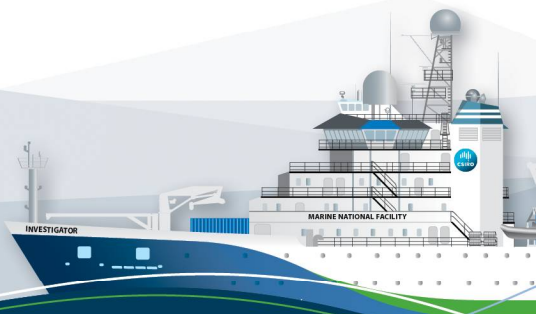
RV *Investigator*

ADCP Processing Report

Voyage:	IN2018_C01
Voyage title:	RAN Hydrographic Survey
Depart:	Hobart, 16:30 Monday, May 28, 2018
Return:	Hobart, 0900 Friday, June 8, 2018
Chief Scientist:	Nigel Townsend
Affiliation:	Royal Australian Navy
Report compiled by:	Anoosh Sarraf
Release date:	5 August 2020



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Contents

1 Summary

Data was collected during in2018_c01 for the duration of the voyage. Data was collected using UHDAS and post-processed using CODAS.

Both the RDI Ocean Surveyor 150kHz ADCP and the RDI Ocean Surveyor 75kHz ADCP were mostly run in narrowband. However, for a small portion of the voyage both broadband and narrowband mode was used for data collection. Internal triggering was used.

The drop keel extension was set at 1.19m thoughout, giving a transducer depth of 7.39m below the waterline for the duration of the voyage.

Both units were switched on and off intermittently throughout the transit to survey site due to testing and configuration of the EM2040. When operational, both units operated mostly in narrow band with some bottom tracking.

See the voyage computing and electronics report for more details regarding data acquisition.

2 Processing Background

The University of Hawaii's CODAS software revision 2903:dd2872d4fef0 dated Apr 09 2019 was used for data post-processing.

3 Processing Notes

Narrowband and some broadband data was collected on OS75 and OS150 sounders. The focus of the voyage was primarily to perform hydrographic survey and therefore both ADCP units were turned off whilst surveying to minimise multibeam interference. Therefore notable amount of ADCP data is not recorded. Moreover, the voyage was mostly in shallow waters with the mean and median water depth of 68 and 65 meters respectively, so full range ensembles could not be recorded for each instrument.

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.

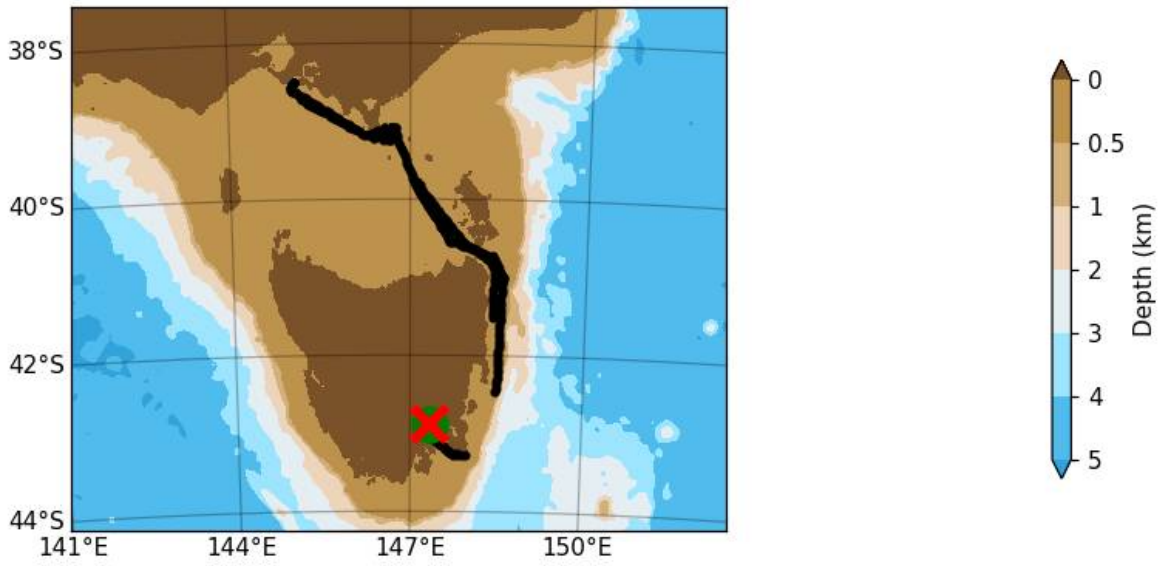
Heading data was corrected using patch_hcorr.py and after rotation the following bottom track calibrations were obtained and applied:

	os75nb	os75bb	os150nb	os150bb
Amplitude	1.0000	1.0087	1.0026	1.0005
Phase	-0.0098	0.0402	0.0054	0.0000
points	464	248	638	363

Data was masked where instrument anomalies were suspected and where the os75 and os150 data differed significantly.

NetCDF files in2018_c01_os75nb.nc, in2018_c01_os75bb.nc and in2018_c01_os150nb.nc, in2018_c01_os150bb.nc were produced.

4 Area Covered



Please see the webpy folders for plots of collected data.

5 netCDF Data Headers

5.1 in2018_c01_os75nb.nc

```
netcdf in2018_c01_os75nb {
dimensions:
   time = 878 ;
   depth_cell = 60 ;
variables:
   int trajectory ;
      trajectory:standard_name = "trajectory_id" ;
   double time(time) ;
      time:long_name = "Decimal day" ;
      time:units = "days since 2018-01-01 00:00:00" ;
      time:C_format = "%12.5f" ;
      time:standard_name = "time" ;
      time:data_min = 147.233472222222 ;
      time:data_max = 158.001423611111 ;
   double lon(time) ;
      lon:missing_value = 1.e+038 ;
      lon:long_name = "Longitude" ;
      lon:units = "degrees_east" ;
      lon:C_format = "%9.4f" ;
      lon:standard_name = "longitude" ;
      lon:data_min = 145.031141666667 ;
      lon:data_max = 148.590311111111 ;
   double lat(time) ;
      lat:missing_value = 1.e+038 ;
      lat:long_name = "Latitude" ;
      lat:units = "degrees_north" ;
      lat:C_format = "%9.4f" ;
      lat:standard_name = "latitude" ;
```

```
   lat:data_min = -43.2874666666667 ;
   lat:data_max = -38.4862333333333 ;
float depth(time, depth_cell) ;
   depth:missing_value = 1.e+038f ;
   depth:long_name = "Depth" ;
   depth:units = "meter" ;
   depth:C_format = "%8.2f" ;
   depth:positive = "down" ;
   depth:data_min = 29.94f ;
   depth:data_max = 973.96f ;
float u(time, depth_cell) ;
   u:missing_value = 1.e+038f ;
   u:long_name = "Zonal velocity component" ;
   u:units = "meter second-1" ;
   u:C_format = "%7.2f" ;
   u:data_min = -0.7447925f ;
   u:data_max = 1.232733f ;
float v(time, depth_cell) ;
   v:missing_value = 1.e+038f ;
   v:long_name = "Meridional velocity component" ;
   v:units = "meter second-1" ;
   v:C_format = "%7.2f" ;
   v:data_min = -1.193483f ;
   v:data_max = 1.235359f ;
short amp(time, depth_cell) ;
   amp:missing_value = 32767s ;
   amp:long_name = "Received signal strength" ;
   amp:C_format = "%d" ;
   amp:data_min = 14s ;
   amp:data_max = 218s ;
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 = 7b ;
float heading(time) ;
   heading:missing_value = 1.e+038f ;
   heading:long_name = "Ship heading" ;
   heading:units = "degrees" ;
   heading:C_format = "%6.1f" ;
   heading:data_min = -179.8015f ;
   heading:data_max = 179.8619f ;
float tr_temp(time) ;
   tr_temp:missing_value = 1.e+038f ;
   tr_temp:long_name = "ADCP transducer temperature" ;
   tr_temp:units = "Celsius" ;
   tr_temp:C_format = "%4.1f" ;
   tr_temp:data_min = 12.42863f ;
   tr_temp:data_max = 16.39893f ;
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 = 10s ;
   num_pings:data_max = 75s ;
float uship(time) ;
   uship:missing_value = 1.e+038f ;
   uship:long_name = "Ship zonal velocity component" ;
   uship:units = "meter second-1" ;
   uship:C_format = "%9.4f" ;
   uship:data_min = -5.947471f ;
   uship:data_max = 6.59782f ;
```

```
   float vship(time) ;
      vship:missing_value = 1.e+038f ;
      vship:long_name = "Ship meridional velocity component" ;
      vship:units = "meter second-1" ;
      vship:C_format = "%9.4f" ;
      vship:data_min = -6.609248f ;
      vship:data_max = 6.350979f ;

// global attributes:
      :featureType = "trajectoryProfile" ;
      :history = "Created: 2020-06-23 15:21:02 UTC" ;
      :Conventions = "COARDS" ;
      :software = "pycurrents" ;
      :hg_changeset = "2993:bc42f2027bfe" ;
      :title = "Shipboard ADCP velocity profiles" ;
      :description = "Shipboard ADCP velocity profiles from in2018_c01 using instrument os75nb
- Short Version." ;
      :cruise_id = "in2018_c01" ;
      :sonar = "os75nb" ;
      :yearbase = 2018 ;
      :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",
```

5.2 in2018_c01_os75bb.nc

```
netcdf in2018_c01_os75bb {
dimensions:
   time = 542 ;
   depth_cell = 80 ;
variables:
   int trajectory ;
      trajectory:standard_name = "trajectory_id" ;
   double time(time) ;
      time:long_name = "Decimal day" ;
      time:units = "days since 2018-01-01 00:00:00" ;
      time:C_format = "%12.5f" ;
      time:standard_name = "time" ;
      time:data_min = 148.948819444444 ;
      time:data_max = 158.001423611111 ;
   double lon(time) ;
      lon:missing_value = 1.e+038 ;
      lon:long_name = "Longitude" ;
      lon:units = "degrees_east" ;
      lon:C_format = "%9.4f" ;
      lon:standard_name = "longitude" ;
      lon:data_min = 145.031141666667 ;
      lon:data_max = 148.425555555556 ;
   double lat(time) ;
      lat:missing_value = 1.e+038 ;
      lat:long_name = "Latitude" ;
      lat:units = "degrees_north" ;
      lat:C_format = "%9.4f" ;
      lat:standard_name = "latitude" ;
      lat:data_min = -43.2718416666667 ;
      lat:data_max = -38.4862333333333 ;
   float depth(time, depth_cell) ;
      depth:missing_value = 1.e+038f ;
```

```
   depth:long_name = "Depth" ;
   depth:units = "meter" ;
   depth:C_format = "%8.2f" ;
   depth:positive = "down" ;
   depth:data_min = 22.47f ;
   depth:data_max = 654.48f ;
float u(time, depth_cell) ;
   u:missing_value = 1.e+038f ;
   u:long_name = "Zonal velocity component" ;
   u:units = "meter second-1" ;
   u:C_format = "%7.2f" ;
   u:data_min = -1.059081f ;
   u:data_max = 0.6720949f ;
float v(time, depth_cell) ;
   v:missing_value = 1.e+038f ;
   v:long_name = "Meridional velocity component" ;
   v:units = "meter second-1" ;
   v:C_format = "%7.2f" ;
   v:data_min = -0.7785692f ;
   v:data_max = 1.37019f ;
short amp(time, depth_cell) ;
   amp:missing_value = 32767s ;
   amp:long_name = "Received signal strength" ;
   amp:C_format = "%d" ;
   amp:data_min = 14s ;
   amp:data_max = 215s ;
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 = 7b ;
float heading(time) ;
   heading:missing_value = 1.e+038f ;
   heading:long_name = "Ship heading" ;
   heading:units = "degrees" ;
   heading:C_format = "%6.1f" ;
   heading:data_min = -179.8015f ;
   heading:data_max = 179.8619f ;
float tr_temp(time) ;
   tr_temp:missing_value = 1.e+038f ;
   tr_temp:long_name = "ADCP transducer temperature" ;
   tr_temp:units = "Celsius" ;
   tr_temp:C_format = "%4.1f" ;
   tr_temp:data_min = 12.42863f ;
   tr_temp:data_max = 16.0104f ;
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 = 18s ;
   num_pings:data_max = 74s ;
float uship(time) ;
   uship:missing_value = 1.e+038f ;
   uship:long_name = "Ship zonal velocity component" ;
   uship:units = "meter second-1" ;
   uship:C_format = "%9.4f" ;
   uship:data_min = -5.965901f ;
   uship:data_max = 5.795412f ;
float vship(time) ;
   vship:missing_value = 1.e+038f ;
   vship:long_name = "Ship meridional velocity component" ;
   vship:units = "meter second-1" ;
```

```
      vship:C_format = "%9.4f" ;
      vship:data_min = -6.595821f ;
      vship:data_max = 5.641772f ;

// global attributes:
      :featureType = "trajectoryProfile" ;
      :history = "Created: 2020-06-23 15:14:45 UTC" ;
      :Conventions = "COARDS" ;
      :software = "pycurrents" ;
      :hg_changeset = "2993:bc42f2027bfe" ;
      :title = "Shipboard ADCP velocity profiles" ;
      :description = "Shipboard ADCP velocity profiles from in2018_c01 using instrument os75bb
- Short Version." ;
      :cruise_id = "in2018_c01" ;
      :sonar = "os75bb" ;
      :yearbase = 2018 ;
      :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",
```

5.3 in2018_c01_os150nb.nc

```
netcdf in2018_c01_os150nb {
dimensions:
   time = 879 ;
   depth_cell = 60 ;
variables:
   int trajectory ;
      trajectory:standard_name = "trajectory_id" ;
   double time(time) ;
      time:long_name = "Decimal day" ;
      time:units = "days since 2018-01-01 00:00:00" ;
      time:C_format = "%12.5f" ;
      time:standard_name = "time" ;
      time:data_min = 147.233449074074 ;
      time:data_max = 158.001446759259 ;
   double lon(time) ;
      lon:missing_value = 1.e+038 ;
      lon:long_name = "Longitude" ;
      lon:units = "degrees_east" ;
      lon:C_format = "%9.4f" ;
      lon:standard_name = "longitude" ;
      lon:data_min = 145.030655555556 ;
      lon:data_max = 148.590188888889 ;
   double lat(time) ;
      lat:missing_value = 1.e+038 ;
      lat:long_name = "Latitude" ;
      lat:units = "degrees_north" ;
      lat:C_format = "%9.4f" ;
      lat:standard_name = "latitude" ;
      lat:data_min = -43.2874694444444 ;
      lat:data_max = -38.4862638888889 ;
   float depth(time, depth_cell) ;
      depth:missing_value = 1.e+038f ;
      depth:long_name = "Depth" ;
      depth:units = "meter" ;
      depth:C_format = "%8.2f" ;
```

```
   depth:positive = "down" ;
   depth:data_min = 17.94f ;
   depth:data_max = 489.98f ;
float u(time, depth_cell) ;
   u:missing_value = 1.e+038f ;
   u:long_name = "Zonal velocity component" ;
   u:units = "meter second-1" ;
   u:C_format = "%7.2f" ;
   u:data_min = -0.8193936f ;
   u:data_max = 1.03993f ;
float v(time, depth_cell) ;
   v:missing_value = 1.e+038f ;
   v:long_name = "Meridional velocity component" ;
   v:units = "meter second-1" ;
   v:C_format = "%7.2f" ;
   v:data_min = -0.4617643f ;
   v:data_max = 0.675621f ;
short amp(time, depth_cell) ;
   amp:missing_value = 32767s ;
   amp:long_name = "Received signal strength" ;
   amp:C_format = "%d" ;
   amp:data_min = 35s ;
   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 = 0b ;
   pflag:data_max = 7b ;
float heading(time) ;
   heading:missing_value = 1.e+038f ;
   heading:long_name = "Ship heading" ;
   heading:units = "degrees" ;
   heading:C_format = "%6.1f" ;
   heading:data_min = -179.8129f ;
   heading:data_max = 179.8325f ;
float tr_temp(time) ;
   tr_temp:missing_value = 1.e+038f ;
   tr_temp:long_name = "ADCP transducer temperature" ;
   tr_temp:units = "Celsius" ;
   tr_temp:C_format = "%4.1f" ;
   tr_temp:data_min = 12.38218f ;
   tr_temp:data_max = 16.33901f ;
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 = 11s ;
   num_pings:data_max = 132s ;
float uship(time) ;
   uship:missing_value = 1.e+038f ;
   uship:long_name = "Ship zonal velocity component" ;
   uship:units = "meter second-1" ;
   uship:C_format = "%9.4f" ;
   uship:data_min = -5.989081f ;
   uship:data_max = 6.573061f ;
float vship(time) ;
   vship:missing_value = 1.e+038f ;
   vship:long_name = "Ship meridional velocity component" ;
   vship:units = "meter second-1" ;
   vship:C_format = "%9.4f" ;
   vship:data_min = -6.586643f ;
   vship:data_max = 6.340164f ;
```

```
// global attributes:
     :featureType = "trajectoryProfile" ;
     :history = "Created: 2020-06-24 13:09:33 UTC" ;
     :Conventions = "COARDS" ;
     :software = "pycurrents" ;
     :hg_changeset = "2993:bc42f2027bfe" ;
     :title = "Shipboard ADCP velocity profiles" ;
     :description = "Shipboard ADCP velocity profiles from in2018_c01 using instrument
os150nb - Short Version." ;
     :cruise_id = "in2018_c01" ;
     :sonar = "os150nb" ;
     :yearbase = 2018 ;
     :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",
```

5.4 in2018_c01_os150bb.nc

```
netcdf in2018_c01_os150bb {
dimensions:
   time = 543 ;
   depth_cell = 80 ;
variables:
   int trajectory ;
      trajectory:standard_name = "trajectory_id" ;
   double time(time) ;
      time:long_name = "Decimal day" ;
      time:units = "days since 2018-01-01 00:00:00" ;
      time:C_format = "%12.5f" ;
      time:standard_name = "time" ;
      time:data_min = 148.94693287037 ;
      time:data_max = 158.001446759259 ;
   double lon(time) ;
      lon:missing_value = 1.e+038 ;
      lon:long_name = "Longitude" ;
      lon:units = "degrees_east" ;
      lon:C_format = "%9.4f" ;
      lon:standard_name = "longitude" ;
      lon:data_min = 145.030655555556 ;
      lon:data_max = 148.425558333333 ;
   double lat(time) ;
      lat:missing_value = 1.e+038 ;
      lat:long_name = "Latitude" ;
      lat:units = "degrees_north" ;
      lat:C_format = "%9.4f" ;
      lat:standard_name = "latitude" ;
      lat:data_min = -43.2718388888889 ;
      lat:data_max = -38.4862638888889 ;
   float depth(time, depth_cell) ;
      depth:missing_value = 1.e+038f ;
      depth:long_name = "Depth" ;
      depth:units = "meter" ;
      depth:C_format = "%8.2f" ;
      depth:positive = "down" ;
      depth:data_min = 14.23f ;
      depth:data_max = 330.24f ;
   float u(time, depth_cell) ;
```

```
      u:missing_value = 1.e+038f ;
      u:long_name = "Zonal velocity component" ;
      u:units = "meter second-1" ;
      u:C_format = "%7.2f" ;
      u:data_min = -0.9855552f ;
      u:data_max = 0.6994305f ;
   float v(time, depth_cell) ;
      v:missing_value = 1.e+038f ;
      v:long_name = "Meridional velocity component" ;
      v:units = "meter second-1" ;
      v:C_format = "%7.2f" ;
      v:data_min = -0.4648414f ;
      v:data_max = 0.6275375f ;
   short amp(time, depth_cell) ;
      amp:missing_value = 32767s ;
      amp:long_name = "Received signal strength" ;
      amp:C_format = "%d" ;
      amp:data_min = 35s ;
      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 = 7b ;
   float heading(time) ;
      heading:missing_value = 1.e+038f ;
      heading:long_name = "Ship heading" ;
      heading:units = "degrees" ;
      heading:C_format = "%6.1f" ;
      heading:data_min = -179.8129f ;
      heading:data_max = 179.8325f ;
   float tr_temp(time) ;
      tr_temp:missing_value = 1.e+038f ;
      tr_temp:long_name = "ADCP transducer temperature" ;
      tr_temp:units = "Celsius" ;
      tr_temp:C_format = "%4.1f" ;
      tr_temp:data_min = 12.38218f ;
      tr_temp:data_max = 15.90344f ;
   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 = 11s ;
      num_pings:data_max = 129s ;
   float uship(time) ;
      uship:missing_value = 1.e+038f ;
      uship:long_name = "Ship zonal velocity component" ;
      uship:units = "meter second-1" ;
      uship:C_format = "%9.4f" ;
      uship:data_min = -5.983763f ;
      uship:data_max = 5.826714f ;
   float vship(time) ;
      vship:missing_value = 1.e+038f ;
      vship:long_name = "Ship meridional velocity component" ;
      vship:units = "meter second-1" ;
      vship:C_format = "%9.4f" ;
      vship:data_min = -6.587112f ;
      vship:data_max = 5.641772f ;

// global attributes:
      :featureType = "trajectoryProfile" ;
      :history = "Created: 2020-06-24 13:34:14 UTC" ;
```

```
      :Conventions = "COARDS" ;
      :software = "pycurrents" ;
      :hg_changeset = "2993:bc42f2027bfe" ;
      :title = "Shipboard ADCP velocity profiles" ;
      :description = "Shipboard ADCP velocity profiles from in2018_c01 using instrument
os150bb - Short Version." ;
      :cruise_id = "in2018_c01" ;
      :sonar = "os150bb" ;
      :yearbase = 2018 ;
      :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",
```