



STIC Note



Wave Characterization Buoy

BACKGROUND

The Science and Technology Innovation Center (STIC) evaluated a buoy called Spotter, manufactured by Sofar Ocean, to determine the utility to the U.S. Coast Guard (USCG). The Spotter is a commercially available “metocean buoy that collects and transmits wave, wind, sea surface temperature, and barometric pressure data in real-time” ([Spotter Buoy by Sofar](#)). Spotter is currently used in operations and research by organizations such as United States Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), and United States Army Corps of Engineers (USACE).



Figure 1. Spotter buoy with dimensions (Source: Sofar Ocean).

The Spotter is composed primarily of plastic and is slightly larger than a basketball. It is solar-powered, which allows it to operate for extended periods of time in conditions with limited light. For safety and visibility, the Spotter is equipped with a flashing strobe light.

The Spotter buoy collects measured data – 3D displacement, sea surface temperature, and barometric pressure at the sea surface – and calculates bulk parameters at 30-minute or 60-minute intervals, depending on the setting. “Standard” data mode can transmit bulk wave statistic data every 30-minutes. “Spectrum” and “Partition” data modes can only transmit data every 60-minutes, due to a larger sampling period. In Spectrum mode, in addition to bulk wave statistics, the Spotter provides an estimate of the wave spectrum and directional moments as a function of wave frequency. In Partition mode, the Spotter separates the bulk wave statistics into two categories: “sea” data and “swell” data. Sofar Ocean categorizes “sea” waves as those with a period shorter than 8s, and “swell” waves as those with a period longer than 8s ([Spotter Data Modes](#)). The bulk wave statistics in all modes include ([Spotter Buoy by Sofar](#)):

- **Significant Wave Height** – Average height of the top third largest waves.
- **Wave Direction and Directional Spread** – Angle from which the waves are coming, for both average wave data and peak wave data.
- **Wave Period** – Time between successive wave peaks, for both average wave data and peak wave data.

- **Location** – Latitude and longitude of the buoy.
- **Humidity** – Relative humidity at the sea surface.
- **Wind Speed and Direction** – Magnitude and angle of the wind at 10 m above the surface. (Wind data is calculated based on wave spectra; wind is not physically measured with a sensor).
- **Barometric Pressure** – Atmospheric pressure at the sea surface measured with a barometer.
- **Sea Surface Temperature** – Water temperature measured at approximately 10 cm below the surface. (Spotter buoys that can connect to Smart Mooring do not have a temperature sensor in the buoy, rather it is anticipated that the user will attach a temperature sensor to the Smart Mooring).

The data and bulk parameters from the Spotter buoy are stored on an SD card, which is installed on the buoy. The bulk parameters are also transmitted via cellular or satellite connection to the Spotter Dashboard, or the application programming interface (API). The Dashboard has an interactive map and allows users to easily visualize real-time or historical data for one or multiple Spotter buoys. The data can be downloaded from the Dashboard to a comma separated values (.csv) file, which is able to be opened on most computers. The Dashboard also facilitates two-way wireless communication to allow for remote firmware updates and configuration changes. Lastly, the Dashboard allows users to set-up wave height, time-fence and geofence notifications.

Sofar Ocean sells two mooring configurations for the Spotter – conventional mooring or Smart Mooring. The Spotter Smart Mooring is capable of being equipped with temperature sensors, for

temperature data at varying underwater depths, or pressure sensors, to measure changes in relative water level. Sofar Ocean also very recently released a sensor package called “Bristlemouth” to allow for a wider variety of sensors to be connected to their Smart Mooring product, including hydrophones. (The STIC did not test the Smart Mooring due to the intentionally shallow water depth of the selected test case).

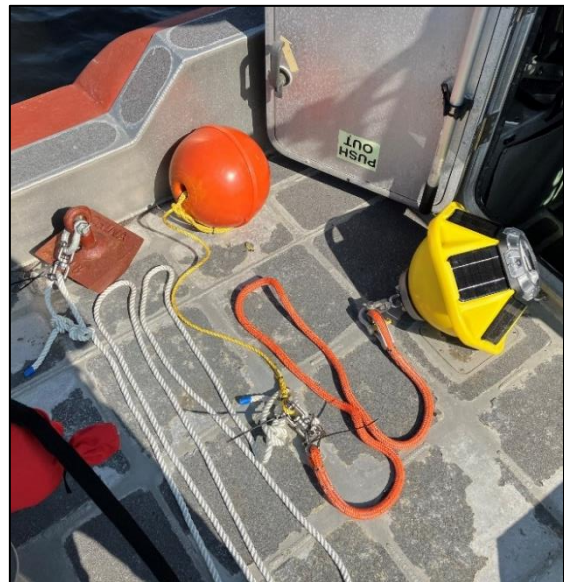


Figure 2. Image of Spotter buoy connected to mooring and ready to be deployed (Source: USCG RDC).

The Spotter buoy is not required to be moored. It may be operated adrift in a data mode called “Track.” In Track mode, the Spotter collects a location data point every three minutes and transmits location data to the Dashboard every 15-minutes. Bulk wave statistics are not calculated in Track mode.

The purpose of this evaluation was to demonstrate the capabilities of the Spotter technology and to determine if the technology can add value to USCG operations.

EVALUATION

In this test case, two Spotter units were deployed in the vicinity of USCG Station (STA) New London, CT. STA New London is centrally located along the Thames River, a high-traffic area. The station experiences turbulence from the wakes of large ferries, fishing vessels, and recreational boats. Observers at the station state the wakes from large vessels can cause disruptive 2-ft. waves at the docks where the STA New London boats are moored. In recent years, a floating wave attenuation pier was installed approximately 200 ft. northeast of the STA New London docks with the intent of isolating the station from the effects of these wakes.

The STIC deployed one buoy on the eastern side of the floating pier and one buoy on the western side of the floating pier to demonstrate the capabilities of the Spotter buoy and determine if it can be used to detect the discrete wave action from large vessel wakes. The buoy deployed on the western side of the floating pier was only deployed for five hours; its watch circle was 30 ft. and would impede STA New London operations if deployed for a longer, continuous period of time. The buoy on the eastern side of the floating pier was deployed for 17 days.



Figure 3. Ariel view of STA New London and the floating dock with two superimposed red dots to represent the intended mooring locations for the two Spotter units (Source: Google Maps).

The buoy deployment process was user friendly. A hex key is used to remove the transparent lid, under which the user can access the on/off switch and check the SD card to ensure it is inserted. The Spotter buoy also has a magnetic switch that can be used to toggle between system idle and system run modes. The purpose of the magnetic switch is to avoid opening the transparent lid while working with Spotter in the field, which could risk the introduction of water to the electronic systems. The Spotter buoy has three indicator lights – System, Go, and Signal – which provide feedback to the user regarding system health, GPS connectivity, solar charging status and cellular network presence to provide positive feedback that the buoy is ready for deployment.

The Spotter Dashboard has a simple interface, and the STIC switched between “Standard” and “Spectrum” data modes while the Spotter buoy was deployed. However, the change took over an hour, and users should be aware that switching between data modes is not an instantaneous process. The STIC also enabled a geofence notification to ensure the buoy did not drift or detach from its mooring.

Data from the buoys was viewed from the Spotter Dashboard and also downloaded from the Dashboard to a .csv file. The data file from the Dashboard included: battery voltage, power, humidity, date & time, significant wave height, peak period, mean period, peak direction, peak directional spread, mean direction, mean directional spread, latitude, longitude, wind speed, wind direction, barometric pressure, surface temperature, and spectrum as a function of frequency (Spectrum mode, only). When the buoy was in Standard mode, this data was reported at 30-minute intervals; when the buoy was in Spectrum mode, this data was reported at 1-hour intervals. In the data file, the

date and time is reported as epoch time. In Excel, and similar programs, a formula can be used to convert epoch time to a readable date and time format (MM/DD/YY hh:mm).

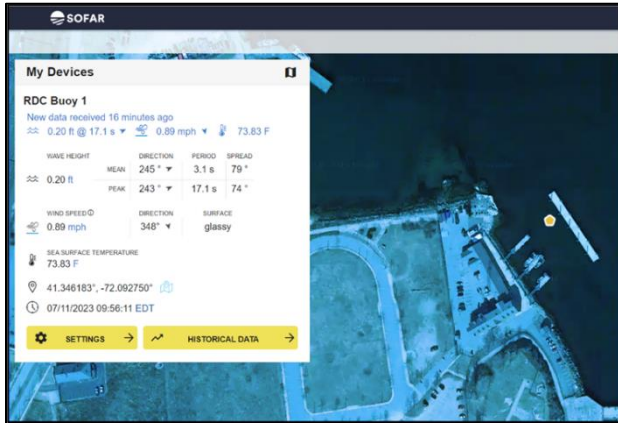


Figure 4. Screenshot of the Spotter Dashboard real-time data (Source: Sofar Ocean).

Data was also available from the SD card. There are six raw data file types logged on the SD card:

- **SYS** – General system info logging.
- **LOC** – 1-minute time series of geographic coordinates.
- **FLT** – 2.5Hz filtered X/Y/Z wave displacement.
- **SPC** – Spectral analysis output.
- **SST** – Sea Surface Temperature sensor readings.

This raw data is split into numbered sessions to prevent any one file from exceeding a size of 10 megabytes (MB). The SD card data requires more processing to convert the raw data into data files with a format similar to that available from the Dashboard. An open-source Python parsing script from the manufacturer, Sofar Ocean, can be used to process the raw data files from the SD card. The STIC noted that this granular data may have utility for future operations but was not value-added for this test case.

CONCLUSIONS

Overall, the STIC identified that the data available from the Spotter Dashboard, which includes the bulk parameters discussed above, is easier to access and process than the data from the SD card. The Dashboard data is precalculated and does not require any parsing script to be able to read. The data on the SD card serves its own purpose – such as providing location, temperature and barometric pressure data on a more granular timescale. However, the calculated bulk wave statistics – which are available on the Dashboard or the SD card – are only available in 30-minute or 60-minute intervals due to the nature of the sampling period used by the Spotter buoy. In Standard mode, the Spotter calculates the bulk statistics using a 30-minute sample period. In Partition and Spectrum modes, the bulk statistics are calculated using a 60-minute sample period. Due to the 30-minute and 60-minute timescale, the bulk statistics are only communicating the average data for that period. For example, although observers at Station New London claim that wakes from large vessels cause waves of over 2 ft., the Spotter buoy on the eastern (unprotected) side of the floating pier reported “Significant Wave Heights” ranging only from 0.06 ft. to 0.71 ft. If the user is interested in evaluating significant wave action from the wake of a vessel, and the wake only occurs for 5-minutes in the 30-minute sample period, then the data from that wake event is likely going to be lost in the averaging calculations that are performed by the buoy. The Spotter buoy is capable of communicating average data, but not reliable for detecting more isolated conditions or discrete events during a shorter time period.

In Track mode, the Spotter transmits location data to the Dashboard every 15-minutes.

However, when Spotter is recovered, historical location data at 1-minute intervals can be gathered from the SD card. Bulk wave statistics and wave spectra are not calculated in Track mode. If location data is needed in real-time at an interval more frequent than every 15-minutes, then Spotter is not an appropriate tool.

These observations align with the mission conveyed by Sofar Ocean. The Spotter buoy is advertised as an affordable and accessible tool that can be used to gain metocean data in locations where data is lacking or not easily accessible. Time intervals of 30-minutes and 60-minutes are acceptable for broad characterization use-cases, but not ideal for use-cases where the user is trying to detect wave or wind events on a smaller time scale.

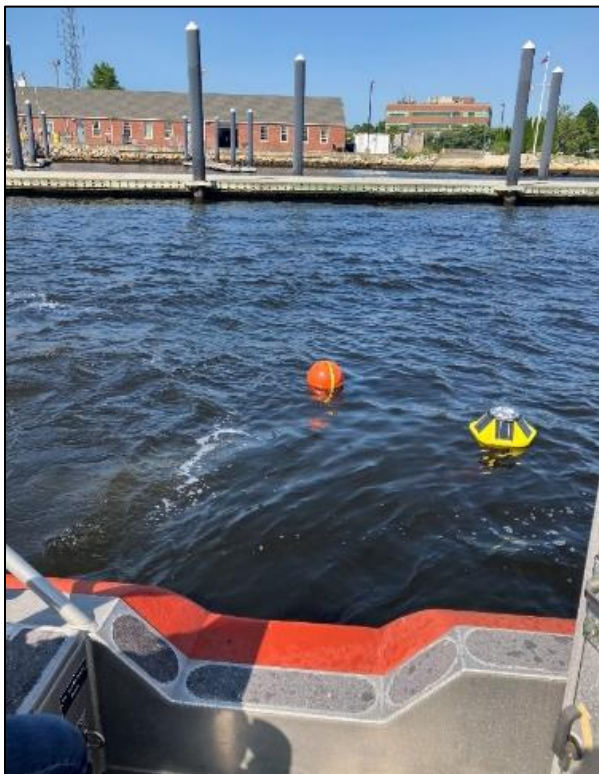


Figure 2. Picture of Spotter buoy deployed in the vicinity of STA New London (Source: USCG RDC).

The USCG can use the Spotter buoy to support its missions. In particular, the Spotter buoy could be useful as a support and research tool. The Spotter can be used by various branches at the USCG Research and Development Center (RDC) to plan for projects, demos and installations in areas where sea surface conditions may not be well characterized. Spotter’s ability to provide sea state data in poorly characterized regions may also be useful for Coast Guard missions that require units to respond offshore. For example, USCG District 13 (D13) advises mariners of the dangers related to the hazardous bars in the Pacific Northwest, including rough bar escorts. USCG District 17 (D17) frequently responds to search and rescue (SAR) cases during fishing season. These example operations, and others that require the USCG to operate offshore in areas with poorly characterized sea state, may benefit from using Spotter as a tool.

FUTURE WORK

Going forward, the USCG RDC Aviation branch plans to use Spotter as a tool in support of Project 1029 – Investigate Effects of Wind Farms on Search and Rescue (SAR). One objective of the project is to collect and analyze real-time wind and current measurements to determine the impact of changes due to wind turbines on wind farms with leeway drift studies. The project team plans to use Spotter, in addition to conventional tools and methods, to determine if Spotter will provide value-added data to meet their objectives. If it is found to be effective, Spotter will continue to be used as a research tool and may be further researched as an operational support tool.

The Science and Technology Innovation Center (STIC) is a DHS S&T and USCG collaboration.