Appendix E2.1. Data Stream Plan: NESDIS Common Cloud Framework with HF-Radar Data Distribution of HF-Radar Derived Hourly Surface Currents (500m, 1km, 2km, 6km), July 2025

1. Data and Information Types

A. Provide a contextual description of the data stream.

NOAA's U.S. Integrated Ocean Observing System (IOOS) Office's Surface Currents Program uses the NOAA National Environmental Satellite, Data, and Information Service (NESDIS) common cloud framework (NCCF) to run its data assembly center (DAC) system, known as "HFRNet", to compute the high-frequency radar (HFR)derived surface current products of the IOOS HFR National Network. The HFRNet DAC was transitioned from the Scripps Institution of Oceanography's Coastal Observing Research and Development Center (CORDC) into an internal NOAA system in July of 2025. The data sets covering the most recent 90 days are made available in near real-time through NOAA's National Data Buoy Center (NDBC) THREDDS server. Older archived data are available through NOAA's National Center for Environmental Information (NCEI) THREDDS, FTP, and HTTPS servers. Links to all data sets, a near-live map view of the HFR surface current velocity and wave data products, and sensor diagnostics for each HFR station are available on the HFRNet website at https://hfradar.ioos.us/hfrnet/.

Surveys of West Coast marine managers, researchers, and general users from both the marine debris and ocean acidification (OA) communities have expressed interest in:

a) general information on coastal oceanographic information across seasons; and
b) specific information on how surface currents move along the West Coast at any given time, to track various components of the water (e.g. floating debris).

HFRNet provides near-real-time information on actual surface currents data off the West Coast. Compared to satellite-based data collection (e.g. SST, SSH), the IOOS HFR National Network system provides the advantage of being able to collect data even on cloudy days. Via HFRNet the public and all other users have free access to a robust, long-term dataset that can be used for applications including, but not limited to:

1) Studying surface water movements off the West Coast;
2) Identifying persistent eddies and frontal features at various locations;
3) Applications to fisheries tracking/management; and
4) Applications to point-source movements (e.g. debris, contaminants, search and rescue).

In brief, high-frequency (HF) radio waves are emitted towards the sea surface from HFR stations near the seashore. These individual stations listen to the scattered return signal, measure the speed of the ocean waves that scatter the signal, and use the return time along with direction finding of the returned radio waves to calculate radial velocities. IOOS's HFRNet DAC ingests these radial velocities from the individual stations and combines them to compute total sea surface current velocity data products gridded at various resolutions. See the documentation available at IOOS's HFRNet website for more technical information.

CeNCOOS maintains a network of 30 oceanographic HFR stations from the Big Sur Coast up to northern California and extending into San Francisco Bay. In 2002, the Coastal Ocean Currents Monitoring Program (COCMP) began creating a California network of HFR instruments to monitor coastal ocean surface currents in real-time and provide surface current forecasting capabilities as mandated by state funding propositions. CeNCOOS worked with COCMP to expand the HFR network in the region, and received funds for operating costs and began creating and distributing products to address stakeholder needs. California State funding for the program ended after 2010.

Current operational funding comes solely from NOAA, with a portion of the overall CeNCOOS Cooperative Agreement funding provided by NOAA directed specifically to operating HFR stations. This funding covers operations and maintenance for a subset of our original HFR stations ranging from the Northern California Border, down to South of Carmel Bay. The Southern California Coastal Ocean Observing System (SCCOOS) is responsible for maintaining HFR stations from San Luis Obispo down to the California-Mexico border. These priority stations are chosen at the federal level and are selected by the economic/commercial/security importance of surface current measurements.

B. How many station locations are there for this data stream?

CeNCOOS maintains a network of 27 HFR stations from the Big Sur Coast up to northern California and extending into San Francisco Bay. See IOOS HFRNet Map (select "Station Placemarks" within the "Overlays" left-hand-list menu)

C. What are the specific variables of the data?

HFRNet produces hourly calculated surface seawater velocity vectors on a regular grid at 500 m, 1 km, 2 km, and 6 km depending on the types of HFR sensors covering the area and their radial velocity resolutions.

D. Provide information about the sampling platform or instrumentation.

The sampling platform includes shore-based HFR systems. Sea surface current data are measured with SeaSondes®, compact HFRs produced by California-based CODAR Ocean Sensors, Ltd. They use patented frequency modulated continuous wave (FMCW) signal processing and cross-loop direction finding to measure ocean surface currents and wave variables of the coastal ocean. General instrumentation for each station consists of a transmitter, receiver, 1 or 2 antennas, and a data acquisition and processing computer. A transmitter broadcasts a frequency modulated radio frequency pulse at 2Hz (two pulses per second). The Doppler shifted return signal, called the sea echo, is detected with a compound cross-loop/monopole receive antenna and the signal is processed into estimates of radial surface current speed and direction.

For example the Bodega Marine Laboratory of University of California, Davis (BML) operates three standard-range 12 MHz HFR Stations around Bodega Bay, California, and combined, have a spatial resolution of 2 km and create hourly maps of surface currents out

to a distance of 30–50 km (20–30 miles) along a 65 km (40 mile) length of shore. This means a total coverage area for the 3-radar array is approximately 2800 km^2. BML's two long-range 5 MHz stations have a spatial resolution of 5 km and create hourly maps of surface currents out to a distance of 90–200 km (55–125 miles).

2. Data Pathway

A. Is a data sharing agreement required?

The data may be used and redistributed for free but is not intended for legal use, since it may contain inaccuracies. Neither the data Contributor, CeNCOOS, IOOS, NOAA, nor the United States Government, nor any of their employees or contractors, makes any warranty, express or implied, including warranties of merchantability and fitness for a particular purpose, or assumes any legal liability for the accuracy, completeness, or usefulness, of this information.

B. In which format(s) was data received by CeNCOOS?

Data are ingested into the CeNCOOS data portal directly from the NDBC THREDDS Data Server (TDS).

C. How can the information be accessed?

The data are available through the CeNCOOS data portal, where they can be downloaded or explored through interactive visualizations. Specifically the data are available from two unique CeNCOOS access points, in addition to those provided by NOAA:
- Web Mapping Service (WMS)
- THREDDS (OpENDAP, NetCDF, etc.)

D. What file formats will be used for sharing data, if different from original?

Data are shared as WMS and through THREDDS. Data are also available for exploration in the CeNCOOS portals via interactive, graphical visualizations.

E. Describe how the data are ingested (e.g. the flow of data from source to CeNCOOS data portals) and any transformations or modifications made to share data in the CeNCOOS data portal.

Raw HFR radial velocity data received at shore-based computer systems are retrieved by the NCCF, which acts as the national node for HFRNet, IOOS HFR DAC. Here raw radial velocity data are converted by HFRNet into surface current vectors, gridded, and quality controlled (QC'd). The data products are made available in the NetCDF format through a NDBC THREDDS data service (TDS) and the raw radial velocity data are made available via an IOOS ERDDAP server..

The following data are contained in the NetCDF files, along with additional metadata:
- Longitude and Latitude
- Current speed and direction vectors (north-south (V) and east-west (U) components)
- Error Flags
- Statistics (U and V Standard Deviation, Covariance)

- X and Y Grid Coordinates
- Range, Bearing, Velocity, and Direction
- HFR sites that contributed to data

Data are then downloaded from the source to the CeNCOOS storage. Custom Java, Scala, and Python scripts are used to convert data formats suitable for internal and external interoperability services. Data are made available in the CeNCOOS portals through the access points and via graphic displays generated through internal JSON-format data requests from these services.

Graphic displays include a mapping service, customized interactive visualizations, and time-series plots of the unit values wherein each parameter is graphed independently. Back-end scripts handle the conversion of visualized data from climate & forecast (CF) standards to other, non-CF units that may be requested by the user. Data files may be downloaded by the user from the CeNCOOS data portal. A user request for a comma-separated value (CSV) file request pulls the data from the server cache. A user request for ERDDAP pulls data from the ERDDAP service using the same cache. The CF standard names are surface_eastward_sea_water_velocity and surface_northward_sea_water_velocity, or additionally it could be sea_water_speed and sea_water_velocity_to_direction if reported as speed and direction instead of components.

Summary statistics generated within the interactive graphical displays may be requested by the user. Summary statistics may include minimum, maximum and mean values. Seasonal statistics, available on time series longer than 3 years, include mean, and 10^{th} and 90^{th} percentiles. Note: the number of points visually available to interactive users from the source data are limited when necessary using temporal binning, such as daily, weekly, monthly, seasonally and yearly.

F. What metadata or contextual information is provided with the data?

Data are shared in the CeNCOOS portals with descriptive project and file metadata describing the data and accompanying fields. Metadata are also available via ERDDAP: http://erddap.cencoos.org/erddap/index.html

G. Are there ethical restrictions to data sharing?

No

a. **If so, how will these be resolved?**

N/A

H. Who holds intellectual property rights (IPR) to the data?

Data are free and open to all under a CC0 1.0 license

I. Describe any effect of IPR on data access.

None

3. Data Source and Quality Control

A. Indicate the data source type (i.e. Federal, Non-Federal, University, State Agency, Local Municipality, Military Establishment (branch), private industry, NGO, non-Profit, Citizen Science, Private individual)

University

a. If Federal data source, were changes applied to the data?

No

b. If Yes, describe any changes to the data that require documentation?

N/A

B. Indicate the data reporting type (e.g. real-time, historical).

Near real-time

C. If real-time, list the QARTOD procedures that are currently applied.

All HFR surface current data in the CeNCOOS portal has been through QC applied at the HFR DAC. Raw radial values are QC'd only by the HFR sensor manufacturer's software and are available through the NOAA IOOS HFRNet system's ERDDAP at https://hfradar.ioos.us/erddap/.

D. If real-time, list the QARTOD procedures that are planned for implementation.

N/A

E. What is the status of the reported data? (e.g. raw, some QC, incomplete, delayed mode processed but not QC'd)

See IOOS HFR QC Practices

F. Describe the data control procedures that were applied by the originator.

See IOOS HFR QC Practices for description of QC tests.

a. Provide a link to any documented procedures.

https://hfradar.ioos.us/hfrnet/documents/HFRNet_QC-RTVproc.pdf

G. Describe the data control procedures that were applied by CeNCOOS.

N/A

a. Provide a link to any documented procedures.

N/A

H. List the procedures taken for data that could not be QC'd as directed.

N/A

4. Stewardship and Preservation Policies

A. Who is responsible for long-term data archiving?

NESDIS and NDBC are responsible for submitting all CeNCOOS-generated HFR data to NCEI for archival. For more information see "A Plan to meet the nation's needs for surface current mapping".

B. Which long-term data storage facility will be used for preservation?

NCEI

C. Describe any transformation necessary for data preservation.

N/A

D. List the metadata or other documentation that will be archived with the data.

N/A