 

Shipboard procedures for XBT data quality:

What things can go wrong besides fall-rate error and what can be done to prevent them?

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Outline

•The SIO High Resolution XBT Network

•System set-up and routine operations

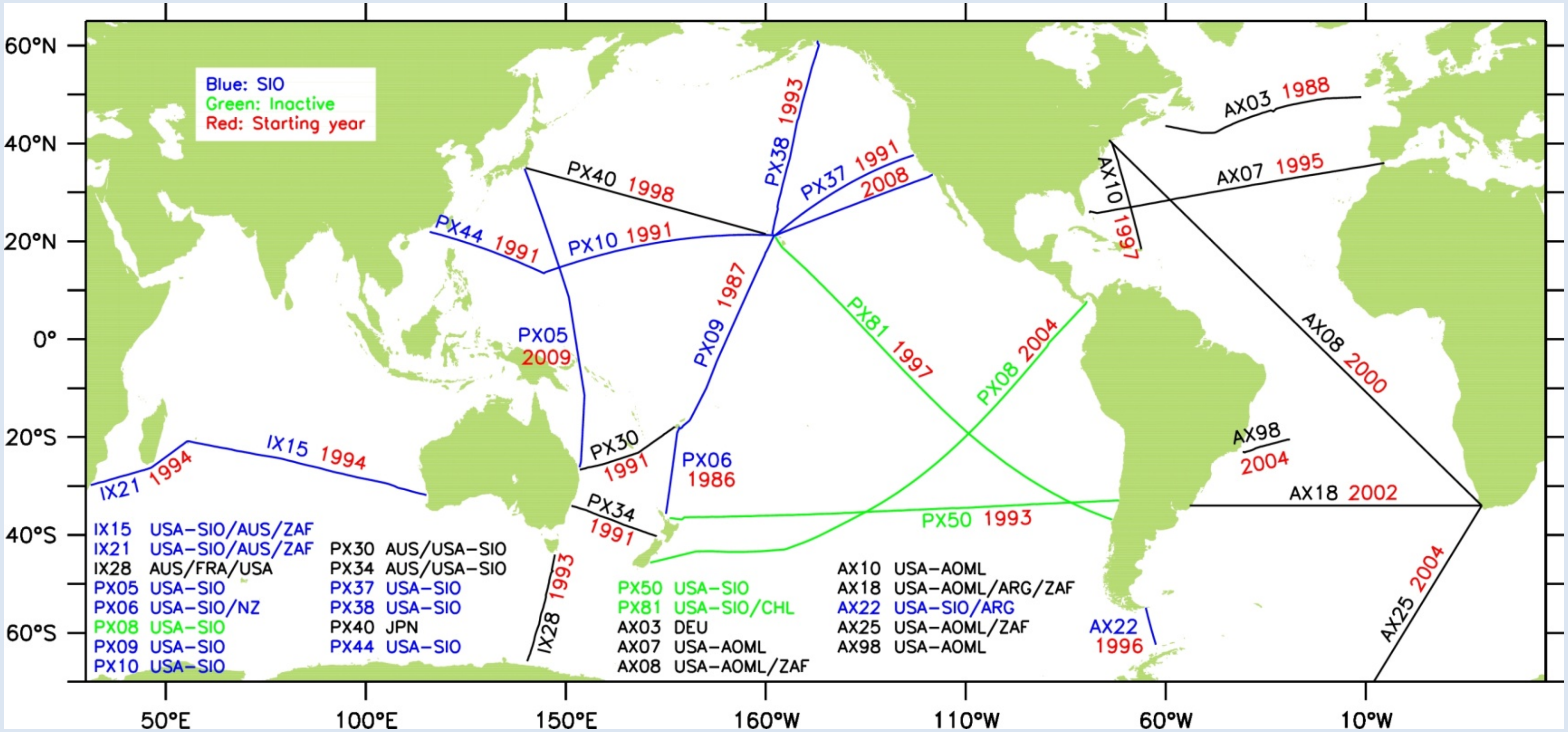
- Minimizing wire problems - location of hand or auto-launcher
- Ship-rider reporting
- Grounding issues/ shipboard electrical systems/ ground loops
- Launcher/MK21 calibration
- Launcher pin assemblies - leakage Splash detection

•Maximizing data quality

- Electrical interference
- Detecting and re-dropping questionable profiles
- Closely-space profiles aid shipboard and delayed qc
- Use of climatologies and buddies in QC

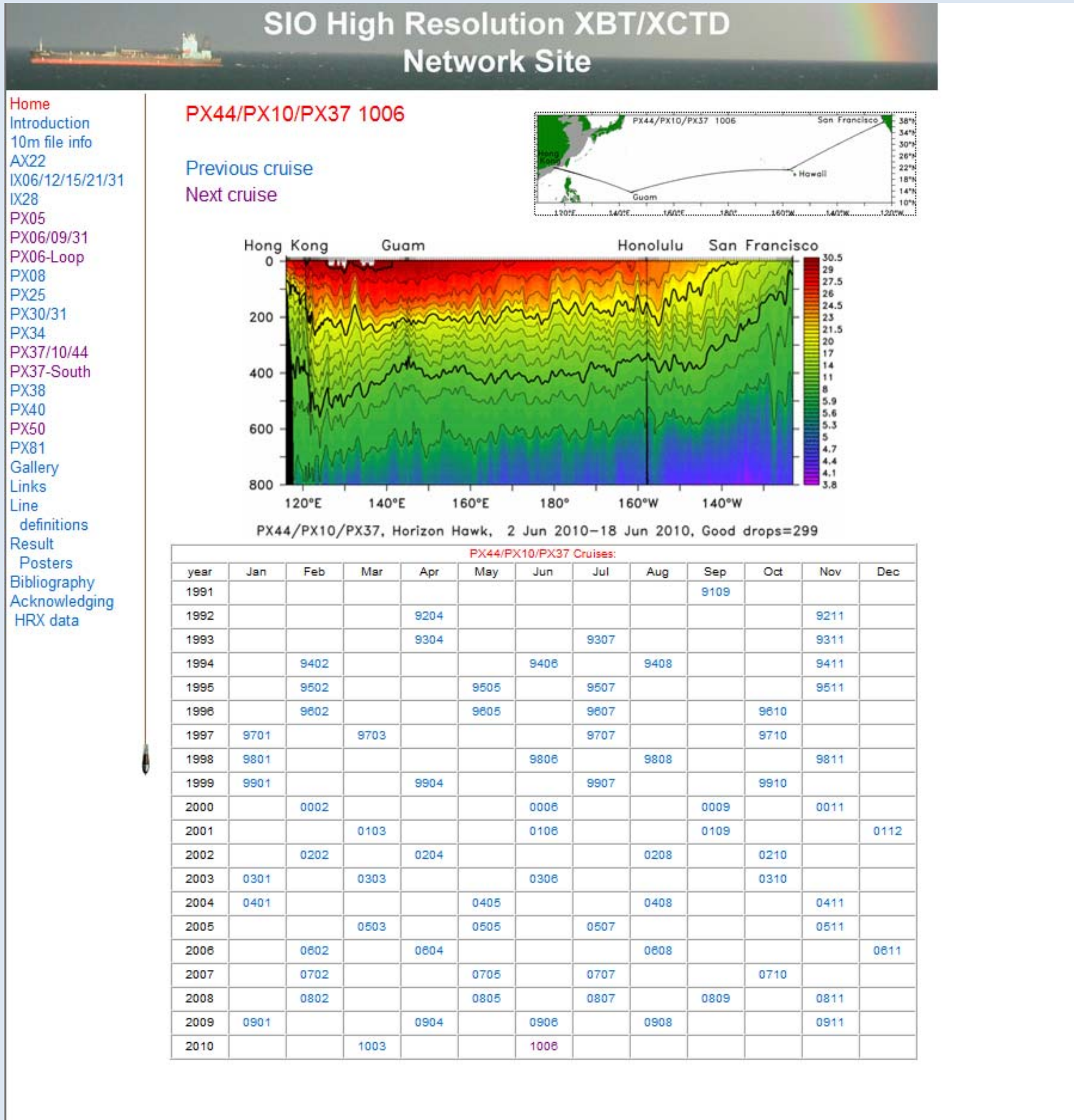
•Changes we know about in probe manufacture (going back to the '90s)

SIO High Resolution XBT transects



- The SIO High Resolution XBT Program (blue lines above) deploys over 6000 XBTs per year, as part of the global HRX partnership.
- Most lines are sampled four times per year by a ship rider.
- Biggest challenge is “disappearance” of many historical shipping routes such as PX50.

SIO HRX web site shows sampling and provides data



PX44/PX10/PX37 Cruises:

year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1991									9109			
1992				9204							9211	
1993				9304			9307				9311	
1994		9402				9406		9408			9411	
1995		9502			9505		9507				9511	
1996		9602			9605		9607			9610		
1997	9701		9703				9707			9710		
1998	9801					9806		9808			9811	
1999	9901			9904			9907			9910		
2000		0002				0006			0009		0011	
2001			0103			0106			0109			0112
2002		0202		0204				0208		0210		
2003	0301		0303			0306				0310		
2004	0401				0405			0408			0411	
2005			0503		0505		0507				0511	
2006		0602		0604				0608				0611
2007		0702			0705		0707			0710		
2008		0802			0805		0807		0809		0811	
2009	0901			0904		0906		0908			0911	
2010			1003			1006						

http://www-hrx.ucsd.edu/

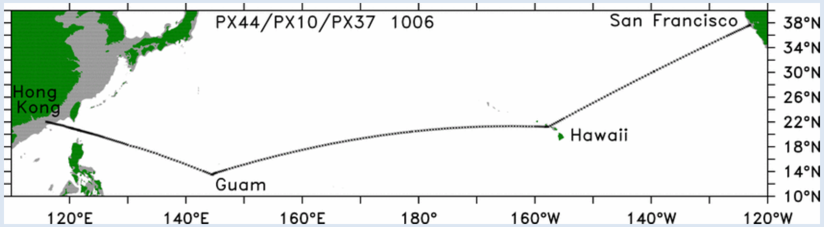
Time-series of 20 years or more along some routes.

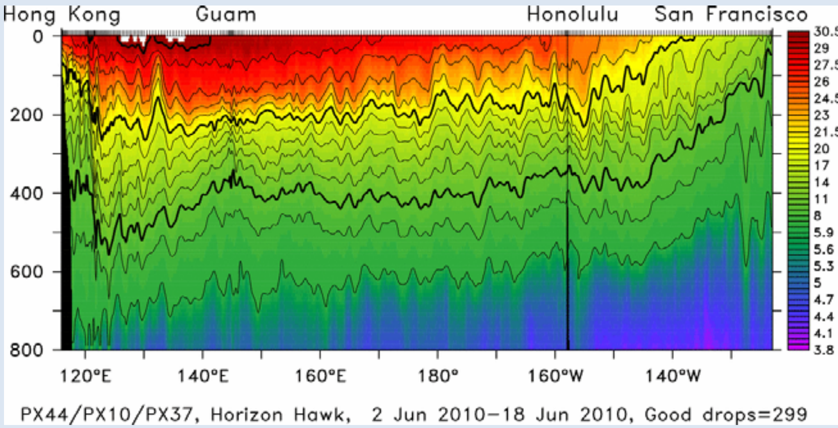
Data are sent in near real-time via SEAS for the GTS.

Delayed-mode data are available as transects via the web site.

Left: 74 transects have been obtained along PX37/10/44 since 1991.

Research uses of the HRX dataset





Each route provides data with many research uses, focused on geostrophic velocity and transport.

Selected pubs from PX37/10/44 are on:

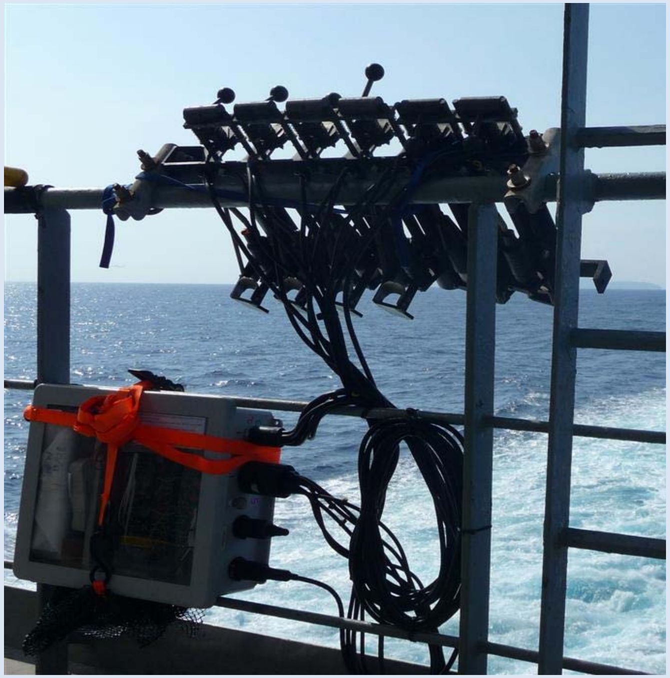
Water mass formation and spreading[1,2]
Large-scale circulation and variability[3]
Transport of the Kuroshio[4]
Mesoscale eddies[5]
Sea surface height[6]
Heat budget of the North Pacific[7,8,9]
California Current System[10]

Selected publications from PX37/10/44

[1]Hautala, S. and D. Roemmich, 1998. Subtropical Mode Water in the Northeast Pacific Basin. *Journal of Geophysical Research, 103,* 13055-13066.
[2] Ueno, H., E. Oka, T. Suga, H. Onishi and D. Roemmich, 2007. Formation and variation of temperature inversions in the eastern subarctic North Pacific. *Geophysical Research Letters, 34,* L05603, doi:10.1029/2006GL028715.
[3] Douglass, E., D. Roemmich, and D. Stammer, 2006. Interannual variability in northeast Pacific circulation, *Journal of Geophysical Research, 111*, C04001, doi:10.1029/2005JC003015.
[4]Gilson, J. and D. Roemmich, 2002. Mean and temporal variability in Kuroshio geostrophic transport south of Taiwan (1993-2001). *Journal of Oceanography, 58*, 183-195.
[5] Roemmich, D. and J. Gilson, 2001. Eddy transport of heat and thermocline waters in the North Pacific: A key to interannual/decadal climate variability. *Journal of Physical Oceanography, 31,* 675-687.
[6]Gilson, J, D. Roemmich, B. Cornuelle and L.-L. Fu, 1998. Relationship of TOPEX/Poseidon altimetric height to the steric height and circulation in the North Pacific. *Journal of Geophysical Research, 103,* 27947-27965.
[7]Roemmich, D., J. Gilson, B. Cornuelle and R. Weller, 2001. The mean and time-varying meridional heat transport at the tropical/subtropical boundary of the North Pacific Ocean. *Journal of Geophysical Research, 106,* 8957-8970.
[8]Uehara, H., S. Kizu, K. Hanawa, Y. Yoshikawa, and D. Roemmich, 2008. Estimation of heat and freshwater transports in the North Pacific using high-resolution expendable bathythermograph data. *Journal of Geophysical Research, 113,* C02014, doi:10.1029/2007JC004165.
[9]Douglass, E.M., D. Roemmich and D. Stammer, 2010. Interannual variability in North Pacific heat and freshwater budgets. *Deep-Sea Research II 57,* 1127-1140.
[10]Auad, G. and D. Roemmich, 2010. The California Current System in relation to the Northeast Pacific Ocean circulation. In preparation.

Data quality begins at sea

- XBTs are deployed from a stern-mounted autolauncher, resulting in many fewer wire problems than bridge-launching.
- Careful system setup includes grounding, cabling/feedthroughs, and connections. All need testing
- Routine calibration using high precision resistors (test cannister) to identify problems occurring anywhere from the MK21 to the autolauncher (electronics, cables, and connectors).
- Experienced ship-riders oversee data collection at sea, so problems are discovered rapidly, repaired, and documented.
- Immediate automated checking compares each profile with the previous one, alerting the ship-rider to failures and unusual features for quick re-drops.



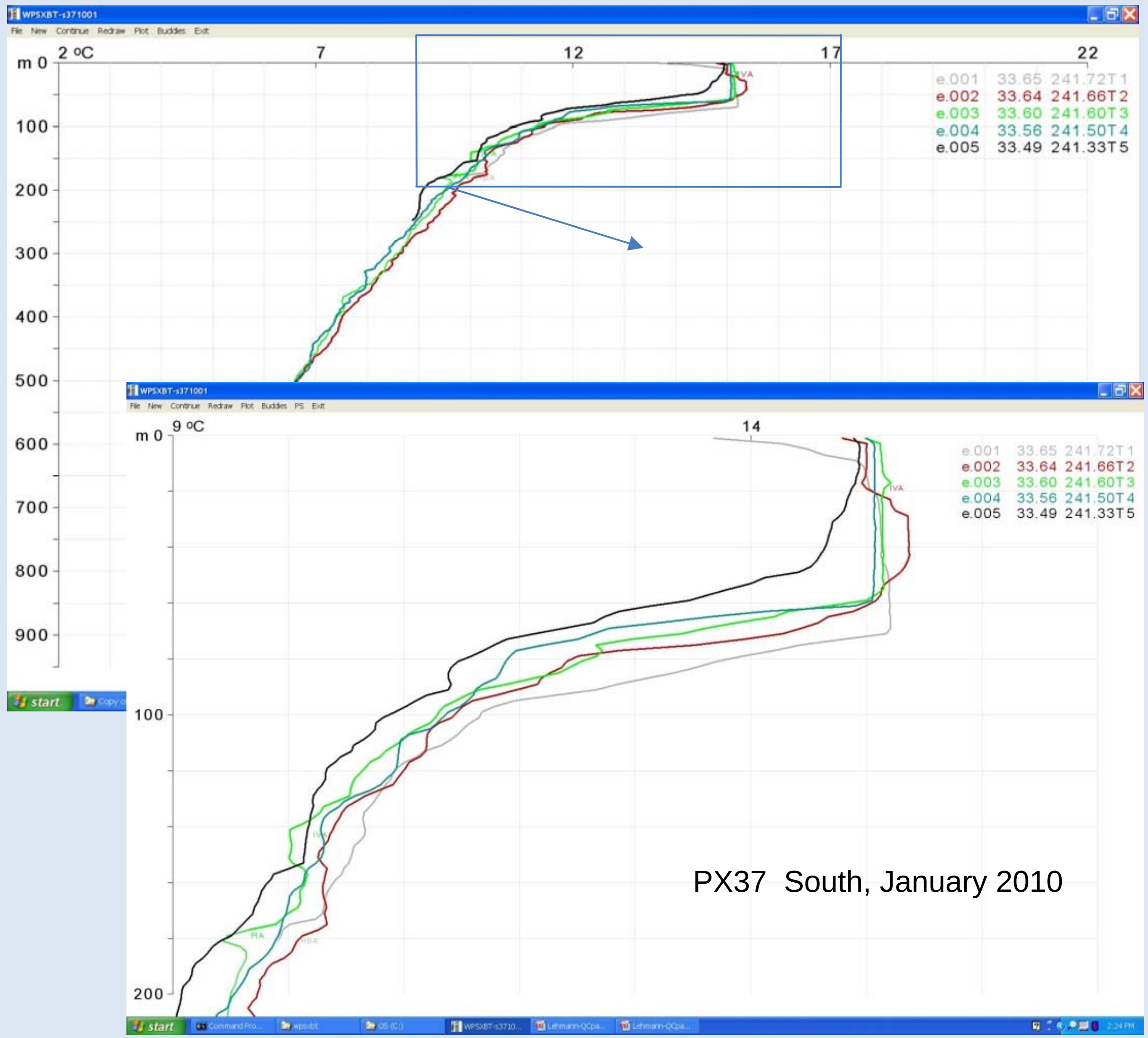
Launcher location is key

- Historically, most XBT drops are from the bridge wings, leading to high failure rates due to wind and to wire contact with the ship.
- The best location for launching XBTs is usually on the stern, leeward side, main deck level. Ship’s architecture may dictate otherwise (clean laminar flow vs swirling eddies). The autolauncher can be re-positioned at sea according to conditions.
- In a recent year we deployed a total of 7031 XBTs and 6847 returned good data (97%), a far higher percentage than bridge-launched XBTs.
- In addition to saving on probe costs, there are many fewer wire-related QC problems.

Autolaunchers on the Horizon Hawk and Maersk Fuji

Accurate and complete ship-rider reporting is essential

Important to understand cruise and weather conditions. Eastern subtropical North Pacific: Drop 001 (in gray, near shelf) shows low salinity cap due to heavy rainfall. If the ship-rider had not document that fact, the DM operator would consider it suspect. The ship-rider's report also documented large swells and deep mixed layers in subsequent profiles.



XBT system setup: grounding and electrical issues

A clean ground must be maintained at a single location (to avoid ground loops).

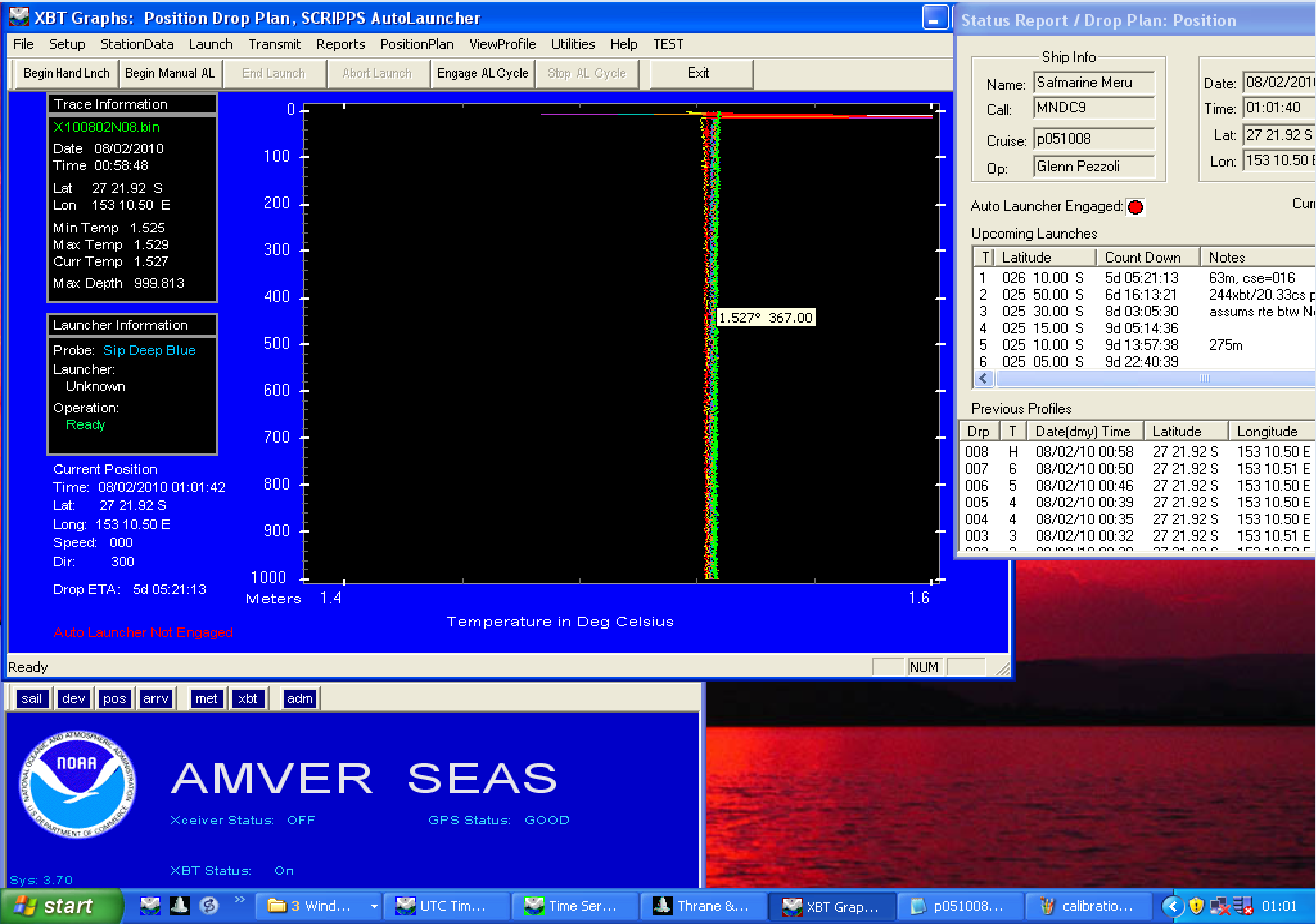
Best ground is to ship's hull, often via porthole frame.

Computer and MK21 are isolated from the ship's electrical system except via the hull ground.

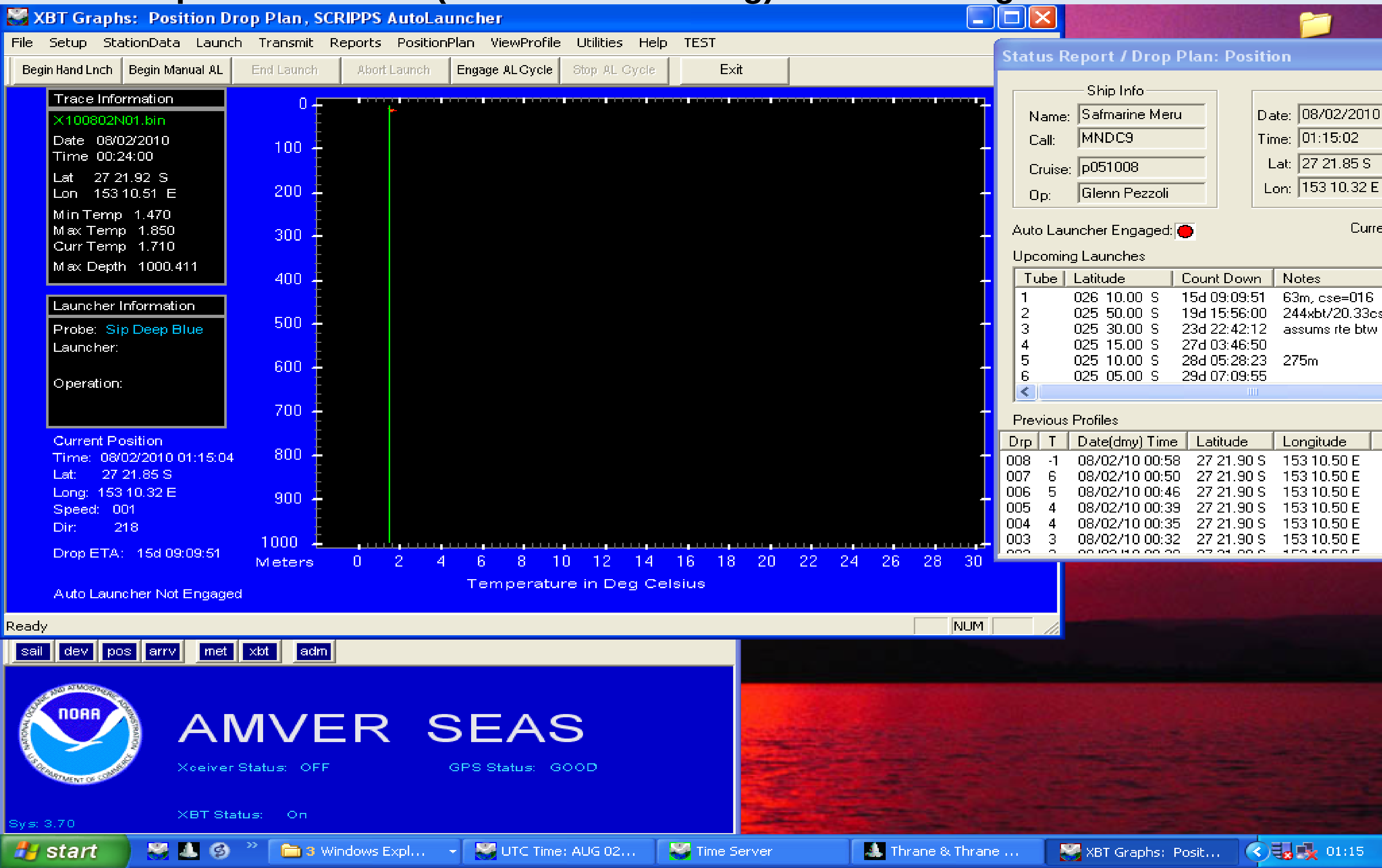
Active cathodic and seachest imbalances sometimes play havoc

Balanced power vs shorebased power schemes. Ship's neutral is hot!

Routine launcher calibration (all 6 AL tubes + HL) – Pre-Cruise Cal



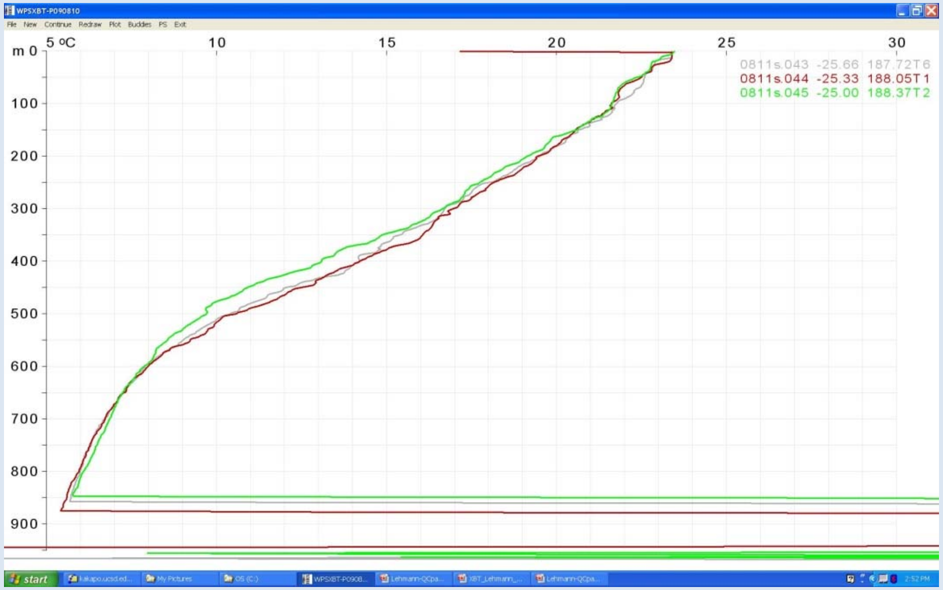
- Same Pre-Cruise calibration (all 6 AL tubes + HL) – Full (normal XBT) Scale.
- Important to look at the mdeg level to avoid introducing systematic offsets, noise and drift.
- Probe to probe variation (random +/- 20mdeg) can be averaged out.



- SIO single point test cans read 1.525 C with 3 Vishay precision resistors.
  Hermetically sealed, no multiple grounding points, double as false splash detectors.
- Planning to build second test can series to read 20.000 C for improved 2 point calibrations.
- Variance from one MK21 to another is as much as 30mdeg.
  Pre/Post cruise cals important. Vital whenever MK21 is swapped out.

False splash problems

False splashes are caused by ground faults, often due to moisture penetrating contact assemblies. Ship-riders are trained to detect these problems and fix the equipment, thus avoiding long sequences of problematic profiles. Although not ideal, profiles with false splash detects can be run through an operator-driven filter for manually locating the splash.   The re-created profile is overlain with it's neighbors and climatology to determine if the data is good.



Profile 44 (red) shows false splash detect

Profile 44 (red) after removing false splash

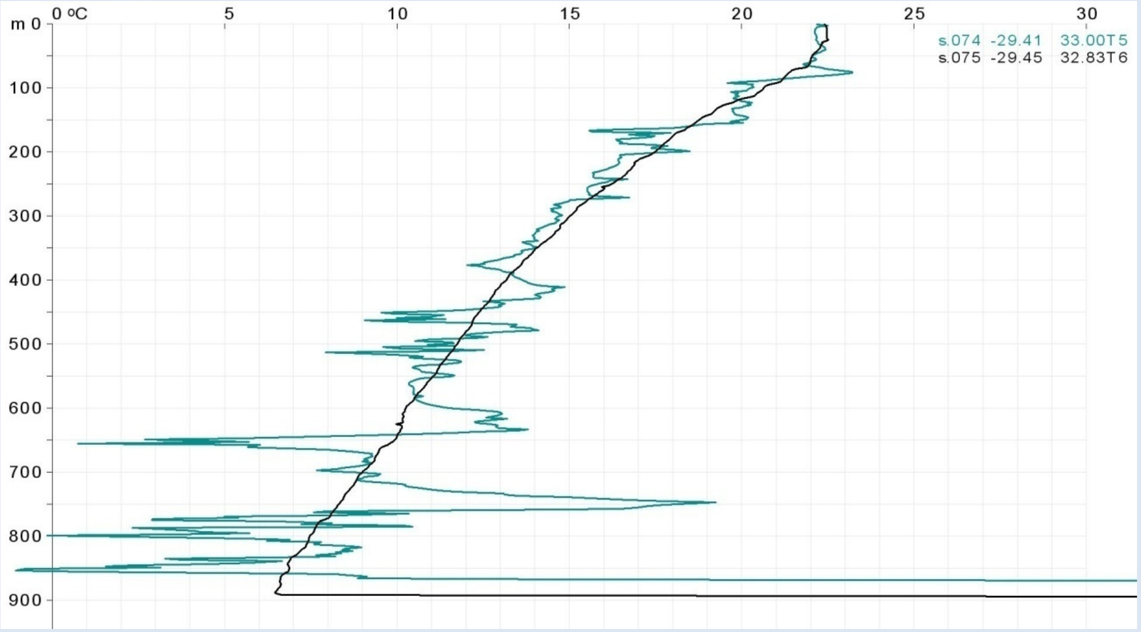
- New SIO contact pin assembly (left)
- Custom water blocked polyurethane cable teflon insulation, potted to XBT head versus cheap pvc insulation, soldered to Belden 8424 microphone (indoor use) cable
- cost effective
- eliminates false splash & reliability problems of original design

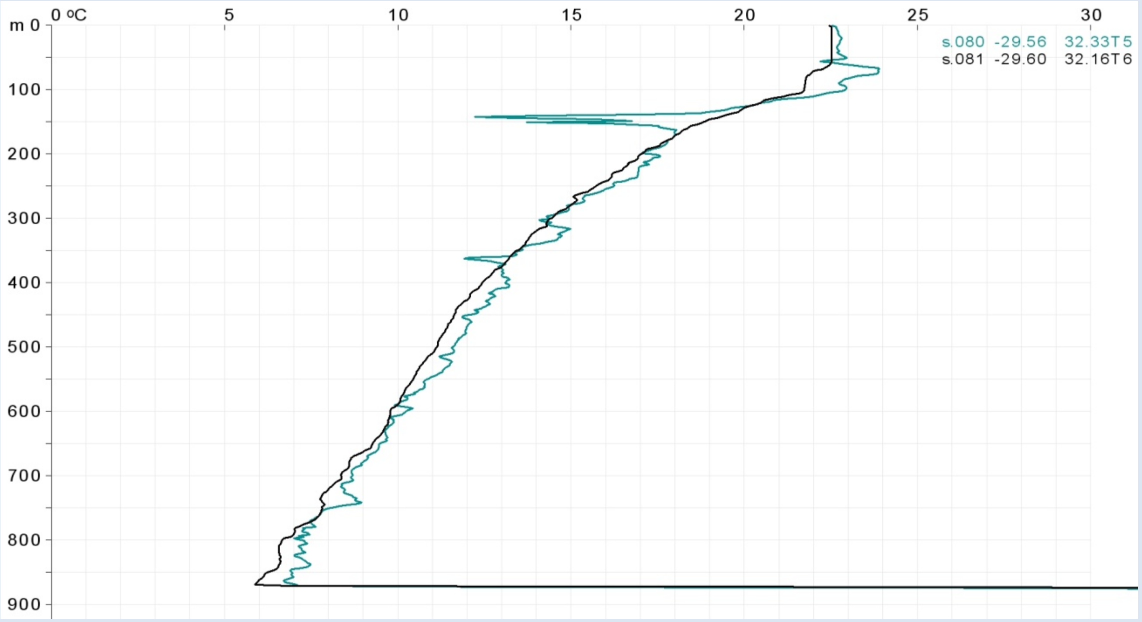
Electrical interference.

Atmospheric electricity causes havoc with XBT drops, occasionally for extended periods of time.

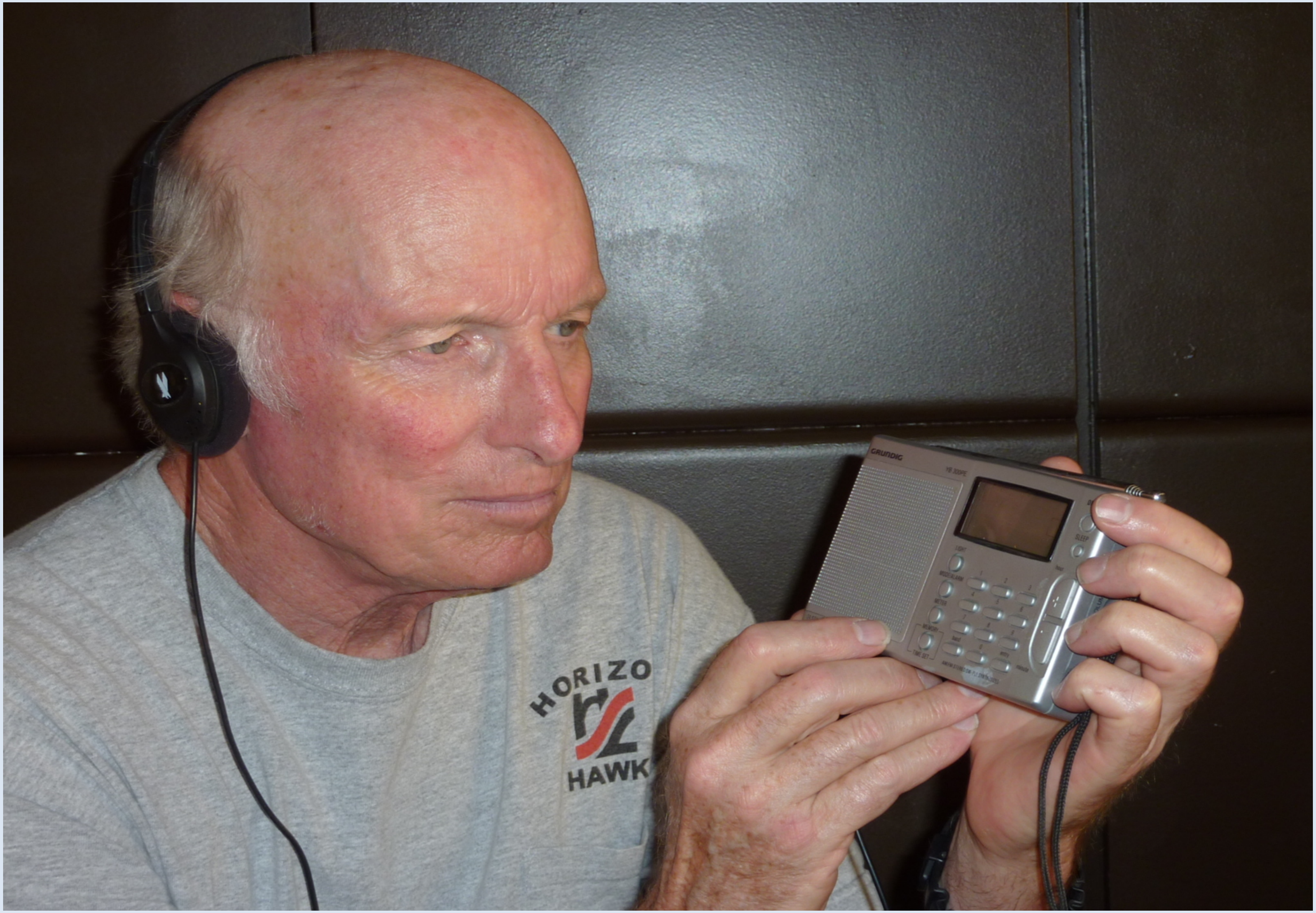
A ship rider can sometimes re-drop XBTs during quiet periods “between clouds”, as in the examples at right where a good drop is collected near a bad one.

The ship-rider’s notes are invaluable in delayed-mode QC to identify causes of failure.



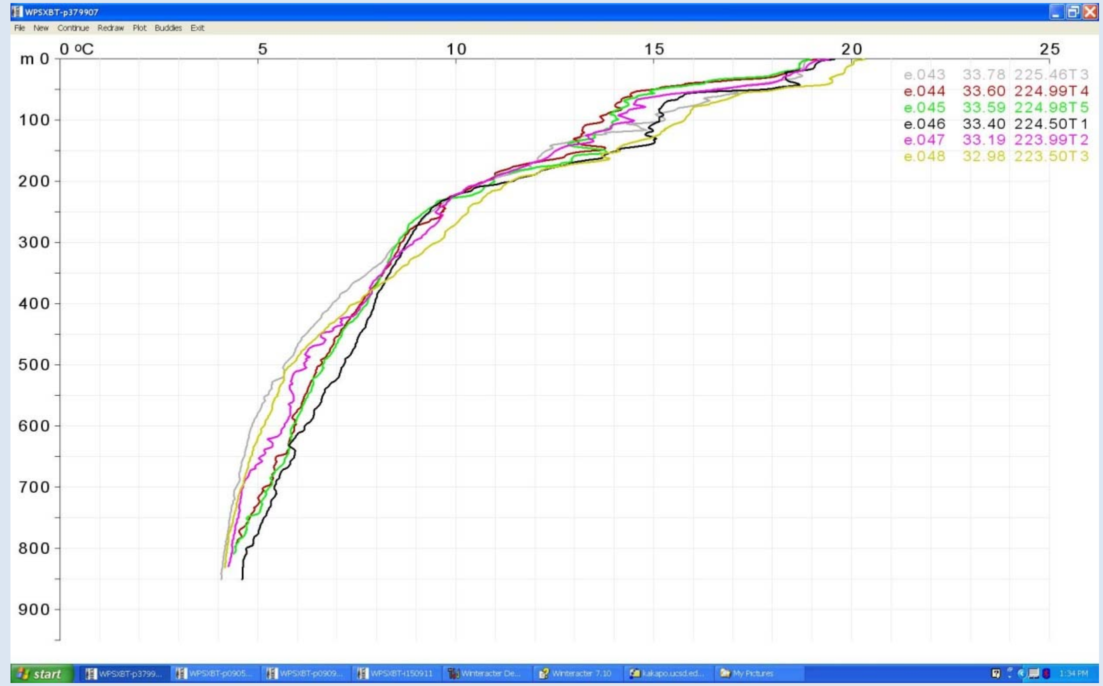


AM radio tuned to static serves as a cheap lightning detector.
Ship's radar works well for detecting rain storms in the area.

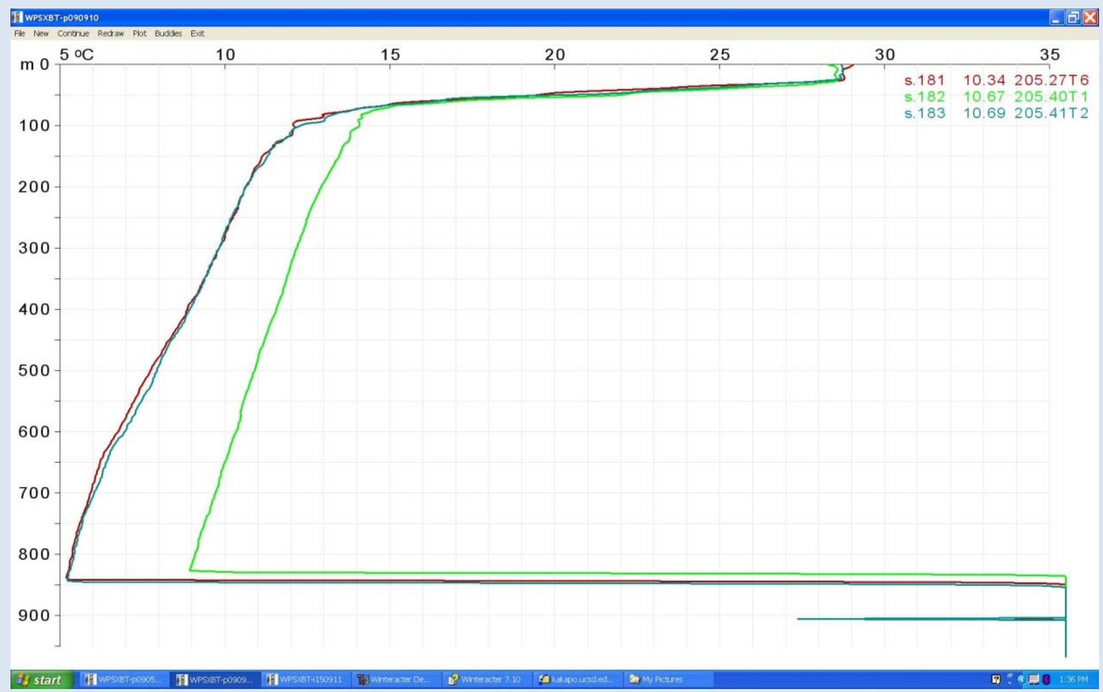


Importance of detecting and re-dropping questionable profiles

Eastern subtropical North Pacific: Drop 44 is quite different from 43 and earlier profiles. A re-drop (45) about 2 km along-track shows that 44 is ok, with subsequent drops “filling in” the transition.



Tropical North Pacific:
Drop 182 is quite different from 181 and earlier profiles. A re-drop (183) about 2 km along-track confirms that 182 is bad.

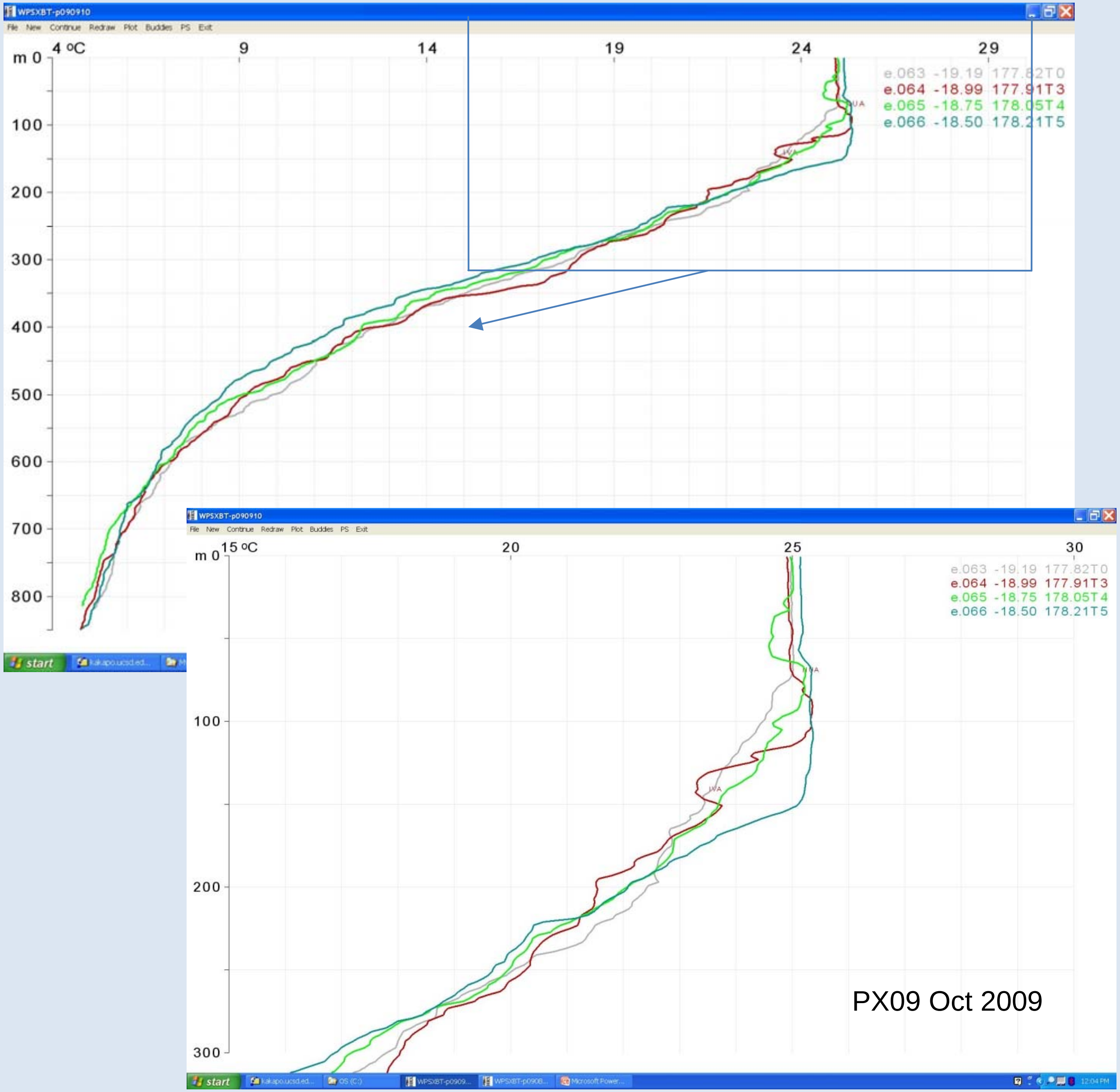


Importance of closely-spaced profiles for QC

HRX drops are closely spaced so that the best source of QC information for each profile is the neighboring profiles.

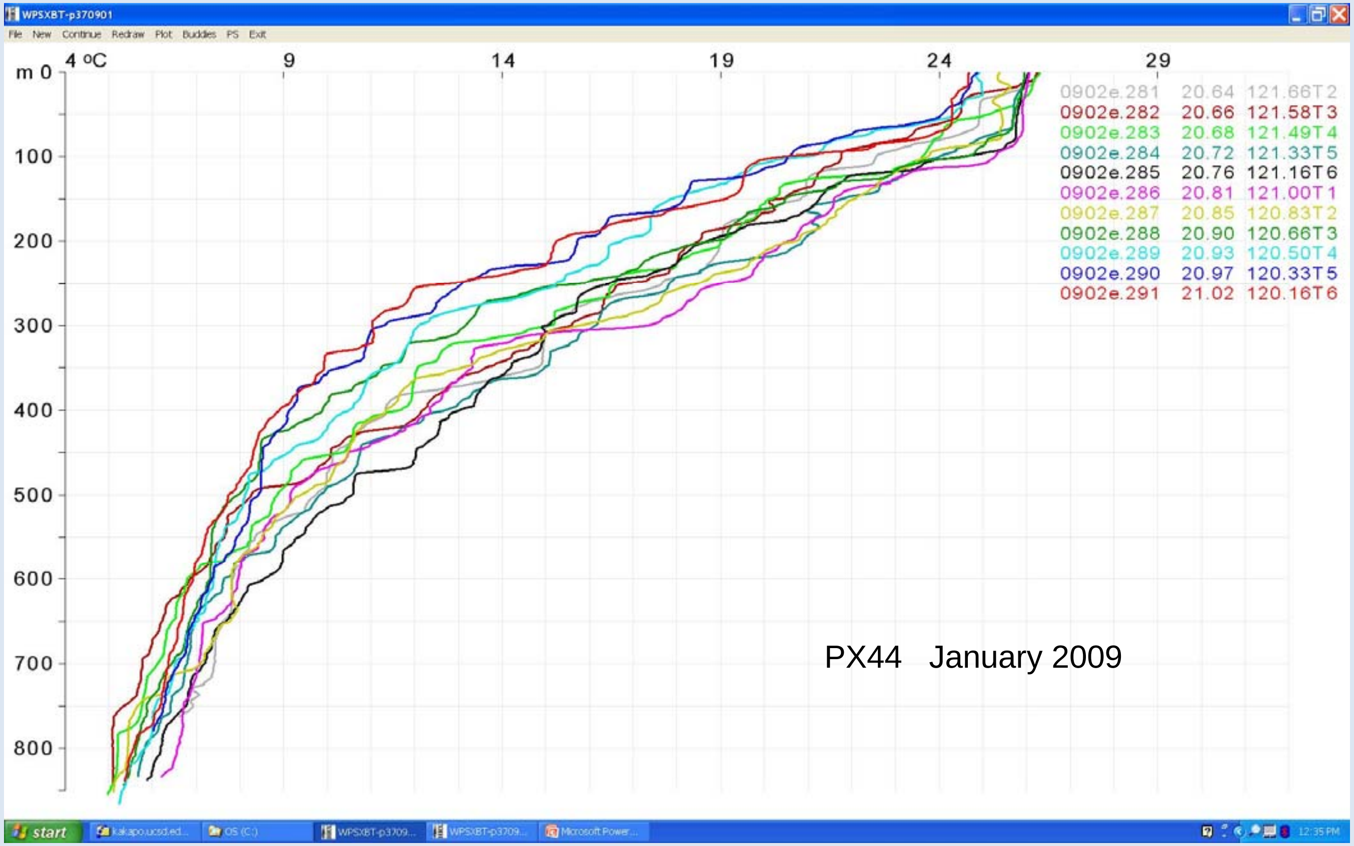
This sequence shows the temperature inversion at the base of the mixed layer just north of Fiji.

Familiarity of ship-riders with regional oceanographic features along a given line is important.



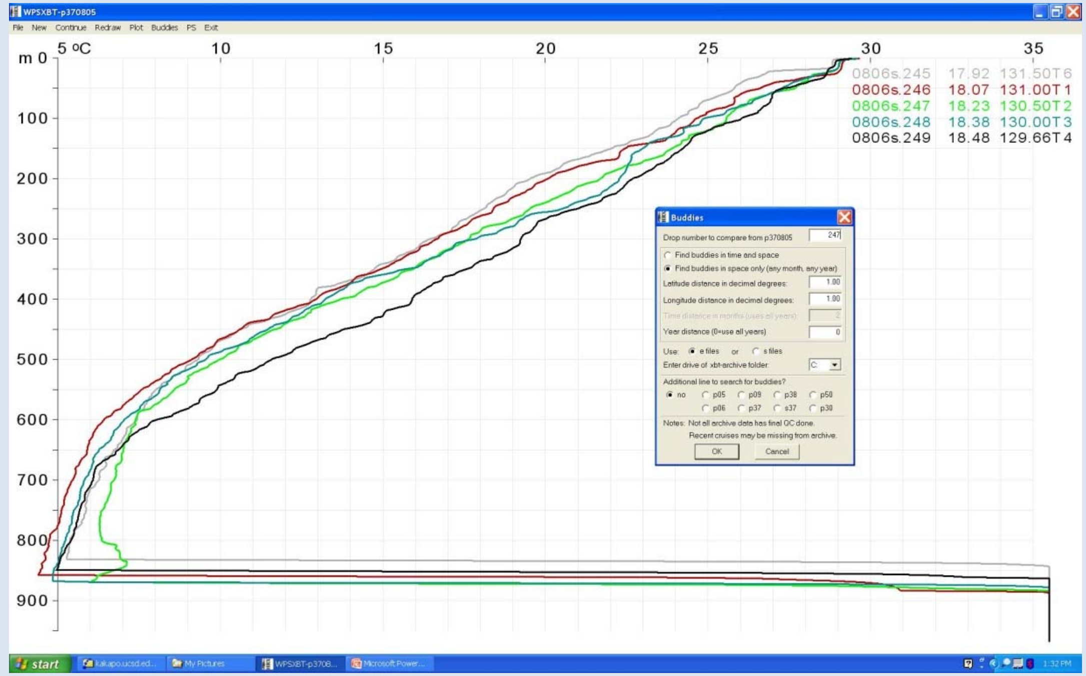
Importance of closely-spaced profiles for QC

This cluster of neighbors in the Kuroshio illustrates how closely spaced profiles (~15 km apart) reveal the highly structured character of the temperature field in a strong current.

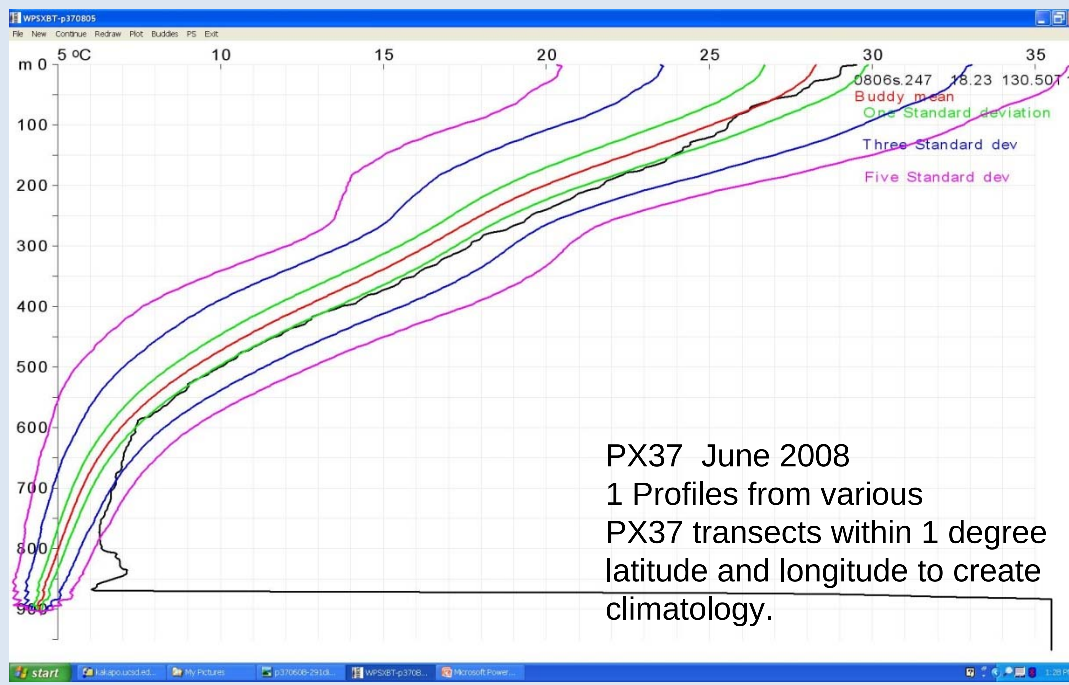


Climatologies for QC

We use a climatology developed from the HRX transects for many checks. Here it is used to determine where profile 247 (Top, green) went bad.



Profile 247 (Bottom, black) is compared to climatology. It appears to have gone bad at 600 m, where it veers abruptly warm to climatology.

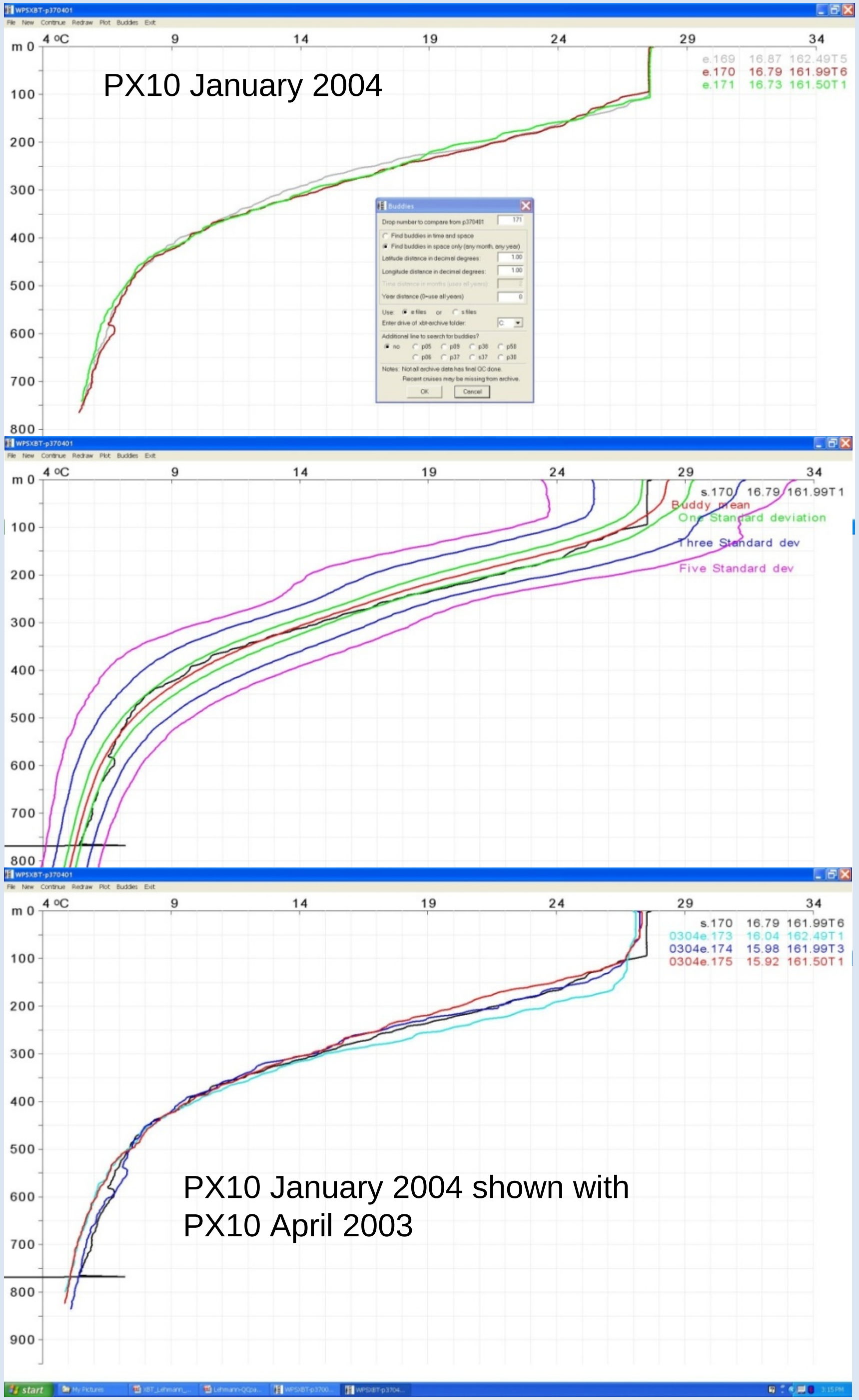


“Buddies” for QC

We can view “buddies” of a profile individually to see if a particular feature has been seen in the past (or future). Profile 170 (Top, red) from PX10 January 2004. Is that an inversion or wirestretch at 580m?

Profile 170 (bottom, black) appears to veer slightly warm to climatology.. However…

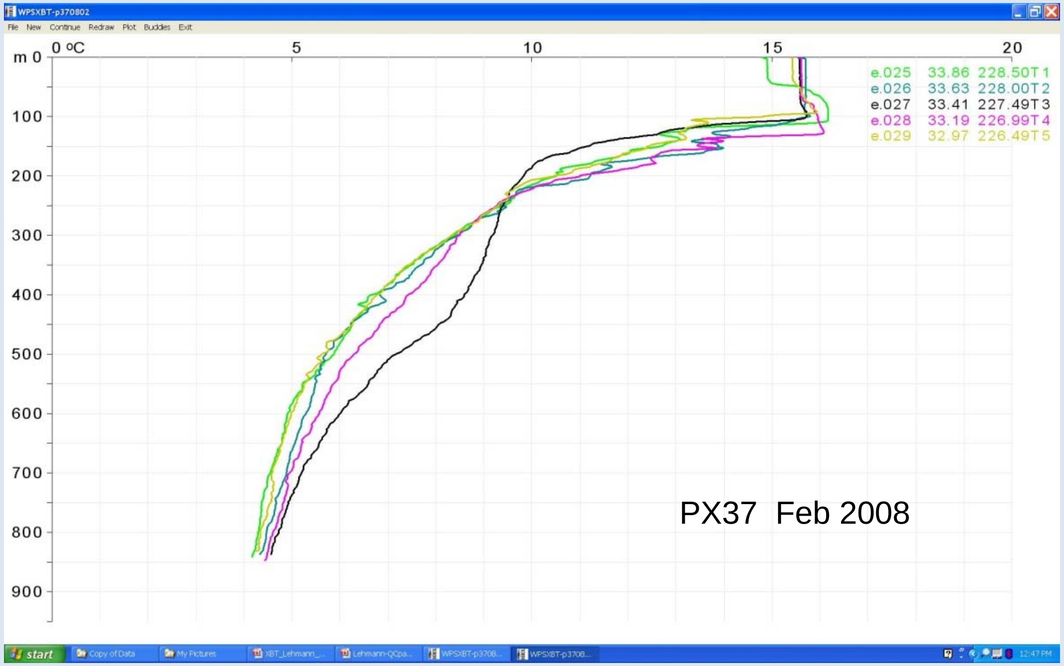
The suspect profile 170 matches nearby profiles from several other cruises – here shown with profile 174 from PX10 April 2003. We’ll call this a PIA (Inversion Probable)

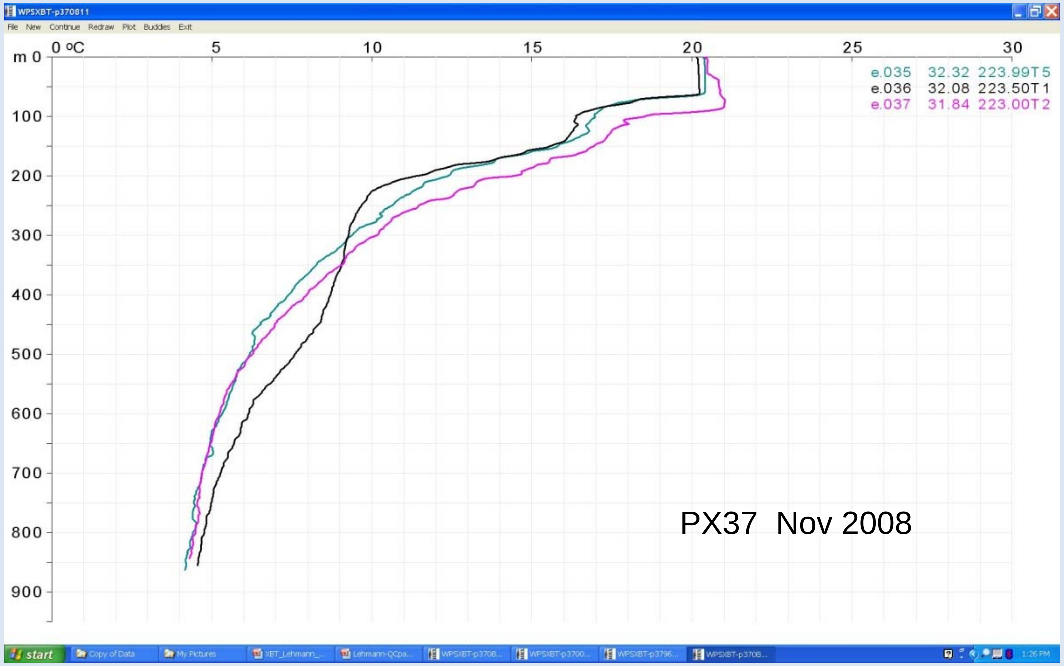


“Buddies” for QC

If a feature (top: profile 027 in black, bottom: profile 036 in black) is not present in neighboring profiles, look for geographical buddies in past cruises.

At right: 0.5º longitude spacing does not resolve the structure of this thermocline eddy, but similar features are seen in the region.





Changes to the Sippican XBT that we are aware of

- Wire manufacture subcontracted, “more springy”.
  Insulation changes from alternating layers of epoxy & polyurethane to?
- Manufacturing moves to Juarez, Mexico
- Paraffin wax replaces motor oil and glycerin gel
- Sparton style plastic sock added to launcher spool, minimizing sloughing during transportation. Eliminates birdnesting, reducing failure rate (at times as high as 50%) to <4%.
- All of these changes occurred during the ’90’s; any one might affect fall rate (with possible exception of the wax).

Summary

SIO ship-riders also support ancillary operations such as float deployment

- SIO has carried out 24 years of High Resolution XBT sampling; we are happy to share our knowledge and experience.
- XBT system setup and routine maintenance have a major impact on probe failure rates and data quality. “An ounce of prevention…….”
- Key factors are launcher location, proper grounding, system calibration, moisture-free contact assemblies, and good record-keeping.
- High resolution sampling together with ship-rider interventions (e.g. re-drops, early diagnosis of problems) also contribute to high data quality.