Thermal Stress and Bleaching in Coral Reef communities during the 2014-2016 Caribbean Bleaching Event

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Objective

Match observations of bleaching with Satellite observations of heat stress.

- Regional Virtual Stations
- Clustered observations 5x5 Km pixels

Maximum Degree Heat Week (DHW) values and in-situ bleaching observations from various contributors.

Introduction

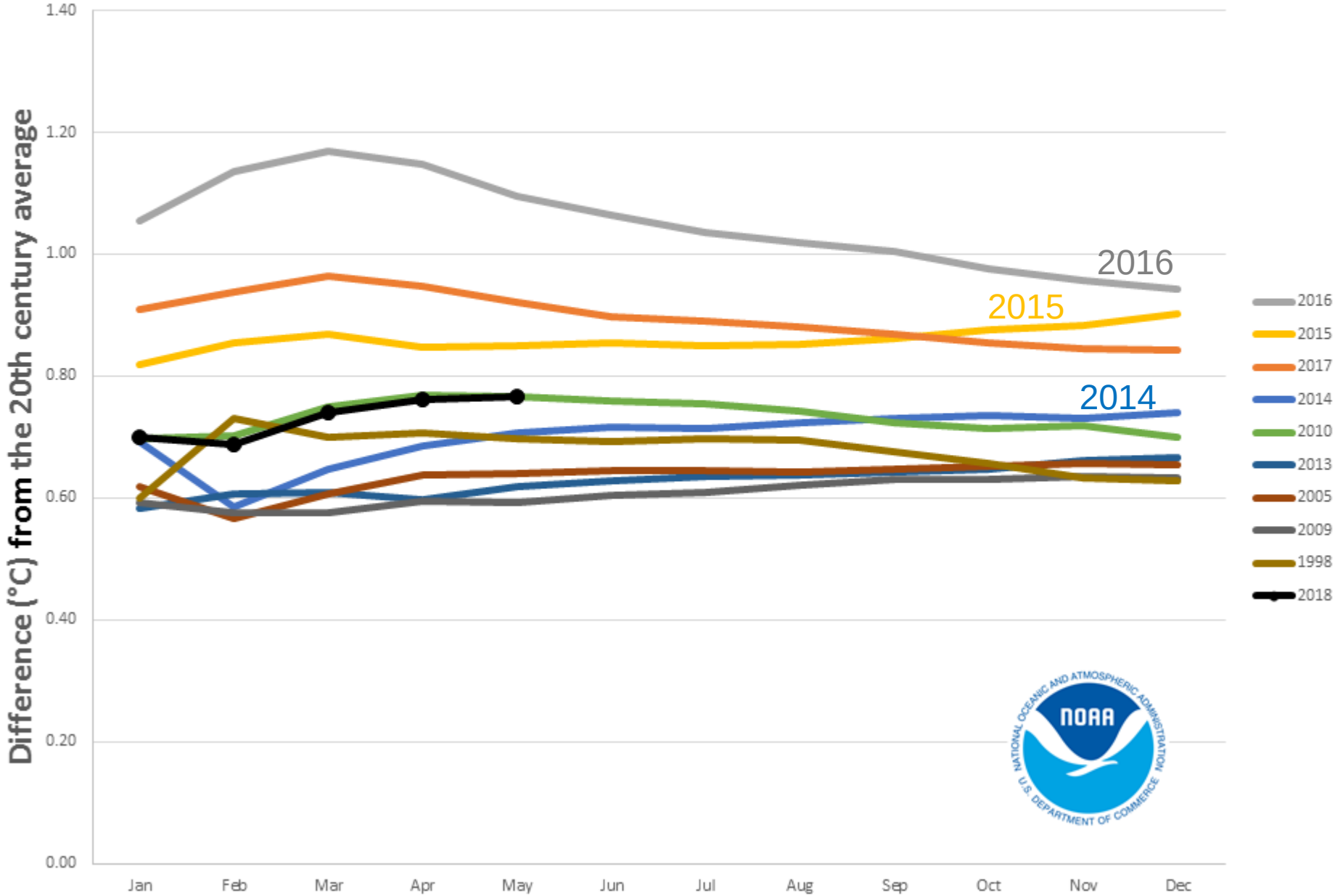
Coral reefs in the Caribbean makes about 7% of the world's total, is very important for:

- The economy of the coastal communities in the region.
- Protect them against the hurricanes and storms.
- Coral reefs support biodiversity which attracts not only fisherman but also tourism.

Mass Coral reefs bleaching is caused by elevated sea surface temperature.

Year-toDate Global Temperatures

for 2018 and the other nine warmest years on record



Notice in the comparison below that the blending technique fills in clouds and gaps (left), whereas a daily composite of all current AVHRR sensors (right) still has gaps caused by persistent cloud coverage.

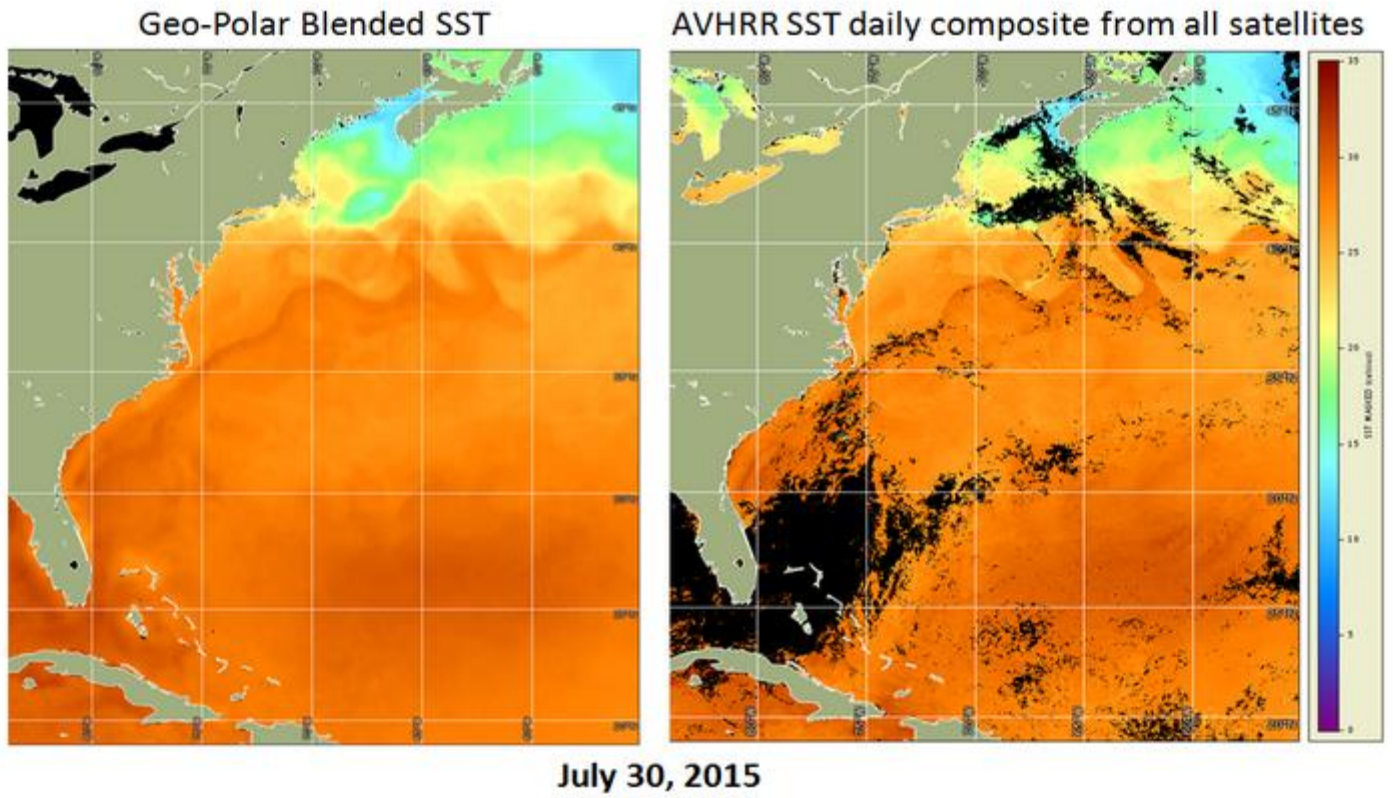
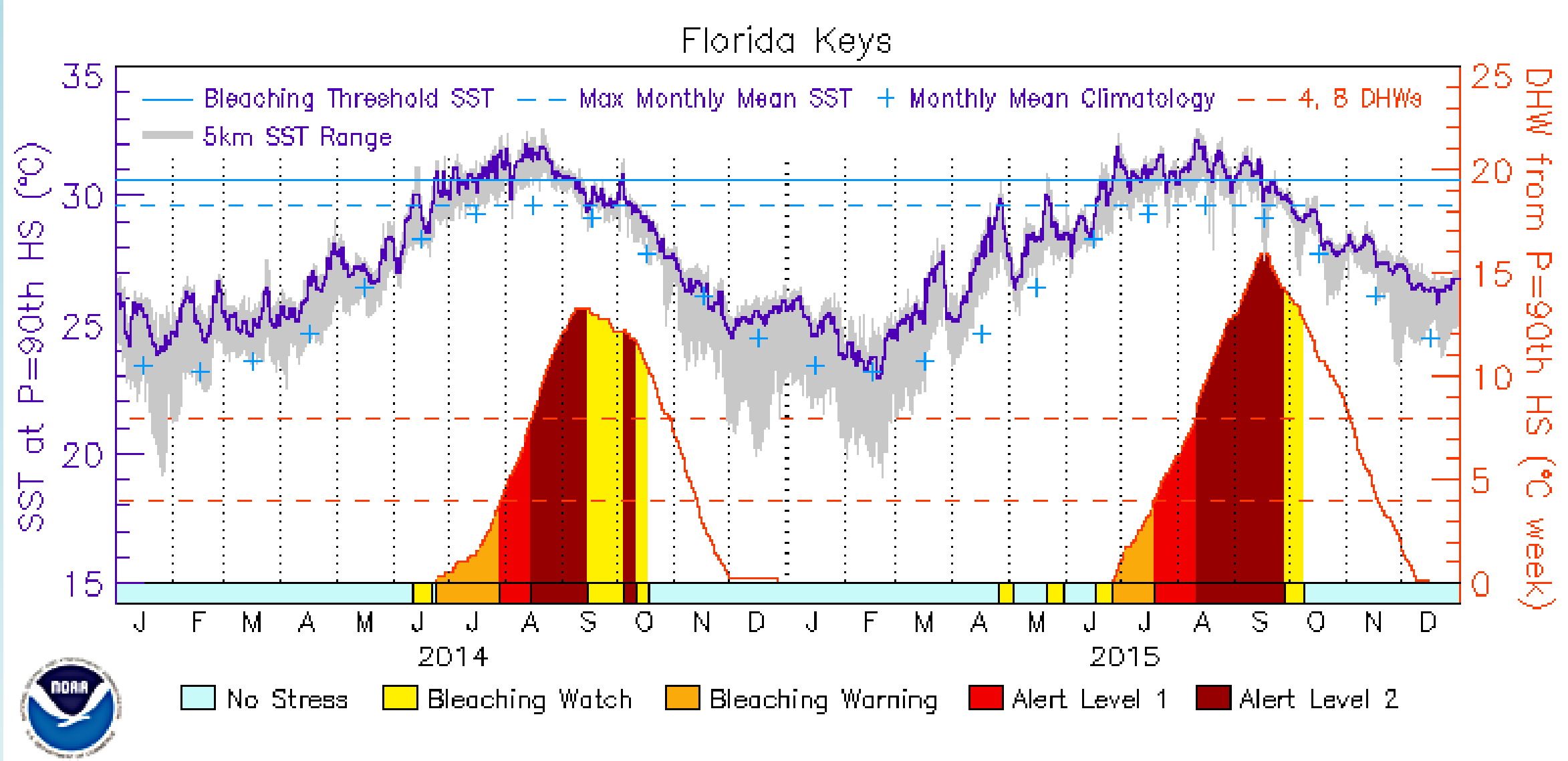


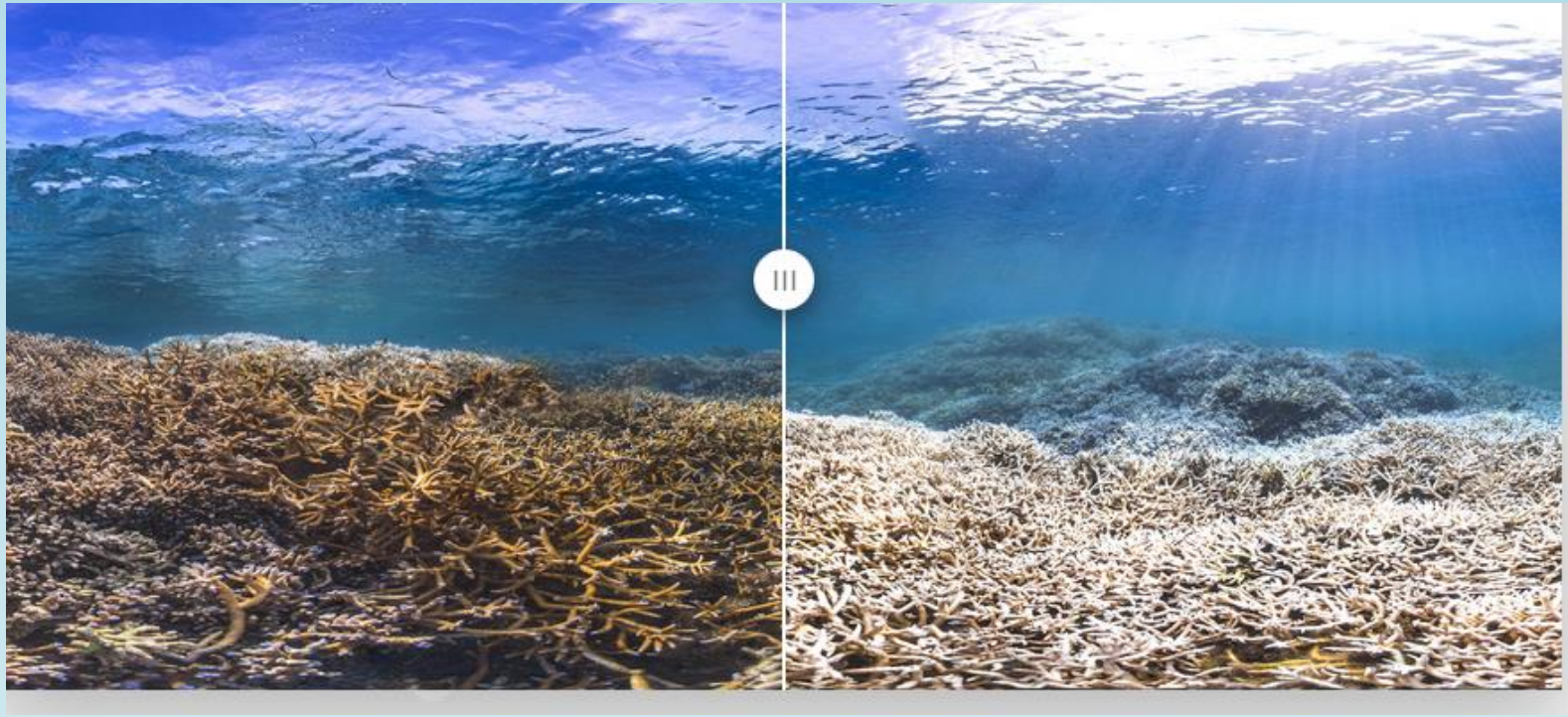
Figure: SST comparison for July 30, 2015:

Geo-Polar Blended SST (left) was generated from nighttime measurements from: MetOp-B AVHRR, S-NPP VIIRS, GOES-East Imager, GOES-West Imager, MSG SEVIRI, and MTSAT Imager. Spatial resolution is 5 km.

AVHRR Daily Composite (right) is the one-day average daytime and nighttime SST from the AVHRR sensors aboard: MetOp-A, MetOp-B, NOAA-15, NOAA-18, and NOAA-19. Spatial resolution is 1 km.



Time series from Regional Virtual Stations

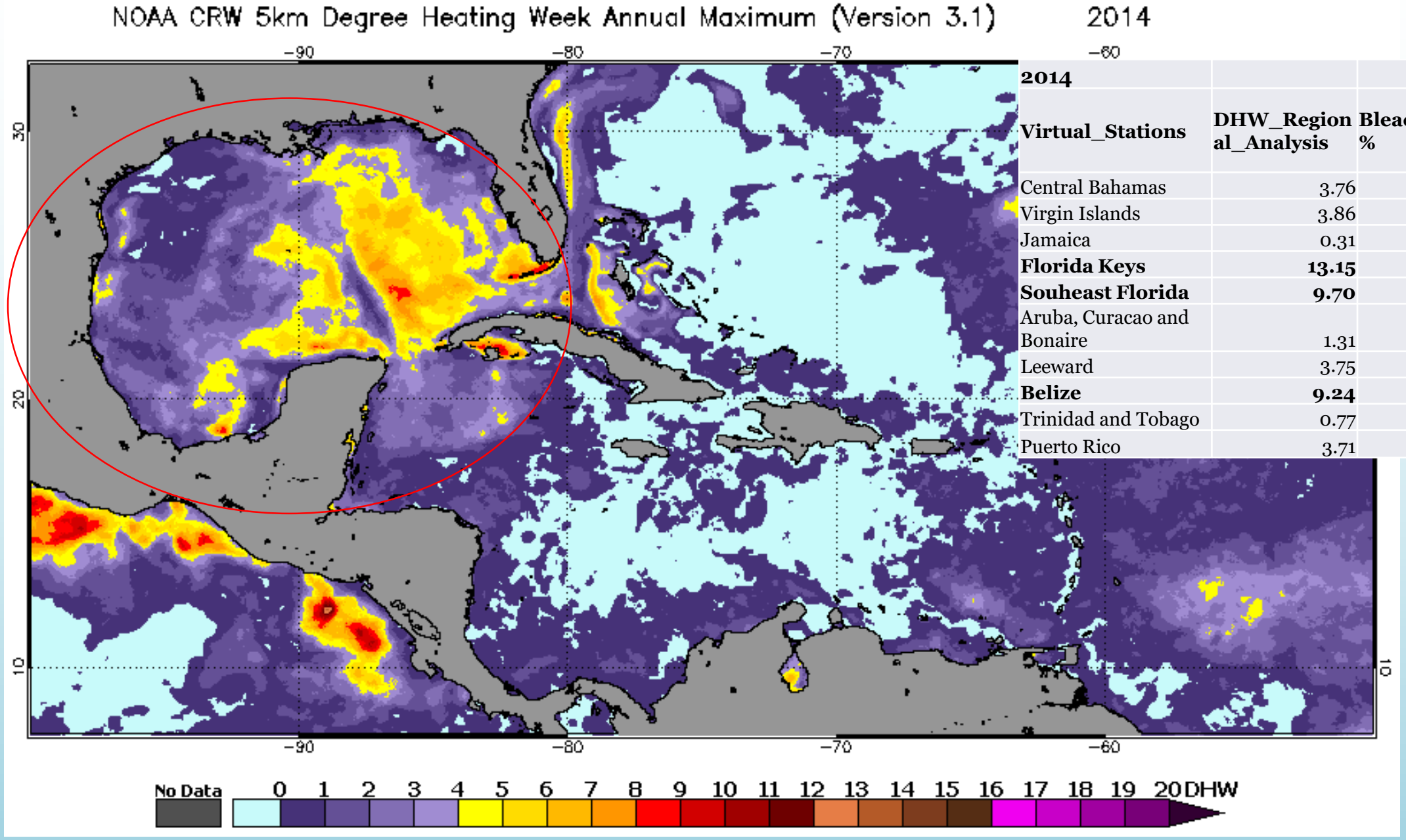


The image on the left is a photo of healthy coral in American Samoa, taken in 2014 by our friends at The Ocean Agency / XL Catlin Seaview Survey. The image on the right is the same reef in 2015 after a bleaching event

Coral Bleaching Degree Heat Weeks (DHW)

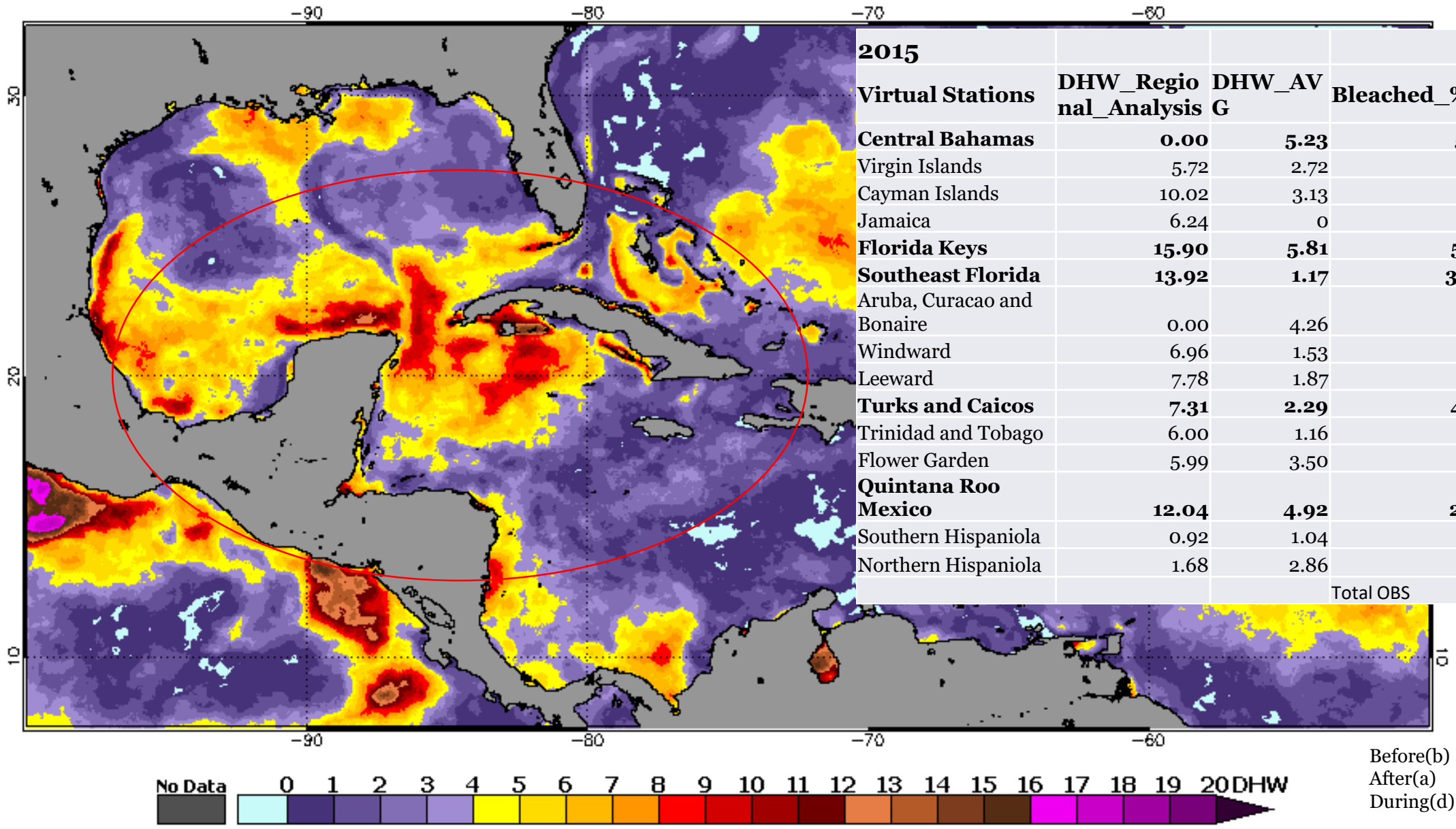
The DHW shows accumulates thermal stress, significant coral bleaching usually occurs when DHW values reach 4 °C –weeks , if the DHW reach 8 °C – weeks wide spread bleaching and mortality is expected.

A healthy coral (left) and a coral that has experienced bleaching (right).
Photo credit: Henry Wolcott/Marine Photobank



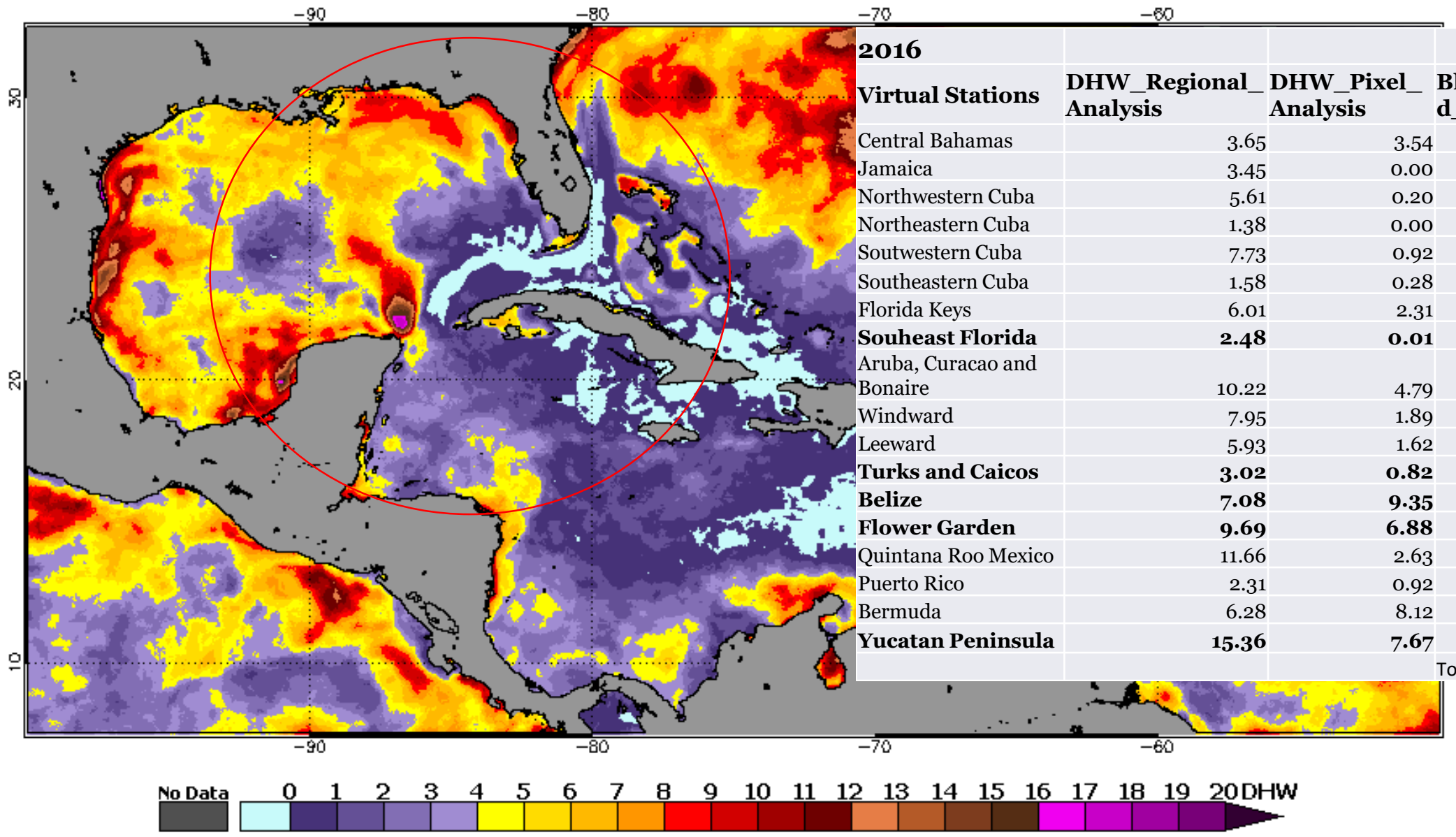
2014		
Virtual_Stations	**DHW_Regional_Analysis**	**Bleached_%**
Central Bahamas	3.76	2.88
Virgin Islands	3.86	9.6
Jamaica	0.31	0.56
Florida Keys	**13.15**	**49.07**
Souheast Florida	**9.70**	**36.52**
Aruba, Curacao and Bonaire	1.31	0.50
Leeward	3.75	0.06
Belize	**9.24**	**14.11**
Trinidad and Tobago	0.77	6.25
Puerto Rico	3.71	0.95

DHW Annual Maximum 2014 for the Caribbean



2015				
Virtual Stations	**DHW_Regional_Analysis**	**DHW_AVG**	**Bleached_%**	**# OBS**
Central Bahamas	**0.00**	**5.23**	**51.18**	**1**
Virgin Islands	5.72	2.72	11.83	12
Cayman Islands	10.02	3.13	58	1
Jamaica	6.24	0	1.83	3
Florida Keys	**15.90**	**5.81**	**52.74**	**145**
Southeast Florida	**13.92**	**1.17**	**30.80**	**64**
Aruba, Curacao and Bonaire	0.00	4.26	18.12	6
Windward	6.96	1.53	2.18	11
Leeward	7.78	1.87	7.91	31
Turks and Caicos	**7.31**	**2.29**	**42.81**	**17**
Trinidad and Tobago	6.00	1.16	3.25	4
Flower Garden	5.99	3.50	3.43	34
Quintana Roo Mexico	**12.04**	**4.92**	**27.02**	**7**
Southern Hispaniola	0.92	1.04	11.25	1
Northern Hispaniola	1.68	2.86	16.88	27
			Total OBS	364

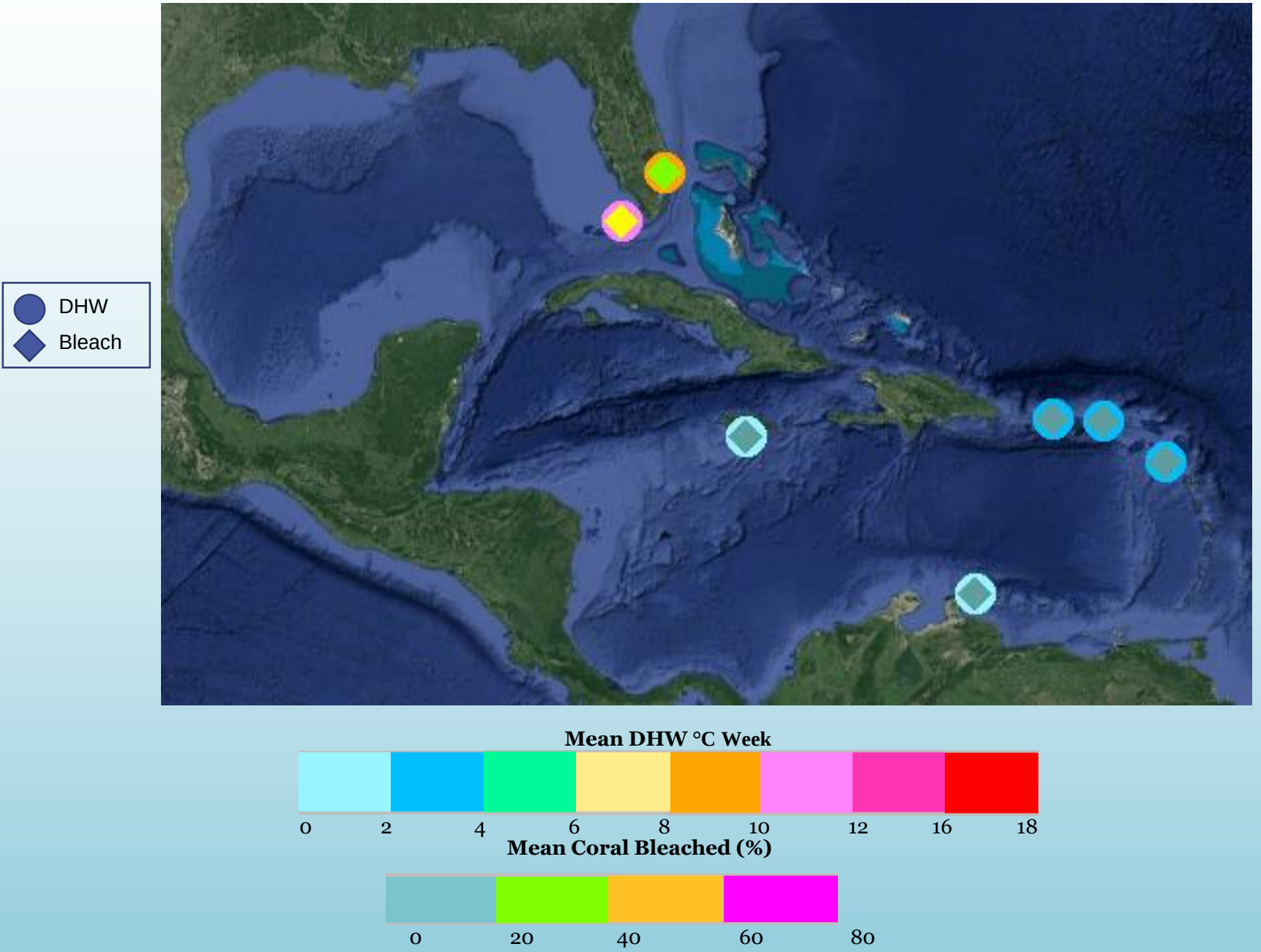
DHW Annual Maximum 2015 for the Caribbean



2016				
Virtual Stations	**DHW_Regional_ Analysis**	**DHW_Pixel_ Analysis**	**Bleached_%**	**# OBS**
Central Bahamas	3.65	3.54	1.64	4
Jamaica	3.45	0.00	0.00	6
Northwestern Cuba	5.61	0.20	13.70	15
Northeastern Cuba	1.38	0.00	13.00	4
Soutwestern Cuba	7.73	0.92	11.55	9
Southeastern Cuba	1.58	0.28	11.50	5
Florida Keys	6.01	2.31	7.65	48
Souheast Florida	**2.48**	**0.01**	**24.64**	**62**
Aruba, Curacao and Bonaire	10.22	4.79	9.17	20
Windward	7.95	1.89	4.87	1
Leeward	5.93	1.62	6.25	2
Turks and Caicos	**3.02**	**0.82**	**42.28**	**1**
Belize	**7.08**	**9.35**	**23.49**	**3**
Flower Garden	**9.69**	**6.88**	**37.20**	**4**
Quintana Roo Mexico	11.66	2.63	17.70	57
Puerto Rico	2.31	0.92	28.33	4
Bermuda	6.28	8.12	12.71	14
Yucatan Peninsula	**15.36**	**7.67**	**23.92**	**12**
			Total OBS	271

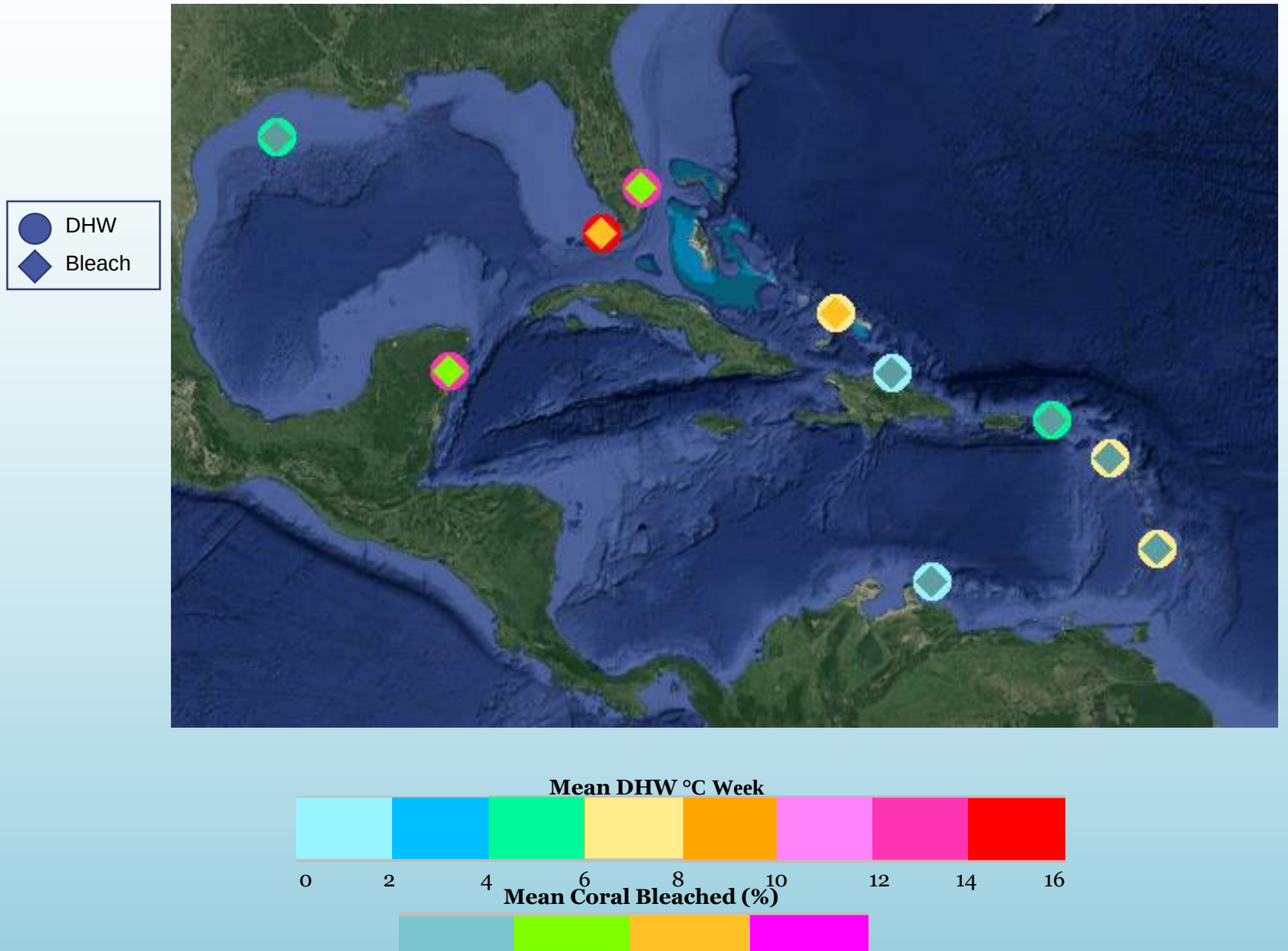
DHW Annual Maximum 2016 for the Caribbean

Thermal Stress (DHW) and Mean Coral Bleached %2014
Regional Virtual Stations



2014				
Virtual Stations	DHW Regional Analysis	DHW AVG	Bleached %	# OBS
Virgin Islands	3.86	0.30	9.6	15
Jamaica	0.31	0.15	0.56	12
Florida Keys	**13.15**	**4.92**	**49.07**	**229**
Southeast Florida	**9.70**	**1.74**	**36.52**	**116**
Aruba, Curacao and Bonaire	1.31	0.03	0.50	14
Leeward	3.75	4.44	0.06	10
Puerto Rico	3.71	0.20	0.95	8
				404

Thermal Stress (DHW) and Mean Coral Bleached % 2015
Regional Virtual Stations



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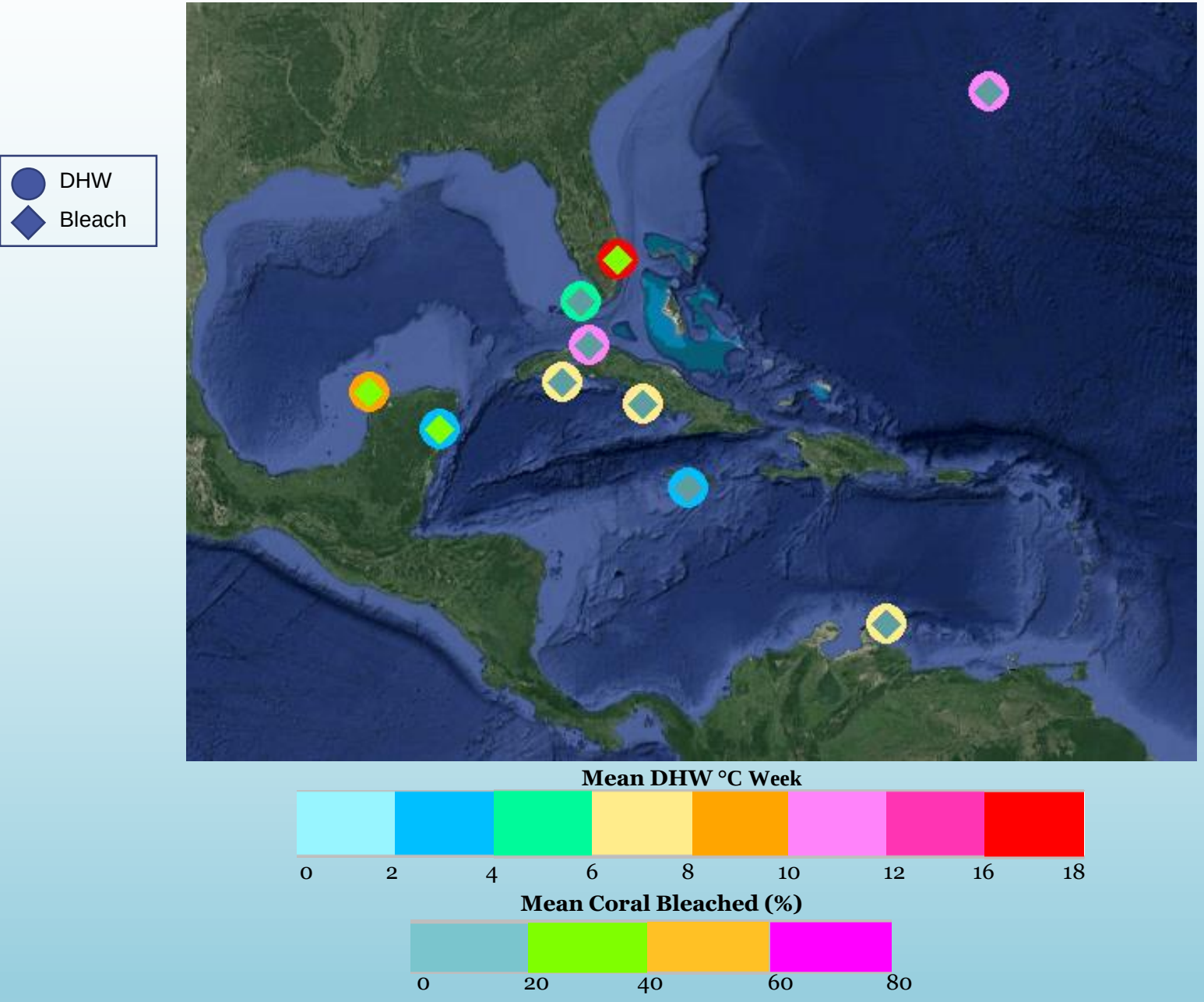
Virtual_Stations	DHW Regional Analysis	DHW AVG	Bleached %	# OBS
Virgin Islands	5.72	2.72	11.83	12
Florida Keys	**15.90**	**5.81**	**52.74**	**145**
Southeast Florida	**13.92**	**1.17**	**30.80**	**64**
Aruba, Curacao and Bonaire	0.00	4.26	18.12	6
Windward	6.96	1.53	2.18	11
Leeward	7.78	1.87	7.91	31
Turks and Caicos	**7.31**	**2.29**	**42.81**	**17**
Flower Garden	5.99	3.50	3.43	34
Quintana Roo Mexico	**12.04**	**4.92**	**27.02**	**7**
Northern Hispaniola	1.68	2.86	16.88	27
Southwestern Cuba	7.72	0.9166	5.5	9
			Total OBS	363

Thermal Stress (DHW) and Mean Coral Bleached % 2016
Regional Virtual Stations



2016				
Virtual Stations	**DHW Regional Analysis**	**DHW AVG**	**Bleached %**	**# OBS**
Jamaica	3.45	0.00	0.00	6
Northwestern Cuba	**5.61**	**0.20**	**13.70**	15
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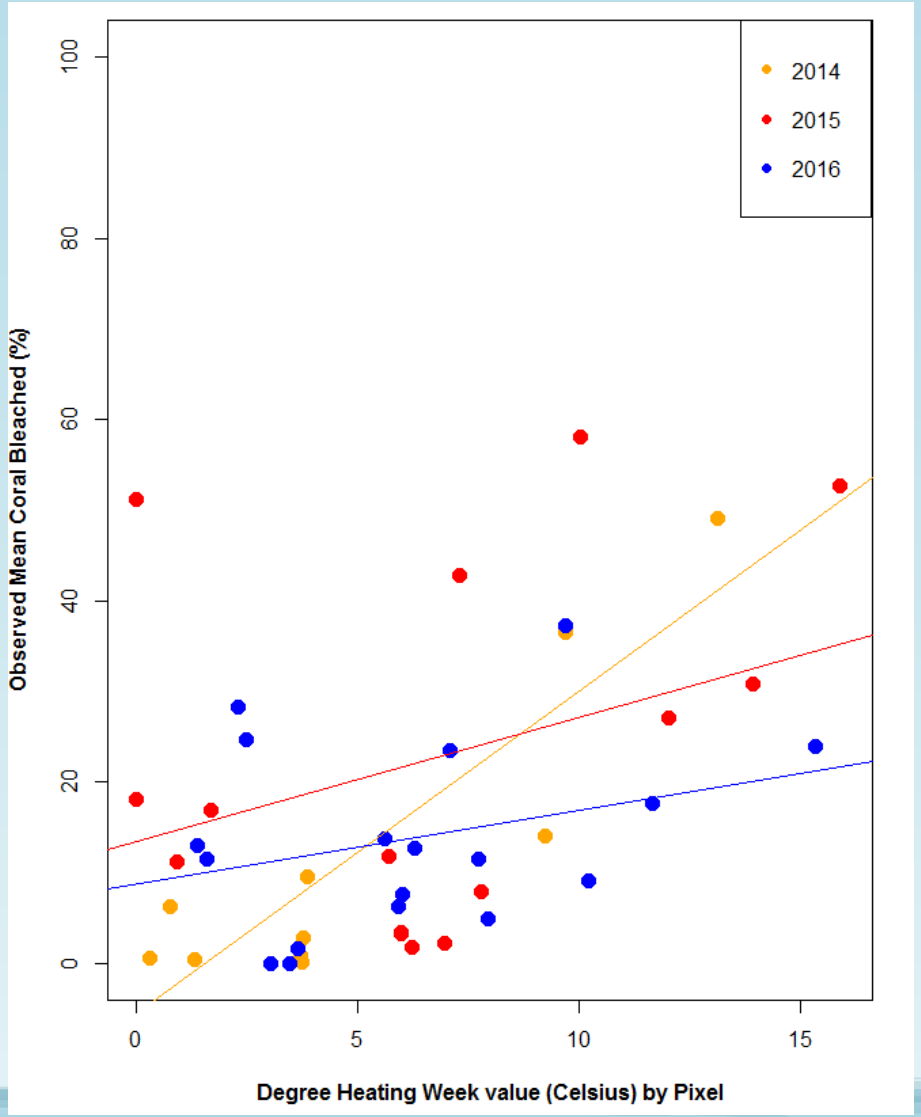
Yucatan Peninsula	**15.36**	**7.67**	**23.92**	**12**
				248

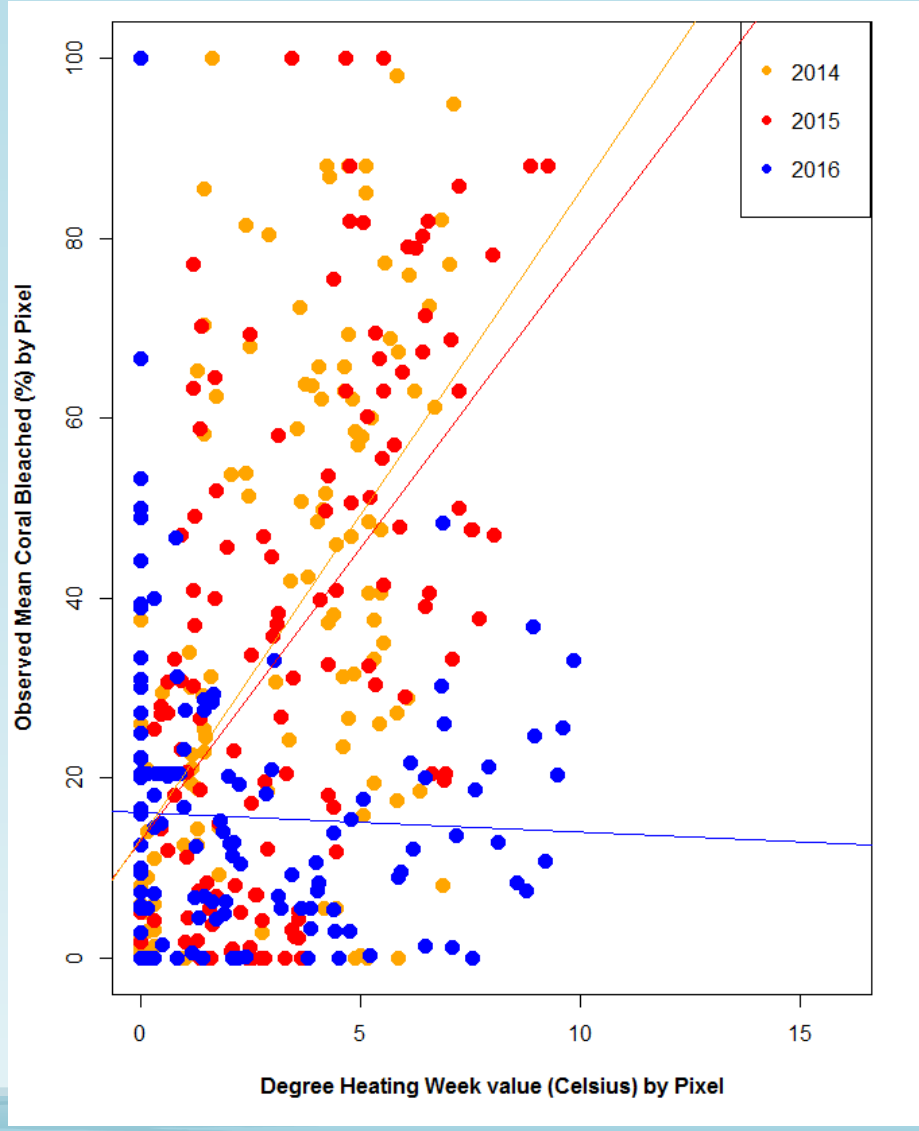
Regional Virtual Stations Analysis 2014, 2015, 2016



2014: p= 0.000508 , R-squared: 0.7969
2015: p= 0.227, R-squared: 0.1101
2016: p= 0.2290, R-squared: 0.08908

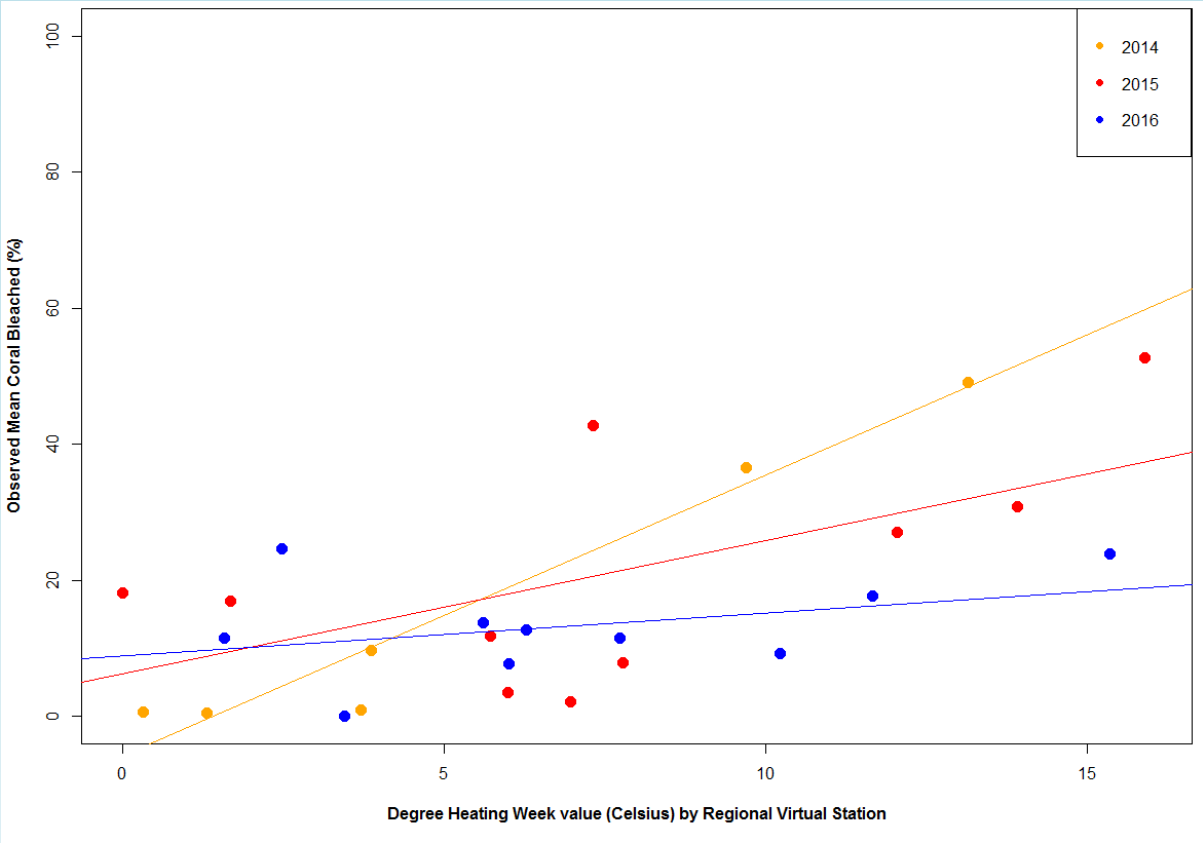
Before removing the Virtual Stations with less than 5 observations

Pixel Analysis (5x5 Km) 2014, 2015, 2016



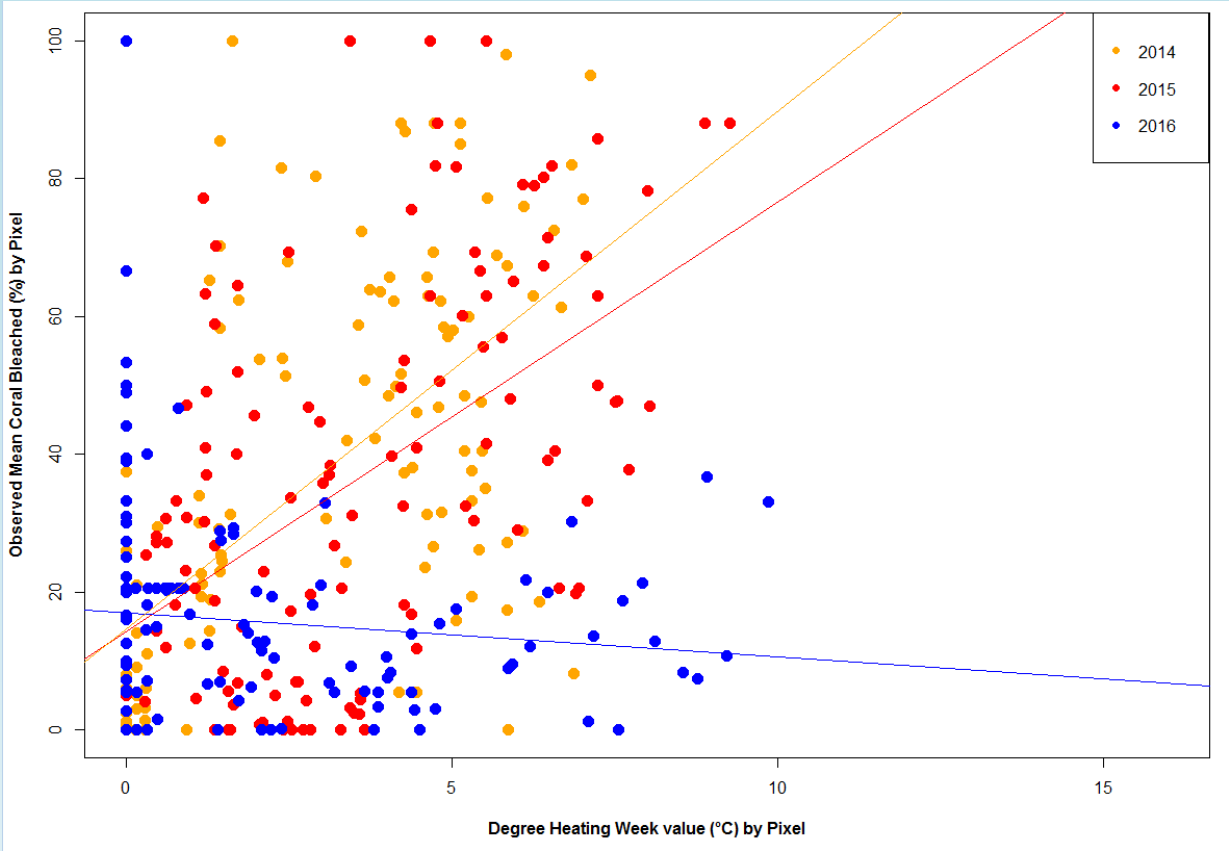
2014: p= 1.11 e-12 , R-squared: 0.3157
2015: p= 6.14e-11, R-squared: 0.285
2016: p= 0.637, R-squared: 0.2243

Regional Virtual Stations Analysis 2014, 2015, 2016



2014: p= 0.000835 , R-squared: 0.9532
2015: p= 0.0755, R-squared: 0.3426
2016: p= 0.2967, R-squared: 0.1348

Pixel Analysis (5x5 Km) 2014, 2015, 2016



2014: p= 8.85 e-14 , R-squared: 0.3625
2015: p= 1.62 e-9, R-squared: 0.2606
2016: p= 0.224, R-squared: 0.01198

Summary

2014 : Florida got the higher DHW and highest bleaching.

2015 : Florida, Turks and Caicos, and Quintana Roo Mexico got the highest DHW and high bleaching.

2016: Northwestern Cuba, Southeast Florida, Yucatan Peninsula and Quintana Roo got the higher DHW and high bleaching.

Satellite remote sensing observations are an important tool for coral reef managers, divers and scientist.

Photo By: Ken Marks,
Source: **Mesoamerican Reefs Report Card**

Thank You