Pacific Islands Land-Ocean Typhoon Experiment (PILOT)

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and

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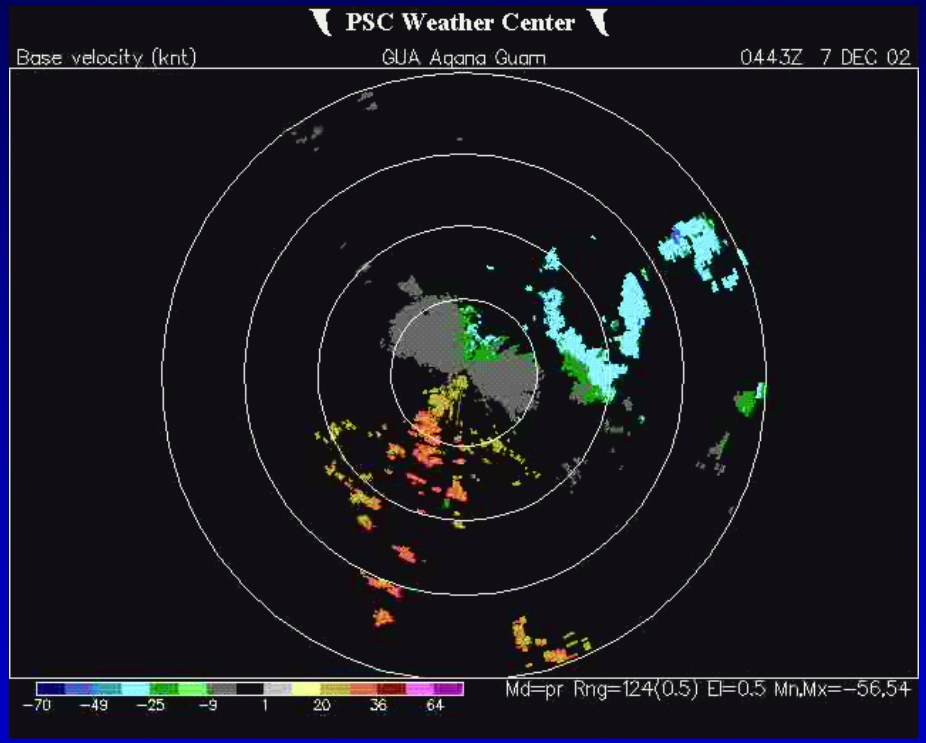
CHL-ERDC

October 2009



Presentation for 11th *International Workshop on Wave Hindcasting and Forecasting*

Pacific Islands Land-Ocean Typhoon Experiment (PILOT)

- **Motivation**

  Past studies (FEMA & USACE) concluded that tropical cyclone response and mitigation measures developed for U.S. mainland populations often are ineffective or inappropriate for island environs.

Island of Guam

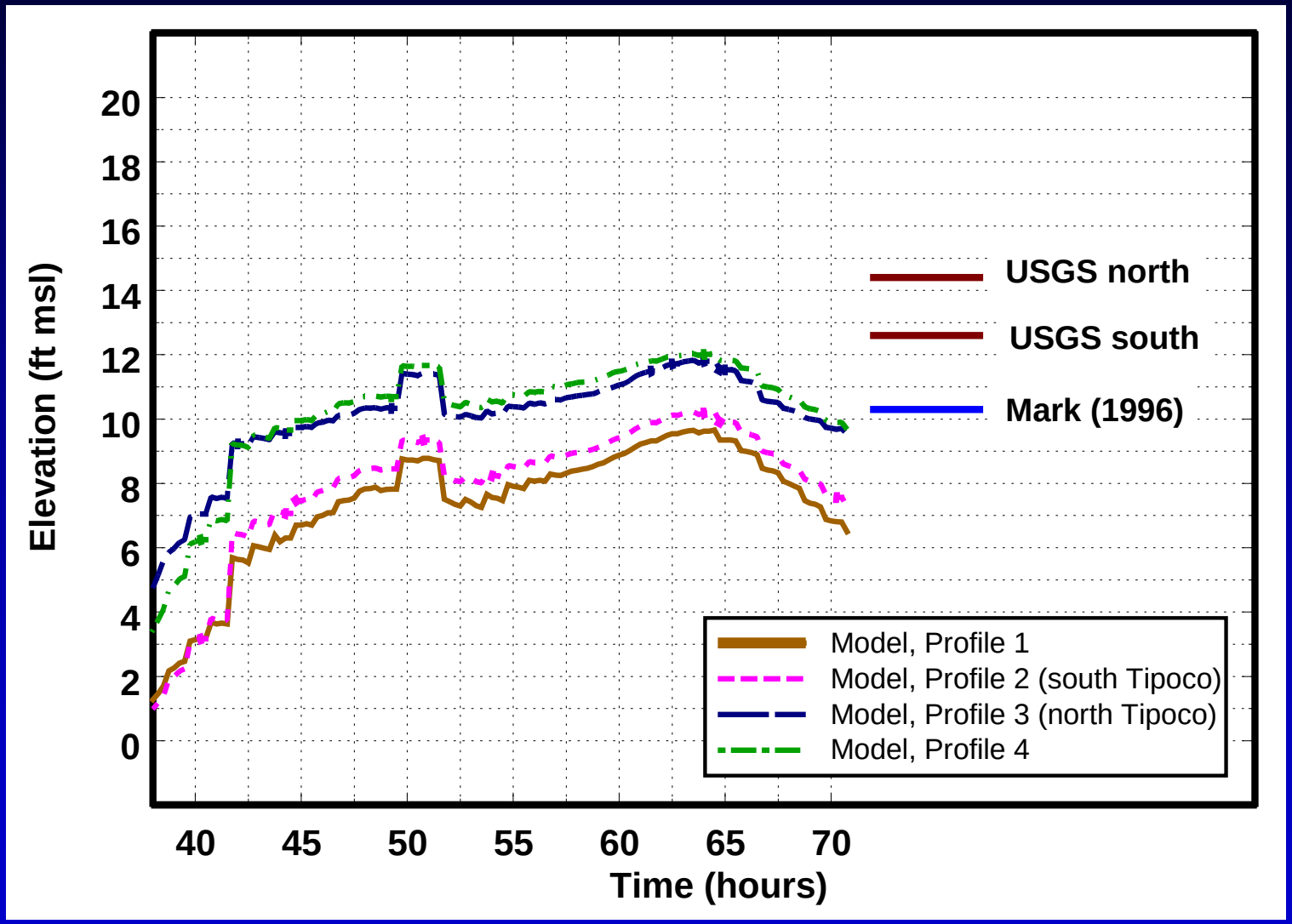
Pacific Islands Land-Ocean Typhoon Experiment (PILOT)

Motivation

Island Cyclone Preparedness Issues (*Islands Task Force Report,* Dec. 2001, Interagency Coordinating Committee on Hurricanes)

- **Cultural, Behavioral, and Special Population Issues**
- ***Wind, Waves, Water Levels, and Hazard Vulnerability Issues***
- **Public Shelter Issues**
- **Transportation Issues**

Inundation, Inarajan Coast, Typhoon Russ



Pacific Islands Land-Ocean Typhoon Experiment (PILOT)
&
Surge & Wave Island Modeling Studies (SWIMS)

Methodology:

- **To acquire coastal hydrodynamic and meteorologic data under cyclone and high- wind conditions in island environments and understand the engineering characteristics of the reef structure (FY09).**
- **To use these data to better understand the physics of coastal waves, water levels, and low-level winds in these environments.**
- **To incorporate this understanding toward improved analytic and computer-aided models for application to cyclone hazard mitigation studies.**
- **To contribute these results to improved *emergency management* tools and procedures for islands.**

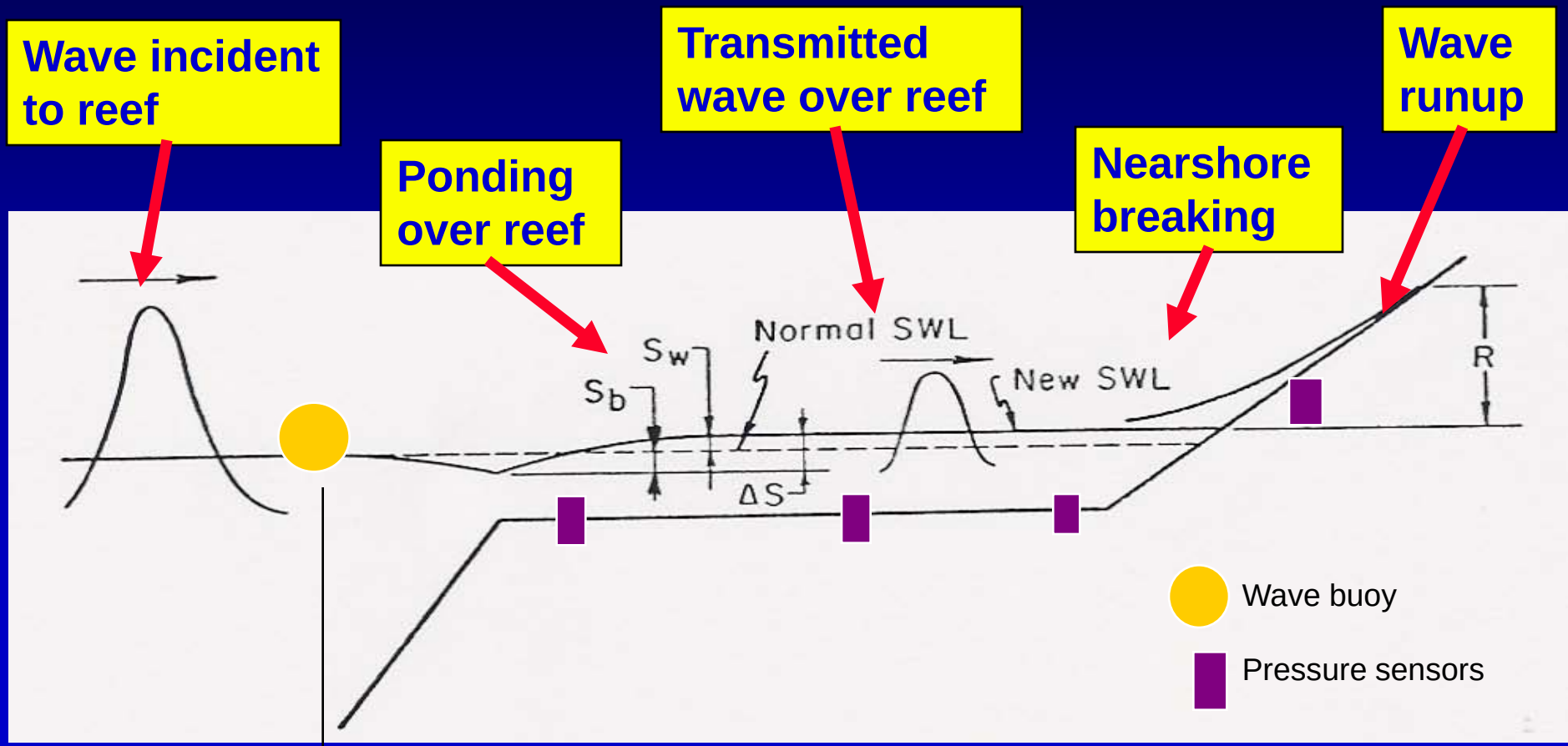
Summary

- Two wave events were recorded in the St Croix deployment of Sea-Bird
- The first event occurred 30 Sep – 1 Oct 2008, with incident large swell and low wind speeds (~7 mph E-ENE) measured at the St Croix airport. Incident wave heights peaked at 2.7m with peak periods of approximately 15 s, and directions from 47 degrees (compass direction from true north) Mean water level (setup/surge) was about 0.2 m above normal.
- A sample of the time series for the cross-shore gauges near the storm peak shows a dominance of infragravity energy (periods > 20s, frequencies < 0.05 Hz), increasing towards shore. Incident wave amplitudes have nearly disappeared at the shoreward most gauge.

SUMMARY

- The second event occurred with the passing of Hurricane Omar on 16 October 2008. Incident waves (wind seas) peaked at 4.4m with peak period near 8 seconds and directions from about 36 degrees. The incident waves were substantially higher, 4.4m vs 2.7m, the peak wave heights over the reef were lower, 0.55m vs 0.72m. Surge and setup were similar and only about 0.2 m
- A sample of time series near the peak of the storm shows that infragravity waves were not as obvious in the time series as during the swell event since the incident wind-wave periods were not as fully dissipated. Time series from the shoreward most gauge (#1) does have a long-period component about 100s.

Wave Measurements Over Reef & Beach



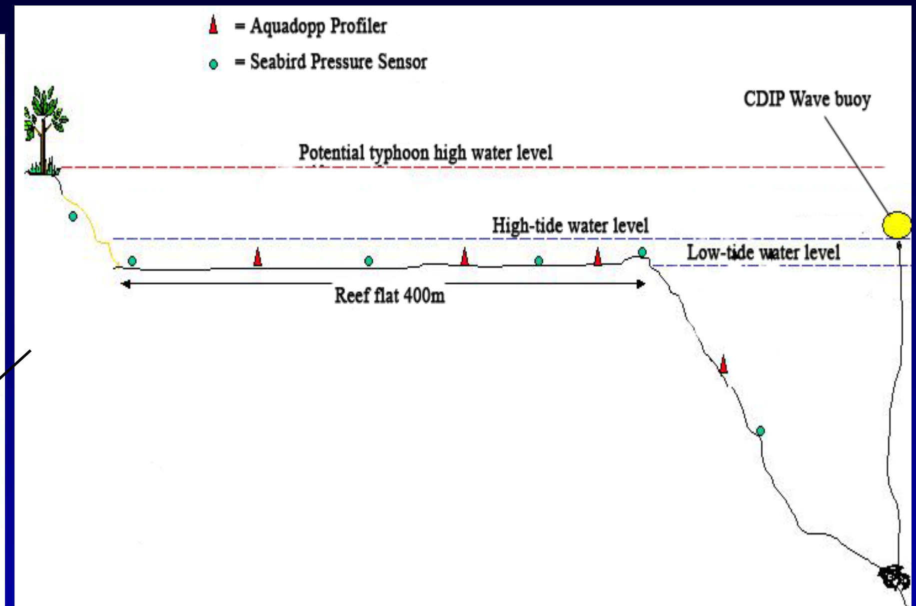
PILOT Ongoing Field Activities

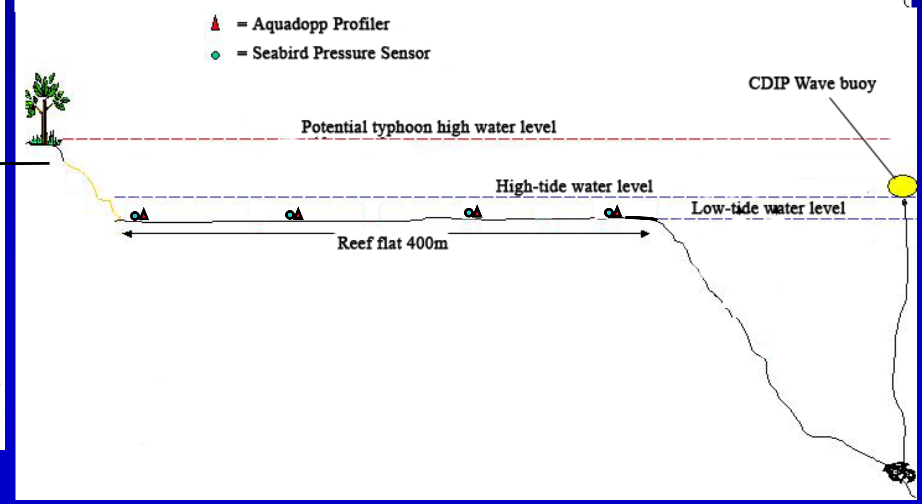
Field Sites

- **Guam**
  - Ipan Reef
- **Oahu, Hawaii**
  - Mokuleia (complete)
- **St. Croix, VI**
  - Pelican Bay
  - Great Salt Pond

Ipan, Guam


Philippine Sea
NORTH
PACIFIC
OCEAN
Guam
(UNITED STATES)
Capital
Road
5 Kilometers
5 Miles
PHILIPPINES
INDONESIA
JAPAN
CHINA
Agana
Andersen Air Force Base
Dededo
Yigo
Talofofo
Yona
Inarajan
Merizo
Umatac
Agat
Santa Rita
Apra Harbor
Orote Point
Cocos Island
Ritidian Point
Pati Point
Pagat Point


= Aquadopp Profiler
= Seabird Pressure Sensor
CDIP Wave buoy
Potential typhoon high water level
High-tide water level
Low-tide water level
Reef flat 400m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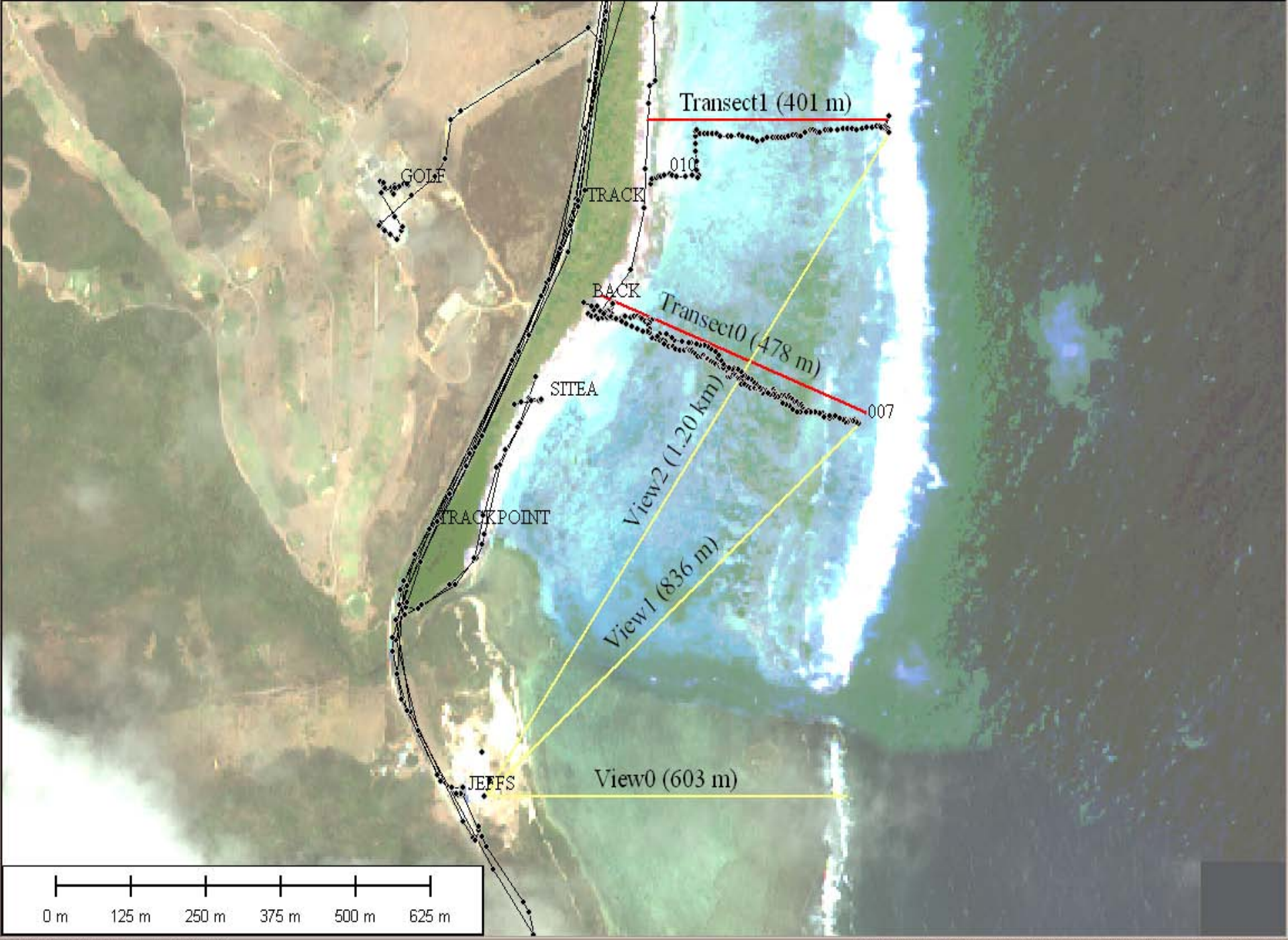


RGB(202,187,160) (GUAM_MOSAIC.IMG)

UTM (WGS84) - (258137.49, 1479254.26) | 13° 22' 15.60" N, 144° 46' 00.45" E

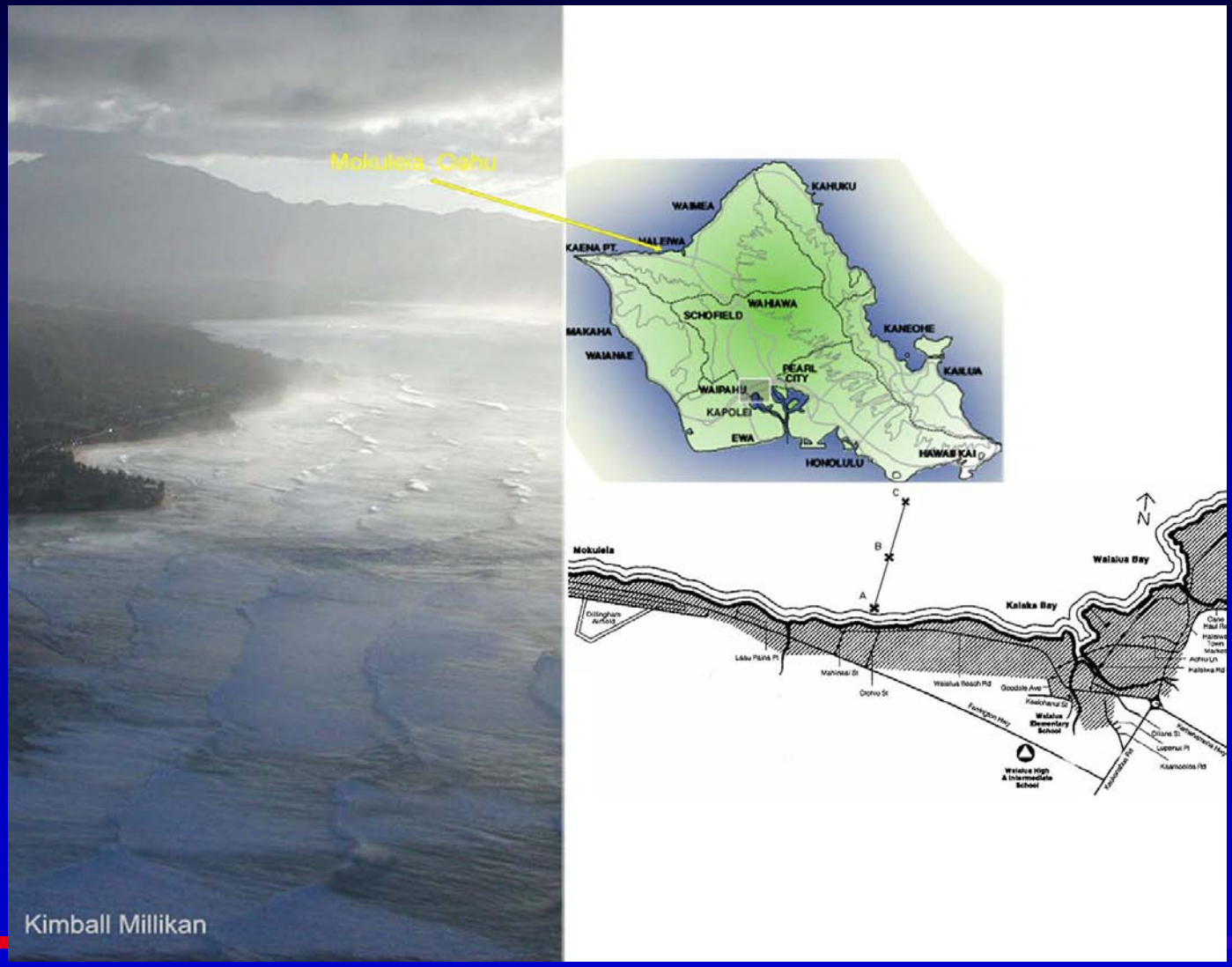
- **Data collection methodology includes:**
  - Hydrodynamic conditions
    - Offshore directional wave-buoy in 200m depth
    - 10 SEABIRD 26+ pressure sensors
    - 8 Aquadopp current profilers (combined)
  - Topography/ Bathymetry
    - SHOALS surveys
  - NOAA waterlevel/meterological station
  - Video acquisition data
    - Real-time video feed via internet to give up to date visual wave and flooding conditions

Notable Results, Guam

- **100% Data record**
- **Reefs are HUGE wave absorbers!**
- **Super Typhoon Man-Yi**
  - In early July 2007, Typhoon Man-Yi (also referred to as Man-Li and Bebeng), passed within 200 nautical miles southwest of Guam as a tropical storm, with the greatest intensity of the storm felt at Guam on 9 July 2007. This storm produced winds gusts reached 20 m/sec and a maximum recorded wave height at the deep-water directional wave gage at the Ipan site of 11.83 m.

Calm Day/Typhoon Man-Yi

Hawaii Study Location – Mokuleia, Aweoweo Beach Park



Hawaii Study Location – Aweoweo Beach Park

- Large Waves, High Winds
- Wide Reef = Good Measurements
- Significant Wave Setup

Notable Results, Hawaii

- The steep reef face and shallow reef flat cause wave energy to reduce by 94 % within 40 m of the reef edge for observed wave heights as large as 2.5 m. Almost zero incident swell energy is propagated to the nearshore.
- Setup is highly correlated with the incident significant wave height (0.97), and setup amplitudes scale at 0.35-0.39 times Hsig measured off the reef in 10m depth
- Comparisons between surface elevation spectra from on (D5) and off (D9) the reef show an increase in the infragravity to sub-infragravity band ($1 \times 10^{-4} < f < 1 \times 10^{-2}$ Hz) energy. The increase of infragravity and the absence of swell-band energy on the reef during offshore swell-wave events, suggest that infragravity energy is generated on the reef in a similar manner to lower frequency setup. The infragravity and sub-infragravity energy appears to be bound to the incoming swell groups; however, fluctuations in this band are 180 degrees out of phase with those on the reef.

Virgin Islands

- **St. Croix**
  - North Shore
  - Northern exposure
  - Narrower reef
  - SHOALS survey
  - New site (South shore – Great Salt Pond)

St. Croix, Virgin Islands


Waverider
Sea-Bird Gauges
Christiansted, US Virgin Islands US Vir

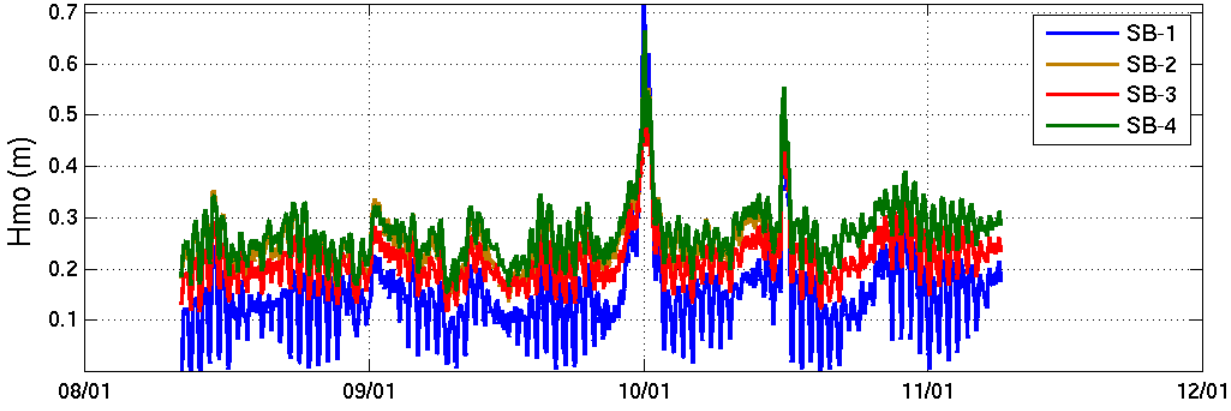
Pelican Bay

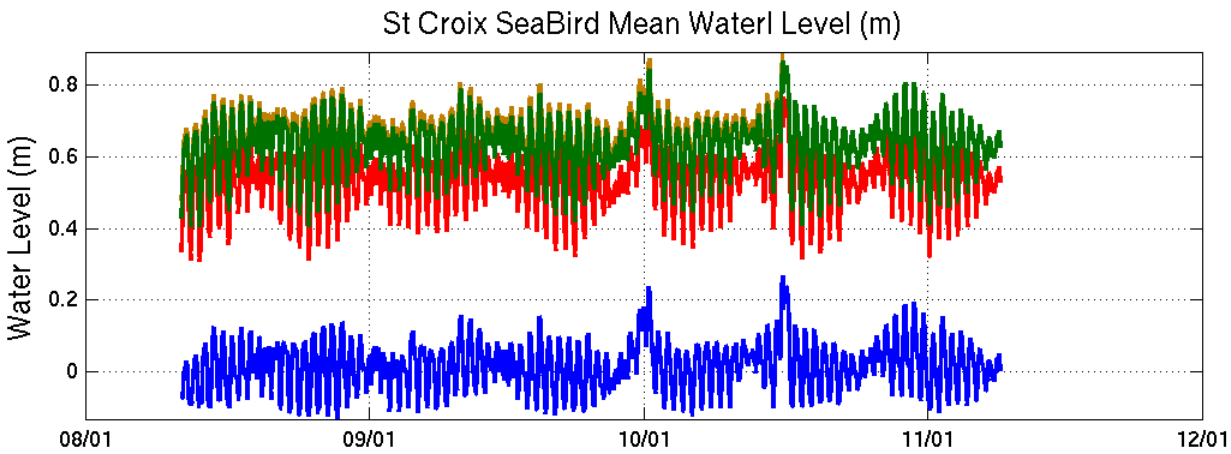
Two wave events

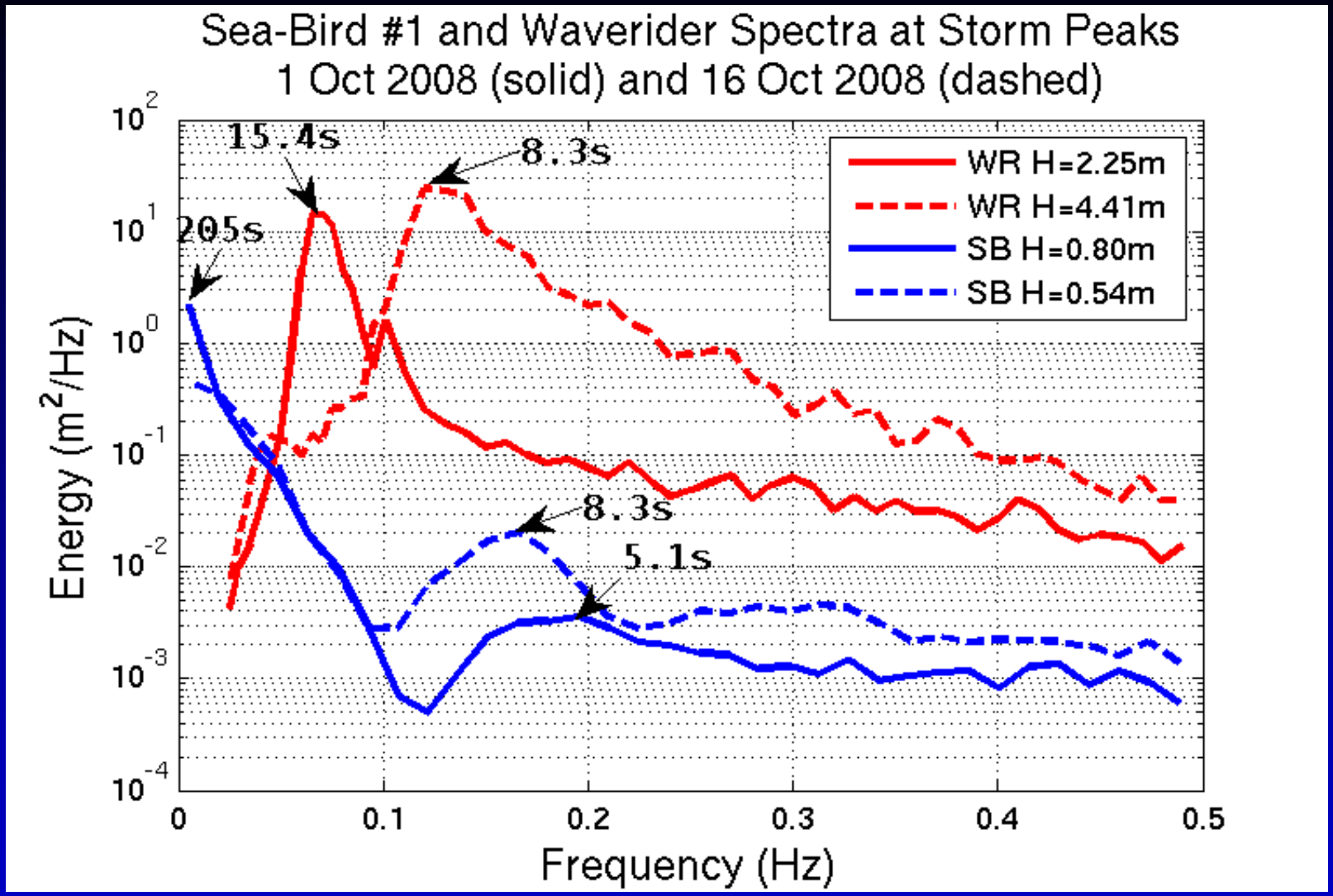
- The first event occurred 30 Sep – 1 Oct 2008, with large swell recorded at the offshore Waverider and low wind speeds (~7 mph E-ENE) measured at the St Croix airport. Incident wave heights peaked at 2.7m with peak periods of approximately 15 s, and directions from 47 degrees. Mean water level (setup/surge) was about 0.2 m above normal.

- The second event occurred with the passing of Hurricane Omar on 16 October 2008. Incident waves (wind seas) peaked at 4.4m with peak period near 8 seconds and directions from about 36 degrees. It is interesting to compare these storm waves to previous swell event. Although the incident waves were substantially higher, 4.4m vs 2.7m, the peak wave heights over the reef were lower, 0.55m vs 0.72m. Surge and setup were similar and only about about 0.2 m

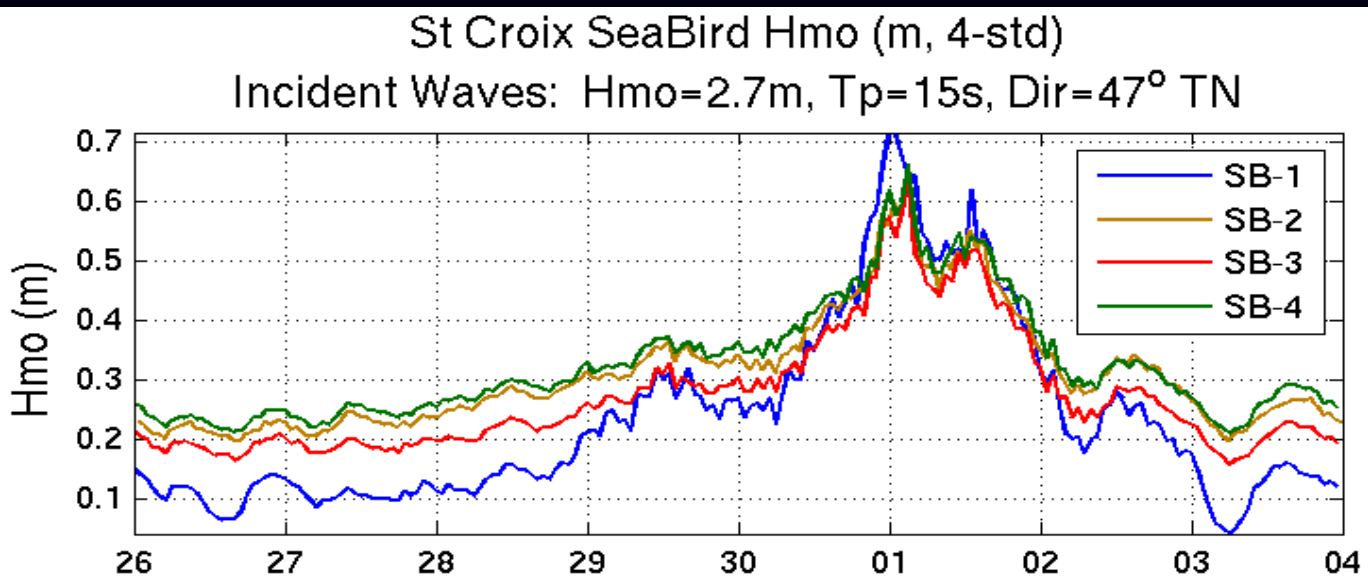
Two wave events

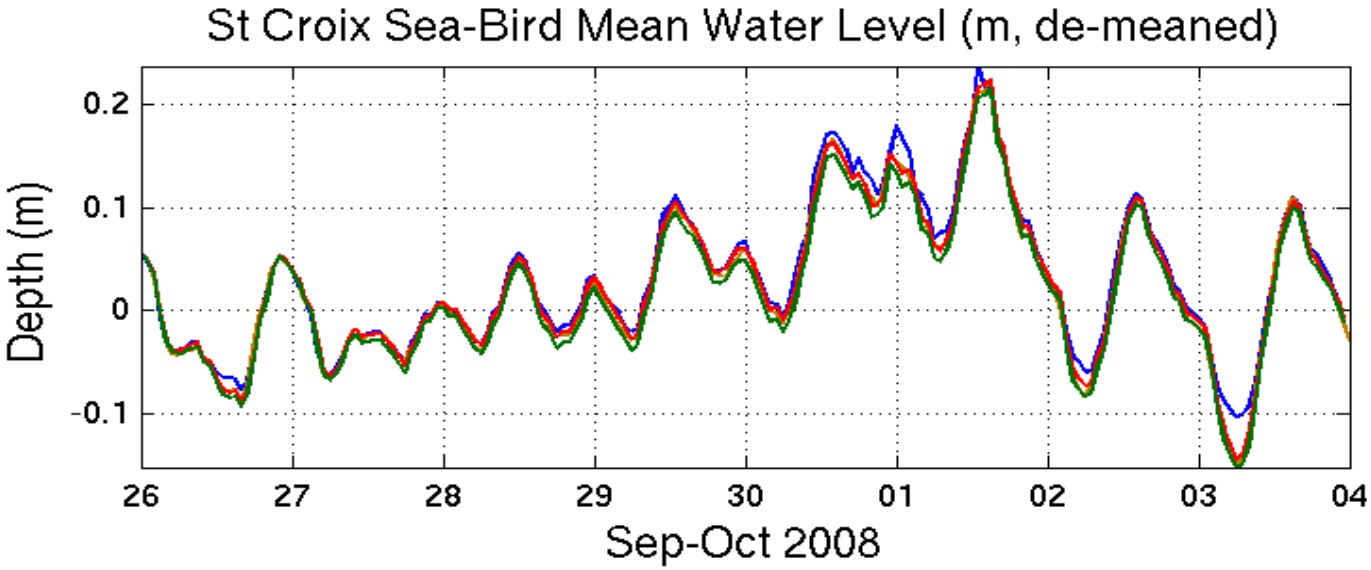


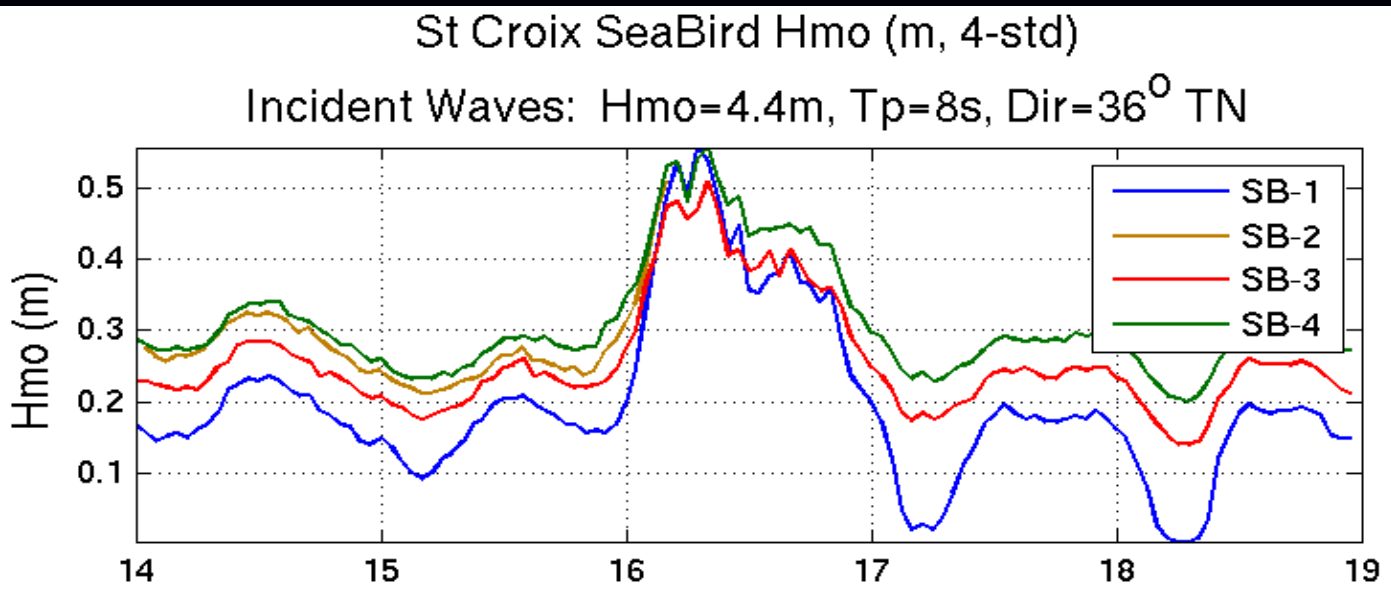


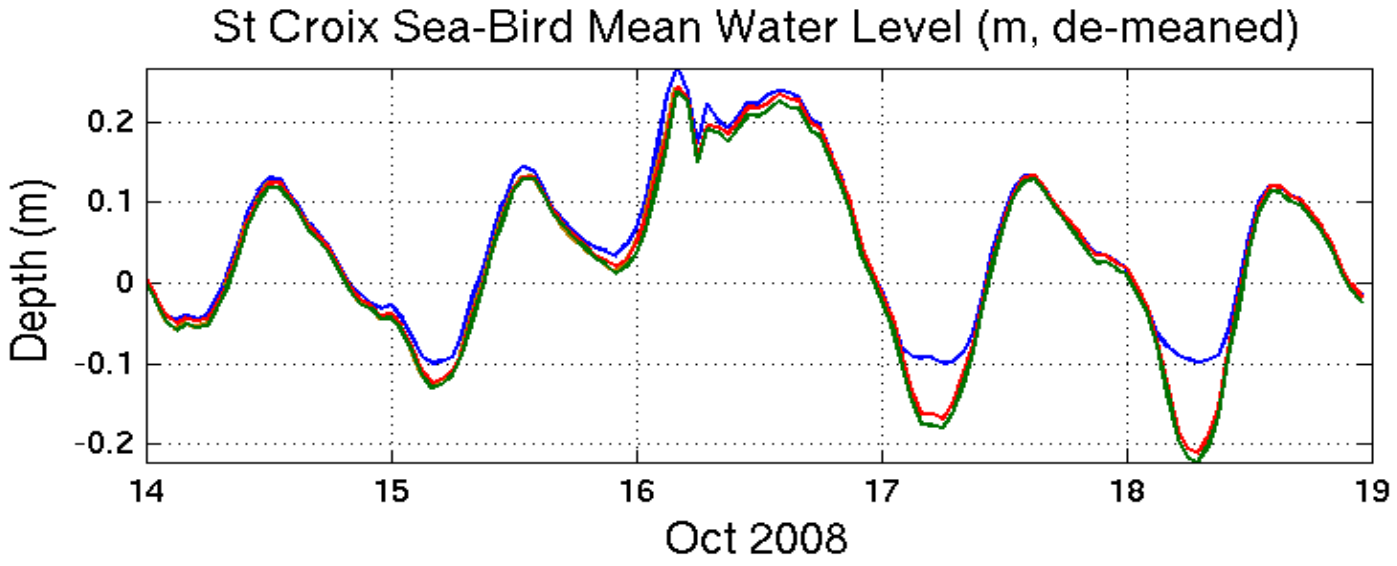


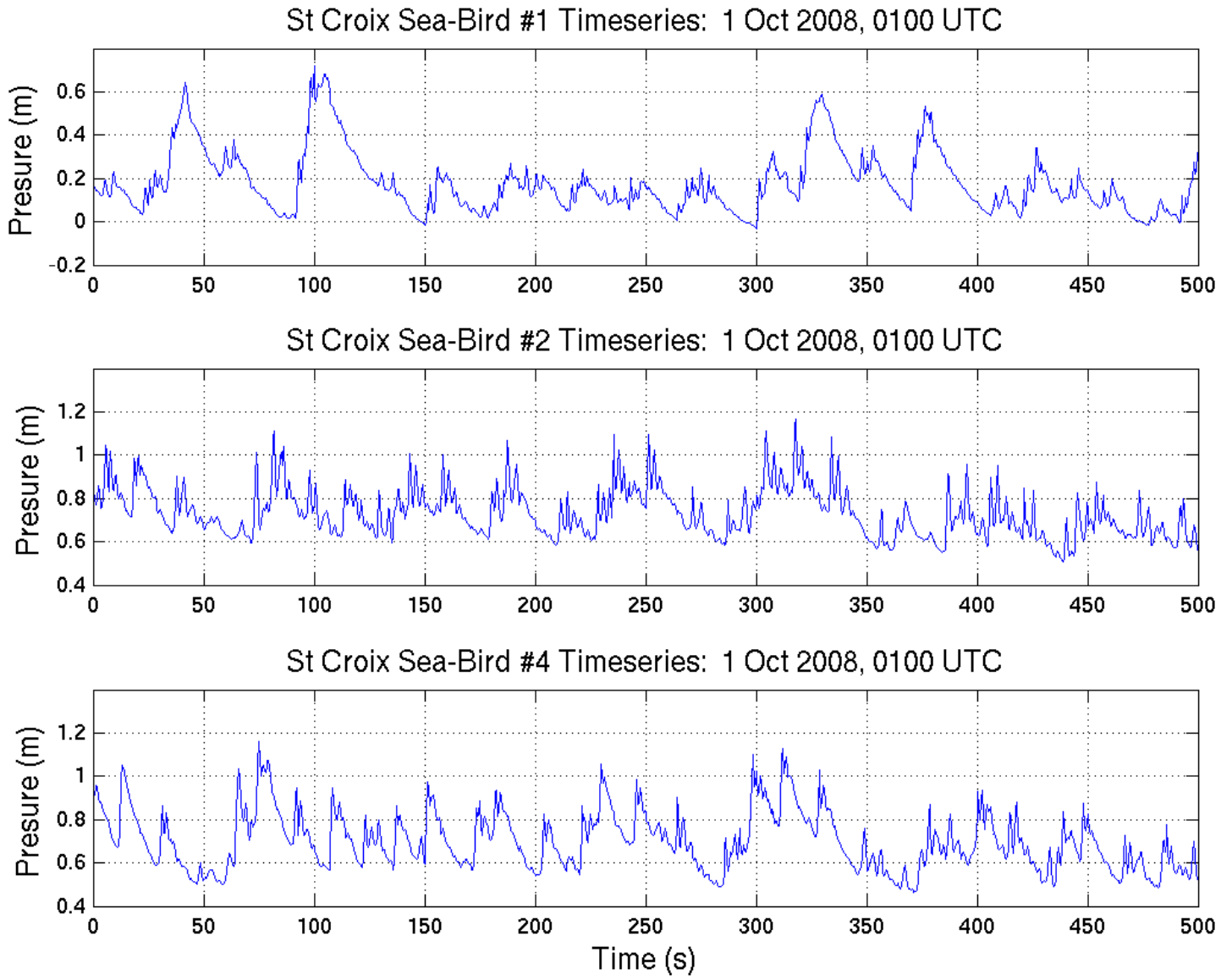
It is interesting to see the Sea-Bird spectra show little energy of the peak incident wave frequencies. There may be possible harmonic peaks of the incident peak frequency.

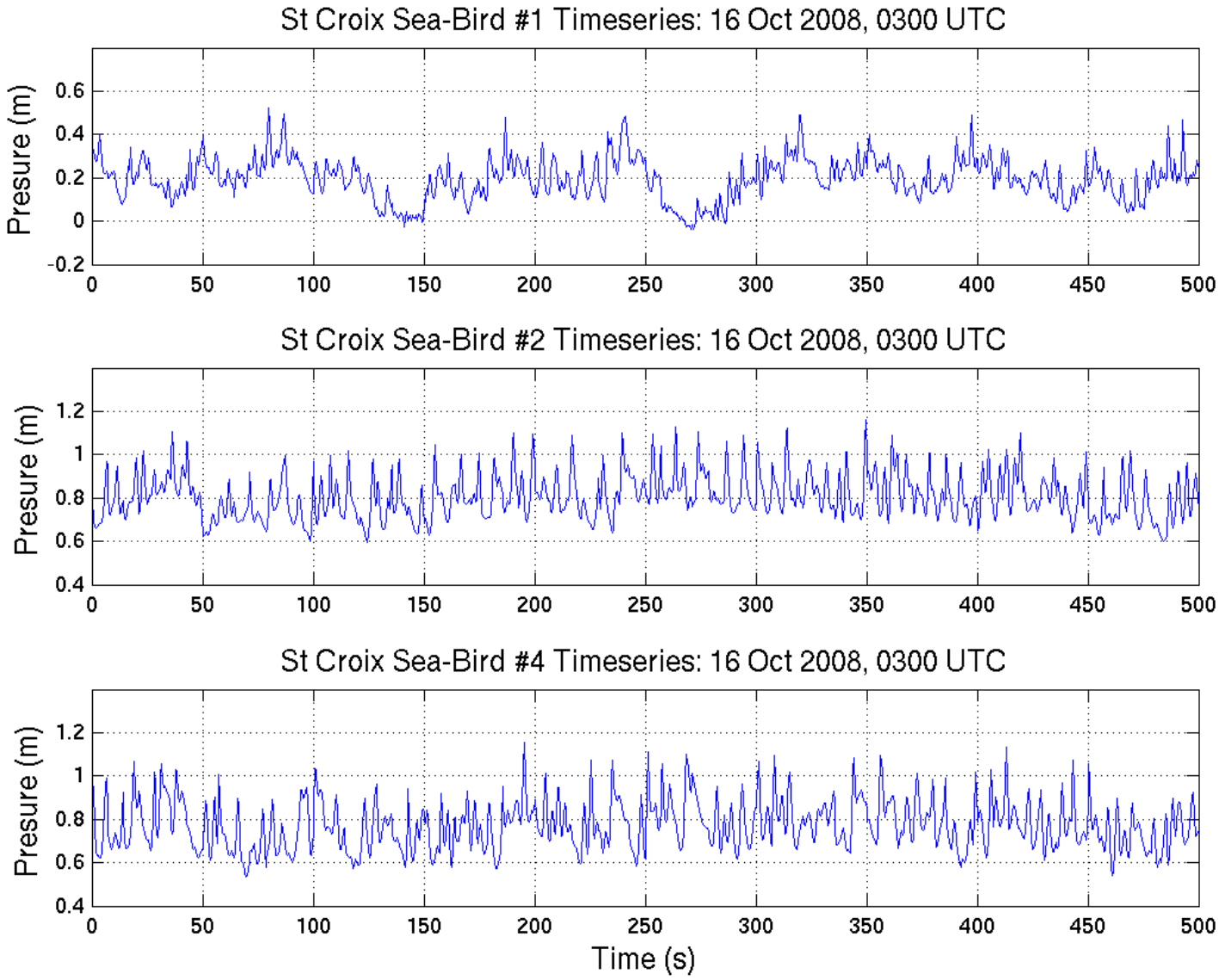

St Croix SeaBird Hmo (m, 4-std)
Incident Waves: Hmo=2.7m, Tp=15s, Dir=47° TN
Hmo (m)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
SB-1
SB-2
SB-3
SB-4
26
27
28
29
30
01
02
03
04

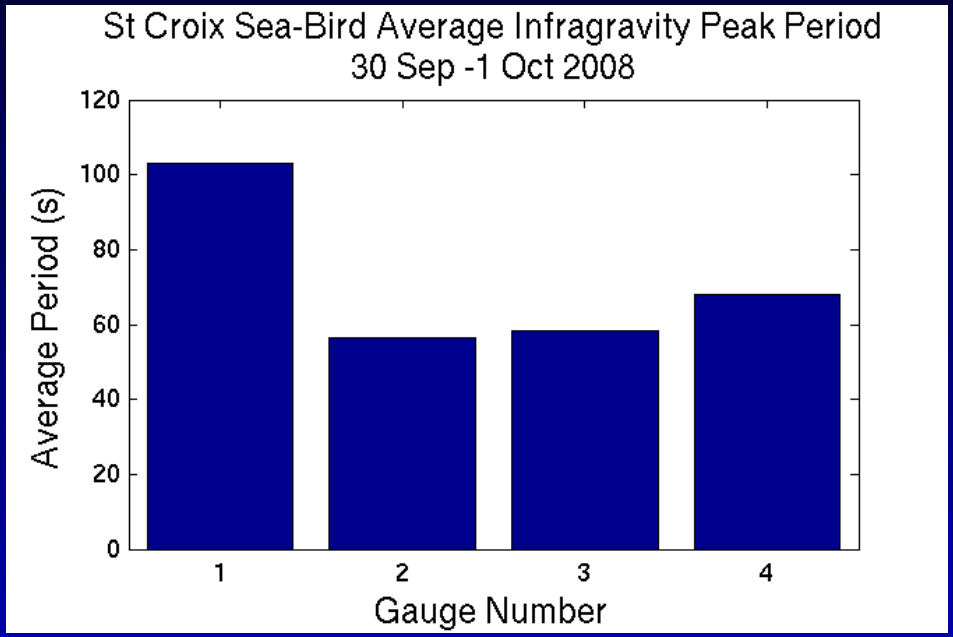

St Croix Sea-Bird Mean Water Level (m, de-meaned)
Depth (m)
0.2
0.1
0
-0.1
26
27
28
29
30
01
02
03
04
Sep-Oct 2008

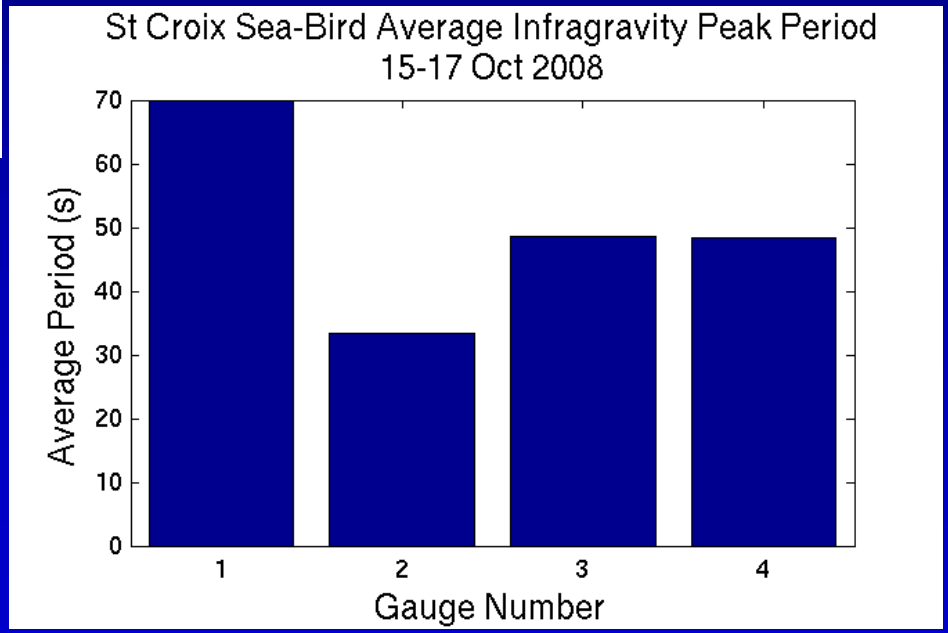

St Croix SeaBird Hmo (m, 4-std)
Incident Waves: Hmo=4.4m, Tp=8s, Dir=36° TN
Hmo (m)
0.5
0.4
0.3
0.2
0.1
14
15
16
17
18
19
SB-1
SB-2
SB-3
SB-4

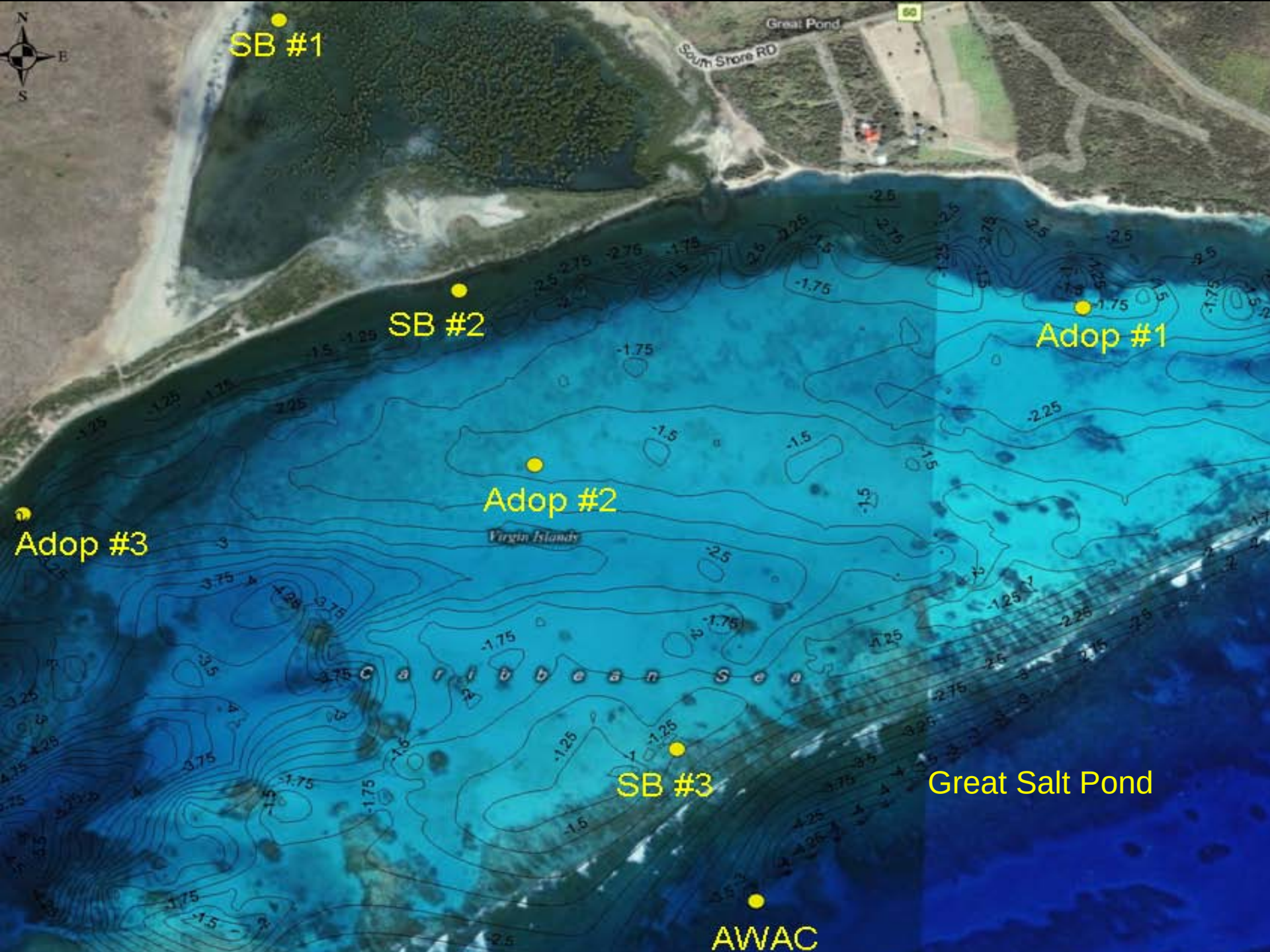

St Croix Sea-Bird Mean Water Level (m, de-meaned)
Depth (m)
0.2
0.1
0
-0.1
-0.2
14
15
16
17
18
19
Oct 2008


St Croix Sea-Bird #1 Timeseries: 1 Oct 2008, 0100 UTC
Presure (m)
0.6
0.4
0.2
0
-0.2
0
50
100
150
200
250
300
350
400
450
500
St Croix Sea-Bird #2 Timeseries: 1 Oct 2008, 0100 UTC
Presure (m)
1.2
1
0.8
0.6
0.4
St Croix Sea-Bird #4 Timeseries: 1 Oct 2008, 0100 UTC
Presure (m)
Time (s)


St Croix Sea-Bird #1 Timeseries: 16 Oct 2008, 0300 UTC
Presure (m)
0.6
0.4
0.2
0
-0.2
0
50
100
150
200
250
300
350
400
450
500
St Croix Sea-Bird #2 Timeseries: 16 Oct 2008, 0300 UTC
Presure (m)
1.2
1
0.8
0.6
0.4
0
50
100
150
200
250
300
350
400
450
500
St Croix Sea-Bird #4 Timeseries: 16 Oct 2008, 0300 UTC
Presure (m)
1.2
1
0.8
0.6
0.4
0
50
100
150
200
250
300
350
400
450
500
Time (s)


St Croix Sea-Bird Average Infragravity Peak Period
30 Sep -1 Oct 2008
Average Period (s)
120
100
80
60
40
20
0
1
2
3
4
Gauge Number

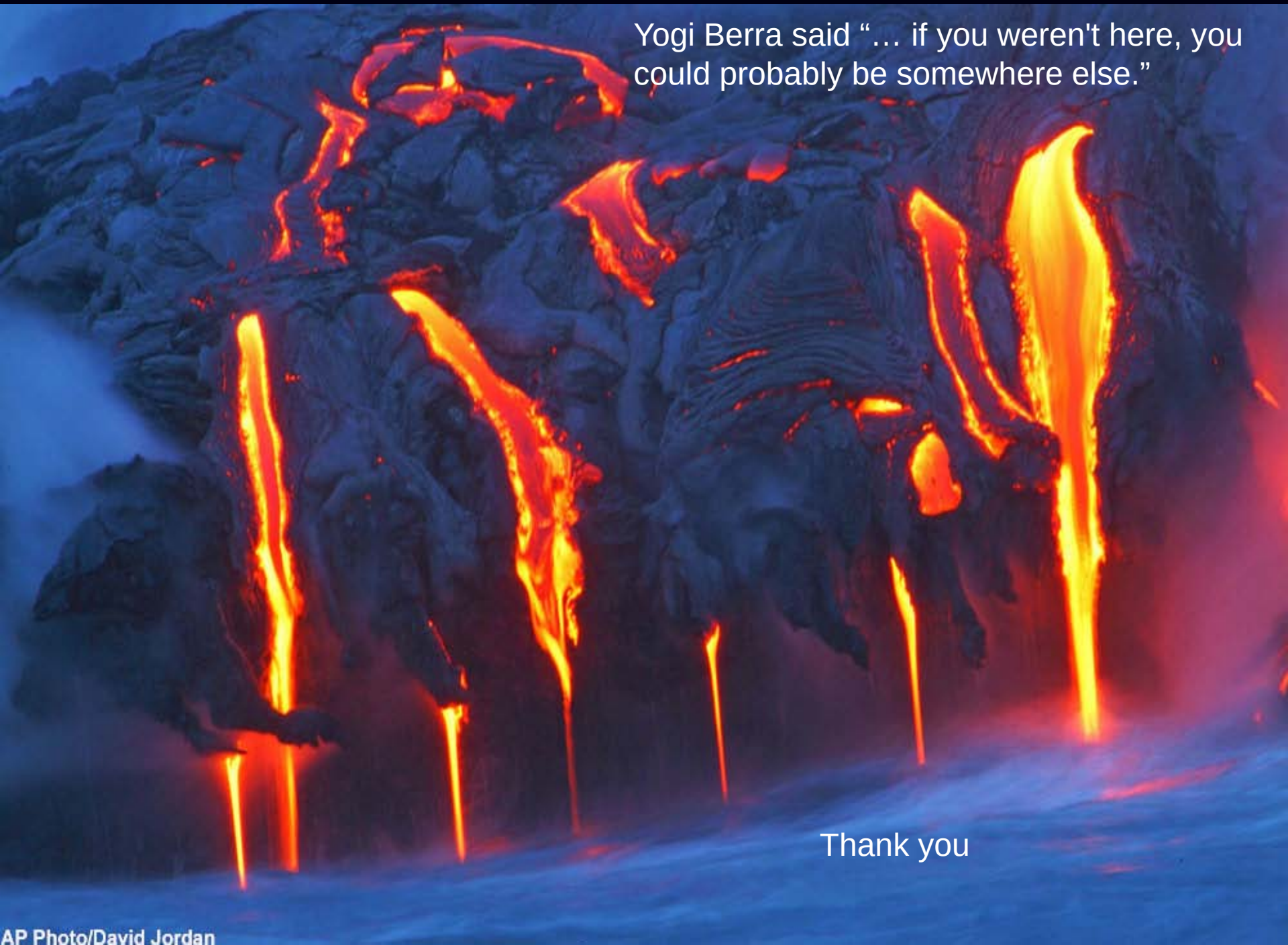

St Croix Sea-Bird Average Infragravity Peak Period
15-17 Oct 2008
Average Period (s)
70
60
50
40
30
20
10
0
1
2
3
4
Gauge Number


SB #1
SB #2
Adop #1
Adop #2
Adop #3
SB #3
AWAC
Great Salt Pond
Great Pond
South Shore RD
Caribbean Sea
Virgin Islands

Coordination/Partnering

- NOAA
- NWS
- USGS
- University of Hawaii
- PRIMO (Pacific Risk Management Ohana
- University of Guam
- SCRIPPS
- PAC IOOS

Need to understand the importance of the reef structure .


Yogi Berra said “… if you weren't here, you could probably be somewhere else.”
Thank you
AP Photo/David Jordan