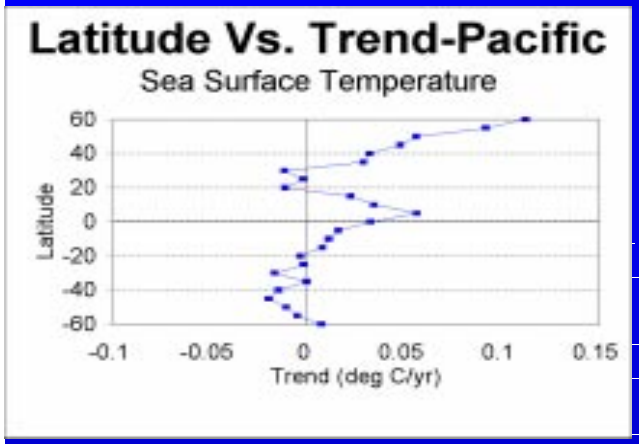
Trend reliability

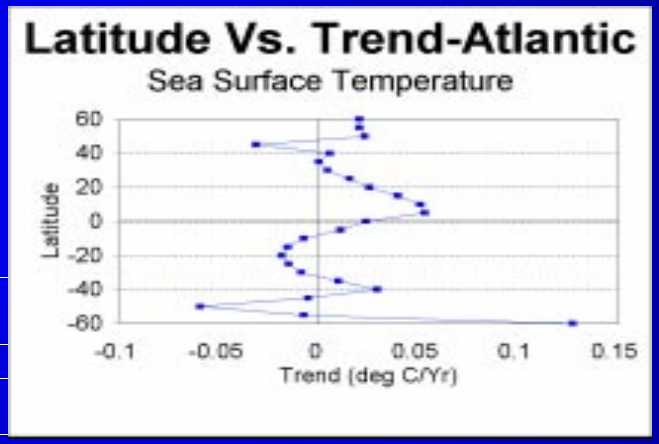
- **Red** = Increasing
- **Blue** = Decreasing
- **Green** = ??

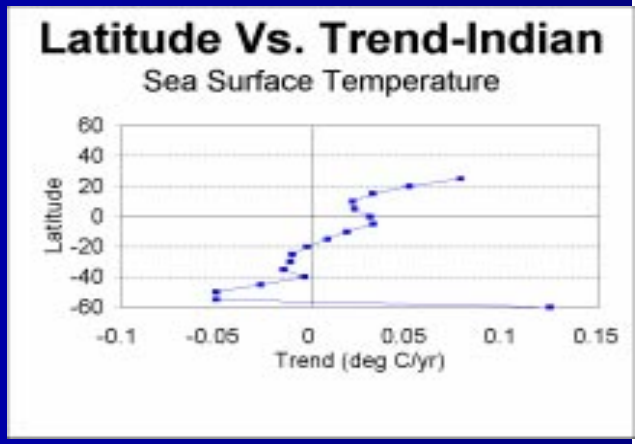


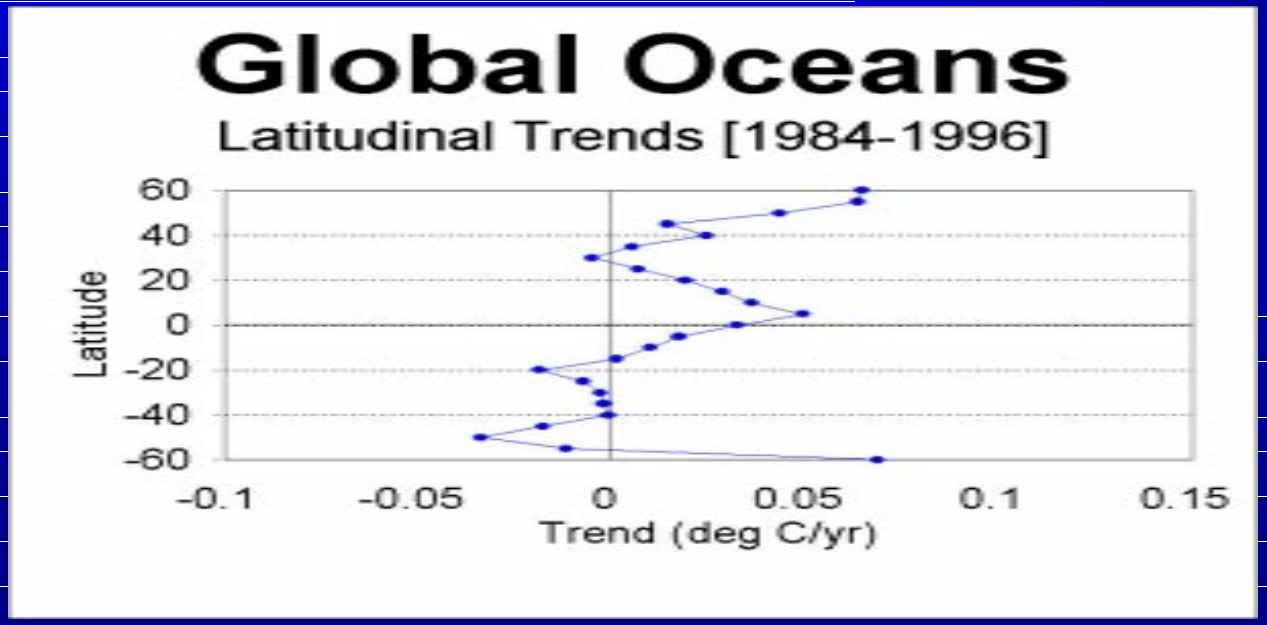
Strong et al., ***GRL***, 2000, 1 Jun

AVHRR SST Trends -- 1984 to 1996









Strong et al., ***GRL***, 1 Jun 2000

“Technology transition is a contact sport.”