RV *Investigator*

ADCP Processing Report

Voyage:	in2021_v01
Voyage title:	Quantifying krill abundance for krill monitoring and management off the Australian Antarctic Territory
Depart:	Hobart, 1300 Friday, 29 January 2021
Return:	Hobart, 0800 Wednesday, 24 March 2021
Chief Scientist:	So Kawaguchi
Affiliation:	CSIRO
Report compiled by:	Steven Van Graas

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1 Summary

Both the RDI Ocean Surveyor 150kHz ADCP and the RDI Ocean Surveyor 75kHz ADCP were run in narrowband for transit to and from the survey area. During survey transects the OS150 was used

Data was collected using UHDAS and post-processed using CODAS.

Internal triggering was used for the transits to and from the survey site only. When run on transect lines or during target trawling, triggering was performed via KSYNC, synchronised to the EK80 with a ping frequency between 1 and 2.5 seconds.

Please see the voyage computing and electronics report for more details regarding operation.

2 Processing Background

The University of Hawaii's CODAS software dated 2020-04-27 was used for data post-processing.

3 Processing Notes

Rough weather during the transit to and from the survey area impacted data quality, particularly in the top bins. Operational requirements prioritised the EK80 data quality over ADCP, resulting in the ADCPs being run externally triggered while on transect. When running triggered the ADCP data quality is reduced, as interference from other acoustics is concentrated in specific bins as opposed to being distributed throughout the water column when untriggered.

Throughout the survey there were occurrences when the vessel traversed over significant swarms of krill. These were apparent in the acquired ADCP data, and can have an effect on the measured current as the active motion of krill can obscure the direction and velocity of the water currents.

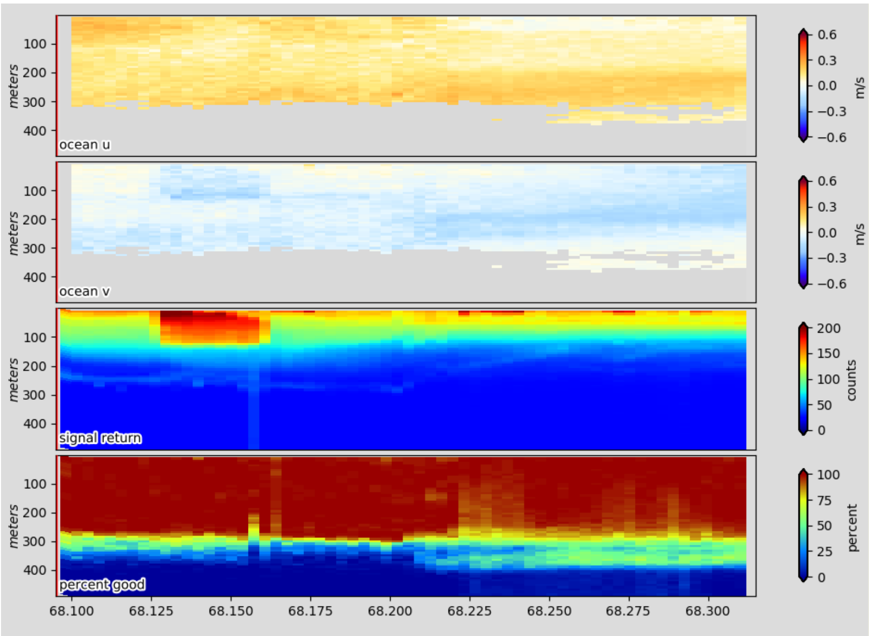

Figure 1. Observation of large krill swarm as evident in the signal return plot.

4 Area Covered

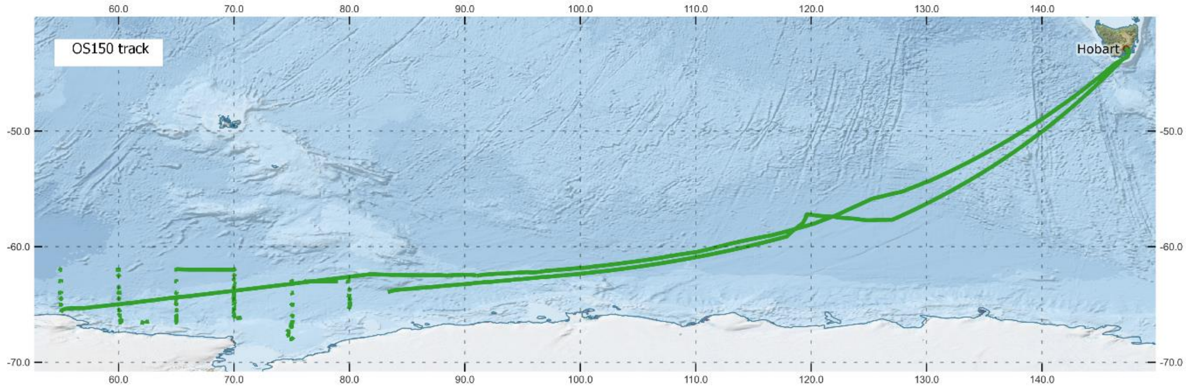

Figure 2. OS150 operational area

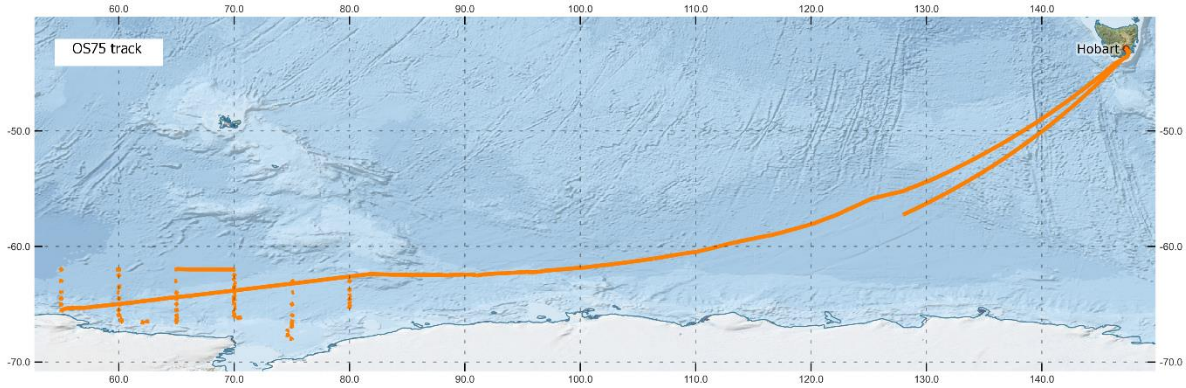

Figure 3. OS75 operational area

Please see the webpy_bb and webpy_nb folders for plots of collected data.

5 netCDF Data Headers

5.1 netcdf in2021_v01_os75nb

```
{
dimensions:
        time = 7849 ;
        depth_cell = 60 ;
variables:
        int trajectory(time) ;
                trajectory:standard_name = "trajectory_id" ;
        double time(time) ;
                time:_FillValue = NaN ;
                time:long_name = "Decimal day" ;
                time:C_format = "%12.5f" ;
                time:standard_name = "time" ;
```

```
        time:units = "days since 2021-01-01 00:00:00" ;
double lon(time) ;
        lon:_FillValue = NaN ;
        lon:long_name = "Longitude" ;
        lon:units = "degrees_east" ;
        lon:C_format = "%9.4f" ;
        lon:standard_name = "longitude" ;
        lon:data_min = 54.9985888888889 ;
        lon:data_max = 147.546225 ;
        lon:missing_value = 1.e+38 ;
double lat(time) ;
        lat:_FillValue = NaN ;
        lat:long_name = "Latitude" ;
        lat:units = "degrees_north" ;
        lat:C_format = "%9.4f" ;
        lat:standard_name = "latitude" ;
        lat:data_min = -66.5657138888889 ;
        lat:data_max = -42.8884666666667 ;
        lat:missing_value = 1.e+38 ;
float depth(time, depth_cell) ;
        depth:_FillValue = NaNf ;
        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 ;
        depth:missing_value = 1.e+38f ;
float u(time, depth_cell) ;
        u:_FillValue = NaNf ;
        u:long_name = "Zonal velocity component" ;
        u:units = "meter second-1" ;
        u:C_format = "%7.2f" ;
        u:data_min = -0.789526f ;
        u:data_max = 0.6217163f ;
        u:missing_value = 1.e+38f ;
float v(time, depth_cell) ;
        v:_FillValue = NaNf ;
        v:long_name = "Meridional velocity component" ;
```

```
        v:units = "meter second-1" ;
        v:C_format = "%7.2f" ;
        v:data_min = -0.7016163f ;
        v:data_max = 0.5773091f ;
        v:missing_value = 1.e+38f ;
short amp(time, depth_cell) ;
        amp:long_name = "Received signal strength" ;
        amp:C_format = "%d" ;
        amp:data_min = 11s ;
        amp:data_max = 216s ;
        amp:missing_value = 32767s ;
byte pg(time, depth_cell) ;
        pg:long_name = "Percent good pings" ;
        pg:C_format = "%d" ;
        pg:data_min = 0b ;
        pg:data_max = 100b ;
        pg:missing_value = -1b ;
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:_FillValue = NaNf ;
        heading:long_name = "Ship heading" ;
        heading:units = "degrees" ;
        heading:C_format = "%6.1f" ;
        heading:data_min = -179.6823f ;
        heading:data_max = 179.7883f ;
        heading:missing_value = 1.e+38f ;
float tr_temp(time) ;
        tr_temp:_FillValue = NaNf ;
        tr_temp:long_name = "ADCP transducer temperature" ;
        tr_temp:units = "Celsius" ;
        tr_temp:C_format = "%4.1f" ;
        tr_temp:data_min = -1.651053f ;
        tr_temp:data_max = 17.89649f ;
        tr_temp:missing_value = 1.e+38f ;
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 = 133s ;
        float uship(time) ;
            uship:_FillValue = NaNf ;
            uship:long_name = "Ship zonal velocity component" ;
            uship:units = "meter second-1" ;
            uship:C_format = "%9.4f" ;
            uship:data_min = -6.159477f ;
            uship:data_max = 4.719614f ;
            uship:missing_value = 1.e+38f ;
        float vship(time) ;
            vship:_FillValue = NaNf ;
            vship:long_name = "Ship meridional velocity component" ;
            vship:units = "meter second-1" ;
            vship:C_format = "%9.4f" ;
            vship:data_min = -5.878965f ;
            vship:data_max = 2.778833f ;
            vship:missing_value = 1.e+38f ;

// global attributes:
            :featureType = "trajectoryProfile" ;
            :history = "Created: 2021-05-18 03:17:06 UTC" ;
            :Conventions = "COARDS" ;
            :software = "pycurrents" ;
            :hg_changeset = "3078:65b2333da2f0" ;
            :title = "Shipboard ADCP velocity profiles" ;
            :description = "Shipboard ADCP velocity profiles from in2021_v01 using
instrument os75nb - Short Version." ;
            :cruise_id = "in2021_v01" ;
            :sonar = "os75nb" ;
            :yearbase = 2021 ;
            :ship_name = "Investigator" ;
            :CODAS_variables = "\nVariables in this CODAS short-form Netcdf file are
intended for most end-user\nscientific analysis and display purposes. For additional
information see\nthe CODAS_processing_note global attribute and the attributes of each\nof the
variables.\n\n\n=============
================================================================\ntime          Time at the
end of the ensemble, days from start of year.\nlon, lat      Longitude, Latitude from GPS at
the end of the ensemble.\nu,v           Ocean zonal and meridional velocity component
profiles.\nuship, vship  Zonal and meridional velocity components of the ship.\nheading
```

Mean ship heading during the ensemble.\ndepth   Bin centers in nominal meters (no sound speed profile correction).\ntr_temp   ADCP transducer temperature.\npg   Percent Good pings for u, v averaging after editing.\npflag   Profile Flags based on editing, used to mask u, v.\namp   Received signal strength in ADCP-specific units; no correction\n   for spreading or attenuation.\n============= ==\n\n" ;

:CODAS_processing_note = "\nCODAS processing note:\n=====================\n\nOverview\n--------\nThe CODAS database is a specialized storage format designed for\nshipboard ADCP data. \"CODAS processing\" uses this format to hold\naveraged shipboard ADCP velocities and other variables, during the\nstages of data processing. The CODAS database stores velocity\nprofiles relative to the ship as east and north components along with\nposition, ship speed, heading, and other variables. The netCDF *short*\nform contains ocean velocities relative to earth, time, position,\ntransducer temperature, and ship heading; these are designed to be\n\"ready for immediate use\". The netCDF *long* form is just a dump of\nthe entire CODAS database. Some variables are no longer used, and all\nhave names derived from their original CODAS names, dating back to the\nlate 1980\'s.\n\nPost-processing\n---------------\nCODAS post-processing, i.e. that which occurs after the single-ping\nprofiles have been vector-averaged and loaded into the CODAS database,\nincludes editing (using automated algorithms and manual tools),\nrotation and scaling of the measured velocities, and application of a\ntime-varying heading correction. Additional algorithms developed more\nrecently include translation of the GPS positions to the transducer\nlocation, and averaging of ship\'s speed over the times of valid pings\nwhen Percent Good is reduced. Such post-processing is needed prior to\nsubmission of \"processed ADCP data\" to JASADCP or other archives.\n\nFull CODAS processing\n---------------------\nWhenever single-ping data have been recorded, full CODAS processing\nprovides the best end product.\n\nFull CODAS processing starts with the single-ping velocities in beam\ncoordinates. Based on the transducer orientation relative to the\nhull, the beam velocities are transformed to horizontal, vertical, and\n\"error velocity\" components. Using a reliable heading (typically from\nthe ship\'s gyro compass), the velocities in ship coordinates are\nrotated into earth coordinates.\n\nPings are grouped into an \"ensemble\" (usually 2-5 minutes duration)\nand undergo a suite of automated editing algorithms (removal of\nacoustic interference; identification of the bottom; editing based on\nthresholds; and specialized editing that targets CTD wire interference\nand \"weak, biased profiles\". The ensemble of single-ping velocities\nis then averaged using an iterative reference layer averaging scheme.\nEach ensemble is approximated as a single function of depth, with a\nzero-average over a reference layer plus a reference layer velocity\nfor each ping. Adding the average of the single-ping reference layer\nvelocities to the function of depth yields the ensemble-average\nvelocity profile. These averaged profiles, along with ancillary\nmeasurements, are written to disk, and subsequently loaded into the\nCODAS database. Everything after this stage is \"post-processing\".\n\nnote (time):\n------------\nTime is stored in the database using UTC Year, Month, Day, Hour,\nMinute, Seconds. Floating point time \"Decimal Day\" is the floating\npoint interval in days since the start of the year, usually the year\nof the first day of the cruise.\n\n\nnote (heading):\n---------------\nCODAS processing uses heading from a reliable device, and (if\navailable) uses a time-dependent correction by an accurate heading\ndevice. The reliable heading device is typically a gyro compass (for\nexample, the Bridge gyro). Accurate heading devices can be POSMV,\nSeapath, Phins, Hydrins, MAHRS, or various Ashtech devices; this\nvaries with the technology of the time. It is always confusing to\nkeep track of the sign of the heading correction. Headings are written\ndegrees, positive clockwise. setting up some variables:\n\nX = transducer angle (CONFIG1_heading_bias)\n positive clockwise (beam 3 angle relative to ship)\nG = Reliable heading (gyrocompass)\nA = Accurate heading\ndh = G - A = time-dependent heading correction (ANCIL2_watrk_hd_misalign)\n\nRotation of the measured velocities into the correct coordinate system\namounts to (u+i*v)*(exp(i*theta)) where theta is the sum of the\ncorrected heading and the transducer angle.\n\ntheta = X + (G - dh) = X + G - dh\n\n\nWatertrack and Bottomtrack calibrations give an indication of the\nresidual angle offset to apply, for example if mean and median of the\nphase are all 0.5 (then R=0.5). Using the \"rotate\" command,\nthe value of R is added to \"ANCIL2_watrk_hd_misalign\".\n\nnew_dh = dh + R\n\nTherefore the total angle used in rotation is\n\nnew_theta = X + G - dh_new\n   = X + G - (dh + R)\n   = (X - R) + (G - dh)\n\nThe new estimate of the transducer angle is: X - R\nANCIL2_watrk_hd_misalign contains: dh + R\n\n==\n\nProfile flags\n-------------\nProfile editing flags are provided for each depth cell:\n\nbinary   decimal   below   Percent\nvalue   value   bottom   Good   bin\n-------+----------+--------+----------+-------+\n000   0\n001   1   bad\n010   2   bad\n011   3   bad   bad\n100   4   bad\n101   5   bad   bad\n110   6   bad   bad\n111   7   bad   bad   bad\n-------+----------+--------+----------+-------+\n" ;

}

5.2 netcdf in2021_v01_os150nb

```
{
dimensions:
        time = 10295 ;
        depth_cell = 60 ;
variables:
        int trajectory(time) ;
                trajectory:standard_name = "trajectory_id" ;
        double time(time) ;
                time:_FillValue = NaN ;
                time:long_name = "Decimal day" ;
                time:C_format = "%12.5f" ;
                time:standard_name = "time" ;
                time:units = "days since 2021-01-01 00:00:00" ;
        double lon(time) ;
                lon:_FillValue = NaN ;
                lon:long_name = "Longitude" ;
                lon:units = "degrees_east" ;
                lon:C_format = "%9.4f" ;
                lon:standard_name = "longitude" ;
                lon:data_min = 54.9257777777778 ;
                lon:data_max = 147.546230555556 ;
                lon:missing_value = 1.e+38 ;
        double lat(time) ;
                lat:_FillValue = NaN ;
                lat:long_name = "Latitude" ;
                lat:units = "degrees_north" ;
                lat:C_format = "%9.4f" ;
                lat:standard_name = "latitude" ;
                lat:data_min = -66.5657138888889 ;
                lat:data_max = -42.8884583333333 ;
                lat:missing_value = 1.e+38 ;
        float depth(time, depth_cell) ;
                depth:_FillValue = NaNf ;
                depth:long_name = "Depth" ;
                depth:units = "meter" ;
                depth:C_format = "%8.2f" ;
                depth:positive = "down" ;
                depth:data_min = 17.93f ;
```

```
        depth:data_max = 490.f ;
        depth:missing_value = 1.e+38f ;
float u(time, depth_cell) ;
        u:_FillValue = NaNf ;
        u:long_name = "Zonal velocity component" ;
        u:units = "meter second-1" ;
        u:C_format = "%7.2f" ;
        u:data_min = -0.5778563f ;
        u:data_max = 0.7085955f ;
        u:missing_value = 1.e+38f ;
float v(time, depth_cell) ;
        v:_FillValue = NaNf ;
        v:long_name = "Meridional velocity component" ;
        v:units = "meter second-1" ;
        v:C_format = "%7.2f" ;
        v:data_min = -0.4951549f ;
        v:data_max = 0.699002f ;
        v:missing_value = 1.e+38f ;
short amp(time, depth_cell) ;
        amp:long_name = "Received signal strength" ;
        amp:C_format = "%d" ;
        amp:data_min = 21s ;
        amp:data_max = 229s ;
        amp:missing_value = 32767s ;
byte pg(time, depth_cell) ;
        pg:long_name = "Percent good pings" ;
        pg:C_format = "%d" ;
        pg:data_min = 0b ;
        pg:data_max = 100b ;
        pg:missing_value = -1b ;
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:_FillValue = NaNf ;
        heading:long_name = "Ship heading" ;
        heading:units = "degrees" ;
```

```
		heading:C_format = "%6.1f" ;
		heading:data_min = -179.9066f ;
		heading:data_max = 179.8674f ;
		heading:missing_value = 1.e+38f ;
	float tr_temp(time) ;
		tr_temp:_FillValue = NaNf ;
		tr_temp:long_name = "ADCP transducer temperature" ;
		tr_temp:units = "Celsius" ;
		tr_temp:C_format = "%4.1f" ;
		tr_temp:data_min = -1.722209f ;
		tr_temp:data_max = 17.84462f ;
		tr_temp:missing_value = 1.e+38f ;
	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 = 12s ;
		num_pings:data_max = 251s ;
	float uship(time) ;
		uship:_FillValue = NaNf ;
		uship:long_name = "Ship zonal velocity component" ;
		uship:units = "meter second-1" ;
		uship:C_format = "%9.4f" ;
		uship:data_min = -6.154896f ;
		uship:data_max = 4.71462f ;
		uship:missing_value = 1.e+38f ;
	float vship(time) ;
		vship:_FillValue = NaNf ;
		vship:long_name = "Ship meridional velocity component" ;
		vship:units = "meter second-1" ;
		vship:C_format = "%9.4f" ;
		vship:data_min = -5.879909f ;
		vship:data_max = 4.274223f ;
		vship:missing_value = 1.e+38f ;

// global attributes:
		:featureType = "trajectoryProfile" ;
		:history = "Created: 2021-05-18 00:46:09 UTC" ;
		:Conventions = "COARDS" ;
```

```
                :software = "pycurrents" ;

                :hg_changeset = "3078:65b2333da2f0" ;

                :title = "Shipboard ADCP velocity profiles" ;

                :description = "Shipboard ADCP velocity profiles from in2021_v01 using
instrument os150nb - Short Version." ;

                :cruise_id = "in2021_v01" ;

                :sonar = "os150nb" ;

                :yearbase = 2021 ;

                :ship_name = "Investigator" ;

                :CODAS_variables = "\nVariables in this CODAS short-form Netcdf file are
intended for most end-user\nscientific analysis and display purposes. For additional
information see\nthe CODAS_processing_note global attribute and the attributes of each\nof the
variables.\n\n\n=============
=================================================================\ntime          Time at the
end of the ensemble, days from start of year.\nlon, lat      Longitude, Latitude from GPS at
the end of the ensemble.\nu,v           Ocean zonal and meridional velocity component
profiles.\nuship, vship  Zonal and meridional velocity components of the ship.\nheading
Mean ship heading during the ensemble.\ndepth         Bin centers in nominal meters (no sound
speed profile correction).\ntr_temp       ADCP transducer temperature.\npg            Percent
Good pings for u, v averaging after editing.\npflag         Profile Flags based on editing,
used to mask u, v.\namp           Received signal strength in ADCP-specific units; no
correction\n              for spreading or attenuation.\n=============
=================================================================\n\n" ;

                :CODAS_processing_note = "\nCODAS processing
note:\n=====================\n\nOverview\n--------\nThe CODAS database is a specialized
storage format designed for\nshipboard ADCP data.  \"CODAS processing\" uses this format to
hold\naveraged shipboard ADCP velocities and other variables, during the\nstages of data
processing.  The CODAS database stores velocity\nprofiles relative to the ship as east and
north components along with\nposition, ship speed, heading, and other variables. The netCDF
*short*\nform contains ocean velocities relative to earth, time, position,\ntransducer
temperature, and ship heading; these are designed to be\n\"ready for immediate use\".  The
netCDF *long* form is just a dump of\nthe entire CODAS database.  Some variables are no longer
used, and all\nhave names derived from their original CODAS names, dating back to the\nlate
1980\'s.\n\nPost-processing\n---------------\nCODAS post-processing, i.e. that which occurs
after the single-ping\nprofiles have been vector-averaged and loaded into the CODAS
database,\nincludes editing (using automated algorithms and manual tools),\nrotation and
scaling of the measured velocities, and application of a\ntime-varying heading correction.
Additional algorithms developed more\nrecently include translation of the GPS positions to the
transducer\nlocation, and averaging of ship\'s speed over the times of valid pings\nwhen
Percent Good is reduced. Such post-processing is needed prior to\nsubmission of \"processed
ADCP data\" to JASADCP or other archives.\n\nFull CODAS processing\n---------------------
\nWhenever single-ping data have been recorded, full CODAS processing\nprovides the best end
product.\n\nFull CODAS processing starts with the single-ping velocities in beam\ncoordinates.
Based on the transducer orientation relative to the\nhull, the beam velocities are transformed
to horizontal, vertical, and\n\"error velocity\" components.  Using a reliable heading
(typically from\nthe ship\'s gyro compass), the velocities in ship coordinates are\nrotated
into earth coordinates.\n\nPings are grouped into an \"ensemble\" (usually 2-5 minutes
duration)\nand undergo a suite of automated editing algorithms (removal of\nacoustic
interference; identification of the bottom; editing based on\nthresholds; and specialized
editing that targets CTD wire interference\nand \"weak, biased profiles\".  The ensemble of
single-ping velocities\nis then averaged using an iterative reference layer averaging
scheme.\nEach ensemble is approximated as a single function of depth, with a\nzero-average
over a reference layer plus a reference layer velocity\nfor each ping.  Adding the average of
the single-ping reference layer\nvelocities to the function of depth yields the ensemble-
average\nvelocity profile.  These averaged profiles, along with ancillary\nmeasurements, are
written to disk, and subsequently loaded into the\nCODAS database. Everything after this stage
is \"post-processing\".\n\nnote (time):\n------------\nTime is stored in the database using
UTC Year, Month, Day, Hour,\nMinute, Seconds.  Floating point time \"Decimal Day\" is the
floating\npoint interval in days since the start of the year, usually the year\nof the first
day of the cruise.\n\n\nnote (heading):\n---------------\nCODAS processing uses heading from a
reliable device, and (if\navailable) uses a time-dependent correction by an accurate
heading\ndevice.  The reliable heading device is typically a gyro compass (for\nexample, the
Bridge gyro).  Accurate heading devices can be POSMV,\nSeapath, Phins, Hydrins, MAHRS, or
various Ashtech devices; this\nvaries with the technology of the time.  It is always confusing
```

```
to\nkeep track of the sign of the heading correction.  Headings are written\ndegrees, positive
clockwise. setting up some variables:\n\nX = transducer angle (CONFIG1_heading_bias)\n
positive clockwise (beam 3 angle relative to ship)\nG = Reliable heading (gyrocompass)\nA =
Accurate heading\ndh = G - A = time-dependent heading correction
(ANCIL2_watrk_hd_misalign)\n\nRotation of the measured velocities into the correct coordinate
system\namounts to (u+i*v)*(exp(i*theta)) where theta is the sum of the\ncorrected heading and
the transducer angle.\n\ntheta = X + (G - dh) = X + G - dh\n\n\nWatertrack and Bottomtrack
calibrations give an indication of the\nresidual angle offset to apply, for example if mean
and median of the\nphase are all 0.5 (then R=0.5).  Using the \"rotate\" command,\nthe value
of R is added to \"ANCIL2_watrk_hd_misalign\".\n\nnew_dh = dh + R\n\nTherefore the total angle
used in rotation is\n\nnew_theta = X + G - dh_new\n          = X + G - (dh + R)\n          =
(X - R) + (G - dh)\n\nThe new estimate of the transducer angle is: X -
R\nANCIL2_watrk_hd_misalign contains: dh +
R\n\n==================================================\n\nProfile flags\n-------------
\nProfile editing flags are provided for each depth cell:\n\nbinary    decimal    below
Percent\nvalue     value      bottom   Good       bin\n-------+----------+--------+----------
+-------+\n000         0\n001         1                            bad\n010         2
bad\n011         3                bad       bad\n100         4        bad\n101         5
bad                bad\n110         6         bad      bad\n111         7         bad      bad
bad\n-------+----------+--------+----------+-------+\n" ;

}
```