

CRUISE: AUV study of the Mouth of Columbia River (MCR)

WHEN: Leaving APL on 05/29/13 in UW van, main 5 day operations on river during 05/30 to 06/03 (inclusive), returning to APL on 06/04.

GOALS: 1) send the AUV through the mouth of the CR on several ebbs (possibly flood if conditions suitable), measuring currents, T/S/O₂ and turbidity (optical and acoustical), and other properties from ecopucks as available to study currents and mixing (shear, boundary layers), identify oceanographic features (liftoff point, internal waves, eddies/rolls/boils), and suspended sediment distributions.
2) compare AUV data to aerial survey data and numerical models

HOW: 1) use transponders to aid navigations where possible. Three transponders are attached to Guy Gelfenbaum's tripods (see positions below). One transponder is reserved as homing beacon out at plume.
2) deploy AUV in estuary with R/V Inferno equipped with ranger
3) recover out at plume with R/V Forerunner equipped with second ranger
4) FR preferentially crosses bar at local high water and return just after low water. All weather and condition dependent!
5) start conservative by flying the AUV at constant depth or preferably height above bottom. Proceed to triangle mode. Proceed to sending AUV back into the estuary.

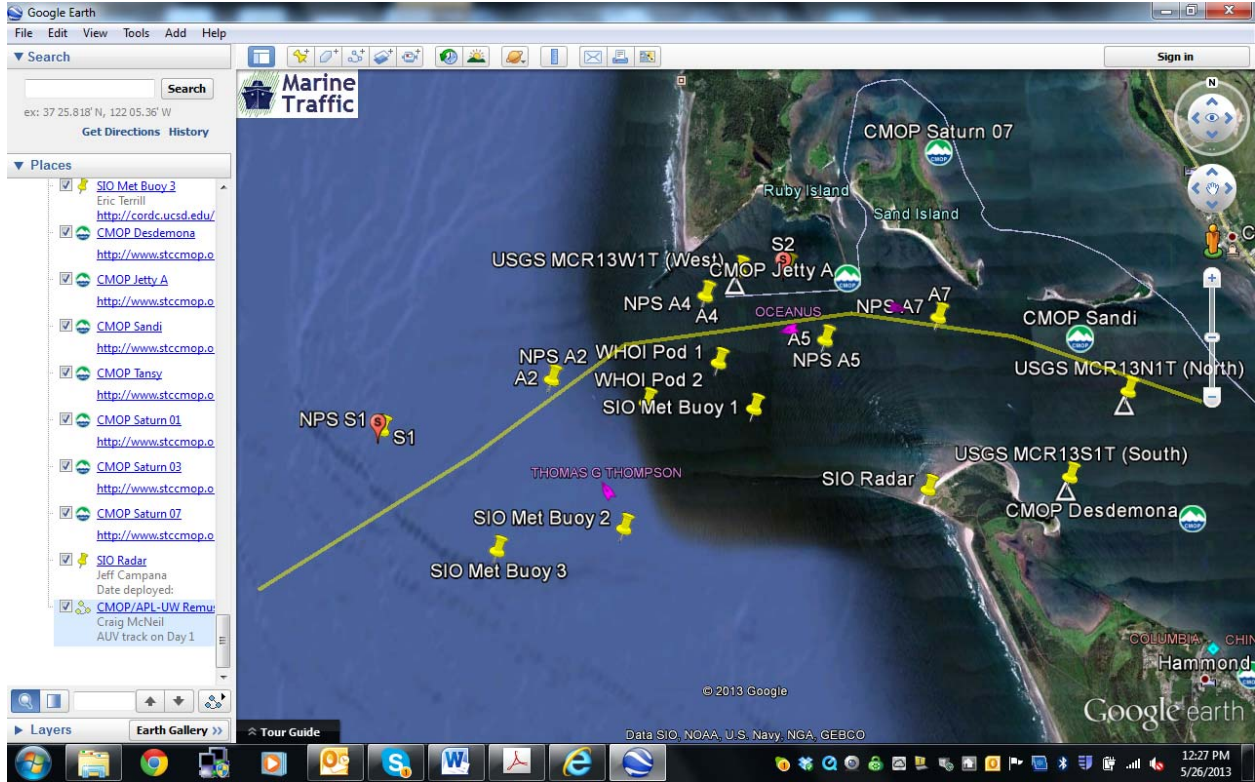
TO DO:

- 1) Determine optimal config (trackline ON/OFF, slop in making a waypoint, # waypoints etc)
- 2) Boat hooks and grappling hooks for recovery (boat or shore)
- 3) Bring both cradles and boxes (?)
- 4) Compass calibration on Day 1: splash well upstream of first waypoint to ensure AUV doesn't have to swim back upstream after doing its surface cal.
- 5) When 3 days out, design best mission based on weather and current forecast and pass to Capt'n Bert for review. Locating the best recovery point is part of that task.

Bert says: "I will pull up the weather reports for all of these dates the day before each trip, keeping watch on the off shore wave buoy report to see if the swell is building or declining. Forerunner can stand by mid channel and on the green side by buoy number 1 so we can stay out of the ship traffic area. If we recover on the red 2 side the package would have to cross the shipping channel which may interfere with any ship traffic."

WEBSITES:

- 1) <http://jamiemacmahan.com/blog/RIVET-II/>
- 2) http://www.stccmop.org/calendar/2013/autonomous_underwater_vehicle_study_mouth_columbia_river_mcr/
- 3) <http://www.marinetraffic.com/ais/default.aspx?&zoom=12¢erx=-124¢ery=46.25#>
- 4) Pilots: <http://crbp.web.kleinsystems.ca/webx/>



Sensors listing:

<http://herschel.apl.washington.edu/darla/SENSORS/>

HOTEL: (same as during September 2012 RedBloom study; R/V Inferno docked at EastBay Marina)

Reservation dates: Check In: Wednesday, May 29, 2013 Check Out: Tuesday, Jun 4, 2013

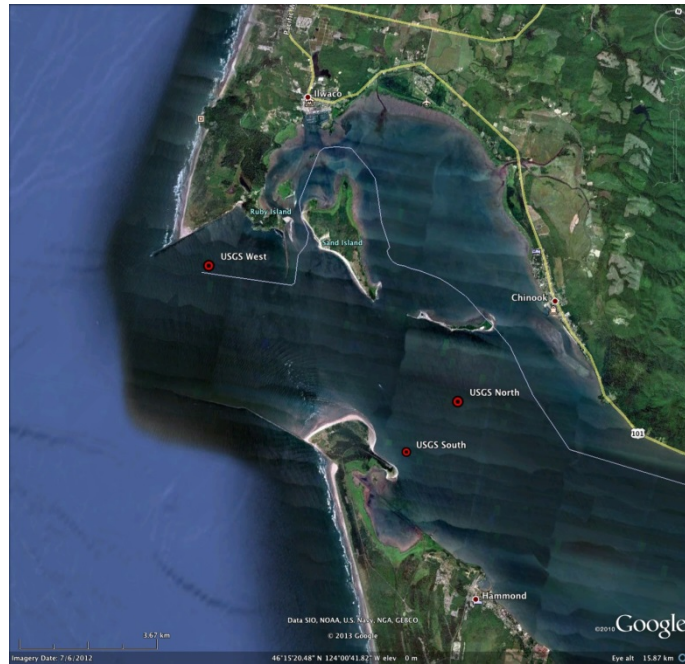
Comfort Suites Columbia River(OR092)
3420 Leif Erickson Dr, Astoria, OR, US, 97103
Phone: (503) 325-2000

**BOATS:**

- R/V Infero: Jim Thomson has the R/V Inferno booked and will trailer down to the East Basin marina. We expect to share the use of the boat for in-estuary AUV deployment (and possibly recovery if we are brave and lucky enough after working out the wrinkles, TBD). I have arranged for two people (in addition to boat driver) to be on the R/V Inferno at all times to assist with deployment of the AUVs.
- R/V Forerunner: reserved for 05/30 to 06/03 (inclusive). There will be two people (in addition to boat driver and any crew) to assist with recovery of the AUV. Swimdeck is requested. Also a capstain to assist with deploying and recovering the 40 lb lead ball anchor mooring for the homing beacon to be deployed out at the recovery site. Its possible that this homing beacon should be deployed and recovered each day. It is easy to deploy and recover with a large orange surface buoy making it visible as the recovery site of the AUV. The AUV will swim underneath it, circling at ~10m depth awaiting the 'surface' command sent by the R/V Forerunner which should be stood off the marker buoy until the AUV surfaces for immediate recovery.
- Bert will meet us around 7pm on Wednesday evening to lock the boat after we have loaded. This gives us an early 0530am start to cross the Bar on Thursday (Day 1). Bert cell is 1-503-739-1071.
- Comm issues, Ch 68 working ok but sometimes handhelds weak indoor. If scientist don't respond, try hailing vessel bridge Ch 14.

TRANSPONDER DETAILS:

Tripod (GMT)	AUV Pinger	Lat	Long	Time deployed
MCR13S1T	4A	46.23073	-123.98542	19:51:43
MCR13W1T	4B	46.26505	-124.06505	18:27:50
MCR13N1T	4C	46.24498	-123.97139	16:36:17



PERSONNEL: (highlighted people are involved in AUV work on either R/V Forerunner or R/V Inferno)

There may be additional one or two people who may want to ride out on the R/V Forerunner or R/V Inferno (ONR program managers), including **Reggie Beach**.

30-May (Thursday)	31-May (Friday)	1-Jun (Saturday)	2-Jun (Sunday)	3-Jun (Monday)	Date (Day)
Inferno					Joe Talbert
Inferno	Inferno	Inferno	Inferno	Inferno	Craig McNeil
Inferno	Inferno	Inferno	Inferno	Inferno	Andy Reay-Ellers
Forerunner	Forerunner	Forerunner	Forerunner	Forerunner	Andrey Shcherbina
Forerunner	Forerunner	Forerunner	Forerunner	Forerunner	Trina Litchendorf
	Inferno				Chris Chickadel
		Inferno	Inferno	Inferno	Guillermo Diaz
	Forerunner?				Jeff Shilling

SIMULATIONS:

Below are simulations (not for the day of deployment since these simulation use model forecasts which are only available 3 days out). But the simulations provide an idea of travel time for the AUV and route.

General logistics Day 1 & 2

Craig/Andy: Breakfast, take Trina/Andrey to R/V Forerunner. Pickup Guillermo when required on weekend. Drive van back to hotel and pickup prepared vehicle, take AUV to R/V Inferno and load, head out to North Channel and deploy vehicle. Wait until the vehicle is well underway (deploy SWIFTS as necessary), back to West Bay Marina. Drive van to Hammond to meet R/V Forerunner, offload vehicle and take all 4 persons back to hotel, download data and backup. Dinner. Charge AUV overnight.

Trina/Andrey: Recover vehicle on R/V Forerunner, cross Bar, wait for AUV, recover, cross Bar and dock Hammond. Met at dock by Craig/Andrey to offload vehicle, back to hotel. Dinner.

Plan of the Day

DAY 0: (Wednesday 05/29/13) finished loading by 7pm at Hammond dock.

0900h: Craig pickup UW rental van

1000h: Trina/Andrey meet at Craig's office (Benhall), help load van

1145h: Capt'n Andy, meet at van

1200h: leave APL in UW rental van

1600h: check in to hotel

1700h: arrive at Hammond dock, load gear onto RV Forerunner, setup, install Iridium antenna

1900h: Capt'n Bert drop by boat to lockup

Plan of the Day

DAY 1: (Thursday 05/30/13): AUV constant altitude mode, drop SWIFTS

0500h: leave dock at Hammond (on R/V Forerunner)

0528h: sunrise

0551h: high tide (+8.1 feet),

0551h: cross Bar (on R/V Forerunner)

0645h: on 30/50m bathy at plume region (on R/V Forerunner)

0645h: leave dock at East Bay Marina (on R/V Inferno)

0700h: deploy homing transponder (on R/V Forerunner)

0800h: deploy AUV inside estuary (on R/V Inferno), on 2h17min mission (with compass cal)

0900h: deploy **SWIFT** at Buoy #21 (on R/V Inferno)

0930h: deploy **SWIFT** at Buoy #21 (on R/V Inferno)

1000h: deploy **SWIFT** at Buoy #21 (on R/V Inferno)

1017h: recover AUV at plume region (on R/V Forerunner)

1030h: recover homing transponder (on R/V Forerunner)

1100h: done operations, waiting to cross Bar (on R/V Forerunner)

1100h: deploy **SWIFT** at Buoy #21 (on R/V Inferno)

1130h: dock at East Bay Marina (on R/V Inferno)

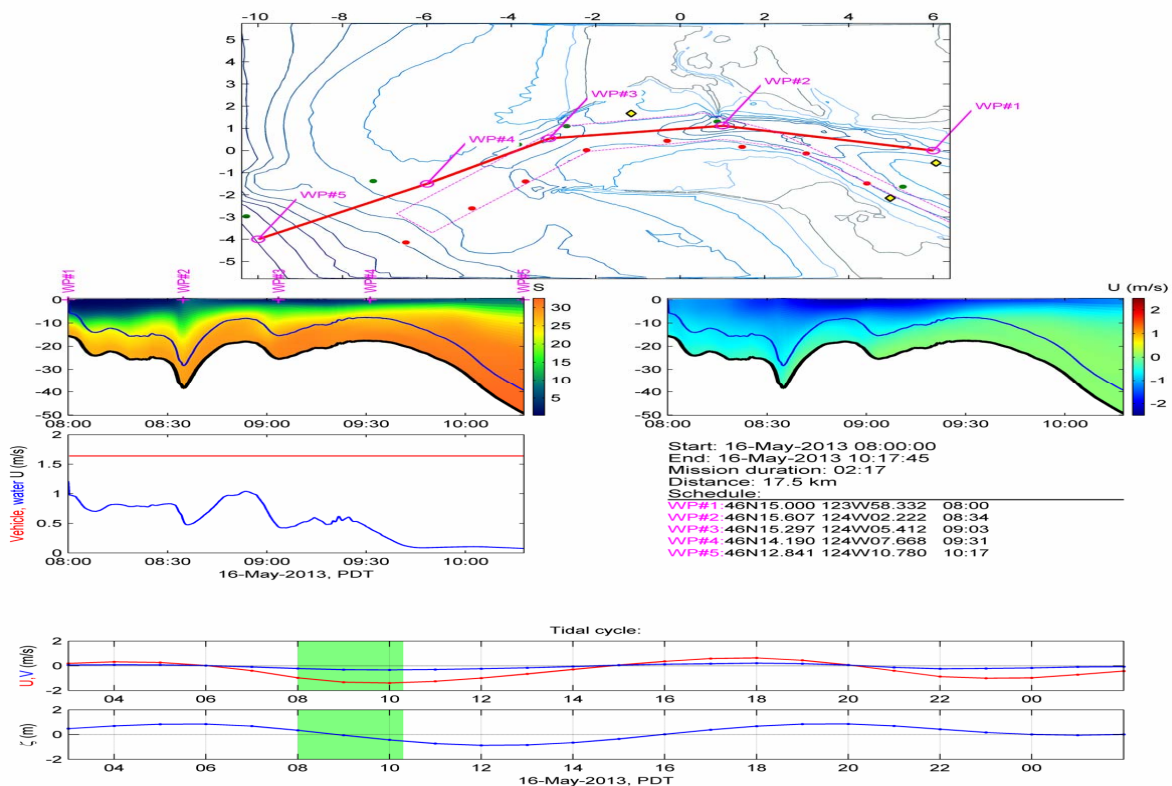
1243h: low tide (-0.3 feet)

1330h: cross Bar (on R/V Forerunner)

1545h: dock at Hammond (on R/V Forerunner)

1919h: high tide (+8 feet)

20:58h: sunset



Plan of the Day

DAY 2: (Friday 05/31/13): AUV triangle mode

0527h: sunrise

0530h: leave dock at Hammond (on R/V Forerunner)

0659h: high tide (+7.4 feet)

0700h: cross Bar (on R/V Forerunner)

0745h: leave dock at East Bay Marina (on R/V Inferno)

0800h: on 30/50m bathy at plume region (on R/V Forerunner)

0815h: deploy homing transponder (on R/V Forerunner)

0900h: deploy AUV inside estuary (on R/V Inferno)

1108h: recover AUV at plume region (on R/V Forerunner)

1130h: recover homing transponder (on R/V Forerunner)

1200h: done operations, waiting to cross Bar (on R/V Forerunner)

1230h: dock at East Bay Marina (on R/V Inferno)

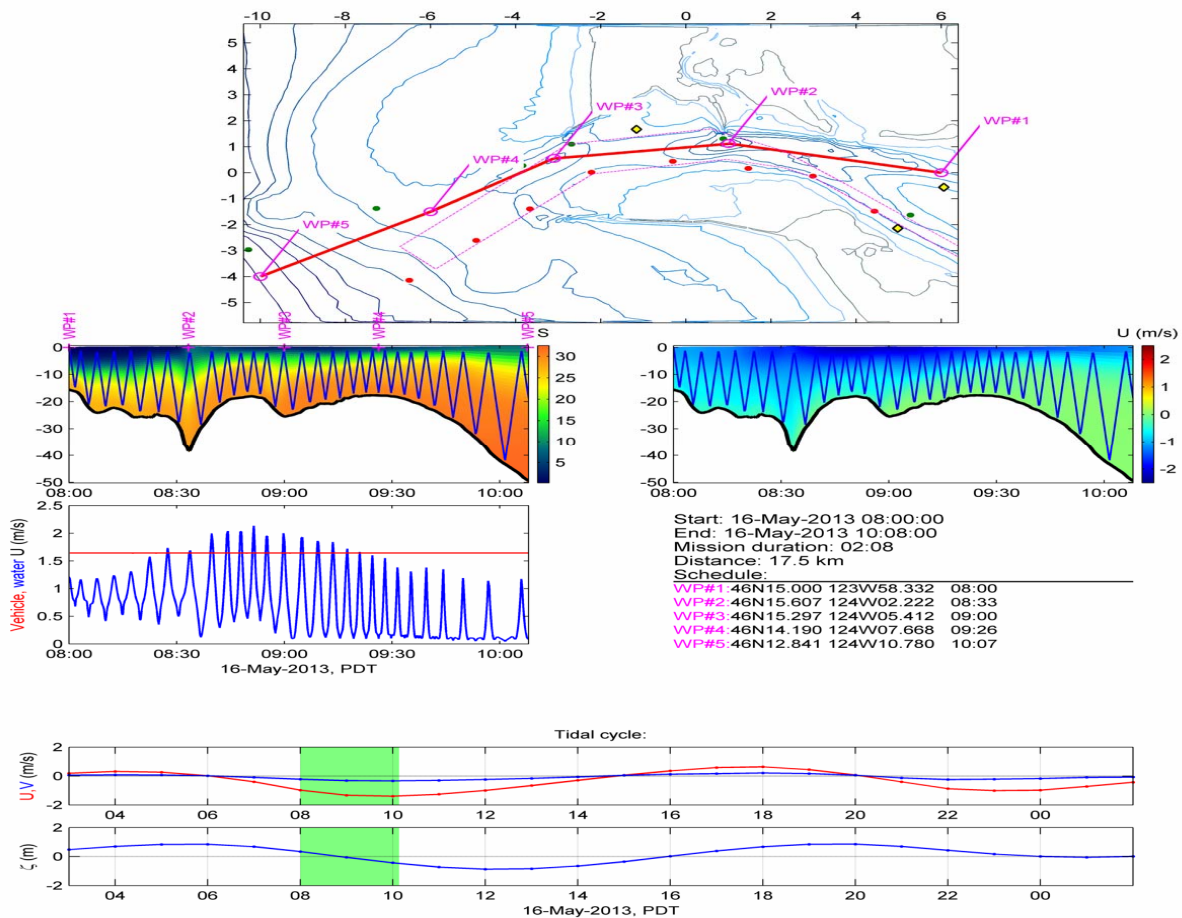
1337h: low tide (+0.4 feet)

1400h: cross Bar (on R/V Forerunner)

1500h: dock at Hammond (on R/V Forerunner)

2013h: high tide (+8.2 feet)

2059h: sunset



DAY 3: (Saturday 06/01/13): AUV triangle mode, send back into estuary after recovery at plume

0527h: sunrise

0630h: leave dock at Hammond (on R/V Forerunner)

0813h: high tide (+6.9 feet)

0815h: cross Bar (on R/V Forerunner)

0815h: leave dock at East Bay Marine (on R/V Inferno)

0915h: on 30/50m bathy at plume region (on R/V Forerunner)

0930h: deploy homing transponder (on R/V Forerunner)

1000h: deploy AUV inside estuary (on R/V Inferno) on Day 2 mission seaward

1208h: recover AUV at plume region (on R/V Forerunner)

1230h: recover homing transponder (on R/V Forerunner)

1300h: redeploy AUV at plume going shoreward (on R/V Forerunner)

1434h: low tide (+0.9 feet)

1445h: cross Bar (on R/V Forerunner)

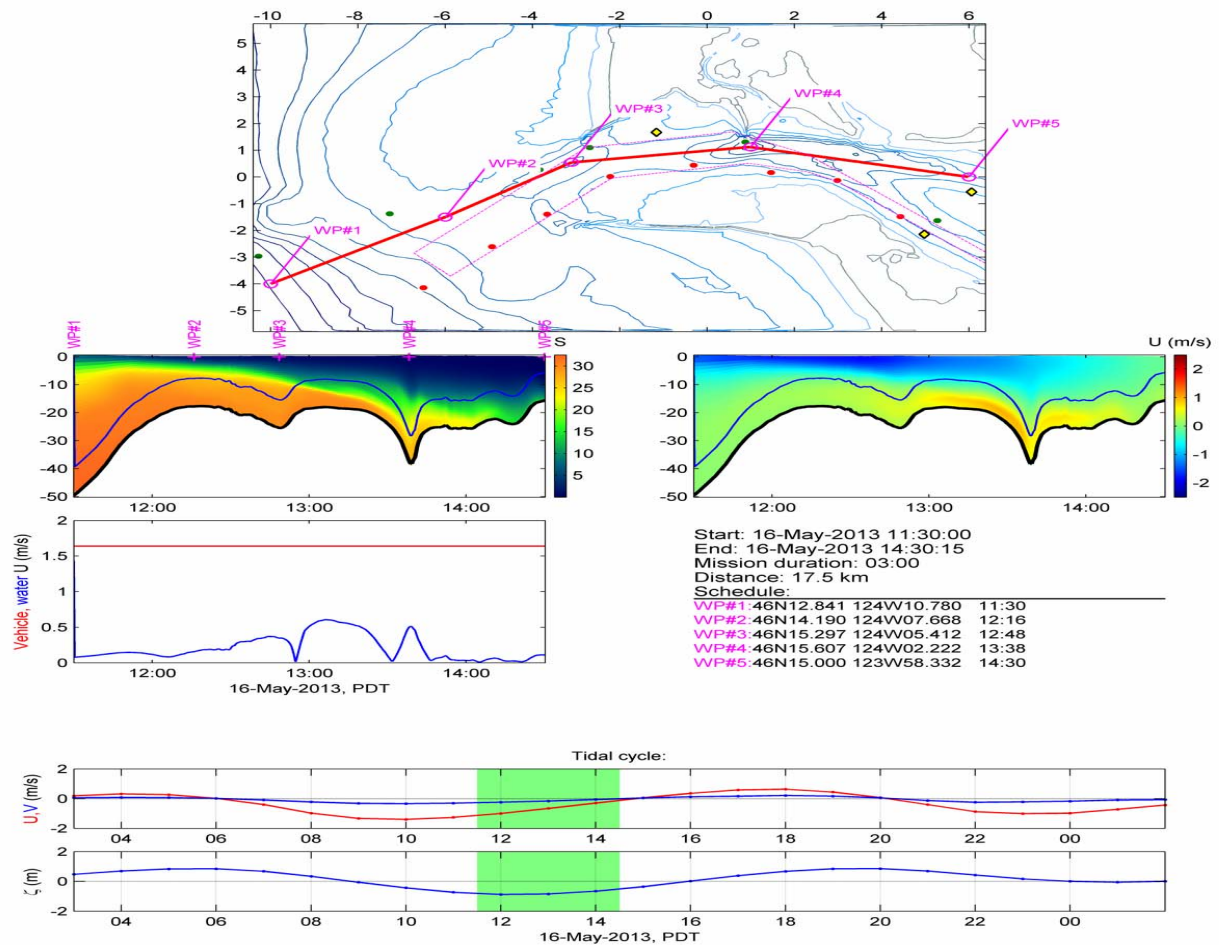
1600h: recover AUV in estuary (R/V Inferno, or possibly R/V Forerunner)

1700h: dock at Hammond (R/V Forerunner)

1715h: dock at East Bay Marina (R/V Inferno)

2107h: high tide (+8.4 feet)

2100h: sunset



DAY 4: (Sunday 06/02/13): Detailed plan TBD!!!

0526h: sunrise

0830h: leave dock at Hammond (on R/V Forerunner)

0928h: high tide (+6.6 feet)

0930h: cross Bar (on R/V Forerunner)

0945h: leave dock at East Bay Marina (R/V Inferno)

1030h: on 30/50m bathy at plume region (on R/V Forerunner)

1045h: deploy homing transponder (on R/V Forerunner)

1100h: deploy AUV inside estuary (on R/V Inferno)

1300h: recover AUV at plume region (on R/V Forerunner)

1330h: recover homing transponder (on R/V Forerunner)

1400h: done operations, waiting to cross Bar (on R/V Forerunner)

1430h: dock at East Bay Marina (R/V Inferno)

1531h: low tide (+1.4 feet)

1630h: cross Bar (on R/V Forerunner)

1730h: dock at Hammond (on R/V Forerunner)

2158h: high tide (+8.6 feet)

2100h: sunset

DAY 5: (Monday 06/03/13): Detailed plan TBD!!!

0526h: sunrise (load)

0930h: leave dock at Hammond (on R/V Forerunner)

1038h: high tide (+6.6 feet)

1040h: cross Bar (on R/V Forerunner)

1045h: leave dock at East Bay Marina (R/V Inferno)

1130h: on 30/50m bathy at plume region (on R/V Forerunner)

1145h: deploy homing transponder (on R/V Forerunner)

1200h: deploy AUV inside estuary (on R/V Inferno)

1400h: recover AUV at plume region (on R/V Forerunner)

1430h: recover homing transponder (on R/V Forerunner)

1500h: done operations, waiting to cross Bar (on R/V Forerunner)

1530h: dock at East Bay Marina (R/V Inferno)

1625h: low tide (+1.8 feet)

1630h: cross Bar (on R/V Forerunner)

1730h: dock at Hammond (on R/V Forerunner)

2245h: high tide (+8.7 feet)

2101h: sunset

DAY 6: (Tuesday 06/04/13): Return to Seattle

1000h: leave hotel in UW rental van, drive back to APL

1400h: arrive APL, offload van at BenHall

1530h: return UW rental van

SATURN LOCATIONS:

"SATURN-01";46.234981;-123.871947

"SATURN-02";46.173; -124.127

"SATURN-03";46.199747;-123.940728

"SATURN-04A";46.190624;-123.746136

"SATURN-05";46.1845;-123.18743

"SATURN-06";45.517511;-122.669272

"SATURN-07";46.286667;-124.016167

MARKER BUOYS:

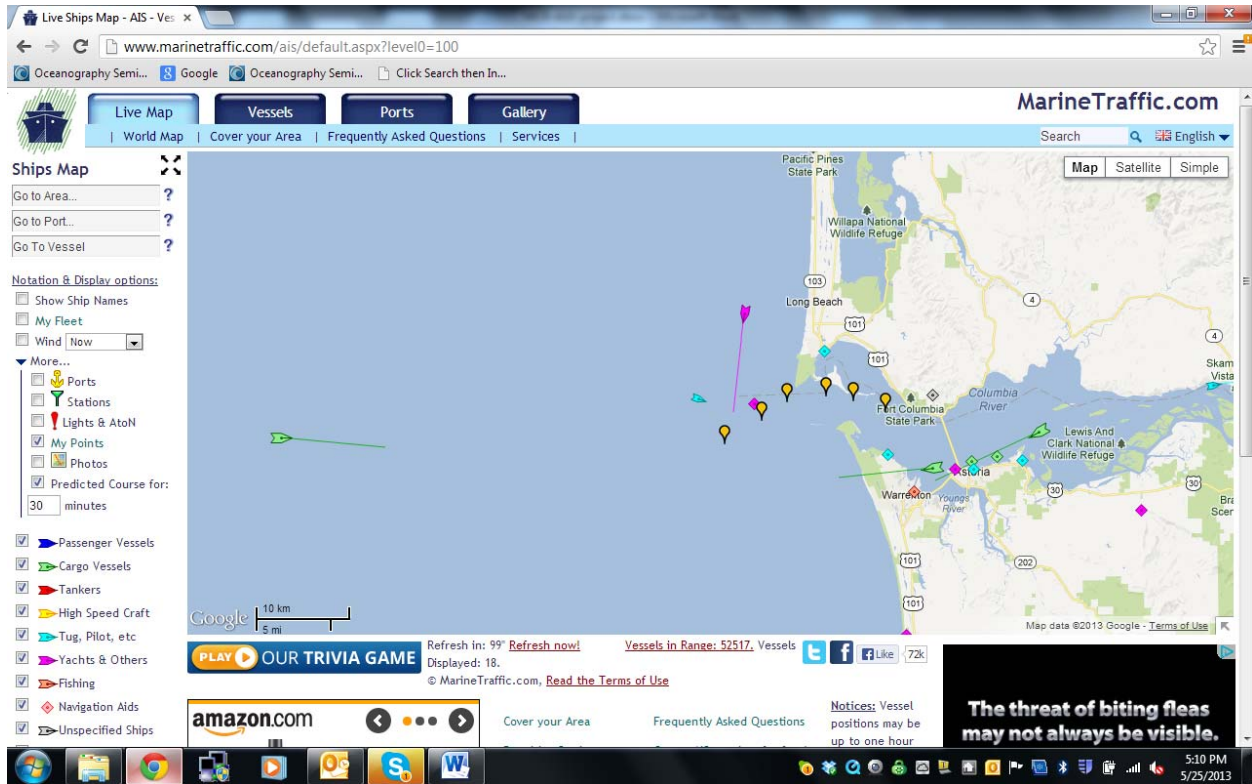
APL Hand Held VHF Radios:

MMSI: 338155372 ('Inferno') and 338155374 ('Forerunner')

Use Ch68, but if scientist doesn't respond try hailing vessel bridge on Ch 14.

SHIP TRAFFIC

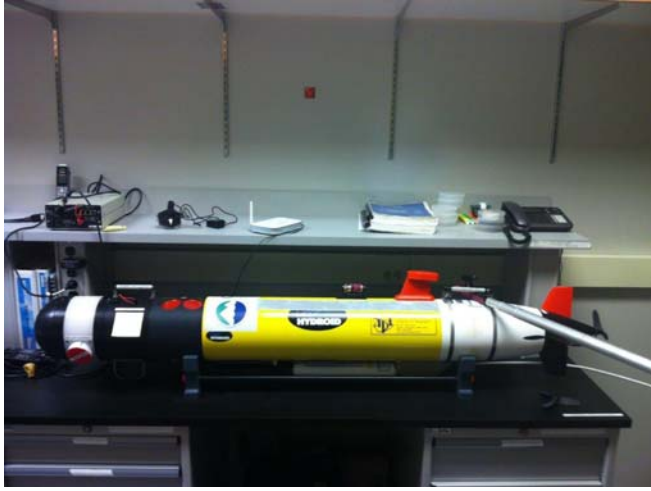
We will track ship traffic relative to AUV path here and use to decide when (and when not) to deploy.



CONTINGENCY PLANS

1. Use RF radios to get information out quickly to APL/UW group about lost AUV (see above for MMSI info)
2. If appropriate, we can relay info to R/V Melville and R/V Point Sur
3. If we can get to the beach region by car we can try recover from shore with line and grappling hook. If it is brought ashore, and hull is breached or flooded its likely toasted and dangerous due to internal batteries.
4. People safety is the focus, so *we don't go chasing the vehicle by R/V Inferno in the MCR*; if the vehicle is lost in the MCR region it will wash up ashore, that's all we can do. Remember that an overturned RHIB floats, an overturned R/V Inferno sinks. See Manual Safety Sheet on flooded vehicle below.

AUV RECOVERY – GENERAL INFORMATION



AUV showing forward and aft **handles** that can be used for handling/lifting the vehicle by hand and catching the vehicle with a pole for recovery. Anything orange is delicate and cannot be grabbed by hand. The AUV will be deployed and recovered from a swimstep or side of small boat.



Propeller is dangerous, but highly unlikely to be turning (ON) during any recovery operation. The AUV surfaces when the propeller is OFF (this is a safety feature). A special magnet is required to completely shut down the vehicle (see photo below). All control fins (orange and black) are 'no touch' and easily damaged. A recovered vehicle always sits on the deck in a **cradle** since the AUV hull is thin and lots of delicate sensors on it (a CTD is hung below the vehicle from welded tabs on the hull).



Magnet (with floating keychain) is installed beside the orange Iridium/GPS antenna to shut the vehicle OFF.

In recovery mode, the vehicle relays **GPS** fixes to the **Iridium** system on the R/V Forerunner which are plotted on the vehicle's software. A **strobe** is mounted on the top of the vehicle to aid recovery when lost. The top of the vehicle has **SOLAS tape** to reflect searchlight beam (or laser).

The following is taken from the AUV Manual FYI in event of flooded vehicle.

3.10.2 Flooded Vehicle

If water gets into the vehicle's pressure housing, the leak sensor(s) will detect the leak. When a water leak is detected, the mission immediately stops and the vehicle floats to the surface if it can.

The rudder fin shifts to the "LEAK" position, providing the user a visual indication that a leak has occurred. Vehicles equipped with Acomms transmit leak status to the Ranger or Gateway buoy if a leak occurs.

CAUTION: *If you suspect a leak, immediately power down the vehicle with the magnet.*

WARNING: *Any time that water might be inside the vehicle's housing, handle it with extreme care and keep the vehicle as level as possible to minimize risks from the battery system's high energy capacity.*

See section 11.7, on page 11•21 for the emergency procedure for opening the housing if a leak is suspected.

One of 3 conditions will exist if the vehicle leaks:

Condition 1) A leak was detected, the vehicle ended the mission and it has floated to the surface.

Condition 2) A leak was detected, the vehicle ended the mission, but is unable to float back to the surface, yet it remains responsive to Ranger interrogations.

Condition 3) A leak was detected, the vehicle ended the mission, is unable to float back to the surface, *and* the vehicle does not respond to Ranger interrogations. Condition 3 indicates that the failure is complete.

Guidelines for recovering the vehicle under each of the three conditions are as follows:

3.10.2.1 Condition 1: The vehicle is on the surface and has stopped for no apparent reason.

1. When alongside the vehicle, **do not** immediately lift the vehicle out of the water. Keep the vehicle's orientation as close to level as possible to minimize sloshing any water that may be in the vehicle. Check the rudder fin position for water leak indication. Before lifting the vehicle to the boat, install the magnet to power down the vehicle.

NOTE: *Vehicles with Acoustic Modems (AComms) transmit the leak fault condition in addition to the rudder fin indicating the leak.*

2. Observe the vertical fin position and follow one of the following three steps.

a. If the fin is turned hard to starboard indicating a fault condition (low battery, no progress), then install the vehicle ON/OFF magnet and recover the vehicle normally.

b. If the fin is turned hard to port, assume that a flooded vehicle fault was detected. Install the vehicle ON/OFF magnet. Recover the vehicle keeping its orientation in both pitch and roll as level as possible. Place the vehicle in the transit case, but **do not rotate the vehicle** 30° off-center as is normally done during transit. Keep the transit case as level as practical during the return transit. Return the vehicle to a location where maintenance can be performed.

NOTE: *It is possible for the vehicle to surface with its rudder seeming to indicate a leak, if the rudder motor fails or the vehicle times out during a starboard turn.*

(fin pointing to port)

c. If the fin is turned hard to port then the vehicle may not have a flood fault, but may be trying to complete a right hand turn of the mission program. Install the vehicle ON/OFF magnet and recover the vehicle normally.

3. Transit to base, with vehicle inside the closed transit container. Do not roll the vehicle in its case to its normal 30 degrees in this situation. Keep the vehicle level in the pitch and roll axes during transit.

4. Unload the vehicle, keeping it as close to horizontal in pitch and roll as possible.

5. Keeping the magnet in place to disable power, open the tail section and inspect for water.

6. Unplug and remove the battery tray. Dry and clean the system using a glass cleaner to minimize corrosion, and then return the system and battery to Hydroid for failure analysis and damage assessment.

3.10.2.2 Condition 2: The vehicle is submerged and stopped for no apparent reason.

Locate the vehicle using the Ranger.

NOTE: *If the Vehicle's transponder is operational, you will be able to locate it. Also, this indicates that there is a small amount of water inside the housing.*

NOTE: *Vehicles with Acoustic Modems (AComms) transmit the leak fault condition as long as the modem is operational.*

Section 3.10.3 below describes a method for driving the vehicle to the surface using the STOP command. Follow the same procedure for recovery and cleaning as described in section 3.10.2.1 above.

Flooded/Submerged Vehicle

A flooded vehicle that is submerged represents the most serious failure of the vehicle, as there are no user-level procedures that can be performed to make the vehicle operational.

The vehicle may be lost if the housing becomes totally flooded and the vehicle transponder stops functioning, as you cannot locate the vehicle using the Ranger without vehicle transponder signals. The high energy density of the REMUS batteries poses potential hazards in the event the vehicle becomes totally flooded.

If the Ranger is still receiving range information from the vehicle, it may be possible to drive the vehicle to the surface using the "Stop" command. When close by the vehicle location, using the Ranger, operators should give the vehicle several successive "Stop" commands in an attempt to drive the vehicle temporarily to the surface.

Boat operators should be prepared to quickly come alongside the vehicle for recovery before the vehicle re-submerges. Operators must remain clear of the spinning propeller to prevent personal injury.

If the above method fails to surface the vehicle, the only way to recover a flooded vehicle is with divers. The shape of the REMUS vehicle does not lend itself to recovery with a grappling hook, and the vehicle case does not have sufficient magnetic qualities for using a large magnet. Divers should place the ON/OFF magnet in its holder, and then use ropes, slings, or other appropriate devices (inflatable lift bags) as needed to raise the vehicle. Once the vehicle is at the surface, operators should lift the vehicle out of the water, keeping the vehicle as level as possible. Place the vehicle in the transit case, but do not rotate the vehicle as with normal recovery procedures. Return the vehicle to a location where maintenance can be performed.

If no range signals are observed on the Ranger, the operator can assume that the vehicle is completely flooded. Divers should follow standard operating procedures for performing an underwater search when attempting to locate the vehicle. The internal characteristics of the REMUS vehicle when completely flooded are unknown. The high-density batteries include several safety circuits. However, in a totally flooded condition the remote potential exists for the water to cause short circuits and rapid battery discharging. This rapid discharging may produce heat and/or gas and result in an increase of pressure within the vehicle.

WARNING: Handle the vehicle with extreme care anytime that there is the possibility that there may be water inside the vehicle's housing. Failure to follow this warning may result in personal injury.

In the event of a totally flooded vehicle, operators must use their best judgment on whether a vehicle should be recovered. If the mid-body section of the vehicle is warm or hot to the touch, or if gas bubbles are observed escaping from the vehicle, it is recommended that the vehicle not be removed from the water until such time as the batteries have dissipated their energy and the vehicle is stable.

Further recovery should be attempted based on operator judgment, taking into consideration the nature of the mission and the criticality of any data stored within the vehicle. Operators should take whatever steps are necessary to secure or dispose of the vehicle (i.e. towing the vehicle to deep water away from the area of operation and releasing it, etc).

3.10.2.3 Condition 3: The vehicle is submerged and stopped; does not respond to Ranger interrogation.

This indicates a likely serious water leak. The vehicle should be treated as a potentially hazardous item and handled accordingly. Most likely in this situation the operator will have difficulty locating the vehicle. A search and recovery plan with safe handling procedures must be developed based on the circumstances.