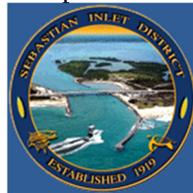


Sebastian Inlet District Oceanographic and Meteorological Monitoring Program

2020 – 2021

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Executive Summary

Currents, wave and weather data recorded between 2020 and the close of 2021 are presented in this report. Visualization of the data time series are presented along with statistical measures over longer term and shorter time intervals. The functioning of the monitoring system in terms of data flow routes and archiving of data over the long term are presented. Links between the local coastal sea level measured at Sebastian Inlet and the basin scale Gulf Stream flow are presented to illustrate the source variability in some data sets. Maintenance tasks and equipment replacement items are discussed for the monitoring period. Monitoring data are archived by year on the Florida Tech Coastal Drive, which is accessible to the public through a login procedure that is protected by a login authorization process. The entire long-term monitoring data set is assembled into a series of MATLAB data files that are organized according data type and parameter. The MATLAB file database can be interrogated by standard or customized scripts to extract and plot data.

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Acknowledgments

We would like to thank the Sebastian Inlet District for their support of long-term monitoring.

1 Introduction

The monitoring network at the Sebastian Inlet includes a meteorological station situated on the north jetty and two nearshore acoustic Doppler current profiler (ADCPs) gauges located approximately 0.5 km north of the inlet in approximately 8 m of water depth. An additional ADCP was deployed in October 2021 within the main conveyance channel of Sebastian Inlet between the AIA bridge and the Sebastian Inlet sand trap. Data from this network serves a diverse audience. Data collected via the ADCPs includes information about currents, waves, water temperature and water level. The real time meteorological station data includes wind direction, wind speed, barometric pressure, air temperature, sea surface temperature and water level. The water level gauge is referenced to the NAVD88 vertical datum. These data are used to calibrate the ongoing coastal processes model used in regional sediment management of the central Florida coast by the Sebastian Inlet District. Real time data for the ADCP that serve as a wave sensor was established in 2012 and provides a resource for the navigation through the narrow throat of the Inlet, which can be difficult under certain wave conditions. An additional resource for inlet safety and navigations is a real time coastal processes model based on the Deltares Delft3D modeling system. This resource provides predicted water level and currents as much as 3-days in advance. In combination with 72-hour forecast model maintained by Florida Tech, the NOAA nearshore buoys 41113 and 41114, and the real-time ADCP data, regional coverages of the directional wave field and coverage of coastal processes is provided beyond what is available in most other areas of US coastal waters. The measured and model data are being used to support shore protection projects by Federal, State and local agencies. This report presents the ADCP and weather station data collected from August, 2020 to December 2021.

The Sebastian Inlet data is made available in the following sources:

- Florida Institute of Technology webpage
 - <http://research.fit.edu/wave-data/index.php>.
- South East Coastal Ocean Observing Regional Association's webpage (SECOORA)
 - <https://www.portal.secoora.org/>
- NOAA's National Data Buoy Center (NDBC) website
 - http://www.ndbc.noaa.gov/station_page.php?station=sipfl.
- Florida Tech Real Time Sebastian Inlet Model
 - https://realtimefl.github.io/Sebastian_Inlet/

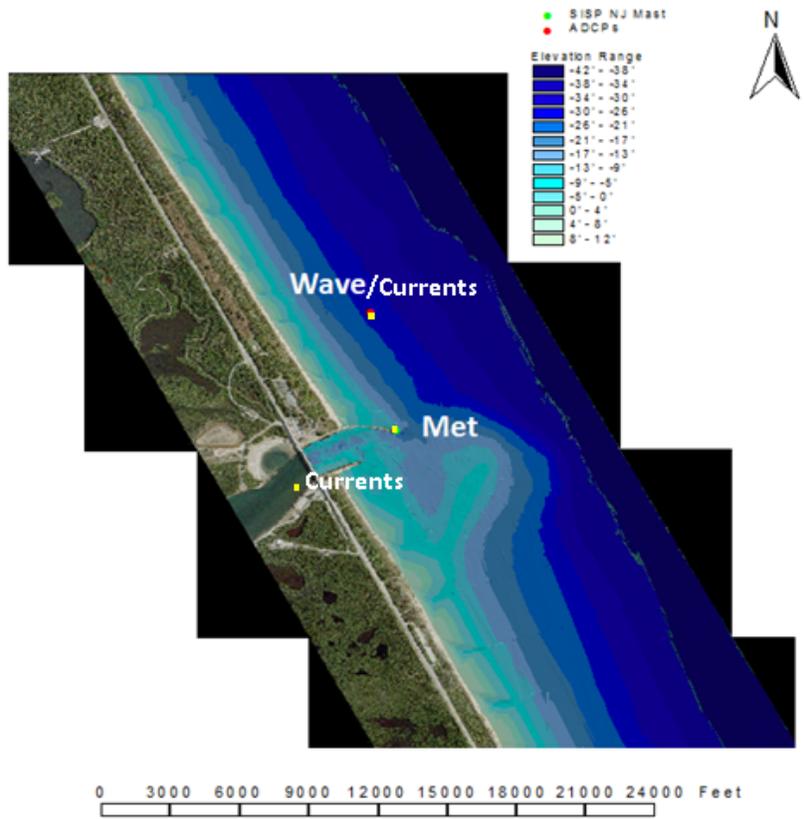


Figure 1. Location of Sebastian Inlet State Park oceanographic and meteorological instrumentation sites. Aerial photo and bottom topography are courtesy of the Sebastian Inlet District.

2 Instrumentation and On Site Operations

2.1 Acoustic Doppler Profilers (ADCPS)

Two ADCPs are located at the offshore wave station; one real time and a second for redundancy. Teledyne R.D.I Instruments (RDI) 1200kHz Workhorse Sentinels ADCP are continuously co-deployed at the site offshore of SISP (Figure 2). Figure 3 shows the cabled ADCP for real time data being attached to the stainless steel pylon. Both instruments collect wave height, wave direction, current magnitude, current direction, water level and water temperature. The RDI has been cabled and powered from a shore station since early 2012. The second autonomous ADCP has a deployment time of approximately six months limited by battery life and biofouling. Routine maintenance of each gauge for biofouling occurs multiple times during the deployment. Each gauge measures the data by using the Doppler Effect of a transmitted signal from three or four transducer heads. Pressure is measured via an internal pressure sensor and water temperature from a thermistor. Data is stored in an internal memory card; each instrument's propriety software is used to download and process the raw data once the instruments are recovered. The cabled ADCP data are also stored on an internal memory card and sent along the cable to a computer onshore and automatically sent to Florida Tech for processing, archiving and posting on the webpage.

The mounting pole for the redundant ADCP site was replaced in September 2018 and a new gauge (RDI Workhorse Sentinel) has been deployed in August 2021 to maintain establish gauge redundancy. This gauge is autonomous and will be replaced in 6 months intervals.

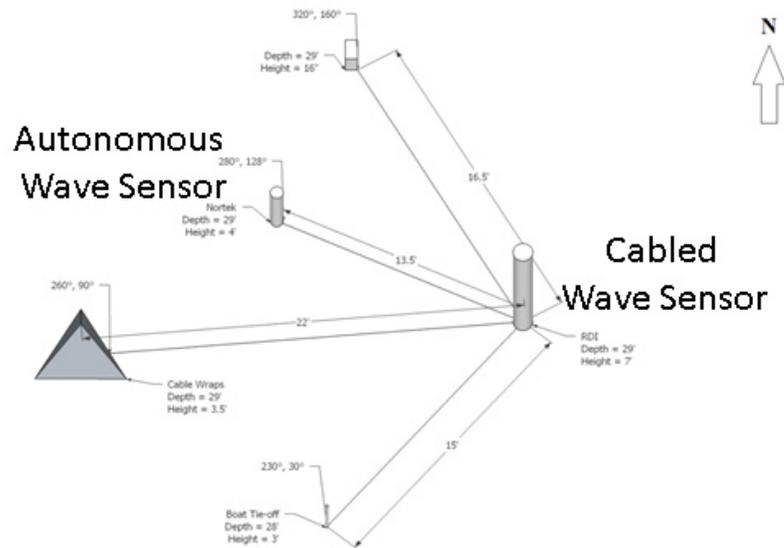


Figure 2. Deployment configuration of the ADCP instruments offshore of SISP.

The real time ADCP gauge is currently functioning following retrofit of surge protection and an extensive down-time due to shore-cable failure and ADCP CPU failure. The real-time system offshore ADCP and the co-located remote ADCP both performed well during the 2020-2021 monitoring period having no downtime time relative to total data collection. The real-time delivery of wave and current data was interrupted several times by issues at the seaward end of the communication cable, which required re-termination of the plug that connects with the ADCP. However, there was no data loss from the ADCP internal recorder. The real time ADCP did experience limited data loss because of significant biofouling over the sensor heads, but these periods were covered by data collected in the remote ADCP unit.

In May 2020, a loss of connectivity to the shore-connected system necessitated investigation. It was determined that the cable, in service since 2016, had begun to fail. Initial attempts at remedy included re-termination of the cable and retrofit of the control box to utilize RS485 communications protocol and the remaining wires which had not yet been compromised. This proved inadequate as they had begun to fail within days of redeployment of the shore-connected system. Cable replacement became the only course of action and redeployment of the shore cable took place on October 14, 2020. This resulted in successful communications with the ADCP. The currently configured system was deployed during the first weather-window in months, on December 11, 2020, and is transmitting data as desired. During this time, the identical co-located stand-alone ADCP reliably collected the required data so was little to no interruption in data recording.

In September 2021 a third ADCP was deployed on trawl resistant mooring within the main tidal conveyance channel of Sebastian Inlet as shown in Figure 1. This sensor collects water level and current velocity data at 30 minute intervals. These data will be used to further measure the hydraulics of Sebastian Inlet and provide a calibration point for the ongoing Delf3D coastal processes model of Sebastian Inlet.

2.2 Meteorologic Station

The Meteorological station is located atop of the mast at the seaward end of the SISP north jetty 10 meters (30 feet) above the water (Figure 3). This is the standard reference height for wind data collection. This system includes an anemometer for measuring wind speed and direction, barometric pressure sensor, air temperature sensor, radar water level gauge. Other components of this station include a data logger with cellular communication and a solar panel which provides power to the station.

A Campbell Scientific Radar Water Level sensor was installed in early September, 2015 which replaced the Yellow Springs Instruments (YSI) water level sonde. This Radar based gauge is mounted to the north jetty cap and sends a radar signal to the water to measure the water level. This is a remote sensing approach to recording water elevation which minimizes the effects of biofouling. A stainless-steel housing was constructed and installed to protect the instrument from damage from fishing equipment entanglement and vandalism. This housing was lost during Hurricane Matthew and a replacement was fabricated and installed during this monitoring cycle. A cable runs from the radar water level gauge along the north jetty cap enclosed in a protective schedule 40 conduit. The cable continues

underneath the cap and runs to the top of the Metrologic station inside the tower mast. Although the water level sensor is more accessible for maintenance and replacement, the lifespan of the unit is only about 1 to 2 years. Since initial installation the units has been replaced four times.

In addition to the ADCP, the weather station has required significant attention during this reporting period. The Campbell Scientific water-level sensor located on the North Jetty began to fail in November 2020 and was replaced in December 2020, along with the rechargeable battery on the weather tower. The water level functioned normally until October 2021. The water level sensor was again replaced and the faulty sensor returned to the manufacturer for repair. The Anemometer providing wind direction and speed was damaged, ostensibly by fishing line, in late August 2020 and required replacement. Replacement was delayed by repair of the Jetty grating sections, which were reinstalled in October 2020 allowing ladder access to the weather station tower.



Figure 3. Weather tower located on the north jetty of Sebastian Inlet.

A further issue concerned the transmission of metrological and water level data to the Florida Tech Lab and on to the project website, SECOORA, and to NOAA , was failure of the cellular modem on the weather tower in July, 2021. This temporarily interrupted the flow of data, but not the data record. The process of purchasing and reprogramming of new modem took about 1 month and was completed in August of 2021.

2 Data Handling, Presentation, and archiving

Figure 4 shows a flow chart of data handling among the various sensors maintained by Florida Tech on behalf of the Sebastian District. Once the data sets stream in to the Florida Tech Coastal Processes Laboratory, the data are archived by year on the Florida Tech Coastal Drive, which is accessible to the public through a controlled procedure that is protected by a login authorization process. In the Florida Tech digital archives, the entire long term monitoring data set is assembled into a series of MATLAB data files that are organized according data type and parameter. The MATLAB file (filename. MAT) can be interrogated by standard or customized scripts to extract and plot data

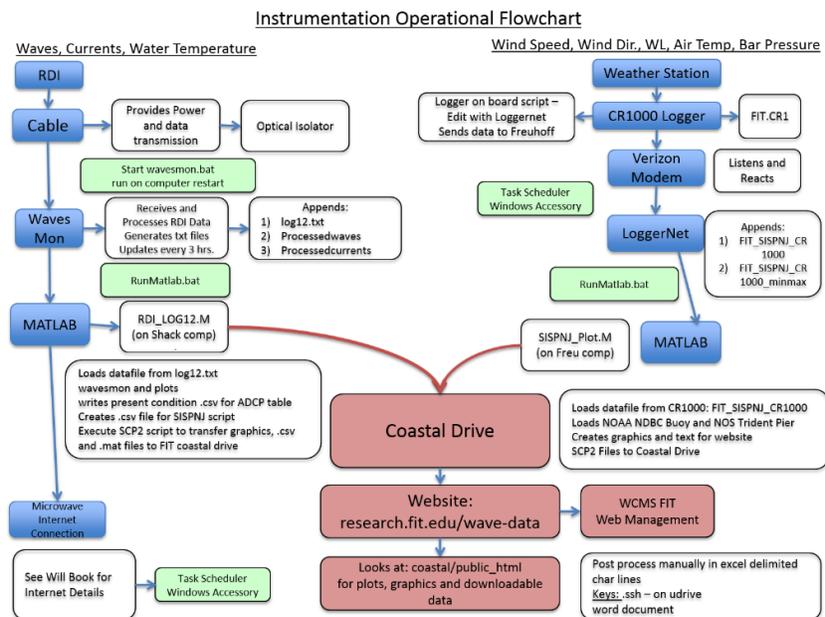


Figure 4. Flow chart of monitoring system data collection

4.1 Statistics

Tables 1 through Table 6 summarize basic statistics from the field gauges spanning August 1, 2020 through August 1st, 2021. Longer term statistics at the 10, 15, and 23-year timescales are also provided for wave parameters. The longest time period available for currents is 19 years since years 2002 through 2004 are not available. The median depth averaged current direction is toward the south; nearly shore parallel. The median wave direction is from the northeast. The range of depth-averaged current speed at the ADCP site over the past two years was from near zero to a maximum of approximately 0.51 m/s. The average speed was about 0.11 m/s in a southerly flow. Wave height ranged from 0.18 m to a maximum of about 2.9 m at the ADCP location during Hurricane Dorian. The average for the 2020-2021 observation period was consistent with previous years at about 0.9 m. The average wave period was about 8.9 s from the east-northeast which also compares well to previous year. Table 5 summarizes meteorological parameters. Wind speeds ranges from near calm to about 21.46 m/s (48 mph). Other metrological parameters are discussed in comparison with water level and Gulf Stream

flux data later in this report. Directional distributions of waves, currents and winds are presented in a series of rose diagrams in the final section of this report.

Table 1. Wave Statistics: August 1 2020 - August 1 2021.

	Wave Height (m)	Wave Period (s)	Wave Direction (°TN)
Minimum	0.2	2.5	
Maximum	2.9	18.1	
Average	0.9	8.9	66.63

Table 2. Wave Statistics: 10,15,23 years [1998 – 2021].

	Wave Height (m)			Wave Period (s)			Wave Direction (°TN)		
	10yr.	15yr.	24yr.	10yr.	15yr.	24yr.	10yr.	15yr.	24yr.
Minimum	0.14	0.01	0.01	1.70	1.70	1.70			
Maximum	5.10	5.10	5.10	18.1	19.50	20.00			
Average	0.82	0.80	0.77	8.67	8.77	8.67	69.39	71.00	70.63

Table 3. Annual Current Statistics: August 1 2020 - August 1 2021.

	Current Speed (m/s)	Current Direction (°TN)
	1 year	1 year
Minimum	0.00	
Maximum	0.51	
Average	0.11	156.74

Table 4. Current Statistics: 10, 15 and 23 Years [2020 – 2021]

	Current Speed (m/s)			Current Direction (°TN)		
	10yr.	15yr.	24yr.	10yr.	15yr.	23yr.
Minimum	0.00	0.00	0.00			
Maximum	0.76	1.60	1.60			
Average	0.10	0.10	0.11	185.00	182.75	180.75

Table 5. Statistics derived from meteorologic data 2020 - 2021.

	Wind Speed (m/s)	Wind Direction (°TN)	Barometric Pressure (mb)	Air Temperature (°C)	Water Temp at Depth (°C)
Minimum	0.00		973	5.51	5.14
Maximum	22.5		1034	32.41	34.65
Average	5.23	162.23	1018	23.21	23.24

4.2 Significant Wave Height and Wave Direction

Wave height time series for the 2020 – 2021 observation period is shown in Figure 5. The seasonal variation in the record is observed as shown by an increase in average and maximum wave heights from October to March. Lower waves are observed in the months May through late This quiescent period is normal for this area during the summer months, but can be interrupted by passing tropical storms. Figure 6 shows the complete record of significant wave heights measured between 1996 and the close of 2021

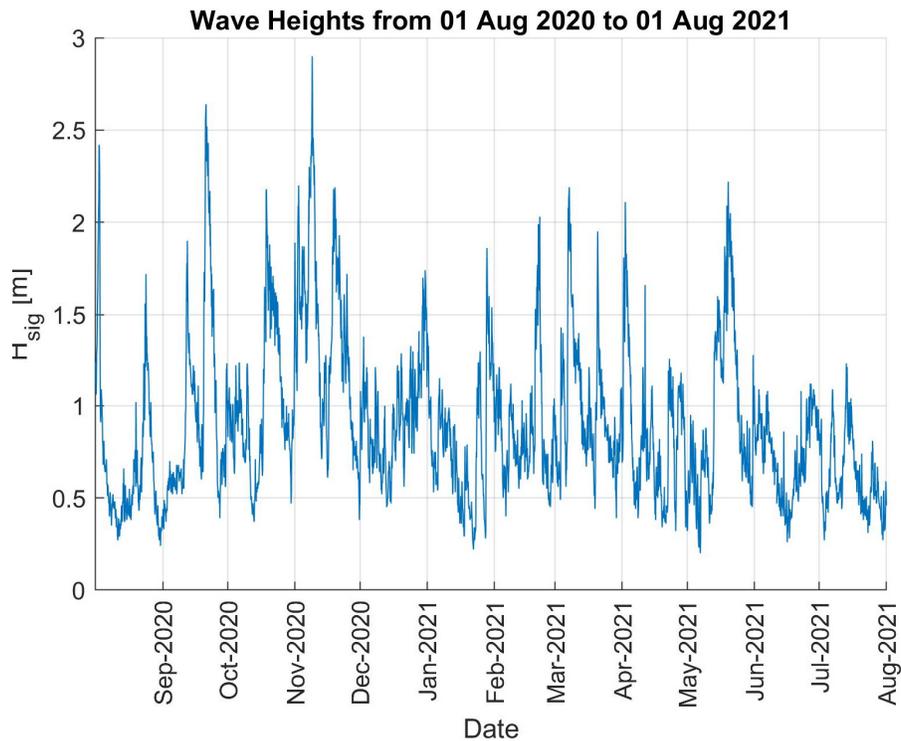


Figure 5. Wave Height time series August 1, 2020 through August 1, 2021.

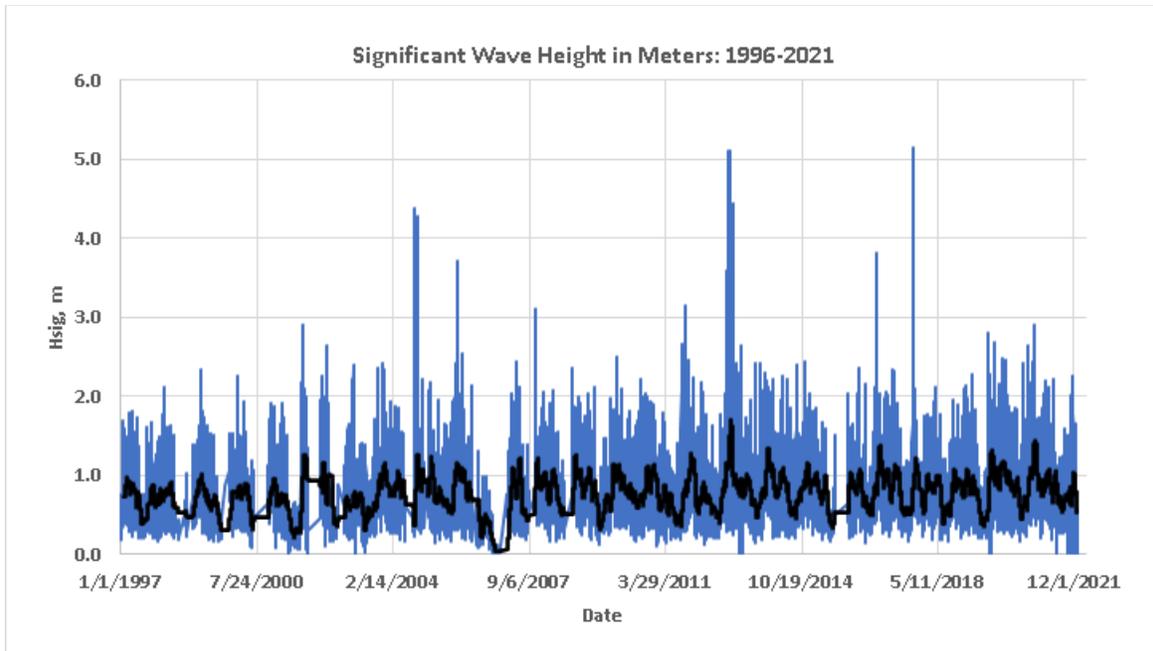


Figure 6. Record of significant wave heights between 1996 and of 2021. Dark lines shows the monthly mean significant wave heights

In Figure 6 extreme wave heights in the mid 2000s correlated with the passage of Hurricanes Jean and Francis. The 5 meter wave height recorded in October of 2012 were generated by Hurricane Sandy that passed offshore of the east coast of Florida. The 5 meter wave height recorded in September of 2017 correlates with the passage of Hurricane Irma along the west side of the Florida Peninsula. Figure 7 shows the distribution of significant wave heights by direction for the recent monitoring period. Similar to all previous periods, the predominate wave direction is from east-northeast quadrants.

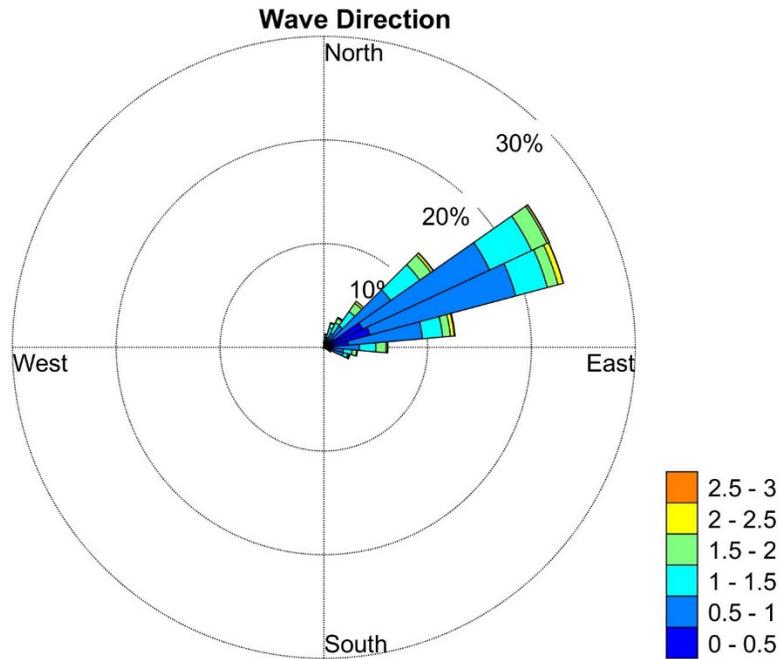


Figure 7. Wave Direction and Height from August 1, 2020 through August 1 2021

4.3 Water Level Records

Water level data from August 2020 through August 2021 is shown in Figure 9. Included in the plot is a moving average trendline used to filter out the tide signal to show sea level changes over the past year. The 10-day moving average of data collected by the combined ADCP systems of the SISP station and water-level data from Trident pier are shown to demonstrate correlation and verify accuracy of the SISP ADCP data. In this record the seasonal high stand of sea level is seen in the October to November period after a period of lower sea level in August and September. Large seasonal variations in sea level are attributable to changes in Gulf Stream flow that influences nearshore sea levels along the east coast of Florida.

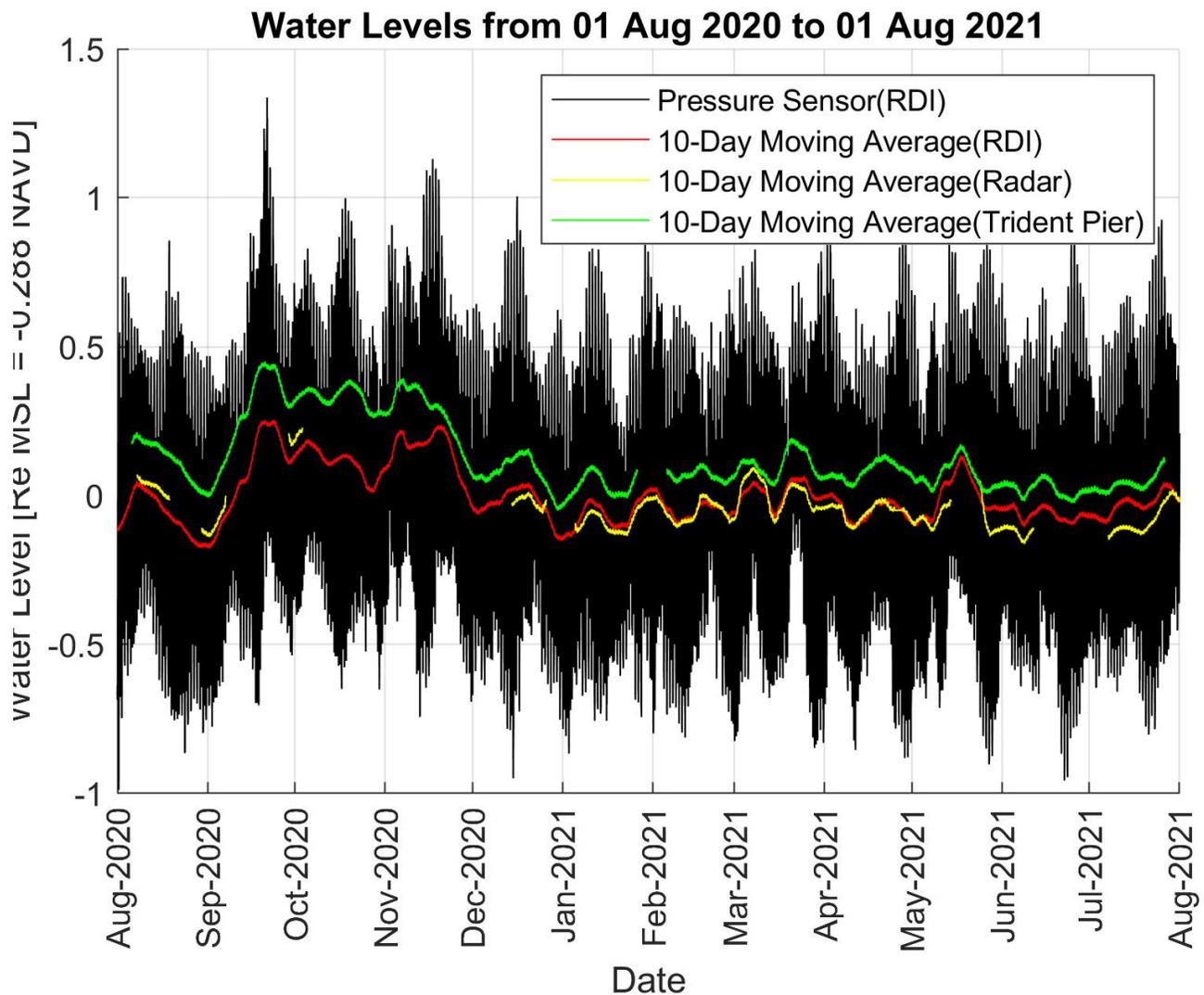


Figure 8. Water level data from August 1, 2020 through August 1st 2021

Figure 9 presents the long term water level time series recorded between 2007 and the close of 2021. The solid dark line shows the sea level record derived from a 25-hour low pass filter of the raw record that includes the tidal frequency band. A trend line is placed through the filtered sea level record showing a sea level rise during this period that is approximated 1 centimeter per year or about 0.5 inches per year. Figure 10 shows the inverse relationship between the magnitude of Gulf Stream flow and coastal sea level. High rates of Gulf Stream flow adjacent to the coastal ocean result in a sea level set down at the coast. Conversely, low rates of Gulf Stream flow correspond to higher coastal sea levels. The dynamics of the Gulf Stream with respect to coastal sea level is analyzed in a paper of Ezer et al., (2013). Gulf Stream Flux records are provided by NOAA.

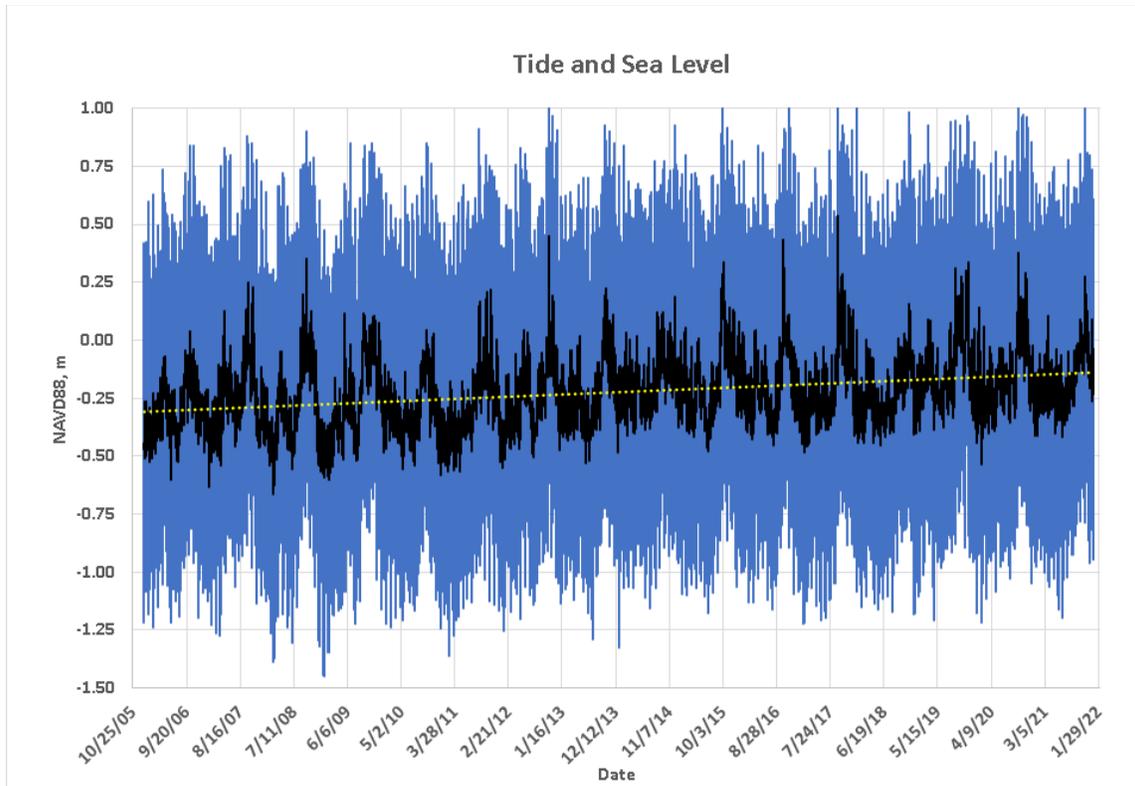


Figure 9. Water Level records of tides and sea level from 2006 though the end of 2021.

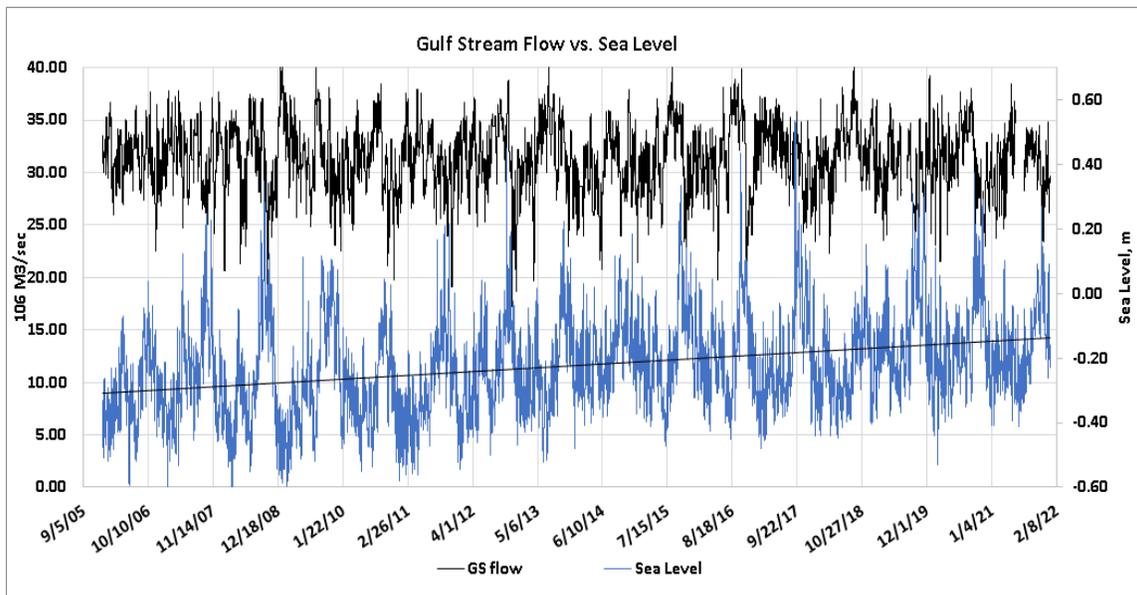


Figure 10. Inverse relation between Florida coastal sea level and Gulf Stream Flow.

4.4 Wind Velocity

The wind speed record from the SISP north jetty weather station is shown in Figure 11. The seasonal variation in wind speed is apparent in the higher speeds occurring in the winter months and lower speed occurring in the summer months. The maximum wind speed recorded in the 2020-21 period was about 23 m/s in mid-April 2021. Figure 12 shows the direction and magnitude recorded by the North Jetty weather station during the same period

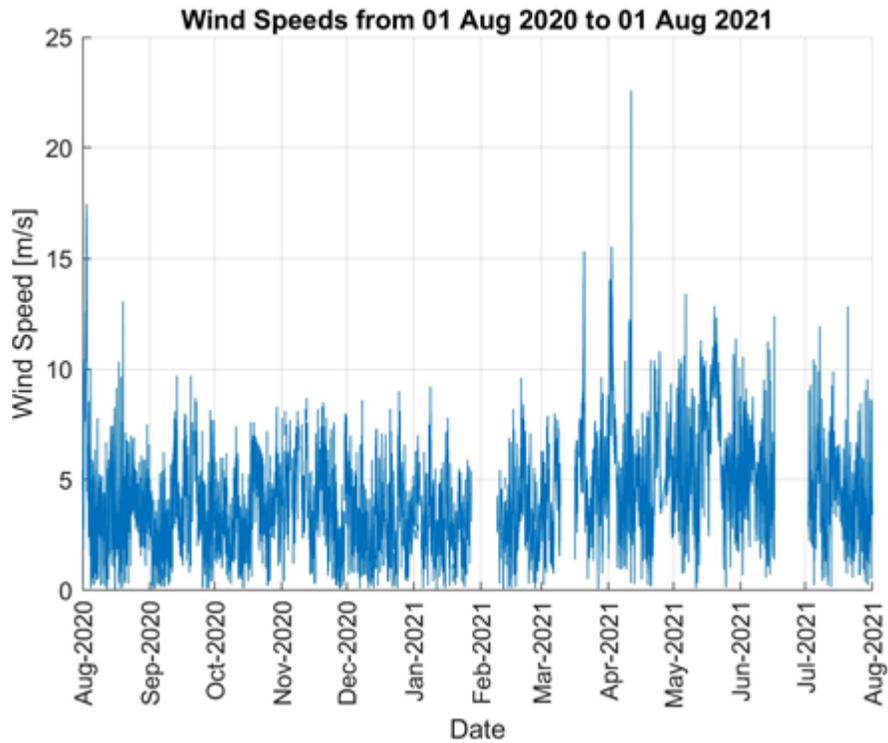


Figure 11. Wind speed time series August 1, 2020 - August 1, 2021

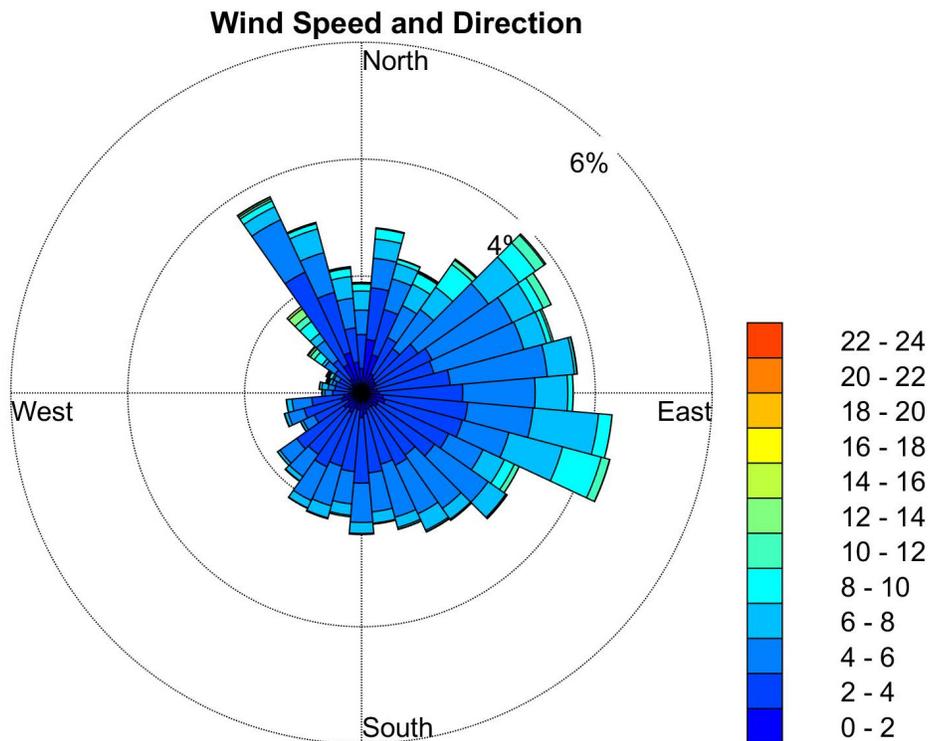


Figure 12. Wind Speed and Velocity magnitude for SISP North Jetty from 1 August 2020 to 1 August 2021

4.5 Sea Surface Temperature

Sea surface water temperature (SST) from the SISP weather station shown in Figure 14. for August 2020 to August 1 2021. Water temperature records both show mid-winter decline in temperatures starting in November 2020/ lasting through April 2021 when temperatures begin to rise. It should be noted that this water temperature is sea surface temperature as measured from the weather station using an infrared (IR) water temperature sensor. Figure 13 presents a comparison between the water temperature measured by the infrared sensor mounted on the weather station and the ADCP recorded temperature located in approximately 6m water depth. Air Temperature has also been provided on this plot. The temperatures recorded by these sensors correlate in seasonal variation, with subsea temperatures maintaining greater stability compared to the fluctuations in air and sea-surface temperatures.

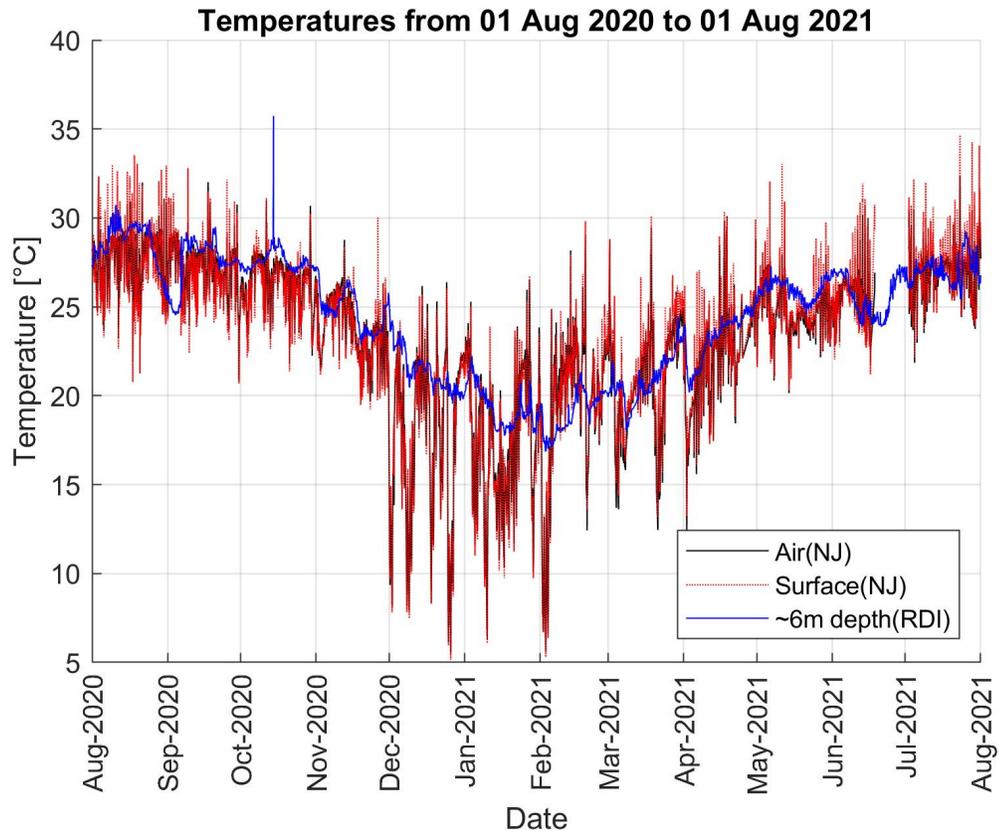


Figure 13. Air, Sea Surface, and bottom Temperature measured at the SISP North Jetty and ADCP locations

4.6 Current Velocity Data at Wave Station Location

Current magnitude and direction are measured at the bottom mounted ADCP. Depth averaged current velocity recorded every 30 minutes is shown in Figure 14, as well as a 24-hour moving average to add clarity. Figure 15 shows the velocity magnitude plotted by current direction. Directional pattern is shore parallel and southward, similar to all previous years. This reflects the local influence of the Sebastian Inlet jetties, as well as the east-northeast dominant wave approach that can drive south director littoral currents, especially during storm conditions.

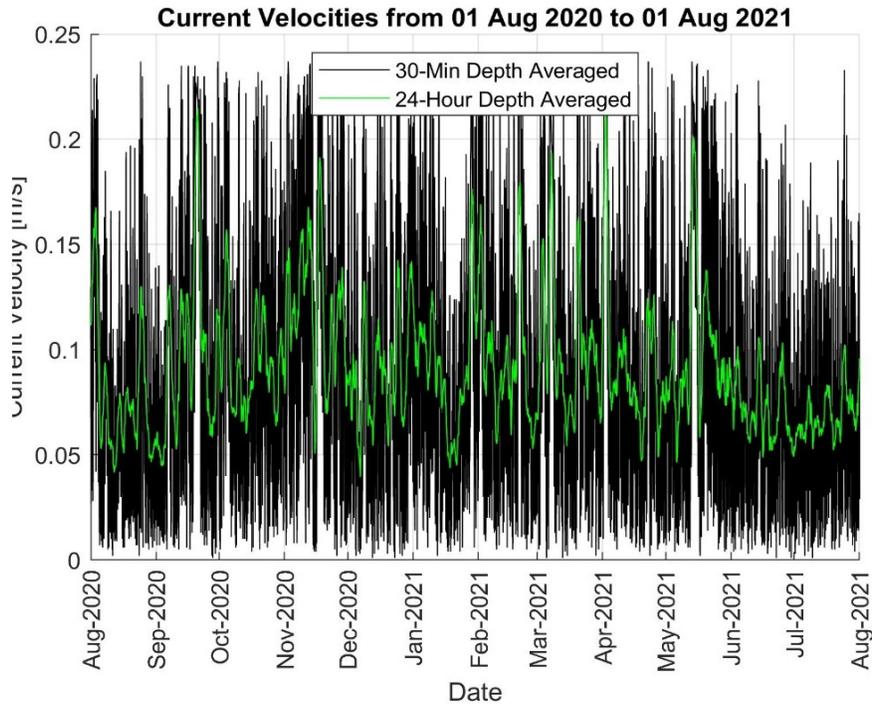


Figure 14. Depth averaged current magnitude from August 2020 to 1 August 2021

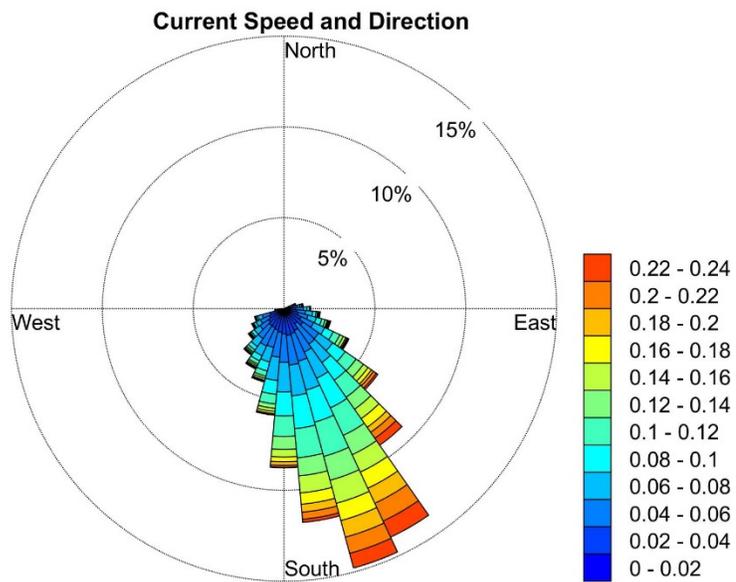


Figure 15. Distribution of current speed, August 2020 to 2021.

5.0 Gulf Stream and Coastal Upwelling

Figure 16 compares bottom water temperature recorded at the offshore ADCP with Gulf Stream Flows. Black arrows indicate possible cool water upwelling driven by high rates of Gulf Stream flow. Similar events have been seen in records recorded of most previous years. High rates of Gulf Stream flow can result in landward flow within the lower water column that drives upwelling in the nearshore coastal ocean.

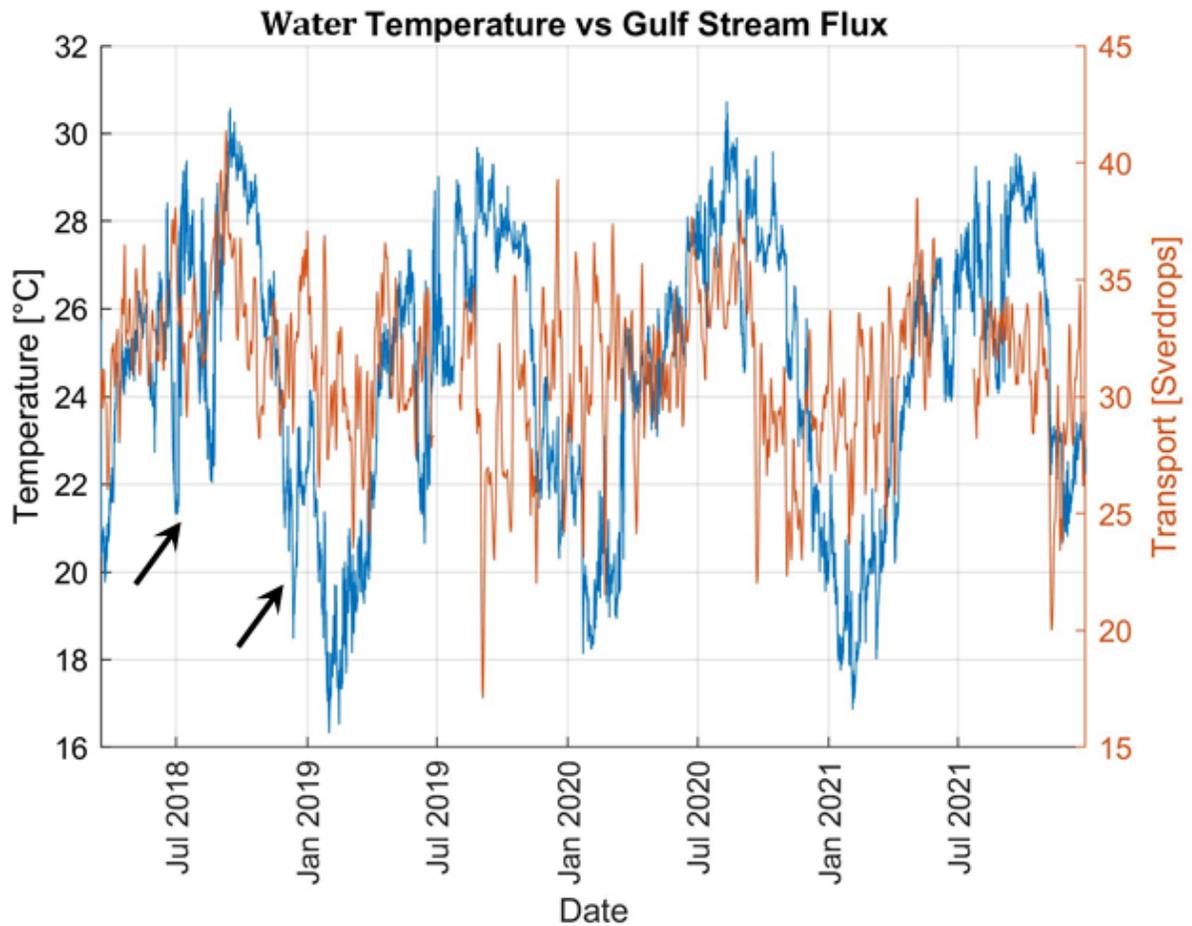


Figure 16. Comparison of bottom water temperature at the offshore ADCP site and Gulf Stream flow. Arrows indicate possible cooler water upwelling event driven by high Gulf Stream flows

6.0 Summary

ADCP and weather data recorded between August 1, 2020 and the end of 2021 are described in this report. Significant wave heights during this period include the seasonal pattern of high energy in the winter months and lower energy in the summer months. Prevailing wave directions from the east-northeast were also similar to previous years. The annual first order sea level cycle including a late summer high stand and a late fall low stand also continued to be present in data records. A nearshore current pattern of southerly shore-parallel flow was also present. At least two mid-summer coastal ocean upwell events were seen in the water temperature data recorded at the offshore ADCP. Comparison with Gulf Stream flows indicates that these events were driven by high Gulf Stream flow rates that induced onshore flows in the lower layer of the inner coastal ocean

Equipment maintenance and replacement during the 2020-2021 monitoring period included two replacements of the Campbell Scientific Radar water level sensor, replacement of the cellular modem on meteorological tower, and repairs to the seaward end of the communications cable connections to the offshore ADCP.