Healy 2011 ADCP Evaluation (HLY11TA)

Dr. Julia M Hummon

University of Hawaii

hummon@hawaii.edu

Revision History

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1 Introduction

USCGC Healy presently has two Doppler current profilers made by Teledyne RDI. Both are the Ocean Surveyor model, which uses a single phased-array transducer to generate all four acoustic beams. The two instruments differ in their operating frequency, nominally 75 kHz (OS75) and 150 kHz (OS150). The lower frequency allows profiling at greater range, but with reduced resolution, compared to the higher frequency. The performance of these instruments during the 2010 season, however, was poor, even taking into account the range reduction owing to signal attenuation by the thick acoustic window required for ice protection. A major cause of the poor range and, in some cases, biased velocity estimates seen in 2010, appears to be electro-magnetic interference (EMI).

During the 2011 in-port period, the deck units were moved to a temporary location in MICA to see whether this would reduce EMI via the transducer cables. Various tests were run during the transit from Seattle to San Francisco and back, and data quality was assessed from useful periods (eg. Multibeam calibrations). Results are presented below, as are recommendations from this evaluation. The key result is that the new location dramatically improved data quality; careful selection of a new permanent location and corresponding transducer cable routing will greatly increase the scientific usefulness of the shipboard ADCPs on the Healy.

2 UHDAS and CODAS

Documentation for the shipboard ADCP data acquisition system (UHDAS) and for the automated data processing included in UHDAS (CODAS) is accessible

- at sea (http://currents)
- on land (http://currents.soest.hawaii.edu/docs/adcp_doc/index.html)

See the accompanying CODAS and UDHAS Overview documents.

3 ADCP data from HLY11TA

3.1.1 Data Collection

The ship sailed April 25, 2011, with UHDAS data collection commencing at 19:20 UTC. During the transit south, data were collected using the standard instrument defaults for each ping type, with interleaved broadband (BB; higher resolution, reduced range) and narrowband (NB; lower resolution, maximum range) pings. The BB and NB data ensembles are processed and evaluated independently. Transducer alignment has not physically changed since last year, and calibrations show that the values used for processing (which incorporate POSMV alignment) remain valid.

During most of HLY11TA, the sea state was moderate. After leaving San Francisco, the winds picked up for about a day, decreasing the range of all instruments as the bubble-laden water under the transducers increased noise and absorbed signal. The ADCPs were able to return valid data during most of the cruise. Range degradation is the primary outcome of higher sea-state, but bias in the measured velocity component in the direction of ship motion can also occur. The OS150 suffered from such underway bias in both BB and NB modes during a short period.

On the transit south, one reciprocal track was run for the ADCP. During the northbound transit, three multibeam tests provided reciprocal tracks. The accumulation of stop/start/course change during these and other maneuvers, yielded sufficient water-track calibration points for calibration. Bottom-track data was collected for each instrument during some shallow sections.

During the Northbound leg, the spare OS75 deck unit was used for the first segment. It seems to be functional, so it was stored back in its box. The transducer cables were originally coiled together in the overhead space. Prior the the northbound leg, the cables were separated and re-secured, but this did not seem to make any difference in the data. Two additional tests were also run: measuring the current drawn by the OS75 deck unit, and built-in tests (PT3, PT6). These are summarized at the end of this document.

3.1.2 Results from Underway Data

The waters off the coast of California are rich in upwelled nutrients, so biological activity should result in good scattering. In good weather this should yield maximum depth penetration for each ADCP. As expected, range and quality were reduced by increased ship speed and sea state. In the best conditions, the OS75 reached 600m in narrowband mode (Figure 1). This range was about double what was seen in 2010. Broadband mode is expected to get 80% of the range of narrowband mode for a given instrument. The best sustained range of the OS75 in broadband mode for this cruise was around 450m, which is consistent with that expectation. OS150 range was not extended much beyond 2010 ranges.

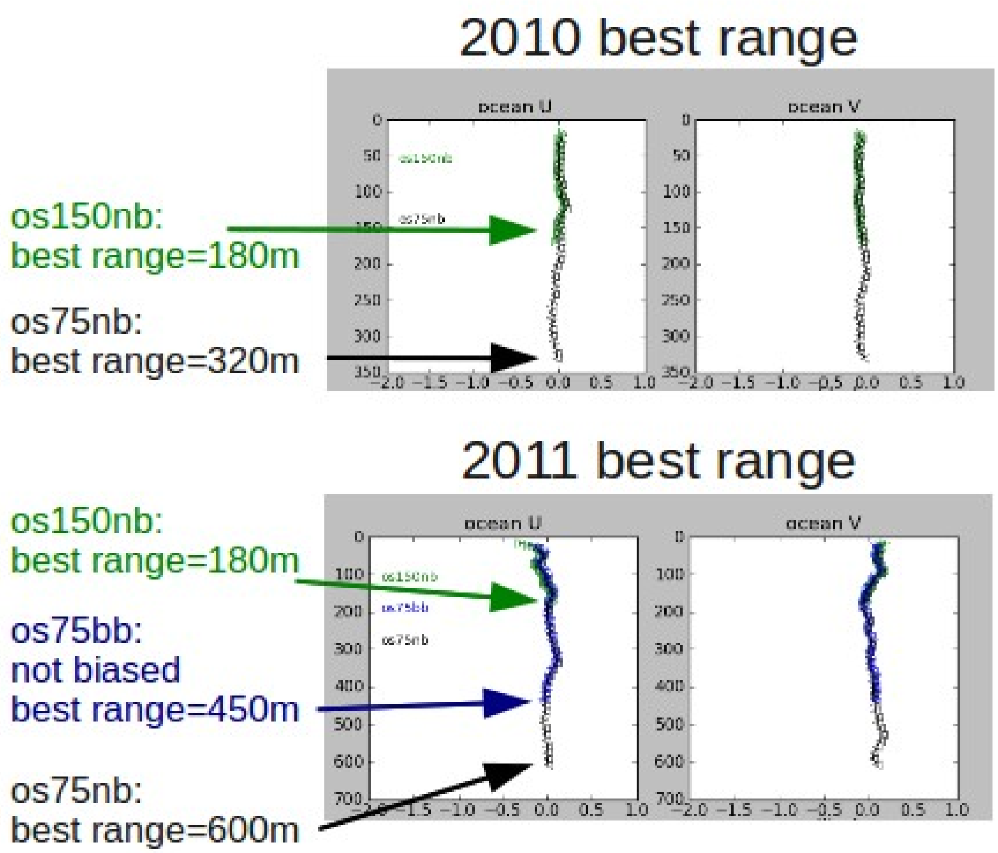

Figure 1: Superimposed simultaneous ocean velocity profiles from each of three instrument/ping combinations: OS150NB (green), OS75NB (black), and OS75BB (blue; 2011 only). The data samples were taken under good conditions, so they indicate the maximum ranges of the different instruments. The improved OS75 range in 2011 compared to 2010 is attributed to the new test location of the deck box and transducer cable, yielding reduced EMI.

3.1.3 Results from Reciprocal Tracks

There were four opportunities to compare ADCP data from reciprocal tracks (Figure 2). On the first three, both instruments were running in interleaved mode (BB+NB pings) with RDI-recommended defaults. It was obvious from all 3 comparisons that the OS150 still suffers from biases, though the magnitude appears to have diminished greatly . On the 4th reciprocal run, the OS150BB was not active, and the remaining profiles show good range and no bias.

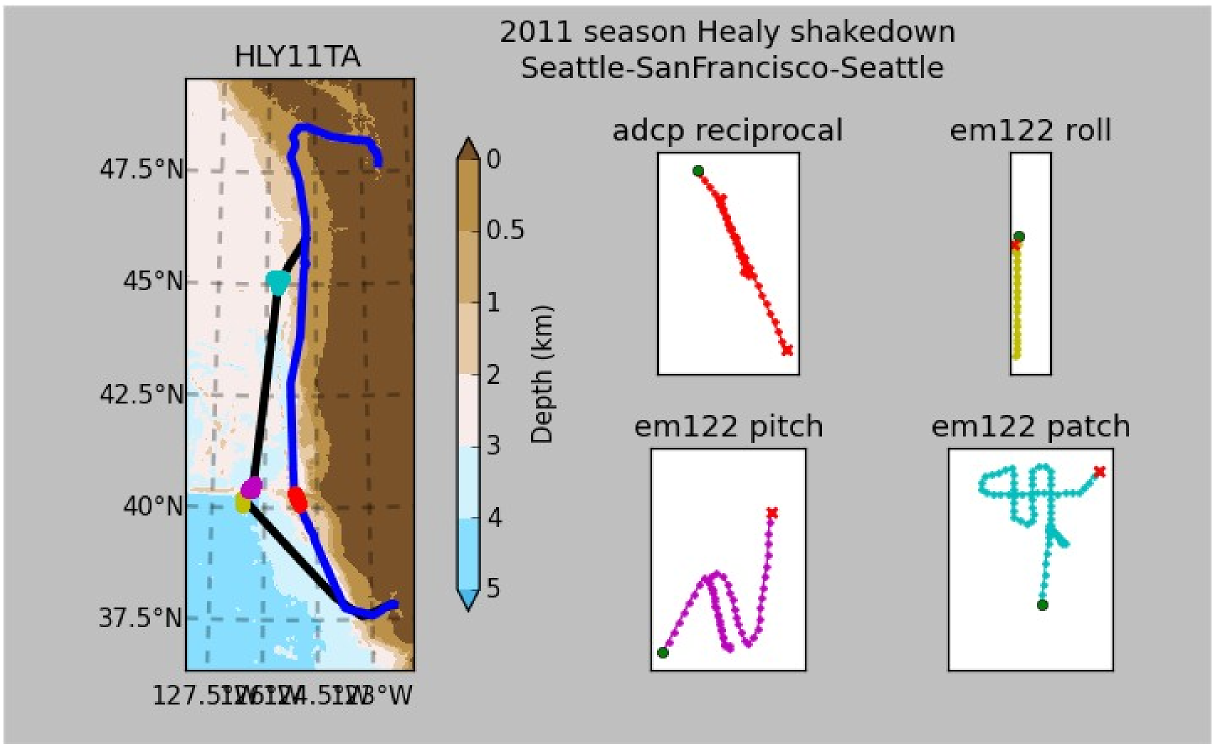

Figure 2: HLY11TA cruise track and reciprocal tests

Figure 3 shows a typical comparison of southbound/northbound legs from one reciprocal run. Note the positive bias in ocean V during the northbound leg, and the negative bias in V in the southbound leg (the OS150 broadband mode, red).

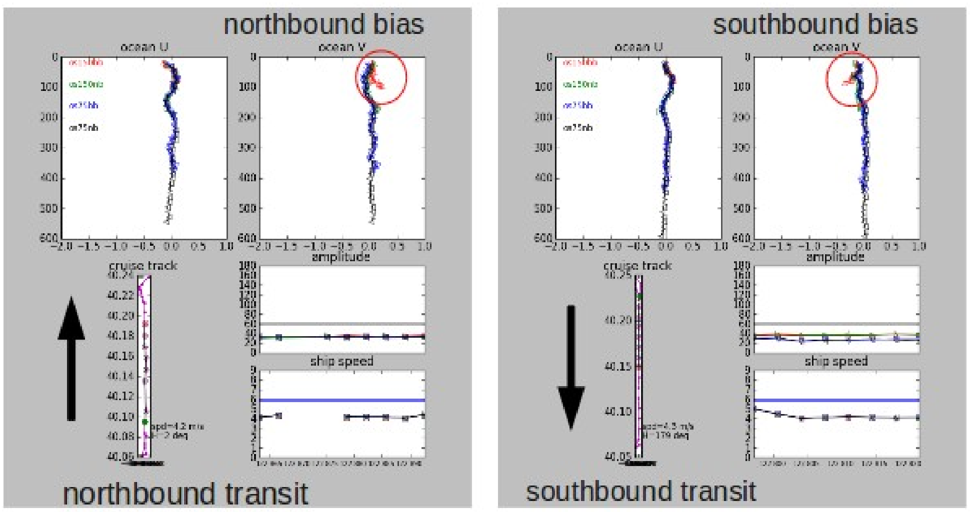

Figure 3: HLY11TA reciprocal: velocity bias in the direction of motion is evident at the bottom of the OS150 broadband mode profile.

This bias is similar in character to the biases in the OS150BB and OS75BB data in 2010 (bias in the ocean velocity, oriented in the direction of travel, increasing with distance from the transducer). In contrast to 2010, during the 2011 tests the bias is only in the OS150BB (not OS75BB) and is reduced by about 60% in magnitude from 2010 (Figure 4).

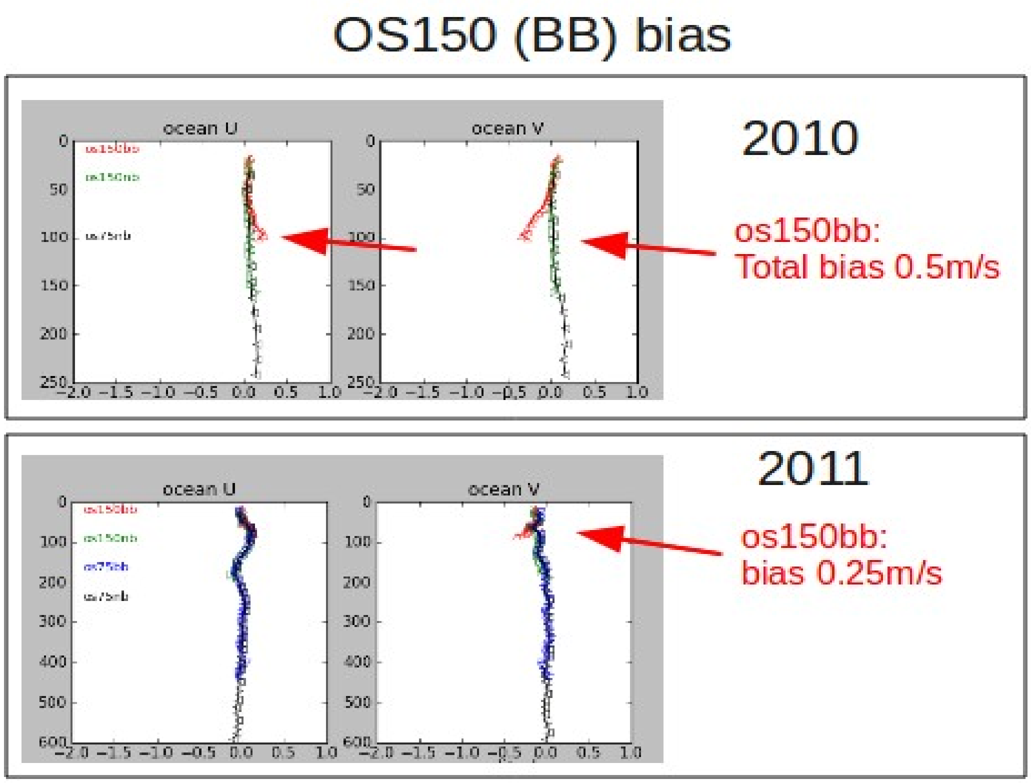

Figure 4 : Comparison of OS150BB velocity bias in 2010 and 2011; the bias was much weaker in 2011. (Note: the 2011 data are plotted for a larger depth range than the 2010 data.)

4 Evaluation

In the past, the Healy ADCP installations have suffered from high noise, poor range, and bias in broadband mode. An experiment in 2006 which involved moving the OS75 deck unit ("chassis") down to the Potable Water room demonstrated that much of the noise and bias in this installation are induced by electrical interference, and that this could be greatly reduced by moving the deck unit and transducer cables closer to the transducers themselves. The experimental deck unit location (aft, port MICA) set up prior to HLY11TA shakedown, was an attempt to use existing space to address the electrical interference problem. The data collected on HLY11TA (e.g., Figure 5) showed a dramatic improvement in OS75 range and in the broadband mode biases of both instruments. The experimental repositioning of the deck box and cables is a significant step in the right direction, greatly improving the scientific potential of the ADCP system for the upcoming season.

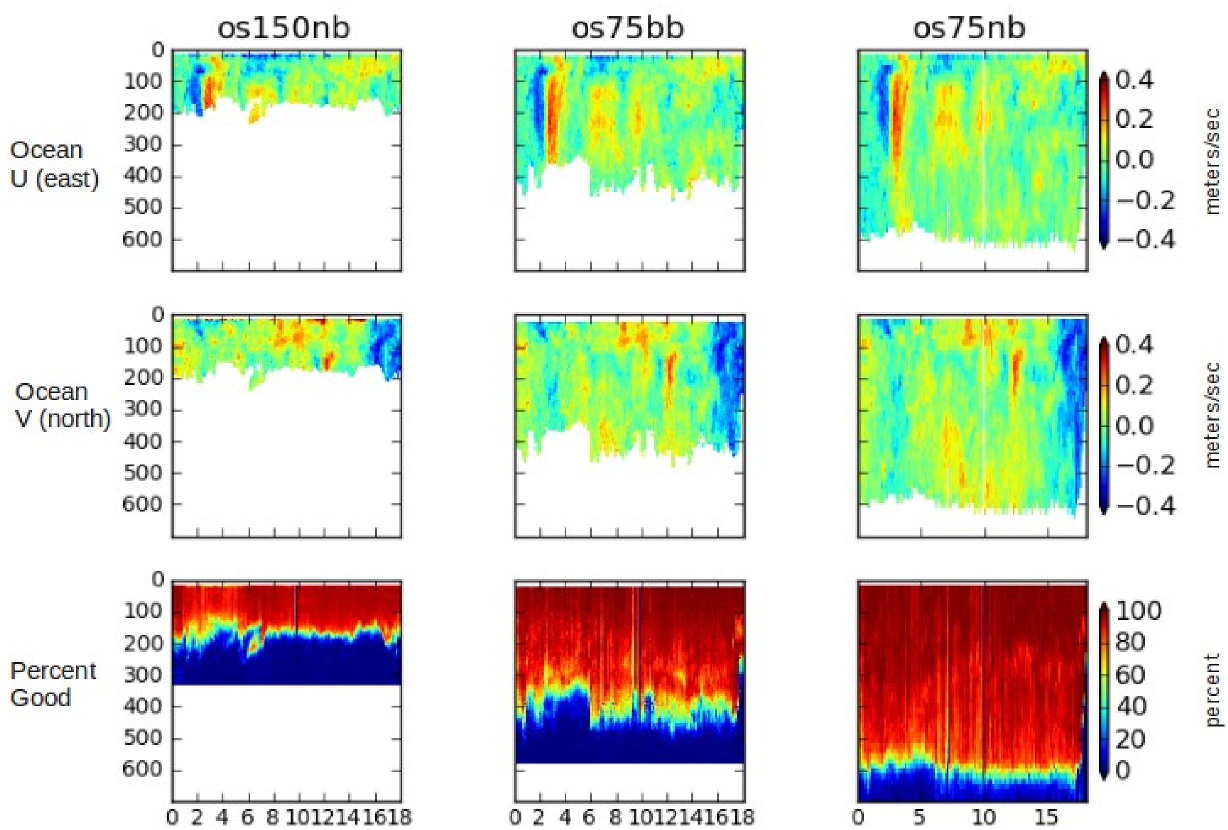

Figure 5: An illustrative short time series of HLY11TA data collected using 2011 field season defaults, showing ocean velocity east component (top), north component (middle), and percentage of single-ping velocity samples that were accepted after editing.

5 Summary: Vast improvement

characteristic	OS150bb	OS150b	OS75bb	OS75nb
noise floor:	• 2010: 40-60 • 2011: 25-35	• 2010: 40-60 • 2011: 25-35	• 2010: 60-80 • 2011: 30-50	• 2010: 60-80 • 2011: 30-50
Depth Range (best):	75m-100m	150m-200m	300m-450m	450m-600m
Depth Range (typical):	50m-100m	80m-180m	200m-350m	400m-500m
bias:	0.2m/s at 12kts	none	none	none

These ranges are not a prediction of Arctic data characteristics, but a record of what was measured during the shakedown cruise, HLY11TA. Noise floor is variable; some of the noise and its variability may result from acoustic noise, some may still be coming from EMI that could be reduced even more.

6 Recommendations

The most important recommendation for improvement of ADCP performance on all time scales is to continue trying to understand and solve the problem of electrical noise. Significant improvement was seen by moving the deck units into aft, port MICA. We recommend that a permanent location in MICA be found and that the present (temporary) installation remain in place for the duration of the 2011 field season. One promising location would be the aft bulkhead (shelves already in place) just to starboard of where the transducer cables come out of Potable Water. The transducer cables should be routed away from other cables and excess should be cut (and cables reterminated). We expect that the removal of the excess OS150 cable will improve its range and decrease bias.

In addition to physical space for the deck units and the UPSs, permanent power and fiber (communications) would have to be provided. Environmental conditions in MICA should be monitored during the year to see whether additional cooling or ventilation would be needed for the deck units (e.g., airconditioned racks). NOTE: synchro gyro feeds have been provided to the deck units at great effort, by maintaining serial-synchro converters and wiring the synchro feeds for the deck units. This was a recommendation made by RDI when the ADCPs were operated with VmDAS, which had a lack of serial ports. The ADCPs are now operated by UHDAS, which does not (at present) use the synchro-fed gyro data, and will never require it. Although nice to have, the synchro feeds are not a requirement of UHDAS.

A long-term recommendation is to ensure that there are instruments operating at two or more frequencies. The present OS150 is loaned; but an instrument operating at 150 or 300 kHz is essential for shallow-water work. Although the Workhorse 300 kHz instrument can fulfill this role on most ships, it almost certainly would not work on the Healy because of the strong sound absorption by the thick acoustic window required for ice protection. Even without a window, shipboard WH300 instruments typically have disappointing range, rarely over 100 m. Therefore an instrument operating at 150 kHz is likely to be the best choice for the Healy. The new "Quartermaster" 150 kHz instrument from RDI, with a discrete transducer for each beam, might provide better performance than an OS150. If the noise problem can be solved, then the Healy's capabilities in deep water could be improved by adding an OS38 to the suite.

Other recommendations:

- formalize monitoring of environmental measurements in MICA and ICGyro
- run ADCPs at all times unless specified by Science
- do not trigger ADCPs from other sonars unless specified by Science
- do not use OS150 broadband mode (we'll try again next year)
- add a statement to IceFloe stating that UHDAS is the data acquisition/processing system in use on Healy, and if Science needs VmDAS they will have to set that up themselves. Please direct concerns or questions about UHDAS to the UHDAS maintainers (email on the web site)

6.1.1 Default Settings for 2011

Because the Healy often operates in shallow water, and because the OS150 broadband mode is not usable at present, the only way to get measurements with high vertical resolution, and close to the hull, is by operating the OS150 ADCPs in narrowband mode but with shorter depth bins than we would ordinarily choose. This reduces the horizontal and temporal resolution; for a given accuracy, more pings must be averaged. The trade-off seems worthwhile, however. The OS75 is now capable of operating in interleaved mode with the usual instrument defaults, so the recommended settings for Healy (2010 season) adcp data acquisition are:

The UHDAS gui starts with defaults for ADCP data acquisition. These are:

ADCP	broadband mode	narrowband mode	bottom track
os150	**biased: do not use**	bin size = 4m 70 bins blank = 5m	not necessary with CODAS processing
os75	bin size = 8m 50 bins blank = 8m	bin size = 16m 50 bins blank = 8m	not necessary with CODAS processing

7 Other Tests

7.1 Amperage drawn

topology	pings	Max amps
AC-UPS-clamp-OS150	BB+NB+BT	6-7 amps
AC-UPS-clamp-OS75	BB+NB+BT	7.5-8 amps
AC-UPS-clamp-OS75	BB+NB	2.6 amps

7.2 Built-In tests

ADCP	os150	os75
PT3 (correlation magnitude)	Passed	Passed
PT6 (bandwidth)	Passed	Passed