Marine National Facility

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RV *Investigator* ADCP Data Processing Report

Voyage ID	**IN2024_V03**
Voyage Title	SEA-MES: Untangling the causes of change over 25 years in the southeast marine ecosystem - Voyage 2
Depart	Hobart, 30 Apr 2024, 22:00 UTC
Return	Sydney, 30 May 2024, 22:00 UTC
Chief Scientist	Rich Little (CSIRO)
Data Processor	Francis Chui (CSIRO – E&T Data Acquisition & Processing)

Document History

Date	Version	Author	Comments
31 March 2025	1.0	Francis Chui	Initial version
14 July 2026	1.1	Francis Chui	Added details about not meeting target for residuals in processing notes

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1 Summary

This voyage, also known as the South-East Australian Marine Ecosystem Survey (SEA-MES), was a project of repeat surveys in an area where fishery and ecosystem assessments were last conducted 25 years ago. Surface water is warming at a rate of four times the global average in this area, with apparent change to species distribution.
The primary objectives of SEA-MES were to document changes and inform the following questions for the Australian southeast marine ecosystem:

1. How and why have fish assemblages and species abundances changed in the southeast ecosystem, and can the causes be mitigated?
2. How does this affect the multiple-use management of the region, particularly conservation and biodiversity management of Australian Marine Parks and the hive of activity from fisheries, oil & gas, and renewable energy sectors?
3. What are the implications for marine spatial planning and adaptive management in the sectors that use the marine ecosystem?

It is also testing new monitoring techniques:

- To measure fish presence and abundance using eDNA two sampling approaches, and how they compare to conventional sampling approaches.
- To detect and count seabirds using deck mounted video camera.

IN2024_V03 is the second of four monitoring surveys planned to help answer the above questions.

This report describes the production of quality controlled ADCP data from RV *Investigator* voyage IN2024_V03.

The OS150 was only turned on during CTD casts so that LADCP data could be acquired and during transits as it interfered with EM2040 which took priority for the scientists.

Due to the ongoing complications with the OS75, and majority of the voyage taking place on the continental shelf, the OS75 and WH75 were both turned off for the entirety of the voyage.

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 in (Hummon, 2009-2021).

The RDI Ocean Surveyor 150kHz ADCP, and RDI Ocean Surveyor 75kHz ADCP were run in narrowband mode.

Internal triggering was used.

The drop keel was set at 2 m below the hull for the duration of the voyage. The nominal transducer depth is set to 6 meters, any additional changes will need to be applied by the user if they believe it is required.

Bottom tracking was run for the first hour of the voyage on the OS150 to aid in calibrations

No major issues were encountered when processing the OS150 data.

To access the full voyage plan and other reports and data associated with this voyage, please see the contact information at the end of this report.

1.1 Voyage Track

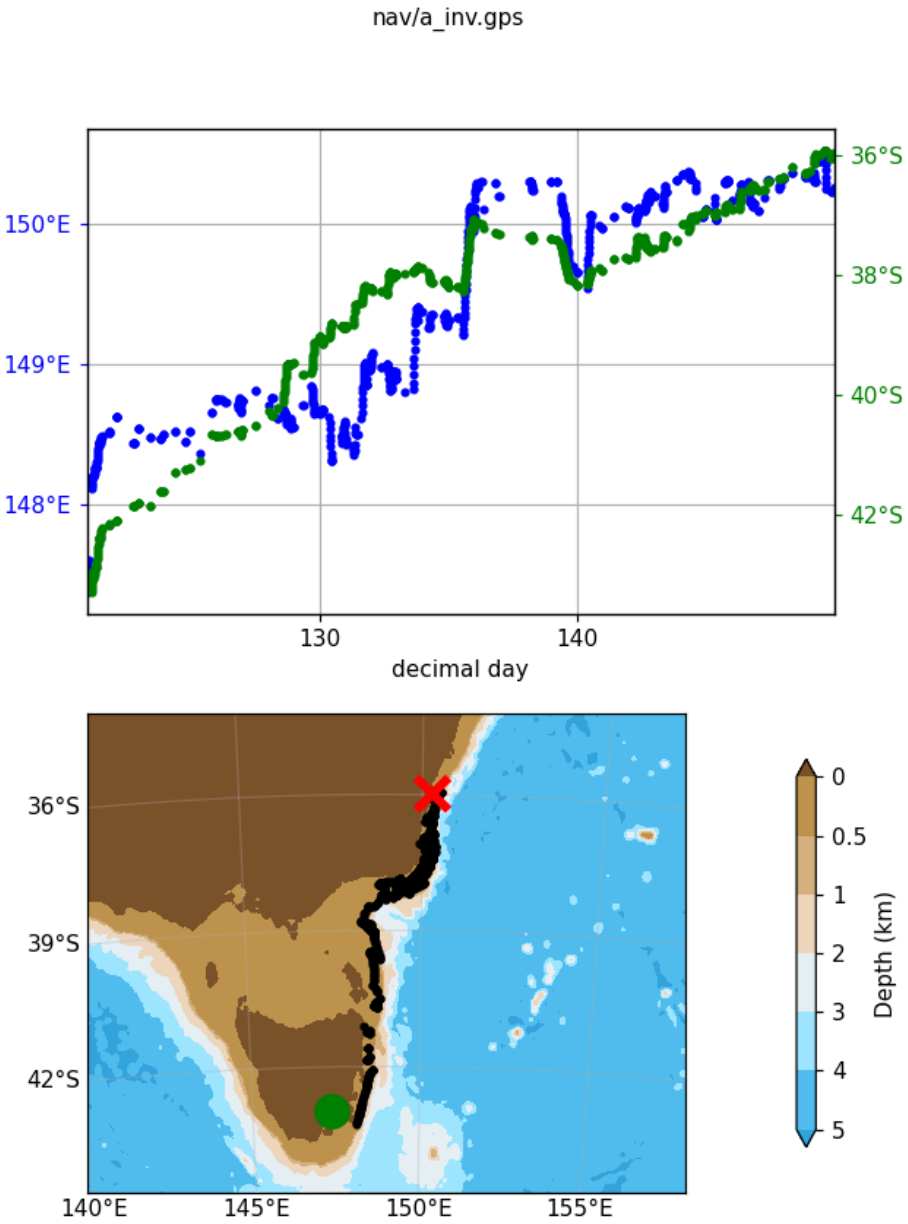

Figure 1: Voyage track

Please see the webpy folders for plots of collected data.

2 Data Processing

2.1 Background Information

The University of Hawaii's CODAS software with changeset number 3389:2fa0841853b2 was used for data post-processing.

The ADCP beam velocities are rotated into earth coordinates using the reliable source (gyro) for heading. CODAS processing corrects the reliable headings to accurate values by a timeseries of the difference between the accurate and reliable heading devices. The accurate heading for this voyage was the Seapath. Errors in this timeseries will occur if the accurate heading device drops out. Patch_hcorr.py interpolates gaps in the heading correction timeseries and is run if small gaps are found.

Additional adjustments to scale factor and angle are needed if water track calibration residuals are out of tolerance. The aim is to get errors due to bad angle or scale factor down to the level of 1cm/s error in the ADCP measurements, the target for residuals

- Amplitude: 0.995 to 1.005
- Phase/Angle: -0.04 to +0.04

Manual calibration corrections with quick_adcp.py (rotate_amplitude and rotate_angle) have been applied to the data if the watertrack calibration residuals have sufficient points for reasonable statistics (>12-15 edited). If there are insufficient watertrack points (eg. a transit), values from adjacent voyages are used.

Manual editing with dataviewer.py was used to remove in water artifacts (e.g. scattering layers, depth below bottom, etc). This can affect watertrack calibration residuals (mostly in scale factor), so check a final application of residuals may be applied.Amplitude is multiplier of all the applied calibration corrections.

Phase is sum of all the applied calibration corrections.

2.2 Processing Notes

No significant processing issues were found with OS150NB. Phase values could not be brought into the desirable range between -0.04 to +0.04. An applied phase of -0.0075 was used as a best fit, similar to the value -0.0738 used for the previous voyage IN2024_V02. There was not sufficient data collected with the OS75NB to process.

2.2.1 Calibration Residuals

Small gaps of lost data in the accurate heading device were found, hence Table 1 below shows the changes to the residual before and after "patch_hcorr.py" was run to interpolate the heading correction through the gaps.

Table 1: Water Track and Bottom Track Calibration Residuals for Narrow Band

		OS150nb		OS75nb	
Total Scale Factor Amplitude		**1.005**		**1**	
Total Scale Factor Phase/Angle		**-0.0075**		**0**	
Final Residuals					
		Water Track	**Bottom Track**	**Water Track**	**Bottom Track**
Number of edited points		69/95	9/11	-	-
Amplitude	Mean	1.0025	1.0001	-	-
	Median	1.0030	1.0004	-	-
Phase/Angle	Mean	0.0596	0.0630	-	-
	Median	-0.0600	0.0725	-	-

2.2.2 Offsets

The offset from the ADCP transducer to the GPS needs to be known to avoid errors when the ship is turning, see Appendix for a visual representation of why this is important. The offsets when processing are shown in Table 2. The actual offset is shown and was determined by a physical survey of the ship. The applied values were determined by UHDAS using empirical observation of data.

Table 2: GPS to ADCP Offsets

	OS150 Actual	OS150 Applied	OS75 Actual	OS75 Applied
dx (m)	-1	1	-1	1
dy (m)	1	8	4	13
	Estimated Transducer – GPS offset			
xducer_dx	-7.406500		-6.261230	
xducer_dy	3.794732		0.395090	
signal	2405.857633		46.492654	

2.3 Instrument Serial Numbers

Table 3: Instrument Serial Numbers

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

3 NetCDF Data Headers

```
netcdf in2024_v03_os150nb {
dimensions:
	time = 2013 ;
	depth_cell = 60 ;
	num_configs = 88 ;
variables:
	double time(time) ;
		time:long_name = "Decimal day" ;
		time:units = "days since 2024-01-01 00:00:00" ;
		time:C_format = "%12.5f" ;
		time:standard_name = "time" ;
		time:calendar = "proleptic_gregorian" ;
		time:axis = "T" ;
		time:data_min = 120.979826388889 ;
		time:data_max = 149.952881944444 ;
	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 = 147.375430555556 ;
		lon:data_max = 150.52025 ;
	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 = -43.2688611111111 ;
		lat:data_max = -35.924275 ;
	float depth(time, depth_cell) ;
		depth:missing_value = 1.e+38f ;
		depth:long_name = "Depth" ;
		depth:units = "meter" ;
		depth:C_format = "%8.2f" ;
		depth:data_min = 17.93f ;
		depth:data_max = 489.99f ;
	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 = -0.8405733f ;
        u:data_max = 0.9492727f ;
    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 = -0.7623891f ;
        v:data_max = 1.581635f ;
    short amp(time, depth_cell) ;
        amp:missing_value = 32767s ;
        amp:long_name = "Received signal strength" ;
        amp:units = "" ;
        amp:C_format = "%d" ;
        amp:data_min = 24s ;
        amp:data_max = 228s ;
    byte pg(time, depth_cell) ;
        pg:missing_value = -1b ;
        pg:long_name = "Percent good pings" ;
        pg:units = "" ;
        pg:C_format = "%d" ;
        pg:data_min = 0b ;
        pg:data_max = 100b ;
    byte pflag(time, depth_cell) ;
        pflag:long_name = "Editing flags" ;
        pflag:units = "" ;
        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 = -179.9944f ;
        heading:data_max = 179.9185f ;
    float tr_temp(time) ;
        tr_temp:missing_value = 1.e+38f ;
        tr_temp:long_name = "ADCP transducer temperature" ;
        tr_temp:units = "degree_Celsius" ;
        tr_temp:C_format = "%4.1f" ;
        tr_temp:data_min = 15.43651f ;
        tr_temp:data_max = 21.57224f ;
    short num_pings(time) ;
        num_pings:long_name = "Number of pings averaged per ensemble" ;
        num_pings:units = "" ;
```

```
		num_pings:C_format = "%d" ;
		num_pings:data_min = 15s ;
		num_pings:data_max = 251s ;
	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 = -4.91696f ;
		uship:data_max = 6.281269f ;
	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 = -6.060614f ;
		vship:data_max = 6.181992f ;
	int index_config_start(num_configs) ;
		index_config_start:long_name = "First zero-based time index of each
configuration" ;
		index_config_start:units = "" ;
	float ensemble_seconds(num_configs) ;
		ensemble_seconds:long_name = "Ensemble average duration" ;
		ensemble_seconds:units = "s" ;
	short num_depth_bins(num_configs) ;
		num_depth_bins:long_name = "Number of depth bins" ;
		num_depth_bins:units = "" ;
	float transducer_depth(num_configs) ;
		transducer_depth:long_name = "Transducer depth" ;
		transducer_depth:units = "m" ;
	float depth_bin_length(num_configs) ;
		depth_bin_length:long_name = "Vertical averaging length" ;
		depth_bin_length:units = "m" ;
	float pulse_length(num_configs) ;
		pulse_length:long_name = "Vertical span of sonar ping" ;
		pulse_length:units = "m" ;
	float blank_length(num_configs) ;
		blank_length:long_name = "Vertical delay between ping and first reception"
;
		blank_length:units = "m" ;
	float ping_interval(num_configs) ;
		ping_interval:long_name = "Typical time between pings" ;
		ping_interval:units = "s" ;
	float transducer_orientation(num_configs) ;
		transducer_orientation:long_name = "Approximate transducer orientation,
clockwise rotation of beam 3 from forward" ;
		transducer_orientation:units = "degrees" ;
```

```
// global attributes:
              :history = "Created: 2025-03-28 04:28:26 UTC" ;
              :Conventions = "COARDS CF-1.8" ;
              :software = "pycurrents" ;
              :hg_changeset = "3389:2fa0841853b2" ;
              :title = "Shipboard ADCP velocity profiles" ;
              :summary = "Shipboard ADCP velocity profiles from in2024_v03 using
instrument os150nb - Short Version." ;
              :cruise_id = "in2024_v03" ;
              :sonar = "os150nb" ;
              :yearbase = 2024 ;
              :platform = "RV Investigator" ;
              :time_coverage_start = "2024-04-30T23:30:57Z" ;
              :time_coverage_end = "2024-05-29T22:52:09Z" ;
              :geospatial_lat_min = -43.26886f ;
              :geospatial_lat_max = -35.92427f ;
              :geospatial_lat_units = "degrees_north" ;
              :geospatial_lon_min = 147.3754f ;
              :geospatial_lon_max = 150.5202f ;
              :geospatial_lon_units = "degrees_east" ;
              :geospatial_vertical_min = 17.93f ;
              :geospatial_vertical_max = 489.99f ;
              :geospatial_vertical_units = "m" ;
              :geospatial_vertical_positive = "down" ;
              :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 eastward and northward velocity component
profiles.\n",
                    "uship, vship  Eastward and northward 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 after editing in vector-averaged
velocities.\n",
                    "pflag          Profile Flags based on editing, used to mask
velocities.\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 References

R. Little. (2024). *The RV Investigator. Voyage Plan* IN2024_V03. Retrieved from Marine National Facility: Voyage Plans and summaries: https://mnf.csiro.au/en/Voyages/Voyage-Catalogue

Hummon, J. (2009-2021). *CODAS+UHDAS Documentation*. Retrieved February 1, 2023, from https://doi.org/10.5281/zenodo.8371260

5 Appendix A

Table 4: os150nb Water Track and Bottom Track Working Calibrations and Residuals

Water Track	Bottom Track
Preliminary	
Number of edited points: 69 out of 96 median mean std amplitude 1.0090 1.0081 0.0109 phase -0.0850 0.0181 0.8638	unedited: 10 points edited: 8 points, 2.0 min speed, 2.5 max dev median mean std amplitude 1.0061 1.0058 0.0018 phase 0.0539 0.0282 0.0807
After patch_hcorr.py	
Number of edited points: 69 out of 96 median mean std amplitude 1.0090 1.0081 0.0109 phase -0.0850 0.0181 0.8638	unedited: 10 points edited: 8 points, 2.0 min speed, 2.5 max dev median mean std amplitude 1.0061 1.0058 0.0018 phase 0.0539 0.0282 0.0807
Calibrations correction values applied	
rotate_amplitude: 1.005	
rotate_angle: -0.040	
After applying calibration corrections	
Number of edited points: 70 out of 96 median mean std amplitude 1.0040 1.0033 0.0100 phase -0.0475 0.0703 0.8346	unedited: 11 points edited: 9 points, 2.0 min speed, 2.5 max dev median mean std amplitude 1.0013 1.0009 0.0023 phase 0.1150 0.0809 0.0748
Calibrations correction values applied	
rotate_amplitude: 0	
rotate_angle: 0.0125	
After applying calibration corrections	
Number of edited points: 70 out of 96 median mean std amplitude 1.0040 1.0032 0.0100 phase -0.0580 0.0560 0.8332	unedited: 11 points edited: 9 points, 2.0 min speed, 2.5 max dev median mean std amplitude 1.0009 1.0008 0.0023 phase 0.0965 0.0653 0.0695
After manual single ping editing	
Number of edited points: 71 out of 94 median mean std amplitude 1.0030 1.0032 0.0101 phase -0.0430 0.0834 0.8437	unedited: 11 points edited: 9 points, 2.0 min speed, 2.5 max dev median mean std amplitude 1.0009 1.0008 0.0023 phase 0.0965 0.0653 0.0695
Calibrations correction values applied	
rotate_amplitude: 0	
rotate_angle: 0.02	
Final calibration correction	
Number of edited points: 71 out of 94	unedited: 11 points

median mean std amplitude 1.0030 1.0031 0.0101 phase -0.0570 0.0644 0.8452	edited: 9 points, 2.0 min speed, 2.5 max dev median mean std amplitude 1.0013 1.0008 0.0023 phase 0.0700 0.0384 0.0731

os150nb_total_rotate_amplitude = 1.005
os150nb_total_rotate_angle = -0.0075

Table 5: os70nb Water Track and Bottom Track Working Calibrations and Residuals

Water Track	Bottom Track
Preliminary	
Number of edited points: 0 out of 2 median mean std amplitude nan nan -0.0000 phase nan nan -0.0000	N/A

6 Appendix B

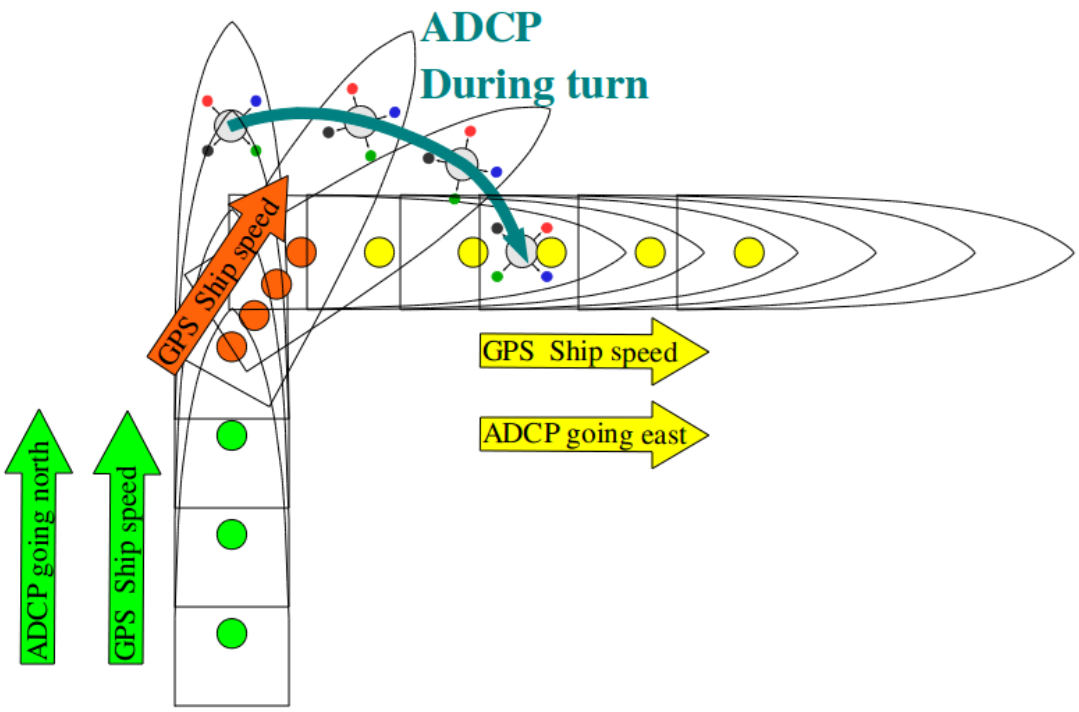

Figure 2: The horizontal offset between the ADCP transducer and the GPS (used to calculate ship speed) can cause errors in the calculated ocean velocity.
https://currents.soest.hawaii.edu/docs/adcp_doc/codas_doc/dataviewer/xducer_dxdy.html

```
OS150NB


**transducer-gps offset**
-----------
guessing ADCP (dx=starboard, dy=fwd) meters from GPS
positions from a_inv.agt
calculation done at 2025/03/28 03:27:43
xducer_dx = -7.406500
xducer_dy = 3.794732
signal = 2405.857633


OS75NB

-----------
guessing ADCP (dx=starboard, dy=fwd) meters from GPS
positions from a_inv.agt
calculation done at 2025/03/27 04:06:55
xducer_dx = 6.261230
xducer_dy = 0.395090
signal = 46.492654
-----------
```

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