Near-bottom Multibeam Surveys for Deep Sea Scientific Applications

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National Deep Submergence Facility

- Operator of submersibles for the ocean research community.
- U.S. Govm't funded, predominantly by the National Science Foundation (NSF).
- Scheduled primarily through the University-National Oceanographic Laboratory System (UNOLS)
- Oversight by Deep Submergence Science Committee (DESSC)

NDSF Fields 3 Vehicles

- HOV *Alvin*
- ROV *Jason/Medea*
- AUV *Sentry*

Autonomous Benthic Explorer- RIP

Alvin

- Operation since 1964.
- Dive #4638 in the Gulf of Mexico, November.
- Permanently carried on RV *Atlantis*

Credit: B. Cushman-Patz, Teacher at Sea

ROV *Jason/Medea*

Operation since 2002, ~dive #529.

- Moves among large DP-capable ships of opportunity (UNOLS).

Control system includes autoDepth, autoXY, autoAltitude, autoHeading.

AUV *Sentry*

- First cruise in ‘09.
- Six cruises, five using multibeam.
- 78 dives to date.
- Joined NDSF, June 2010.

Sentry cont'd

- Beyond Seabat 7125: still photo, eH, optode, sub-bottom, magnetometer.
- Science-provided (Tethys mass spec).
- Crew of 4-5 (2 data processors).
- Suitable for smaller vessels.
- DP not required.

The vehicles as multibeam platforms

- *Sentry* was designed as a mapping platform.
  - Quiet dynamics with robust loop control
- *Jason/Medea* is a sampling vehicle.
  - Manipulators, sample baskets, bioboxes, slurps, video.
  - Speed ¼ of Sentry.
  - Contends with towed, two-body dynamics.

Jason (and *Alvin)* as an MB platform

- The ocean research community requested multibeam for *Alvin* & *Jason.*
- "You survey with the vehicle you have on site".
- Applications beyond bathymetry.
  - Seabottom classification.
  - Acoustic detection of hydrothermal or bubble plumes.

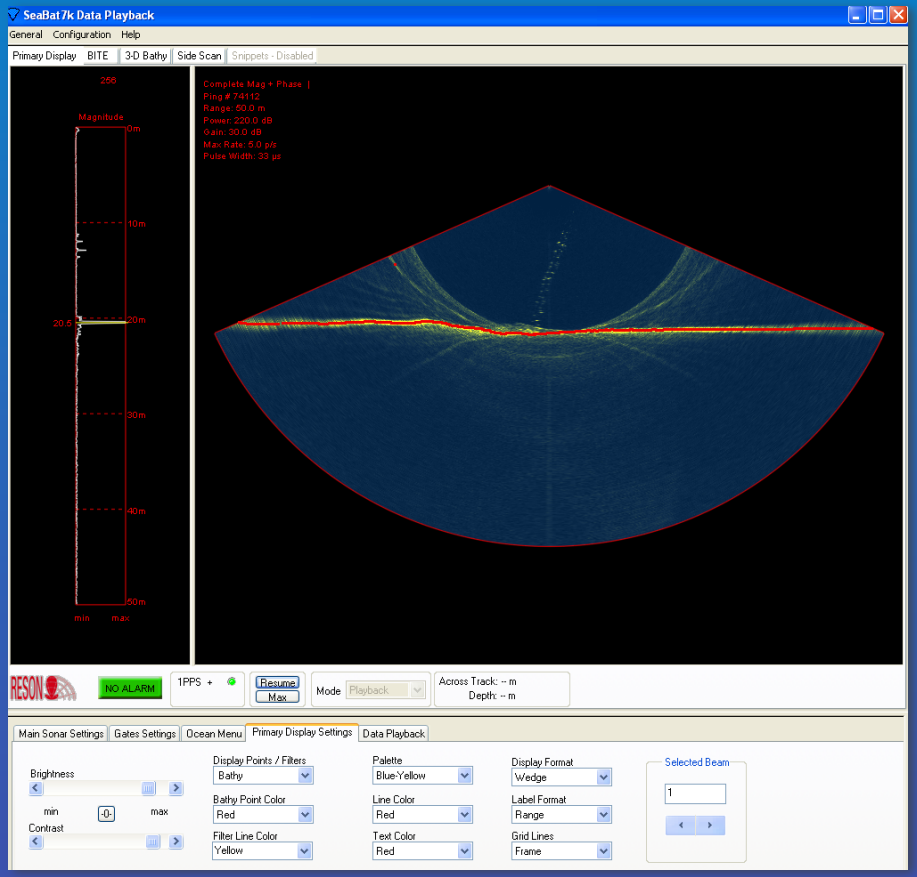
Vehicle Multibeam Capabilities

- *Jason*
  - Survey speed is 0.25 m/sec.
  - "Unlimited" power and bottom time.
- *Sentry*
  - Stable
    - High righting moment
    - Design emphasis on dynamic control.
  - Power for ~20 hrs, 70 linear km @ 1m/s.

Sentry multibeam capabilities cont'd

- @80m alt, 200-220m swath spacing.
  - 0.7 km^2/hr
- @20 m altitude, 50 m spacing.
- Preprogrammed line segments and interactive control via acoustic telemetry.
- Recent success with plume detection.

Other research using Seabat 7125s



NDSF cruises with SeaBat 7125

- Lophelia2-2, *Sentry*, Gulf of Mexico, Jul09.
- Seeps2009, *Sentry*, S. Cal., Sept09. Combined *Sentry/Alvin.*
- GRUVEE, *Sentry*, Galapagos Spreading Center, Mar-Apr10. Combined *Sentry/Alvin.*
- Enlighten'10, *Sentry* and *Jason*, Juan de Fuca, July-Aug10.
- Upcoming Uses:
  - *Jason* on RV Ron Brown, Oct10
  - *Alvin* in Gulf of Mexico.

Sequential/Simultaneous Operations

- *Sentry* by night/ Alvin by day.
- *Sentry* in 1st area with LBL, *Jason* or towcam in 2nd area with USBL.

Simultaneous cont'd

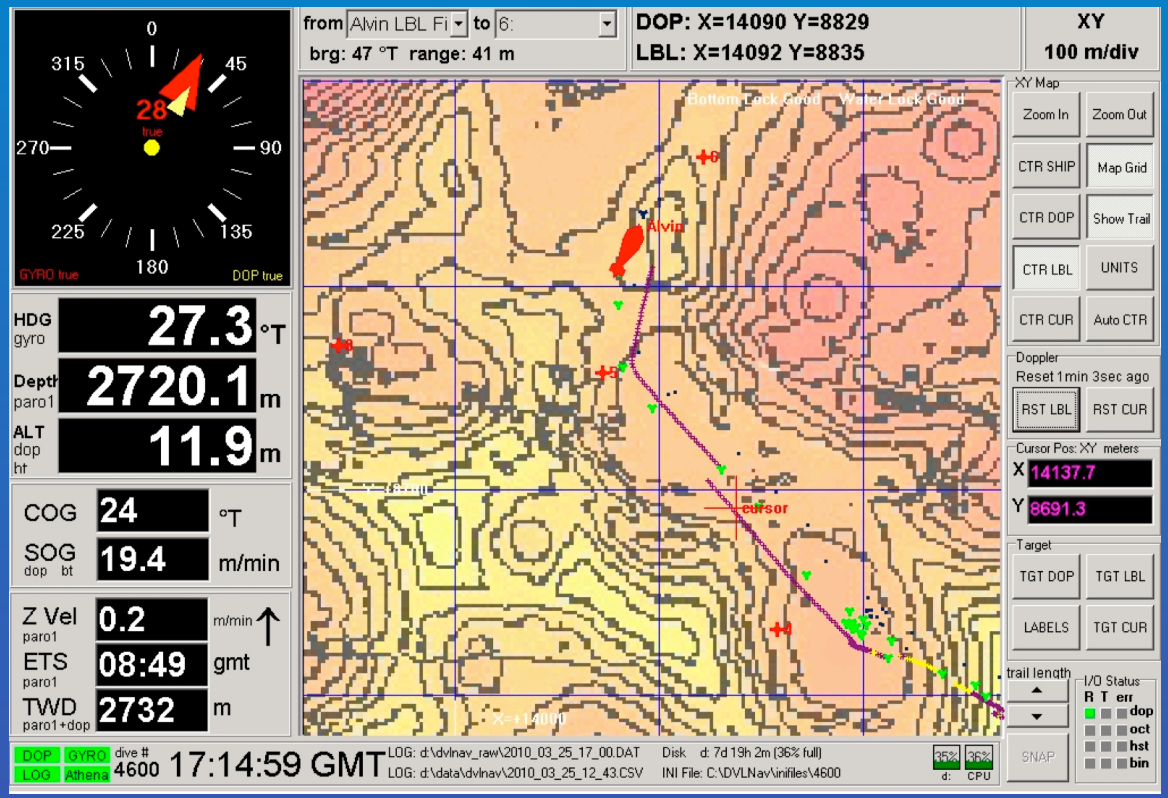
- *Sentry* team produced quick look bathymetry for use by *Alvin* observers during next dive, ~2 hrs after *Sentry* recovery (GRUVEE, April 2010).
- *Jason* was placed in bubble plume to demonstrate detection, *Sentry* surveyed later.

NDSF Navigation Overview

- Primary: DVL+ heading from INS.
- Bottom lock required. 1200 kHz:25 m; 600 kHz:110m;300 kHz:200m
- Augmented by WHOI LBL or USBL.

Vehicle/Sensor	DVL-1	DVL-2	INS
Alvin	RDI Workhorse Navigator 1200 kHz	RDI Workhorse Navigator 600 kHz	Ixsea Octans
Jason	RDI Workhorse Navigator 1200 kHz	RDI Workhorse Navigator 300 kHz	Ixsea Octans
Sentry	RDI Workhorse Navigator 300 kHz	n/a	Ixsea Phins

DVLNav Software



- Real-time display and log of all navigation sensors, several vehicles.

Whitcomb and Kinsey, Johns Hopkins U/Dynamical Systems and Control Lab

USBL and LBL

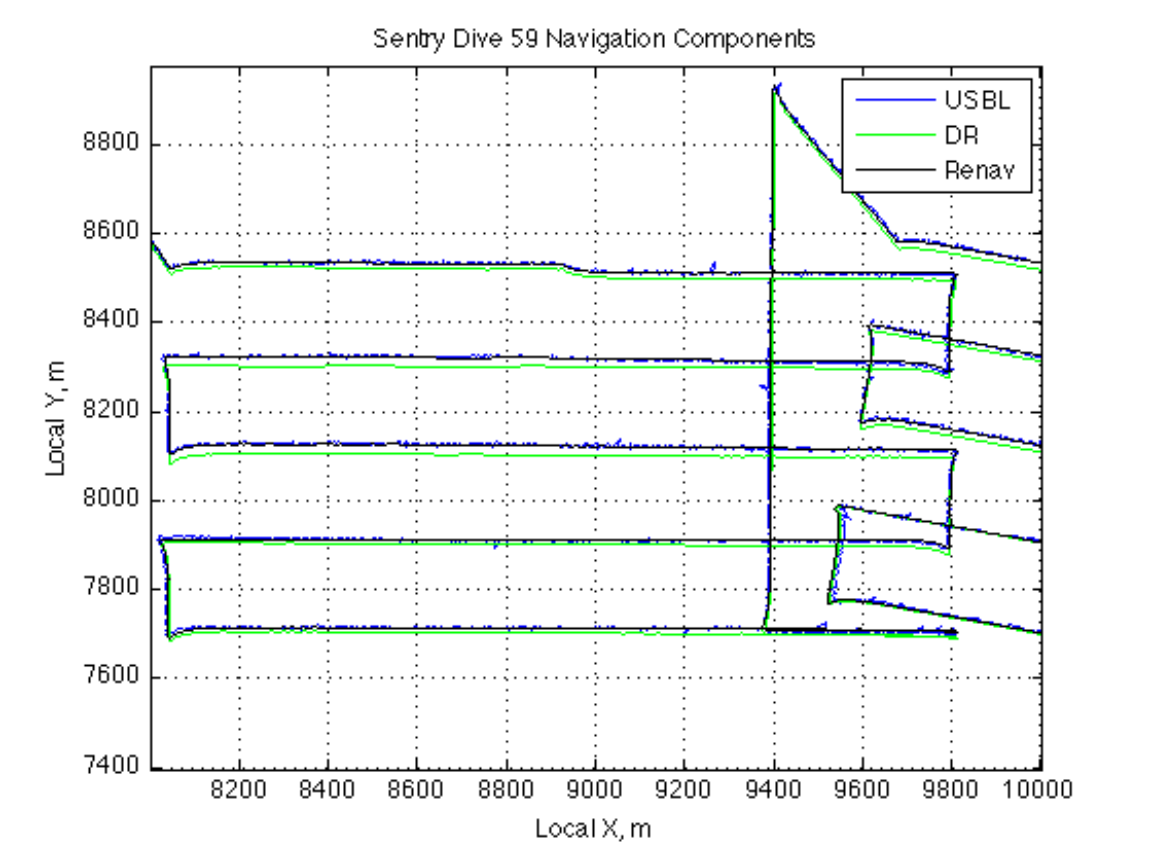
- In 2009 and 2010:
  - New homegrown LBL system for *Alvin* and *Jason*.
  - Sonardyne Ranger USBL for all three vehicles.
- Similar performance for depth <~ 4km.
- Cruise logistics weigh heavily in choice.
  - LBL: 3 hrs/xponder; USBL 5 hrs/cruise.

USBL Transceiver Mounting

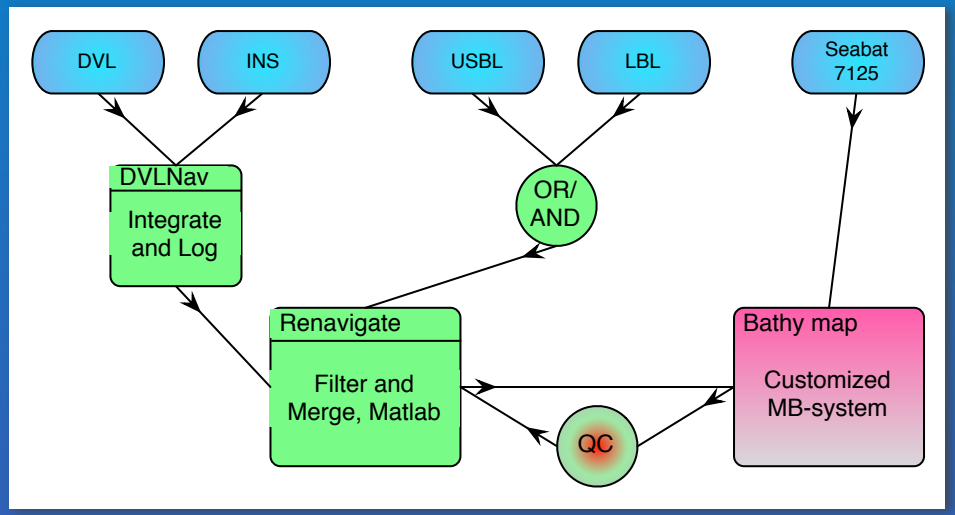
Renavigation Methods

- DVL augmented with LBL or/and USBL
- Two methods of renavigation.
  - Complementary filter
    - Low pass filtering of USBL/LBL (0.1-0.25 Hz).
    - High pass filtering of DVL (1-5 Hz).
  - Affine xform of DVL based on LSQ fit of DVL and USBL/LBL.

A Renavigated Track Product

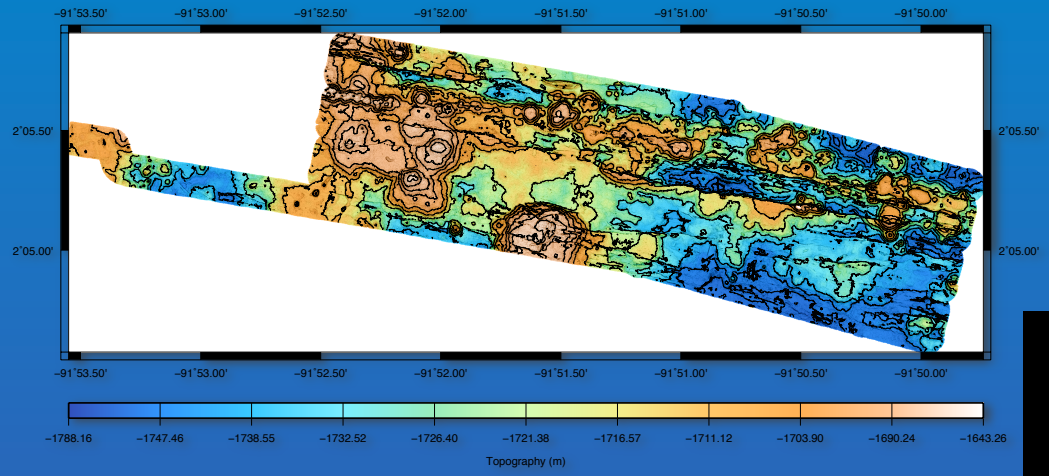


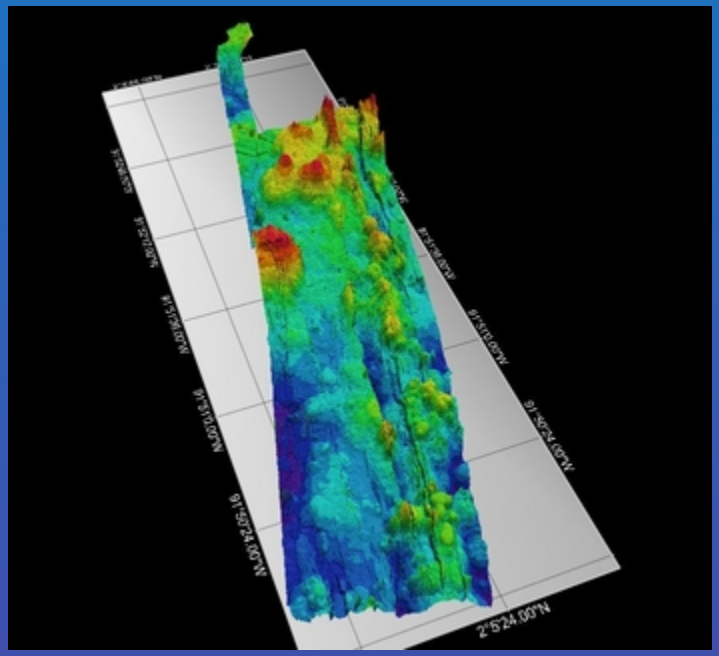
Basic bathymetry post-processing flow diagram



No hand editing of pings!

Sentry Dive #55





Galapagos Spreading Center
April 2010
80m altitude, 200m spacing.

Jason Dive #515

Juan de Fuca Plate
30m altitude, 50m spacing