

Sentry AUV Delivered Data Summary for RR2106.

November 3, 2021

This document summarizes the data obtained with the Sentry AUV during the RR2106 2021-resing cruise. At the end of this cruise Joe Resing was provided with a copy of all the Sentry data from this cruise and the best “at-sea” data products produced by the Sentry team. This document summarizes the organization of this data with an emphasis on providing the client with ready access to the files needed for their research and reporting requirements. The document concludes with a tally of the data provided.

On this expedition, the total raw and processed data value is approximately 7.2TB of data. A large portion of this data is the raw data necessary to obtain final processed data products. Clients may choose to only use the at-sea processed data products discussed below.

This document does not serve as the cruise report (the Sentry team provides that in a separate document) nor does it provide any analysis or interpretation of the obtained data.

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1 Cruise Structure Organization

The Sentry cruise structure is a set of nested file-system directories, the top level composed of the following:

```
2021-resing
├── dives
├── docs
├── engineering
├── planning
├── planning-bathy
├── products
├── raw-usbl
├── svp
└── watercolumn-scc
```

- **planning-bathy**- This is the bathy provided by science or generated during the cruise for planning purposes
- **docs**- Documents pertaining to the cruise such as launch positions and dive statistic summaries
- **products**- The best at sea derived data products from the cruise organized by dive number. May also contain extra data products specific to the cruise, such as multiple dive combined bathymetry.
- **dives**- All raw and processed data from individual dives organized by dive
- **engineering**- All raw and processed data from decktests and dive debugging
- **planning**- Files pertaining to mission planning. These are not generally needed by science
- **raw-usbl**- Log and configuration files from the Sonardyne USBL system
- **svp**- Sound velocity profiles used during the cruise
- **watercolumn-scc**- SCC Files that cover the length of a dive from deck to deck

Of these directories, **dives** and **products** hold all of the normal data products generated during the cruise. Cruise-specific data products are outlined in the At-Sea Processed Data Products section.

2 At-Sea Processed Data Products: 2021-resing/products

The products directory contains a directory for each dive. Most data products include a time and date stamp in the file name. For photos, that is the time the image was taken, for

all other products that is the time of the renavigation process and can be matched to other files created with the same navigation.

Most, if not all, of the files present in the `products` directory for a dive are copies from another location, most often from the corresponding `2021-resing/dives/sentryXXX` directory. The main purpose of the `products` structure is to separate a final product (such as a multi-beam grid file) from the raw and intermediate data (such raw multibeam swath data). Some data is not duplicated here due to file size considerations, the most notable example being the processed photos which are only present in `2021-resing/dives/sentryXXX/photos/proc`. Within each dive directory the following directories are included:

```
products
├── sentryXXX
│   ├── blueview (processed blueview data, usually empty)
│   ├── hf-sss (processed high-frequency 410kHz data from the Edgetek sidescan)
│   ├── lf-sss (processed low-frequency 120kHz data from the Edgetek sidescan)
│   ├── multibeam (processed data from the Kongsberg EM2040 multibeam)
│   ├── sbp (processed sub-bottom profiler data data from the Edgetek sidescan)
│   ├── photos (processed digital camera still photos)
│   ├── plots (Plots of timeseries data generated during dive)
│   └── scc (Navigation and post-processed data for selected instruments)
```

2.1 Blueview Forward-looking Sonar:

`2021-resing/products/sentryXXX/blueview`

This contains any data products created from the blueview sonar. The blueview sonar is a forward looking sonar, operating at 900KHz with a 90 degree field of view. Products are not normally created even if that sonar is installed and this directory is often empty.

2.2 High-frequency Sidescan Sonar:

`2021-resing/products/sentryXXX/hf-sss`

This directory contains data products generated from the 540kHz sidescan sonar system. hf-sss stands for high frequency side scan sonar. Note that for a particular survey it is typical to have only HF or LF products, not both. Data in this folder is a subset of the files in `2021-resing/dives/sentryXXX/sss-sbp/hf-sss`

```
hf-sss
├── geotiffs (Processed single-file sidescan data in geotiff format)
└── mosaics (Mosaic surveys, combining multiple files and look-directions)
```

2.3 Low-frequency Sidescan Sonar: `2021-resing/products/sentryXXX/lf-sss`

This directory contains data products generated from the 120kHz or 230kHz sidescan sonar system. lf-sss stands for low frequency side scan sonar. Note that for a particular survey it

is typical to have only HF or LF products, not both. Please see the associated cruise report for information on whether the 120kHz or 230kHz frequency was used. Data in this folder is a subset of the files in `2021-resing/dives/sentryXXX/sss-sbp/lf-sss`

```
lf-sss
├── geotiffs (Processed single-file sidescan data in geotiff format)
└── mosaics (Mosaic surveys, combining multiple files and look-directions)
```

2.4 Sub-bottom Profiler Sonar: `2021-resing/products/sentryXXX/sbp`

This directory contains SEG-Y, seismic-unix, and image files derived from the Edgetech sub-bottom profiler. Data in this folder is a subset of the files in `2021-resing/dives/sentryXXX/sss-sbp/sbp`

```
sbp
├── images (PDFs of trace plots for each SEG-Y file)
├── segy (Extracted sub-bottom data in SEG-Y format)
└── su (SEG-Y data converted to Seismic Unix format)
```

2.5 Kongsberg EM2040 Multibeam: `2021-resing/products/sentryXXX/multibeam`

This directory contains the data products from Sentry's Kongsberg EM2040 multibeam sonar including `grd` and `pdf` files. The multibeam sonar operates at 400KHz with an additional 200KHz option that is rarely used.

```
sentryxxx_yyyymmdd_hhmm_tide_XxX_BVXX.grd
```

where X is the grid size. If `_nav_` is included in the file name this means that `mbnavadjust` was applied. This is not common but if available these files are probably preferred to others. Data in this folder is a subset of the files in `2021-resing/dives/sentryXXX/multibeam`

```
multibeam
├── images (PDFs, EPSs, PNGs of gridded bathymetry)
└── grids (Processed gridded bathymetry)
```

2.6 Digital Still Photos: `2021-resing/products/sentryXXX/photos`

This directory contains thumbnails and movies of the photos collected by Sentry. Full resolution photos can be found in the `dives` directory. The movies created by post processing is the collection of photos combined to make a movie. Sentry does not take continuous video during the dive. The photo thumbnails are created to give an alternative to the larger 24Mbyte `.tif` files with a smaller easier to load 200kbyte `.jpg` image file. Data in this folder is a subset of the files in `2021-resing/dives/sentryXXX/photos`

```
photos
├── movies (Video of processed images)
└── thumbnails (Smaller sized thumbnail images of processed images)
```

2.7 SCC 2021-resing/products/sentryXXX/scc

SCCs are 1Hz ASCII files containing post processed navigation and selected other science data. The timestamps on the SCCs can be matched to other data products. This flat ASCII file contains the date, time, latitude, longitude, depth, pressure, heading, altitude, optical back scatter, eh, conductivity, temperature, sound speed, ORP sensor (if installed) and data from all three magnetometers (if installed). The file name contains both the dive number and the date on which the scc file was generated. If there are multiple scc files for a single dive, *use the file with the most recent date*. All fields in the scc file have been interpolated onto a 1 second time base. Users wanting to load the data into Matlab should use the mat files in the nav-sci directory. Data in this folder is a subset of the files in 2021-resing/dives/sentryXXX/nav-sci/proc

3 Raw and Intermediate Data: 2021-resing/dives

The `2021-resing/dives` directory contains the raw and intermediate data for each dive. Within the dives directory there will be a directory for each dive labeled as `sentryxxx`. Typically there will also be a directory labeled `decktest` that contains assorted data from tests conducted prior to the first dive, or during days at-sea without dives.

3.1 Blueview Forward-looking Sonar:

`2021-resing/dives/sentryXXX/blueview`

This directory contains the raw data from the blueview sonar if installed and active. The blueview is stored in the following directory structure:

```
blueview (data files produced by driver)
├── son (raw data files produced by sonar)
```

3.2 Instrument Metadata: 2021-resing/dives/sentryXXX/metadata

This directory contains plain-text files with sensor-specific metadata (e.g. serial numbers, configuration parameters, etc.). These files are generated during Sentry's normal pre-dive process and are mostly of use to the Sentry team to ensure the sensors are set up correctly before the dive. However, some instruments may report information useful for science (such as instrument calibration coefficients). The list of sensors covered by this procedure is not a complete inventory of the sensors on board Sentry for the dive. The following sensors report information:

- APS1540 Magnetometers
- Seabird SBE49 CTC
- Sonardyne Avtrak USBL beacon
- RDI DVL
- Sentry's acoustic trigger synchroniser.
- Sentry's analog instrument digitizers (a2d2 pods)

3.3 Kongsberg EM2040 Multibeam: 2021-resing/dives/sentryXXX/multibeam

We provide the raw and processed data in several formats. The most common products used by our scientific collaborators are 2D plots (pdf, ps, png) and gridded bathymetry in GMT-compatible `grd` files and `asc` files for input into other GIS tools. The gridded data has been edited using our automated scripts and the soundings geolocated using our post-processed navigation. MB-system or Caris tools can be used by the client to hand-edit soundings, however our automated scripts work well. We also provide the edited data in `fbt` format, which can be imported directly to Fledermaus for gridding and display.

The multibeam is stored in the following directory structure:

```
multibeam
├── raw (raw data files from the multibeam sonar)
├── log (log files from the reson driver that configures the reson subsea)
├── timing_test (separate directory used to compute or check timing offsets)
├── proc (all intermediate MB-system files, parameter files used during processing,
    and 2D and gridded multibeam products)
├── nav (vehicle navigation data)
└── extra folders may exist with additional processing
```

3.4 Sentry time-series data: 2021-resing/dives/sentryXXX/nav-sci

This directory contains all of the navigation, science, and engineering data logged by the vehicle during the dive. Most of this data is provided for archival purposes only (the scc files provide all standard sensor and vehicle navigation data. Users wishing to load data into Matlab, can use the mat files in /proc.

The navigation and science files are stored in the following directory structure:

```
nav-sci
├── proc (Processed navigation and science files)
├── raw (Raw navigation and science files)
│   ├── mc (mission controller files)
│   ├── rosbag (ROS data logs, these is the ‘‘raw’’ data)
│   ├── topside-nav (Filtered ship-board navigation data)
│   └── roslog (ROS status logs)
```

3.4.1 Renavigated Vehicle Data:

2021-resing/dives/sentryXXX/nav-sci/proc

The final vehicle data product (e.g. vehicle position, non-sonar instrument data, etc.) is a large number of Matlab data structures in the 2021-resing/dives/sentryxxx/nav-sci/proc folder. These files can be grouped into two classes: Raw data converted from ROS “.bag” files and “renav” files that combine Sentries “renavigated” position at sensor-specific timestamps (e.g. Sentries interpolated lat/lon position for each CTD reading). Typical filenames for each group are listed below.

- Vehicle (Engineering) Data:
 - sentry123_acomms.mat: Data transmitted/received acoustically
 - sentry123_controllers.mat: Vehicle flight controller data
 - sentry123_actuators.mat: Vehicle actuator data (thrusters, servos)
 - sentry123_cfg.mat: Misc. sensor metadata (e.g. serial numbers)
 - sentry123_dvz.mat: Dead-reckoning DVL (vehicle XYZ, altitude, attitude, depth)

- sentry123_globals.mat: Global vehicle status
- sentry123_goals.mat: Mission controller goals
- sentry123_hotel.mat: Sentry hotel data (e.g. batteries, housing temperatures, etc.)
- sentry123_model.mat: Sentry deadreckoning navigation
- sentry123_navpp_param.mat: Parameters applied to Dead-reckoning/USBL filter.
- sentry123_usbl.mat: Sentry position based on USBL fixes
- sentry123_shipnav.mat: Topside ship position
- Timestamped Science Data:
 - sentry123_config.mat: Dive metadata (name, start and end times, etc.)
 - sentry123_ctd.mat: CTD data
 - sentry123_def.mat: depth data
 - sentry123_gvx.mat: Attitude (heading, pitch, roll) in radians
 - sentry123_hsvp.mat: Sound velocity
 - sentry123_mevt.mat: Mission block metadata, including timestamps.
 - sentry123_nav.mat: Dead-reckoning position, velocities, and accelerations
 - sentry123_obs.mat: Optical Backscatter
 - sentry123_optode.mat: Oxygen Concentration
 - sentry123_org.mat: The latitude and lognitude for the dive origin
 - sentry123_orp.mat: Oxygen Reduction Potential
 - sentry123_sensors.mat: Raw sensor data, including magnetometers, ctd, orp, obs, etc.
- Navigated Data (vehicle position and attitude interpolated to sensor timestamp):
 - sentry123_YYYYMMDD_HHMM_mag_renav.mat: Magnetometer data
 - sentry123_YYYYMMDD_HHMM_obs_renav.mat: Optical Backscatter
 - sentry123_YYYYMMDD_HHMM_optode_renav.mat: Oxygen Concentration
 - sentry123_YYYYMMDD_HHMM_orp_renav.mat: Oxygen Reduction Potential
 - sentry123_YYYYMMDD_HHMM_rnv.mat: Gyro (attitude) with position.
 - sentry123_YYYYMMDD_HHMM_sbe49_renav.mat: CTD
 - sentry123_YYYYMMDD_HHMM_svp_renav.mat
- Miscellaneous Data:
 - sentry123_YYYYMMDD_HHMM.scc: Many data streams interpolated to common 1Hz clock in a plain text format. This file is also copied into the scc folder in the products directory

- sentry123_YYYYMMDD_HHMM_scc.mat: Same data as the .scc file, but in a Matlab structure
- sentry123_ascent_svp.pro: Sonardyne Ranger compatible sound velocity profile generated during vehicle descent.
- sentry123_descent_svp.pro: Sonardyne Ranger compatible sound velocity profile generated during vehicle ascent.

3.4.2 Common Matlab Structure Fields

Many of the Matlab structures in the above files have fields names by convention (timestamps, for example). Below is a list of the most common:

- `hdr_t`: Sensor data timestamp in POSIX time (seconds since 01-01-1970 UTC).
- `hdr_datetime`: Same time as `hdr_t`, but converted to a Matlab datetime
- `bag_t`: Timestamp data was saved to file (may be different if sensor provides its own timestamp)
- `bag_datetime`: Same as `bag_t`, but converted to a Matlab datetime `t`: same as `hdr_t`

3.5 Digital Still Photos: 2021-resing/dives/sentryXXX/photos

We provide images in several formats with different levels of processing. These include the raw bayer encoded (color) tif files directly from the camera real-time software should users choose to reprocess those images. We also provide automated processing for color compensation and equalization. Filenames include date and time and can be used in conjunction with the SCC to obtain information on vehicle state and scientific sensors.

The photos are stored in the following directory structure:

```
photos
├── raw (Bayer encoded original images)
├── proc (color corrected color tif photos)
├── movie (contains movies in .mp4 formats)
└── thumbnails (reduced resolution jpgs of each processed image)
```

Presently, Sentry takes photos during the planned camera surveys and in the event that the dive ends with a photo survey, also during the ascent. Thus there will be photos of the water column.

3.6 Time series and Navigated plots: 2021-resing/dives/sentryXXX/plots

Much of the scalar (e.g. non-sonar, non-image) timeseries data recorded and processed during a dive is plotted during normal post-dive processing for basic Q/A purposes. A smaller section of data is also plotted against vehicle position, giving a rough estimate of spatial values during a dive. This directory contains a mixture of both vehicle engineering plots, (e.g. thruster output current vs. time), and science plots (e.g. CTD Temperature vs

time). These plots can serve as a high-level overview for the dive data and can help narrow down what time ranges warrant further investigation.

3.7 Sidescan and Sub-bottom Profiler: 2021-resing/dives/sentryXXX/sss-sbp

All of the data from Sentry's sub-bottom profiler and sidescan sonar We provide the raw and processed Edgetech sonar data. This data is processed using MB-System. For each dive, there is a folder containing the raw data (jsf) files, a nav directory for navigation the jsf files, and lf-sss=120kHz, hf-sss=230kHz, vhf-sss=540kHz, and sbp=Chirp Subbottom data processing directories.

The side scan data is stored in the following directory structure:

```
sss-sbp
├── hf-sss (processes high frequency sidescan
│   ├── geotiff (raw grd tiff files images with turns and not merged into full
│   │   │   length track lines
│   ├── images (hf image files)
│   │   ├── flt (Raw data images after removing turns but before merging the data
│   │   │   into full length track lines)
│   │   ├── raw (raw data images before removing turns and merging the data into
│   │   │   full length track lines)
│   │   └── tracklines (postscripts and pdfs of merged tracklines with turns removed)
│   │       └── raw (postscripts and pdfs of merged tracklines with turns included)
├── lf-sss (processes low frequency sidescan)
│   ├── geotiff (raw grd tiff files images with turns and not merged into full
│   │   │   length track lines
│   ├── images (hf image files)
│   │   ├── flt (Raw data images after removing turns but before merging the data
│   │   │   into full length track lines)
│   │   ├── raw (raw data images before removing turns and merging the data into
│   │   │   full length track lines)
│   │   └── tracklines (postscripts and pdfs of merged tracklines with turns removed)
│   │       └── raw (postscripts and pdfs of merged tracklines with turns included)
├── nav (processed nav data)
├── proc (common processed data and config)
├── raw (raw sidescan and sub bottom data)
├── sbp (Processed sub bottom data)
└── sonarwiz (Processed sidescan data from sonarwiz program, Refer to SonarWiz
    user guide for additional details, See sonarwiz folder outline on the next
    page)
```

3.7.1 Sonarwiz project structure

The sonarwiz data is stored in the following directory structure:

```
sonarwiz
├── 3DView (The default location of the files created in the 3D export process)
├── Backup (Contains backup files of project data that are automatically created
    by SonarWiz)
├── CSF (Contains SonarWiz Common Sensor Format (CSF) files that are created
    either in recording raw data or when importing sonar data files into the
    program)
├── DEP (Empty, not typically used)
├── GeoTiff (GeoTiff image files generated by Save Project as GeoTiff function)
│   └── Tiles (prj tfw and tif files)
├── Images (Default directory for Batch Image Export from Sonar File Manager)
├── jsf (Navigation injected jsf files used for processing, created by Sentry
    post processing)
├── MAG (Contains CMF magnetometers files)
├── Misc (Not currently used by sonarwiz)
├── Rasters (Not currently used by sonarwiz)
├── SBP (Empty, not typically used)
├── SHP (Default directory for exported shp files from the Grid and Contour
    Utility)
├── Targets (Contains data and image files for all digitized targets)
├── Tmp (Used by some of the utility programs to store temporary files)
├── Web (Contains the html and associated image files generated by the Save
    Project as Website function)
├── XTF (Contains raw sonar files created during Real-time data recording)
└── sentryXXX mml (Sonarwiz project file)
```

3.8 Vehicle Acoustic Communication:

2021-resing/dives/sentryXXX/subsea-acomm

This folder contains logging output from the driver for Sentry's Micro-Modem acoustic modem. It is not generally of importance to science.

3.9 Topside (ship) Communications:

2021-resing/dives/sentryXXX/topside-comms

This folder contains logging output from a number of software drivers running on the ship that monitor communication pathways with Sentry while underway. It is not generally of importance to science.

```
topside-comms
├── acomm (ship-side Micro-Modem acoustic modem logs)
```

|_iridium (ship-side iridium beacon logs)
|_sdyne (ship-side Sonardyne SMS logs)

4 Cruise-specific Data Products

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A Required Software

Sentry produces a large amount of data for each dive from a wide variety of instruments. Most of the processed data is viewable by common, free programs. However, the raw data formats may require proprietary software to view. Usually this software, (or another with similar capabilities) is freely distributed by the hardware vendor upon request.

- blueview: The ProViewer program available from BlueView and can replay raw sonar files.
- multibeam: The Kongsberg multibeam produces .kml files that can be processed using MBSysstem or other commercial software packages. Sentry processes multibeam data at sea with MBSysstem and the resulting .grd files are compatible with many GIS programs such as ArcGIS, QGIS, etc.
- sidescan: The Edgetech sidescan produces .jsf files that can be processed using Sonarwiz or other commercial software packages. Sentry processes sidescan data with Sonarwiz at sea, producing GeoTIFF images that can be opened in any image viewer.
- raw vehicle data: Sentry uses the ROS software framework and logs all raw vehicle data in ROS .bag files. The raw data is not typically used by Science.
- processed vehicle data: Sentrys post-dive processing of vehicle data creates a large number of Matlab structures, each of which is saved in its own file in the `2021-resing/dives/sentryXX/nav-sci/proc` folder. For Sentry’s chemical sensors (e.g. ORP, Optode, CTD) these files are the main processed data product.

B Coordinate origins

The vehicle’s control system uses simple equidistant coordinates. This system uses an origin, defined in terms of latitude and longitude (WGS84), and a fixed scaling between meters displacement from the origin. We use the identical routines that have been used by the NDSF assets Alvin and Jason for decades. These simple coordinates have several advantages for realtime control of a vehicle. Unlike UTM grid coordinates, the x and y axes intersect at right angles and align with true east and north respectively at the origin. These coordinates distort quickly as one moves away from the origin, but we solve that problem by putting the origin close to the operating area. We almost always report our results in latitude/longitude, so most users need not be aware of these details.

Individual Origins for each dive can be found in the dive summaries appended to the cruise report.

C Data Receipt

Prior to departure from San Diego, CA, the Sentry team delivered one copy of the entire raw and processed data to Joe Resing of University of Washington. This data delivery comprises the final deliverable of both raw and processed data from the Sentry AUV. The data

structure on the dive is descibed in detail in this report. Additional copies of the data will be transported back to WHOI for archiving.

D Cruise Data Totals

Table 1: Tally of Sentry data obtained on RR2106

Data	Number of Files	Size (bytes)
Total	634525	7.2T
svp	0	4.1K
docs	52	52.5K
planning	102	6.9M
planning-bathy	15	50.9M
products	70300	34.1G
raw-usbl	705	2.9G
dives	501352	6.8T
engineering	61999	369.4G