RV *Investigator*

ADCP Processing Report

Voyage:	IN2022_V07
Voyage title:	HALO - Halimeda bioherm origins, function and fate in the northern Great Barrier Reef
Depart:	Brisbane, 1000 Sunday 14th August 2022
Return:	Cairns, 0900 Wednesday 7th September 2022
Chief Scientist:	Jody Webster, University of Sydney
Data Processor	Vito Dirita (CSIRO – E&T Data Acquisition and Processing)

Document History

Date	Version	Author	Comments
02 Aug 2022	1.0	Stephanie Petillo	ADCP Report Template
08 Dec 2022	1.1	Vito Dirita	Draft Version (to be reviewed)
01 Mar 2023	1.2	Vito Dirita, Stephanie Petillo	Final Release version

Contents

1   Summary

The POSMV had issues which required systems to be moved to Seapath (see GSM report). Early in the voyage there were problems with the POSMV, which continued intermittently throughout the voyage. The choice was made to move the ADCP to use the Seapath instead (Part 2 of the data). The OS75 was turned off for all reef sites and transits between reef sites due to the very shallow waters. It was turned back on in the last week of the voyage when the ship moved off the shelf. To further accommodate the shallow depth, the settings on the OS150 were changed on 19/08/2022 to 20 bins (from 60), 4m bin length (from 8m) and 2m blanking distance (from 4m). As the data was already split into two parts, these settings were not changed again when moving off the shelf. It was confirmed with GSM that the ADCPs needed to be off for EM2040 surveys to stop interference, hence there are periods with no ADCP data.

ADCP data were collected using the University of Hawaii Data Acquisition System (UHDAS) and post-processed using the Common Ocean Data Access System (CODAS). Documentation for these systems can be found here: https://currents.soest.hawaii.edu/docs/adcp_doc.

The RDI Ocean Surveyor 150kHz ADCP was run in narrowband mode at the start of the voyage and thereafter in broadband mode, the RDI Ocean Surveyor 75kHz ADCP was run in narrowband mode only. There is no data for the OS75 for the first part of the voyage.

Internal triggering was used.
Both drop keels lowered to flush with gondola (approx 8m below waterline) to reduce interference with EM2040 system.

See the voyage computing and electronics report for more details regarding data acquisition.
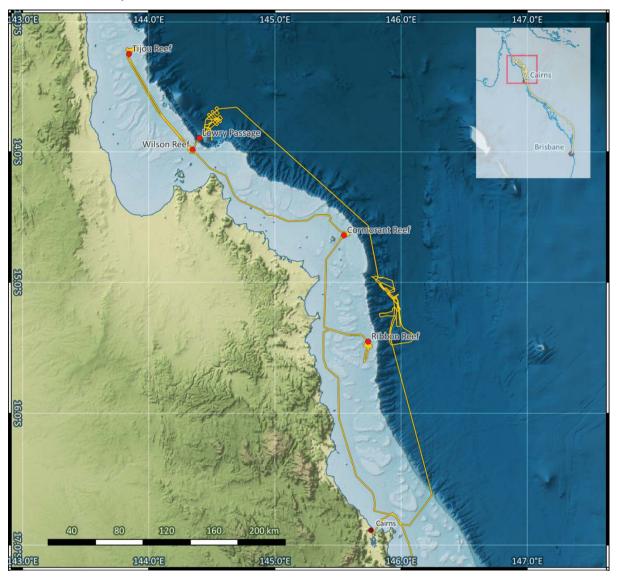
Data Dates: (UTC)

PART-1	Start:	End:
OS150 narrowband	14 Aug. 04:57am (225.21)	19 Aug. 15:39pm (230.65)
OS150 broadband	19 Aug. 15:49pm (230.66)	21 Aug. 02:11am (232.09)
PART-2:		
OS150 broadband:	21 Aug. 06:22am (232.27)	06 Sep. 20:55pm (248.87)
OS75 narrowband:	01 Sep. 09:05am (243.38)	06 Sep. 14:00pm (248.58)

2   Voyage Details

2.1   Voyage Objectives

The primary objective of this voyage was to investigate the Halimeda Bioherms on the northern Great Barrier Reef. This was achieved through thorough geophysical mapping, sea floor imaging, sea water and seabed sampling.

2.2   Area of Operation

Please see the webpy folders for plots of collected data.

3   Data Processing

3.1   Background Information

The University of Hawaii's CODAS software contained in their "focal_20.04" Virtual Machine image was used for data post-processing.

3.2   Processing Notes

Only minor editing was required, data was masked where instrument anomalies were suspected and where the os75 and os150 data differed significantly. A heading correction was applied only to the os150bb, the phase was rotated by 0.1390 and scaled by 1.0070 for part-2 of the data. No additional amplitude or phase adjustments were applied to the remaining data as the transducer angles of any of the data as they were all within acceptable limits.

When processing the data, the true transducer offsets in metres from the GPS position of the ship of 75kHz dx=-1 dy=4 and 150kHz dx=-1 dy=1 were used.

Instrument Serial Numbers:

Manufacturer	Instrument	Serial Number
TRDI	ADCP 75 KHz	65008
TRDI	ADCP 150 KHz	61315

Table.1

NetCDF Output Files:

in2022_v07_ADCP_pt1_os150bb.nc
in2022_v07_ADCP_pt1_os150nb.nc
in2022_v07_ADCP_pt2_os150bb.nc
in2022_v07_ADCP_pt2_os75nb.nc

4   netCDF Data Headers

4.1   OS150nb (part-1)

```
netcdf in2022_v07_pt1_os150nb {
dimensions:
        time = 1225 ;
        depth_cell = 60 ;
variables:
        int trajectory ;
                trajectory:standard_name = "trajectory_id" ;
        double time(time) ;
                time:long_name = "Decimal day" ;
                time:units = "days since 2022-01-01 00:00:00" ;
                time:C_format = "%12.5f" ;
                time:standard_name = "time" ;
                time:data_min = 225.20650462963 ;
                time:data_max = 230.652488425926 ;
        double lon(time) ;
                lon:missing_value = 1.e+38 ;
                lon:long_name = "Longitude" ;
                lon:units = "degrees_east" ;
                lon:C_format = "%9.4f" ;
                lon:standard_name = "longitude" ;
                lon:data_min = 145.718305555556 ;
                lon:data_max = 153.514577777778 ;
        double lat(time) ;
                lat:missing_value = 1.e+38 ;
                lat:long_name = "Latitude" ;
                lat:units = "degrees_north" ;
                lat:C_format = "%9.4f" ;
                lat:standard_name = "latitude" ;
                lat:data_min = -26.6826055555556 ;
                lat:data_max = -15.4812888888889 ;
        float depth(time, depth_cell) ;
                depth:missing_value = 1.e+38f ;
                depth:long_name = "Depth" ;
                depth:units = "meter" ;
                depth:C_format = "%8.2f" ;
                depth:positive = "down" ;
                depth:data_min = 11.95f ;
                depth:data_max = 489.98f ;
        float u(time, depth_cell) ;
                u:missing_value = 1.e+38f ;
```

```
                u:long_name = "Zonal velocity component" ;
                u:units = "meter second-1" ;
                u:C_format = "%7.2f" ;
                u:data_min = -0.525852f ;
                u:data_max = 0.5808082f ;
        float v(time, depth_cell) ;
                v:missing_value = 1.e+38f ;
                v:long_name = "Meridional velocity component" ;
                v:units = "meter second-1" ;
                v:C_format = "%7.2f" ;
                v:data_min = -0.7861695f ;
                v:data_max = 0.705749f ;
        short amp(time, depth_cell) ;
                amp:missing_value = 32767s ;
                amp:long_name = "Received signal strength" ;
                amp:C_format = "%d" ;
                amp:data_min = 27s ;
                amp:data_max = 229s ;
        byte pg(time, depth_cell) ;
                pg:missing_value = -1b ;
                pg:long_name = "Percent good pings" ;
                pg:C_format = "%d" ;
                pg:data_min = 0b ;
                pg:data_max = 100b ;
        byte pflag(time, depth_cell) ;
                pflag:long_name = "Editing flags" ;
                pflag:C_format = "%d" ;
                pflag:data_min = -1b ;
                pflag:data_max = 6b ;
        float heading(time) ;
                heading:missing_value = 1.e+38f ;
                heading:long_name = "Ship heading" ;
                heading:units = "degrees" ;
                heading:C_format = "%6.1f" ;
                heading:data_min = -175.2079f ;
                heading:data_max = 158.6419f ;
        float tr_temp(time) ;
                tr_temp:missing_value = 1.e+38f ;
                tr_temp:long_name = "ADCP transducer temperature" ;
                tr_temp:units = "Celsius" ;
                tr_temp:C_format = "%4.1f" ;
                tr_temp:data_min = 19.20424f ;
                tr_temp:data_max = 25.60462f ;
        short num_pings(time) ;
                num_pings:long_name = "Number of pings averaged per ensemble" ;
                num_pings:units = "None" ;
                num_pings:C_format = "%d" ;
                num_pings:data_min = 23s ;
                num_pings:data_max = 274s ;
        float uship(time) ;
                uship:missing_value = 1.e+38f ;
                uship:long_name = "Ship zonal velocity component" ;
                uship:units = "meter second-1" ;
                uship:C_format = "%9.4f" ;
                uship:data_min = -5.882517f ;
                uship:data_max = 4.297389f ;
        float vship(time) ;
                vship:missing_value = 1.e+38f ;
                vship:long_name = "Ship meridional velocity component" ;
                vship:units = "meter second-1" ;
                vship:C_format = "%9.4f" ;
                vship:data_min = -70.19971f ;
                vship:data_max = 54.85859f ;

// global attributes:
                :featureType = "trajectoryProfile" ;
                :history = "Created: 2022-12-06 01:52:18 UTC" ;
                :Conventions = "COARDS" ;
                :software = "pycurrents" ;
                :hg_changeset = "3211:63370479787a" ;
                :title = "Shipboard ADCP velocity profiles" ;
                :description = "Shipboard ADCP velocity profiles from in2022_v07_pt1 using instrument os150nb
- Short Version." ;
                :cruise_id = "in2022_v07_pt1" ;
```

```
        :sonar = "os150nb" ;
        :yearbase = 2022 ;
        :ship_name = "RV_Investigator" ;
        :CODAS_variables = "\n",
                "Variables in this CODAS short-form Netcdf file are intended for most end-user\n",
                "scientific analysis and display purposes. For additional information see\n",
                "the CODAS_processing_note global attribute and the attributes of each\n",
                "of the variables.\n",
                "\n",
                "\n",
                "============ =====================================================================\n",
                "time         Time at the end of the ensemble, days from start of year.\n",
                "lon, lat     Longitude, Latitude from GPS at the end of the ensemble.\n",
                "u,v          Ocean zonal and meridional velocity component profiles.\n",
                "uship, vship Zonal and meridional velocity components of the ship.\n",
                "heading      Mean ship heading during the ensemble.\n",
                "depth        Bin centers in nominal meters (no sound speed profile correction).\n",
                "tr_temp      ADCP transducer temperature.\n",
                "pg           Percent Good pings for u, v averaging after editing.\n",
                "pflag        Profile Flags based on editing, used to mask u, v.\n",
                "amp          Received signal strength in ADCP-specific units; no correction\n",
                "             for spreading or attenuation.\n",
                "============ =====================================================================\n",
                "\n",
                "" ;
        :CODAS_processing_note = "\n",
                "CODAS processing note:\n",
                "======================\n",
                "\n",
                "Overview\n",
                "--------\n",
                "The CODAS database is a specialized storage format designed for\n",
                "shipboard ADCP data.  \"CODAS processing\" uses this format to hold\n",
                "averaged shipboard ADCP velocities and other variables, during the\n",
                "stages of data processing.  The CODAS database stores velocity\n",
                "profiles relative to the ship as east and north components along with\n",
                "position, ship speed, heading, and other variables. The netCDF *short*\n",
                "form contains ocean velocities relative to earth, time, position,\n",
                "transducer temperature, and ship heading; these are designed to be\n",
                "\"ready for immediate use\".  The netCDF *long* form is just a dump of\n",
                "the entire CODAS database.  Some variables are no longer used, and all\n",
                "have names derived from their original CODAS names, dating back to the\n",
                "late 1980\'s.\n",
                "\n",
                "Post-processing\n",
                "---------------\n",
                "CODAS post-processing, i.e. that which occurs after the single-ping\n",
                "profiles have been vector-averaged and loaded into the CODAS database,\n",
                "includes editing (using automated algorithms and manual tools),\n",
                "rotation and scaling of the measured velocities, and application of a\n",
                "time-varying heading correction.  Additional algorithms developed more\n",
                "recently include translation of the GPS positions to the transducer\n",
                "location, and averaging of ship\'s speed over the times of valid pings\n",
                "when Percent Good is reduced. Such post-processing is needed prior to\n",
                "submission of \"processed ADCP data\" to JASADCP or other archives.\n",
                "\n",
                "Full CODAS processing\n",
                "---------------------\n",
                "Whenever single-ping data have been recorded, full CODAS processing\n",
                "provides the best end product.\n",
                "\n",
                "Full CODAS processing starts with the single-ping velocities in beam\n",
                "coordinates.  Based on the transducer orientation relative to the\n",
                "hull, the beam velocities are transformed to horizontal, vertical, and\n",
                "\"error velocity\" components.  Using a reliable heading (typically from\n",
                "the ship\'s gyro compass), the velocities in ship coordinates are\n",
                "rotated into earth coordinates.\n",
                "\n",
                "Pings are grouped into an \"ensemble\" (usually 2-5 minutes duration)\n",
                "and undergo a suite of automated editing algorithms (removal of\n",
                "acoustic interference; identification of the bottom; editing based on\n",
                "thresholds; and specialized editing that targets CTD wire interference\n",
                "and \"weak, biased profiles\".  The ensemble of single-ping velocities\n",
                "is then averaged using an iterative reference layer averaging scheme.\n",
```

```
"Each ensemble is approximated as a single function of depth, with a\n",
"zero-average over a reference layer plus a reference layer velocity\n",
"for each ping.  Adding the average of the single-ping reference layer\n",
"velocities to the function of depth yields the ensemble-average\n",
"velocity profile.  These averaged profiles, along with ancillary\n",
"measurements, are written to disk, and subsequently loaded into the\n",
"CODAS database. Everything after this stage is \"post-processing\".\n",
"\n",
"note (time):\n",
"-----------\n",
"Time is stored in the database using UTC Year, Month, Day, Hour,\n",
"Minute, Seconds.  Floating point time \"Decimal Day\" is the floating\n",
"point interval in days since the start of the year, usually the year\n",
"of the first day of the cruise.\n",
"\n",
"\n",
"note (heading):\n",
"--------------\n",
"CODAS processing uses heading from a reliable device, and (if\n",
"available) uses a time-dependent correction by an accurate heading\n",
"device.  The reliable heading device is typically a gyro compass (for\n",
"example, the Bridge gyro).  Accurate heading devices can be POSMV,\n",
"Seapath, Phins, Hydrins, MAHRS, or various Ashtech devices; this\n",
"varies with the technology of the time.  It is always confusing to\n",
"keep track of the sign of the heading correction.  Headings are written\n",
"degrees, positive clockwise. setting up some variables:\n",
"\n",
"X = transducer angle (CONFIG1_heading_bias)\n",
"    positive clockwise (beam 3 angle relative to ship)\n",
"G = Reliable heading (gyrocompass)\n",
"A = Accurate heading\n",
"dh = G - A = time-dependent heading correction (ANCIL2_watrk_hd_misalign)\n",
"\n",
"Rotation of the measured velocities into the correct coordinate system\n",
"amounts to (u+i*v)*(exp(i*theta)) where theta is the sum of the\n",
"corrected heading and the transducer angle.\n",
"\n",
"theta = X + (G - dh) = X + G - dh\n",
"\n",
"\n",
"Watertrack and Bottomtrack calibrations give an indication of the\n",
"residual angle offset to apply, for example if mean and median of the\n",
"phase are all 0.5 (then R=0.5).  Using the \"rotate\" command,\n",
"the value of R is added to \"ANCIL2_watrk_hd_misalign\".\n",
"\n",
"new_dh = dh + R\n",
"\n",
"Therefore the total angle used in rotation is\n",
"\n",
"new_theta = X + G - dh_new\n",
"          = X + G - (dh + R)\n",
"          = (X - R) + (G - dh)\n",
"\n",
"The new estimate of the transducer angle is: X - R\n",
"ANCIL2_watrk_hd_misalign contains: dh + R\n",
"\n",
"==================================================\n",
"\n",
"Profile flags\n",
"-------------\n",
"Profile editing flags are provided for each depth cell:\n",
"\n",
"binary    decimal    below    Percent\n",
"value     value      bottom   Good       bin\n",
"-------+----------+--------+----------+-------+\n",
"000       0\n",
"001       1                            bad\n",
"010       2                  bad\n",
"011       3                  bad       bad\n",
"100       4         bad\n",
"101       5         bad                bad\n",
"110       6         bad      bad\n",
"111       7         bad      bad       bad\n",
"-------+----------+--------+----------+-------+\n",
```

```
                                "" ;
}
```

4.2 OS150bb (part-1)

```
codaspy:(os150bb)$ ncdump -h in2022_v07_pt1_os150bb.nc
netcdf in2022_v07_pt1_os150bb {
dimensions:
        time = 382 ;
        depth_cell = 30 ;
variables:
        int trajectory ;
                trajectory:standard_name = "trajectory_id" ;
        double time(time) ;
                time:long_name = "Decimal day" ;
                time:units = "days since 2022-01-01 00:00:00" ;
                time:C_format = "%12.5f" ;
                time:standard_name = "time" ;
                time:data_min = 230.659270833333 ;
                time:data_max = 232.091319444444 ;
        double lon(time) ;
                lon:missing_value = 1.e+38 ;
                lon:long_name = "Longitude" ;
                lon:units = "degrees_east" ;
                lon:C_format = "%9.4f" ;
                lon:standard_name = "longitude" ;
                lon:data_min = 145.706386111111 ;
                lon:data_max = 145.760147222222 ;
        double lat(time) ;
                lat:missing_value = 1.e+38 ;
                lat:long_name = "Latitude" ;
                lat:units = "degrees_north" ;
                lat:C_format = "%9.4f" ;
                lat:standard_name = "latitude" ;
                lat:data_min = -15.6070861111111 ;
                lat:data_max = -15.4751972222222 ;
        float depth(time, depth_cell) ;
                depth:missing_value = 1.e+38f ;
                depth:long_name = "Depth" ;
                depth:units = "meter" ;
                depth:C_format = "%8.2f" ;
                depth:positive = "down" ;
                depth:data_min = 10.23f ;
                depth:data_max = 90.28f ;
        float u(time, depth_cell) ;
                u:missing_value = 1.e+38f ;
                u:long_name = "Zonal velocity component" ;
                u:units = "meter second-1" ;
                u:C_format = "%7.2f" ;
                u:data_min = -0.302329f ;
                u:data_max = 0.2251875f ;
        float v(time, depth_cell) ;
                v:missing_value = 1.e+38f ;
                v:long_name = "Meridional velocity component" ;
                v:units = "meter second-1" ;
                v:C_format = "%7.2f" ;
                v:data_min = -0.2087555f ;
                v:data_max = 0.1836546f ;
        short amp(time, depth_cell) ;
                amp:missing_value = 32767s ;
                amp:long_name = "Received signal strength" ;
                amp:C_format = "%d" ;
                amp:data_min = 50s ;
                amp:data_max = 225s ;
        byte pg(time, depth_cell) ;
                pg:missing_value = -1b ;
                pg:long_name = "Percent good pings" ;
                pg:C_format = "%d" ;
                pg:data_min = 0b ;
                pg:data_max = 100b ;
        byte pflag(time, depth_cell) ;
                pflag:long_name = "Editing flags" ;
```

```
            pflag:C_format = "%d" ;
            pflag:data_min = -1b ;
            pflag:data_max = 6b ;
    float heading(time) ;
            heading:missing_value = 1.e+38f ;
            heading:long_name = "Ship heading" ;
            heading:units = "degrees" ;
            heading:C_format = "%6.1f" ;
            heading:data_min = -179.3325f ;
            heading:data_max = 179.2908f ;
    float tr_temp(time) ;
            tr_temp:missing_value = 1.e+38f ;
            tr_temp:long_name = "ADCP transducer temperature" ;
            tr_temp:units = "Celsius" ;
            tr_temp:C_format = "%4.1f" ;
            tr_temp:data_min = 25.13879f ;
            tr_temp:data_max = 25.60103f ;
    short num_pings(time) ;
            num_pings:long_name = "Number of pings averaged per ensemble" ;
            num_pings:units = "None" ;
            num_pings:C_format = "%d" ;
            num_pings:data_min = 17s ;
            num_pings:data_max = 275s ;
    float uship(time) ;
            uship:missing_value = 1.e+38f ;
            uship:long_name = "Ship zonal velocity component" ;
            uship:units = "meter second-1" ;
            uship:C_format = "%9.4f" ;
            uship:data_min = -3.487553f ;
            uship:data_max = 2.270044f ;
    float vship(time) ;
            vship:missing_value = 1.e+38f ;
            vship:long_name = "Ship meridional velocity component" ;
            vship:units = "meter second-1" ;
            vship:C_format = "%9.4f" ;
            vship:data_min = -5.795614f ;
            vship:data_max = 3.230029f ;

// global attributes:
            :featureType = "trajectoryProfile" ;
            :history = "Created: 2022-12-06 01:52:42 UTC" ;
            :Conventions = "COARDS" ;
            :software = "pycurrents" ;
            :hg_changeset = "3211:63370479787a" ;
            :title = "Shipboard ADCP velocity profiles" ;
            :description = "Shipboard ADCP velocity profiles from in2022_v07_pt1 using instrument os150bb
- Short Version." ;
            :cruise_id = "in2022_v07_pt1" ;
            :sonar = "os150bb" ;
            :yearbase = 2022 ;
            :ship_name = "RV_Investigator" ;
            :CODAS_variables = "\n",
                "Variables in this CODAS short-form Netcdf file are intended for most end-user\n",
                "scientific analysis and display purposes. For additional information see\n",
                "the CODAS_processing_note global attribute and the attributes of each\n",
                "of the variables.\n",
                "\n",
                "\n",
                "============= ===================================================================\n",
                "time          Time at the end of the ensemble, days from start of year.\n",
                "lon, lat      Longitude, Latitude from GPS at the end of the ensemble.\n",
                "u,v           Ocean zonal and meridional velocity component profiles.\n",
                "uship, vship  Zonal and meridional velocity components of the ship.\n",
                "heading       Mean ship heading during the ensemble.\n",
                "depth         Bin centers in nominal meters (no sound speed profile correction).\n",
                "tr_temp       ADCP transducer temperature.\n",
                "pg            Percent Good pings for u, v averaging after editing.\n",
                "pflag         Profile Flags based on editing, used to mask u, v.\n",
                "amp           Received signal strength in ADCP-specific units; no correction\n",
                "              for spreading or attenuation.\n",
                "============= ===================================================================\n",
                "\n",
                "" ;
            :CODAS_processing_note = "\n",
```

```
"CODAS processing note:\n",
"=====================\n",
"\n",
"Overview\n",
"--------\n",
"The CODAS database is a specialized storage format designed for\n",
"shipboard ADCP data.  \"CODAS processing\" uses this format to hold\n",
"averaged shipboard ADCP velocities and other variables, during the\n",
"stages of data processing.  The CODAS database stores velocity\n",
"profiles relative to the ship as east and north components along with\n",
"position, ship speed, heading, and other variables. The netCDF *short*\n",
"form contains ocean velocities relative to earth, time, position,\n",
"transducer temperature, and ship heading; these are designed to be\n",
"\"ready for immediate use\".  The netCDF *long* form is just a dump of\n",
"the entire CODAS database.  Some variables are no longer used, and all\n",
"have names derived from their original CODAS names, dating back to the\n",
"late 1980\'s.\n",
"\n",
"Post-processing\n",
"---------------\n",
"CODAS post-processing, i.e. that which occurs after the single-ping\n",
"profiles have been vector-averaged and loaded into the CODAS database,\n",
"includes editing (using automated algorithms and manual tools),\n",
"rotation and scaling of the measured velocities, and application of a\n",
"time-varying heading correction.  Additional algorithms developed more\n",
"recently include translation of the GPS positions to the transducer\n",
"location, and averaging of ship\'s speed over the times of valid pings\n",
"when Percent Good is reduced. Such post-processing is needed prior to\n",
"submission of \"processed ADCP data\" to JASADCP or other archives.\n",
"\n",
"Full CODAS processing\n",
"--------------------\n",
"Whenever single-ping data have been recorded, full CODAS processing\n",
"provides the best end product.\n",
"\n",
"Full CODAS processing starts with the single-ping velocities in beam\n",
"coordinates.  Based on the transducer orientation relative to the\n",
"hull, the beam velocities are transformed to horizontal, vertical, and\n",
"\"error velocity\" components.  Using a reliable heading (typically from\n",
"the ship\'s gyro compass), the velocities in ship coordinates are\n",
"rotated into earth coordinates.\n",
"\n",
"Pings are grouped into an \"ensemble\" (usually 2-5 minutes duration)\n",
"and undergo a suite of automated editing algorithms (removal of\n",
"acoustic interference; identification of the bottom; editing based on\n",
"thresholds; and specialized editing that targets CTD wire interference\n",
"and \"weak, biased profiles\".  The ensemble of single-ping velocities\n",
"is then averaged using an iterative reference layer averaging scheme.\n",
"Each ensemble is approximated as a single function of depth, with a\n",
"zero-average over a reference layer plus a reference layer velocity\n",
"for each ping.  Adding the average of the single-ping reference layer\n",
"velocities to the function of depth yields the ensemble-average\n",
"velocity profile.  These averaged profiles, along with ancillary\n",
"measurements, are written to disk, and subsequently loaded into the\n",
"CODAS database. Everything after this stage is \"post-processing\".\n",
"\n",
"note (time):\n",
"-----------\n",
"Time is stored in the database using UTC Year, Month, Day, Hour,\n",
"Minute, Seconds.  Floating point time \"Decimal Day\" is the floating\n",
"point interval in days since the start of the year, usually the year\n",
"of the first day of the cruise.\n",
"\n",
"\n",
"note (heading):\n",
"--------------\n",
"CODAS processing uses heading from a reliable device, and (if\n",
"available) uses a time-dependent correction by an accurate heading\n",
"device.  The reliable heading device is typically a gyro compass (for\n",
"example, the Bridge gyro).  Accurate heading devices can be POSMV,\n",
"Seapath, Phins, Hydrins, MAHRS, or various Ashtech devices; this\n",
"varies with the technology of the time.  It is always confusing to\n",
"keep track of the sign of the heading correction.  Headings are written\n",
"degrees, positive clockwise. setting up some variables:\n",
```

```
                "\n",
                "X = transducer angle (CONFIG1_heading_bias)\n",
                "    positive clockwise (beam 3 angle relative to ship)\n",
                "G = Reliable heading (gyrocompass)\n",
                "A = Accurate heading\n",
                "dh = G - A = time-dependent heading correction (ANCIL2_watrk_hd_misalign)\n",
                "\n",
                "Rotation of the measured velocities into the correct coordinate system\n",
                "amounts to (u+i*v)*(exp(i*theta)) where theta is the sum of the\n",
                "corrected heading and the transducer angle.\n",
                "\n",
                "theta = X + (G - dh) = X + G - dh\n",
                "\n",
                "\n",
                "Watertrack and Bottomtrack calibrations give an indication of the\n",
                "residual angle offset to apply, for example if mean and median of the\n",
                "phase are all 0.5 (then R=0.5).  Using the \"rotate\" command,\n",
                "the value of R is added to \"ANCIL2_watrk_hd_misalign\".\n",
                "\n",
                "new_dh = dh + R\n",
                "\n",
                "Therefore the total angle used in rotation is\n",
                "\n",
                "new_theta = X + G - dh_new\n",
                "          = X + G - (dh + R)\n",
                "          = (X - R) + (G - dh)\n",
                "\n",
                "The new estimate of the transducer angle is: X - R\n",
                "ANCIL2_watrk_hd_misalign contains: dh + R\n",
                "\n",
                "==================================================\n",
                "\n",
                "Profile flags\n",
                "-------------\n",
                "Profile editing flags are provided for each depth cell:\n",
                "\n",
                "binary    decimal    below    Percent\n",
                "value     value      bottom   Good      bin\n",
                "-------+----------+--------+----------+-------+\n",
                "000       0\n",
                "001       1                             bad\n",
                "010       2                   bad\n",
                "011       3                   bad       bad\n",
                "100       4         bad\n",
                "101       5         bad                 bad\n",
                "110       6         bad       bad\n",
                "111       7         bad       bad       bad\n",
                "-------+----------+--------+----------+-------+\n",
                "" ;
}
```

4.3 OS75nb (part-2)

```
codaspy:(os75nb)$ ncdump -h in2022_v07_pt2_os75nb.nc
netcdf in2022_v07_pt2_os75nb {
dimensions:
        time = 1500 ;
        depth_cell = 60 ;
variables:
        int trajectory ;
                trajectory:standard_name = "trajectory_id" ;
        double time(time) ;
                time:long_name = "Decimal day" ;
                time:units = "days since 2022-01-01 00:00:00" ;
                time:C_format = "%12.5f" ;
                time:standard_name = "time" ;
                time:data_min = 243.378784722222 ;
                time:data_max = 248.583634259259 ;
        double lon(time) ;
                lon:missing_value = 1.e+38 ;
                lon:long_name = "Longitude" ;
                lon:units = "degrees_east" ;
                lon:C_format = "%9.4f" ;
```

```
        lon:standard_name = "longitude" ;
        lon:data_min = 144.394205555556 ;
        lon:data_max = 146.226763888889 ;
double lat(time) ;
        lat:missing_value = 1.e+38 ;
        lat:long_name = "Latitude" ;
        lat:units = "degrees_north" ;
        lat:C_format = "%9.4f" ;
        lat:standard_name = "latitude" ;
        lat:data_min = -16.5456277777778 ;
        lat:data_max = -13.6537111111111 ;
float depth(time, depth_cell) ;
        depth:missing_value = 1.e+38f ;
        depth:long_name = "Depth" ;
        depth:units = "meter" ;
        depth:C_format = "%8.2f" ;
        depth:positive = "down" ;
        depth:data_min = 29.99f ;
        depth:data_max = 973.99f ;
float u(time, depth_cell) ;
        u:missing_value = 1.e+38f ;
        u:long_name = "Zonal velocity component" ;
        u:units = "meter second-1" ;
        u:C_format = "%7.2f" ;
        u:data_min = -0.7980547f ;
        u:data_max = 0.3982574f ;
float v(time, depth_cell) ;
        v:missing_value = 1.e+38f ;
        v:long_name = "Meridional velocity component" ;
        v:units = "meter second-1" ;
        v:C_format = "%7.2f" ;
        v:data_min = -0.4269354f ;
        v:data_max = 0.6870871f ;
short amp(time, depth_cell) ;
        amp:missing_value = 32767s ;
        amp:long_name = "Received signal strength" ;
        amp:C_format = "%d" ;
        amp:data_min = 25s ;
        amp:data_max = 195s ;
byte pg(time, depth_cell) ;
        pg:missing_value = -1b ;
        pg:long_name = "Percent good pings" ;
        pg:C_format = "%d" ;
        pg:data_min = 0b ;
        pg:data_max = 100b ;
byte pflag(time, depth_cell) ;
        pflag:long_name = "Editing flags" ;
        pflag:C_format = "%d" ;
        pflag:data_min = 0b ;
        pflag:data_max = 6b ;
float heading(time) ;
        heading:missing_value = 1.e+38f ;
        heading:long_name = "Ship heading" ;
        heading:units = "degrees" ;
        heading:C_format = "%6.1f" ;
        heading:data_min = -179.7135f ;
        heading:data_max = 176.8902f ;
float tr_temp(time) ;
        tr_temp:missing_value = 1.e+38f ;
        tr_temp:long_name = "ADCP transducer temperature" ;
        tr_temp:units = "Celsius" ;
        tr_temp:C_format = "%4.1f" ;
        tr_temp:data_min = 25.51233f ;
        tr_temp:data_max = 26.36114f ;
short num_pings(time) ;
        num_pings:long_name = "Number of pings averaged per ensemble" ;
        num_pings:units = "None" ;
        num_pings:C_format = "%d" ;
        num_pings:data_min = 132s ;
        num_pings:data_max = 133s ;
float uship(time) ;
        uship:missing_value = 1.e+38f ;
        uship:long_name = "Ship zonal velocity component" ;
        uship:units = "meter second-1" ;
```

```
                uship:C_format = "%9.4f" ;
                uship:data_min = -4.403536f ;
                uship:data_max = 5.304805f ;
        float vship(time) ;
                vship:missing_value = 1.e+38f ;
                vship:long_name = "Ship meridional velocity component" ;
                vship:units = "meter second-1" ;
                vship:C_format = "%9.4f" ;
                vship:data_min = -4.680024f ;
                vship:data_max = 5.086902f ;

// global attributes:
                :featureType = "trajectoryProfile" ;
                :history = "Created: 2022-12-07 02:22:00 UTC" ;
                :Conventions = "COARDS" ;
                :software = "pycurrents" ;
                :hg_changeset = "3211:63370479787a" ;
                :title = "Shipboard ADCP velocity profiles" ;
                :description = "Shipboard ADCP velocity profiles from in2022_v07_pt2 using instrument os75nb -
Short Version." ;
                :cruise_id = "in2022_v07_pt2" ;
                :sonar = "os75nb" ;
                :yearbase = 2022 ;
                :ship_name = "RV_Investigator" ;
                :CODAS_variables = "\n",
                        "Variables in this CODAS short-form Netcdf file are intended for most end-user\n",
                        "scientific analysis and display purposes. For additional information see\n",
                        "the CODAS_processing_note global attribute and the attributes of each\n",
                        "of the variables.\n",
                        "\n",
                        "\n",
                        "============= =======================================================================\n",
                        "time         Time at the end of the ensemble, days from start of year.\n",
                        "lon, lat     Longitude, Latitude from GPS at the end of the ensemble.\n",
                        "u,v          Ocean zonal and meridional velocity component profiles.\n",
                        "uship, vship Zonal and meridional velocity components of the ship.\n",
                        "heading      Mean ship heading during the ensemble.\n",
                        "depth        Bin centers in nominal meters (no sound speed profile correction).\n",
                        "tr_temp      ADCP transducer temperature.\n",
                        "pg           Percent Good pings for u, v averaging after editing.\n",
                        "pflag        Profile Flags based on editing, used to mask u, v.\n",
                        "amp          Received signal strength in ADCP-specific units; no correction\n",
                        "             for spreading or attenuation.\n",
                        "============= =======================================================================\n",
                        "\n",
                        "" ;
                :CODAS_processing_note = "\n",
                        "CODAS processing note:\n",
                        "======================\n",
                        "\n",
                        "Overview\n",
                        "--------\n",
                        "The CODAS database is a specialized storage format designed for\n",
                        "shipboard ADCP data.  \"CODAS processing\" uses this format to hold\n",
                        "averaged shipboard ADCP velocities and other variables, during the\n",
                        "stages of data processing.  The CODAS database stores velocity\n",
                        "profiles relative to the ship as east and north components along with\n",
                        "position, ship speed, heading, and other variables. The netCDF *short*\n",
                        "form contains ocean velocities relative to earth, time, position,\n",
                        "transducer temperature, and ship heading; these are designed to be\n",
                        "\"ready for immediate use\".  The netCDF *long* form is just a dump of\n",
                        "the entire CODAS database.  Some variables are no longer used, and all\n",
                        "have names derived from their original CODAS names, dating back to the\n",
                        "late 1980\'s.\n",
                        "\n",
                        "Post-processing\n",
                        "---------------\n",
                        "CODAS post-processing, i.e. that which occurs after the single-ping\n",
                        "profiles have been vector-averaged and loaded into the CODAS database,\n",
                        "includes editing (using automated algorithms and manual tools),\n",
                        "rotation and scaling of the measured velocities, and application of a\n",
                        "time-varying heading correction.  Additional algorithms developed more\n",
                        "recently include translation of the GPS positions to the transducer\n",
                        "location, and averaging of ship\'s speed over the times of valid pings\n",
```

```
"when Percent Good is reduced. Such post-processing is needed prior to\n",
"submission of \"processed ADCP data\" to JASADCP or other archives.\n",
"\n",
"Full CODAS processing\n",
"---------------------\n",
"Whenever single-ping data have been recorded, full CODAS processing\n",
"provides the best end product.\n",
"\n",
"Full CODAS processing starts with the single-ping velocities in beam\n",
"coordinates.  Based on the transducer orientation relative to the\n",
"hull, the beam velocities are transformed to horizontal, vertical, and\n",
"\"error velocity\" components.  Using a reliable heading (typically from\n",
"the ship\'s gyro compass), the velocities in ship coordinates are\n",
"rotated into earth coordinates.\n",
"\n",
"Pings are grouped into an \"ensemble\" (usually 2-5 minutes duration)\n",
"and undergo a suite of automated editing algorithms (removal of\n",
"acoustic interference; identification of the bottom; editing based on\n",
"thresholds; and specialized editing that targets CTD wire interference\n",
"and \"weak, biased profiles\".  The ensemble of single-ping velocities\n",
"is then averaged using an iterative reference layer averaging scheme.\n",
"Each ensemble is approximated as a single function of depth, with a\n",
"zero-average over a reference layer plus a reference layer velocity\n",
"for each ping.  Adding the average of the single-ping reference layer\n",
"velocities to the function of depth yields the ensemble-average\n",
"velocity profile.  These averaged profiles, along with ancillary\n",
"measurements, are written to disk, and subsequently loaded into the\n",
"CODAS database. Everything after this stage is \"post-processing\".\n",
"\n",
"note (time):\n",
"-----------\n",
"Time is stored in the database using UTC Year, Month, Day, Hour,\n",
"Minute, Seconds.  Floating point time \"Decimal Day\" is the floating\n",
"point interval in days since the start of the year, usually the year\n",
"of the first day of the cruise.\n",
"\n",
"\n",
"note (heading):\n",
"--------------\n",
"CODAS processing uses heading from a reliable device, and (if\n",
"available) uses a time-dependent correction by an accurate heading\n",
"device.  The reliable heading device is typically a gyro compass (for\n",
"example, the Bridge gyro).  Accurate heading devices can be POSMV,\n",
"Seapath, Phins, Hydrins, MAHRS, or various Ashtech devices; this\n",
"varies with the technology of the time.  It is always confusing to\n",
"keep track of the sign of the heading correction.  Headings are written\n",
"degrees, positive clockwise. setting up some variables:\n",
"\n",
"X = transducer angle (CONFIG1_heading_bias)\n",
"    positive clockwise (beam 3 angle relative to ship)\n",
"G = Reliable heading (gyrocompass)\n",
"A = Accurate heading\n",
"dh = G - A = time-dependent heading correction (ANCIL2_watrk_hd_misalign)\n",
"\n",
"Rotation of the measured velocities into the correct coordinate system\n",
"amounts to (u+i*v)*(exp(i*theta)) where theta is the sum of the\n",
"corrected heading and the transducer angle.\n",
"\n",
"theta = X + (G - dh) = X + G - dh\n",
"\n",
"\n",
"Watertrack and Bottomtrack calibrations give an indication of the\n",
"residual angle offset to apply, for example if mean and median of the\n",
"phase are all 0.5 (then R=0.5).  Using the \"rotate\" command,\n",
"the value of R is added to \"ANCIL2_watrk_hd_misalign\".\n",
"\n",
"new_dh = dh + R\n",
"\n",
"Therefore the total angle used in rotation is\n",
"\n",
"new_theta = X + G - dh_new\n",
"          = X + G - (dh + R)\n",
"          = (X - R) + (G - dh)\n",
"\n",
```

```
                    "The new estimate of the transducer angle is: X - R\n",
                    "ANCIL2_watrk_hd_misalign contains: dh + R\n",
                    "\n",
                    "=================================================\n",
                    "\n",
                    "Profile flags\n",
                    "-------------\n",
                    "Profile editing flags are provided for each depth cell:\n",
                    "\n",
                    "binary     decimal    below    Percent\n",
                    "value      value      bottom   Good        bin\n",
                    "-------+----------+--------+----------+-------+\n",
                    "000         0\n",
                    "001         1                                bad\n",
                    "010         2                   bad\n",
                    "011         3                   bad         bad\n",
                    "100         4          bad\n",
                    "101         5          bad                  bad\n",
                    "110         6          bad      bad\n",
                    "111         7          bad      bad         bad\n",
                    "-------+----------+--------+----------+-------+\n",
                    "" ;
}
```

4.4 OS150bb (part-2)

```
codaspy:(os150bb)$ ncdump -h in2022_v07_pt2_os150bb.nc
netcdf in2022_v07_pt2_os150bb {
dimensions:
        time = 3558 ;
        depth_cell = 30 ;
variables:
        int trajectory ;
                trajectory:standard_name = "trajectory_id" ;
        double time(time) ;
                time:long_name = "Decimal day" ;
                time:units = "days since 2022-01-01 00:00:00" ;
                time:C_format = "%12.5f" ;
                time:standard_name = "time" ;
                time:data_min = 232.265787037037 ;
                time:data_max = 248.871828703704 ;
        double lon(time) ;
                lon:missing_value = 1.e+38 ;
                lon:long_name = "Longitude" ;
                lon:units = "degrees_east" ;
                lon:C_format = "%9.4f" ;
                lon:standard_name = "longitude" ;
                lon:data_min = 143.823422222222 ;
                lon:data_max = 146.246486111111 ;
        double lat(time) ;
                lat:missing_value = 1.e+38 ;
                lat:long_name = "Latitude" ;
                lat:units = "degrees_north" ;
                lat:C_format = "%9.4f" ;
                lat:standard_name = "latitude" ;
                lat:data_min = -16.9050666666667 ;
                lat:data_max = -13.2015777777778 ;
        float depth(time, depth_cell) ;
                depth:missing_value = 1.e+38f ;
                depth:long_name = "Depth" ;
                depth:units = "meter" ;
                depth:C_format = "%8.2f" ;
                depth:positive = "down" ;
                depth:data_min = 10.22f ;
                depth:data_max = 68.23f ;
        float u(time, depth_cell) ;
                u:missing_value = 1.e+38f ;
                u:long_name = "Zonal velocity component" ;
                u:units = "meter second-1" ;
                u:C_format = "%7.2f" ;
                u:data_min = -0.8275878f ;
                u:data_max = 0.4430929f ;
        float v(time, depth_cell) ;
```

```
                v:missing_value = 1.e+38f ;
                v:long_name = "Meridional velocity component" ;
                v:units = "meter second-1" ;
                v:C_format = "%7.2f" ;
                v:data_min = -0.3661945f ;
                v:data_max = 0.6969352f ;
        short amp(time, depth_cell) ;
                amp:missing_value = 32767s ;
                amp:long_name = "Received signal strength" ;
                amp:C_format = "%d" ;
                amp:data_min = 34s ;
                amp:data_max = 225s ;
        byte pg(time, depth_cell) ;
                pg:missing_value = -1b ;
                pg:long_name = "Percent good pings" ;
                pg:C_format = "%d" ;
                pg:data_min = 0b ;
                pg:data_max = 100b ;
        byte pflag(time, depth_cell) ;
                pflag:long_name = "Editing flags" ;
                pflag:C_format = "%d" ;
                pflag:data_min = 0b ;
                pflag:data_max = 6b ;
        float heading(time) ;
                heading:missing_value = 1.e+38f ;
                heading:long_name = "Ship heading" ;
                heading:units = "degrees" ;
                heading:C_format = "%6.1f" ;
                heading:data_min = -179.705f ;
                heading:data_max = 177.8735f ;
        float tr_temp(time) ;
                tr_temp:missing_value = 1.e+38f ;
                tr_temp:long_name = "ADCP transducer temperature" ;
                tr_temp:units = "Celsius" ;
                tr_temp:C_format = "%4.1f" ;
                tr_temp:data_min = 23.39267f ;
                tr_temp:data_max = 26.0678f ;
        short num_pings(time) ;
                num_pings:long_name = "Number of pings averaged per ensemble" ;
                num_pings:units = "None" ;
                num_pings:C_format = "%d" ;
                num_pings:data_min = 47s ;
                num_pings:data_max = 275s ;
        float uship(time) ;
                uship:missing_value = 1.e+38f ;
                uship:long_name = "Ship zonal velocity component" ;
                uship:units = "meter second-1" ;
                uship:C_format = "%9.4f" ;
                uship:data_min = -6.322773f ;
                uship:data_max = 5.294677f ;
        float vship(time) ;
                vship:missing_value = 1.e+38f ;
                vship:long_name = "Ship meridional velocity component" ;
                vship:units = "meter second-1" ;
                vship:C_format = "%9.4f" ;
                vship:data_min = -4.74833f ;
                vship:data_max = 6.312308f ;

// global attributes:
                :featureType = "trajectoryProfile" ;
                :history = "Created: 2022-12-07 02:20:58 UTC" ;
                :Conventions = "COARDS" ;
                :software = "pycurrents" ;
                :hg_changeset = "3211:63370479787a" ;
                :title = "Shipboard ADCP velocity profiles" ;
                :description = "Shipboard ADCP velocity profiles from in2022_v07_pt2 using instrument os150bb -
Short Version." ;
                :cruise_id = "in2022_v07_pt2" ;
                :sonar = "os150bb" ;
                :yearbase = 2022 ;
                :ship_name = "RV_Investigator" ;
                :CODAS_variables = "\n",
                        "Variables in this CODAS short-form Netcdf file are intended for most end-user\n",
                        "scientific analysis and display purposes. For additional information see\n",
```

```
                    "the CODAS_processing_note global attribute and the attributes of each\n",
                    "of the variables.\n",
                    "\n",
                    "\n",
                    "============= =====================================================================\n",
                    "time          Time at the end of the ensemble, days from start of year.\n",
                    "lon, lat      Longitude, Latitude from GPS at the end of the ensemble.\n",
                    "u,v           Ocean zonal and meridional velocity component profiles.\n",
                    "uship, vship  Zonal and meridional velocity components of the ship.\n",
                    "heading       Mean ship heading during the ensemble.\n",
                    "depth         Bin centers in nominal meters (no sound speed profile correction).\n",
                    "tr_temp       ADCP transducer temperature.\n",
                    "pg            Percent Good pings for u, v averaging after editing.\n",
                    "pflag         Profile Flags based on editing, used to mask u, v.\n",
                    "amp           Received signal strength in ADCP-specific units; no correction\n",
                    "              for spreading or attenuation.\n",
                    "============= =====================================================================\n",
                    "\n",
                    ""  ;
          :CODAS_processing_note = "\n",
                    "CODAS processing note:\n",
                    "======================\n",
                    "\n",
                    "Overview\n",
                    "--------\n",
                    "The CODAS database is a specialized storage format designed for\n",
                    "shipboard ADCP data.  \"CODAS processing\" uses this format to hold\n",
                    "averaged shipboard ADCP velocities and other variables, during the\n",
                    "stages of data processing.  The CODAS database stores velocity\n",
                    "profiles relative to the ship as east and north components along with\n",
                    "position, ship speed, heading, and other variables. The netCDF *short*\n",
                    "form contains ocean velocities relative to earth, time, position,\n",
                    "transducer temperature, and ship heading; these are designed to be\n",
                    "\"ready for immediate use\".  The netCDF *long* form is just a dump of\n",
                    "the entire CODAS database.  Some variables are no longer used, and all\n",
                    "have names derived from their original CODAS names, dating back to the\n",
                    "late 1980\'s.\n",
                    "\n",
                    "Post-processing\n",
                    "---------------\n",
                    "CODAS post-processing, i.e. that which occurs after the single-ping\n",
                    "profiles have been vector-averaged and loaded into the CODAS database,\n",
                    "includes editing (using automated algorithms and manual tools),\n",
                    "rotation and scaling of the measured velocities, and application of a\n",
                    "time-varying heading correction.  Additional algorithms developed more\n",
                    "recently include translation of the GPS positions to the transducer\n",
                    "location, and averaging of ship\'s speed over the times of valid pings\n",
                    "when Percent Good is reduced. Such post-processing is needed prior to\n",
                    "submission of \"processed ADCP data\" to JASADCP or other archives.\n",
                    "\n",
                    "Full CODAS processing\n",
                    "---------------------\n",
                    "Whenever single-ping data have been recorded, full CODAS processing\n",
                    "provides the best end product.\n",
                    "\n",
                    "Full CODAS processing starts with the single-ping velocities in beam\n",
                    "coordinates.  Based on the transducer orientation relative to the\n",
                    "hull, the beam velocities are transformed to horizontal, vertical, and\n",
                    "\"error velocity\" components.  Using a reliable heading (typically from\n",
                    "the ship\'s gyro compass), the velocities in ship coordinates are\n",
                    "rotated into earth coordinates.\n",
                    "\n",
                    "Pings are grouped into an \"ensemble\" (usually 2-5 minutes duration)\n",
                    "and undergo a suite of automated editing algorithms (removal of\n",
                    "acoustic interference; identification of the bottom; editing based on\n",
                    "thresholds; and specialized editing that targets CTD wire interference\n",
                    "and \"weak, biased profiles\".  The ensemble of single-ping velocities\n",
                    "is then averaged using an iterative reference layer averaging scheme.\n",
                    "Each ensemble is approximated as a single function of depth, with a\n",
                    "zero-average over a reference layer plus a reference layer velocity\n",
                    "for each ping.  Adding the average of the single-ping reference layer\n",
                    "velocities to the function of depth yields the ensemble-average\n",
                    "velocity profile.  These averaged profiles, along with ancillary\n",
                    "measurements, are written to disk, and subsequently loaded into the\n",
```

```
            "CODAS database. Everything after this stage is \"post-processing\".\n",
            "\n",
            "note (time):\n",
            "-----------\n",
            "Time is stored in the database using UTC Year, Month, Day, Hour,\n",
            "Minute, Seconds.  Floating point time \"Decimal Day\" is the floating\n",
            "point interval in days since the start of the year, usually the year\n",
            "of the first day of the cruise.\n",
            "\n",
            "\n",
            "note (heading):\n",
            "--------------\n",
            "CODAS processing uses heading from a reliable device, and (if\n",
            "available) uses a time-dependent correction by an accurate heading\n",
            "device.  The reliable heading device is typically a gyro compass (for\n",
            "example, the Bridge gyro).  Accurate heading devices can be POSMV,\n",
            "Seapath, Phins, Hydrins, MAHRS, or various Ashtech devices; this\n",
            "varies with the technology of the time.  It is always confusing to\n",
            "keep track of the sign of the heading correction.  Headings are written\n",
            "degrees, positive clockwise. setting up some variables:\n",
            "\n",
            "X = transducer angle (CONFIG1_heading_bias)\n",
            "    positive clockwise (beam 3 angle relative to ship)\n",
            "G = Reliable heading (gyrocompass)\n",
            "A = Accurate heading\n",
            "dh = G - A = time-dependent heading correction (ANCIL2_watrk_hd_misalign)\n",
            "\n",
            "Rotation of the measured velocities into the correct coordinate system\n",
            "amounts to (u+i*v)*(exp(i*theta)) where theta is the sum of the\n",
            "corrected heading and the transducer angle.\n",
            "\n",
            "theta = X + (G - dh) = X + G - dh\n",
            "\n",
            "\n",
            "Watertrack and Bottomtrack calibrations give an indication of the\n",
            "residual angle offset to apply, for example if mean and median of the\n",
            "phase are all 0.5 (then R=0.5).  Using the \"rotate\" command,\n",
            "the value of R is added to \"ANCIL2_watrk_hd_misalign\".\n",
            "\n",
            "new_dh = dh + R\n",
            "\n",
            "Therefore the total angle used in rotation is\n",
            "\n",
            "new_theta = X + G - dh_new\n",
            "          = X + G - (dh + R)\n",
            "          = (X - R) + (G - dh)\n",
            "\n",
            "The new estimate of the transducer angle is: X - R\n",
            "ANCIL2_watrk_hd_misalign contains: dh + R\n",
            "\n",
            "=================================================\n",
            "\n",
            "Profile flags\n",
            "-------------\n",
            "Profile editing flags are provided for each depth cell:\n",
            "\n",
            "binary     decimal    below    Percent\n",
            "value      value      bottom   Good       bin\n",
            "-------+----------+--------+----------+-------+\n",
            "000        0\n",
            "001        1                                 bad\n",
            "010        2                      bad\n",
            "011        3                      bad        bad\n",
            "100        4          bad\n",
            "101        5          bad                    bad\n",
            "110        6          bad        bad\n",
            "111        7          bad        bad        bad\n",
            "-------+----------+--------+----------+-------+\n",
            "" ;
    }
```