Field Measurement Plan Draft
Katie Kohlman
CEWA 590 Spring 2024

Colvos Passage Waterflow [31 May 2024]

Overview

Since 2022, undergraduates at the University of Washington have been refurbishing Seagliders donated by the Applied Physics Laboratory as part of the Student Seaglider Center (SSC). As of now, the SSC has three fully operational Seagliders (SG175, SG194, SG195). The goal of this project is to deploy these three Seagliders simultaneously just west of the northernmost part of Vashon Island, WA, in the area known as Colvos Passage, to track the water flow as it moves into the main basin through three different routes. The results of this study will provide valuable insights into the flow of pollutants and overall estuarine circulation in the region.

Location

Figure 1. Map of portion of Puget sound that displays Colvos Passage with possible flows of water into the main basin.

Figure 2. Tide and surface current predictions for 13 May 2024. Can be used as a reference for the average maximum water speeds that the gliders will experience on 31 May 2024. Left figure is displaying surface currents during ebb tide. Right figure is displaying surface currents during flood tide. Source: LiveOcean

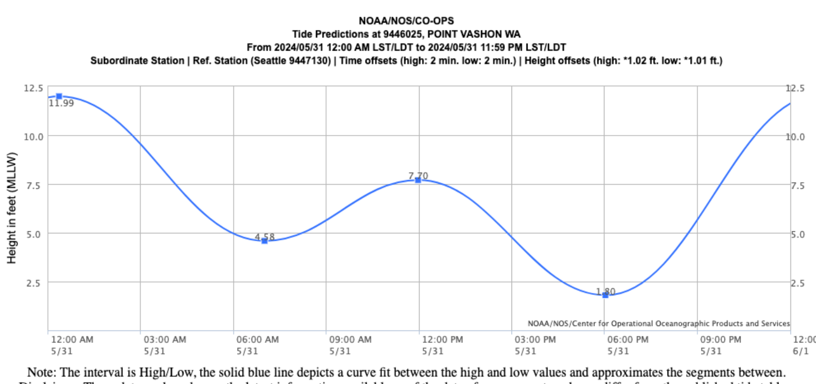

Figure 3. Tide predictions at Point Vashon, WA for 31 May 2024.

Colvos Passage is a waterway located directly west of Vashon Island, WA (Figure 1), and east of the Kitsap Peninsula in Washington state. Unlike the rest of the Puget Sound, where surface currents generally change direction with the tides, the currents in Colvos Passage predominantly flow northward, regardless of the tidal cycle. Within Colvos Passage, the surface current speeds range from 0 to 1 meter per second, with peaks occurring during the ebb tide. LiveOcean predictions suggest that the fastest currents (which occur during ebb tide) for 13 May 2024 will be approximately 0.5 m/s. Although this is not the exact day of the deployment, this value can be used to reference as the maximum speed bound for the gliders. Figure 3 displays the predicted tides on 31 May 2024. The goal of this study is to study how the water flows out of Covlos Passage and into the main basin, so we want to target the lower tides (when water is flushing out) which occur between 6:00 am and 6:00 pm.

The full passageway has an approximate length of 20 km and an average width of 1.5-2 km, with a seabed primarily composed of soft sludge. As water exits Colvos Passage and enters the main basin, there are three possible routes it can take, as indicated by red arrows in Figure 1.

Figure 4. (to be replaced with NOAA bathy maps in the final draft, currently just a screenshot of DeepZoom) Bathymetric maps near the mission site.

While the majority of Colvos Passage has an average depth on the order of 90-100 meters (in the center), there are shallow points of concern that need to be taken into consideration for the gliders when exiting the passage and traveling east (Figure 4). A Seaglider can operate best and collect more meaningful data in dives greater than 30 m. Just east of Blake Island, the water depths get as shallow as 16 m. There is one route that allows the gliders to dive to a maximum of 23 m directly east of the island. In order for the best possible data collection, this is the path that the eastward traveling gliders will take.

Boat Traffic
At the northernmost part of Vashon Island, there are active ferry routes to be cautious about. Ferries to particularly monitor are the Fauntleroy/Vashon and Southwaorth/Vashon tracks. The schedules can be seen ahead of time at https://wsdot.com/Ferries/Schedule/Default.aspx. During the day of the mission, monitor AIS tracking systems (such as: https://www.marinevesseltraffic.com/2013/06/vessel-cruise-finder.html) to be aware of ferries traveling near the field team and glider. ESPECIALLY during recoveries.

Water Tracking Method
With the goal to 'track' water as it exits Puget Sound and enters the main basin, we will use T-S diagrams and water tagging methods to track the water. Gliders are not lagrangian floats and do not have enough power to fight currents above 1 m/s and are often heavily influenced by currents greater than 0.5 m/s. With this in mind, the gliders will be deployed at the northernmost part of Colvos Passage during high-low tide. The gliders will first complete 1-2 profiles within the passage to sample the passageway water.

Figure 5. Mission of SG175 within Colvos Passage (black dots show dive locations and red crosses show targets). Temperature (a) and salinity (b) profiles from the mission are also plotted.

In a previous mission, we deployed SG175 within the passage to understand the passageway's water properties. SG175 sampled exclusively within the passageway and the temperature and salinity profiles (Figure 5) suggest that there is little to no stratification within the passage (i.e., it is very well mixed).

Because the water with Colvos Passage is well mixed, the T-S diagrams will provide information on the water's properties within the passage. As the gliders exit the passage and start to diverge from one another, the transects of temperature and salinity that the gliders will collect can be used to ‘track’ the water mass identified from the dives within the passage along the tracks of each glider.

Two of the three gliders will also be collecting oxygen data. The optodes have not been calibrated for over a decade and the values are expected to be incorrect. However, an offset from CTD casts can be used to correct the data. The oxygen data can then be used to verify the tracking techniques above by using oxygen as a secondary tracer.

The gliders also compute the depth average current. The pilots have the gliders set to dive with a vertical speed of 0.1 m/s. Knowing this, the locations of the start and end of dive, and the total time of the dive, we can back out the depth-averaged current. This will be a great addition to plot alongside the profiles to get an idea of not only where the water is traveling, but how fast too.

Instrumentation/Measurements

Seaglider

Figure 6. Photo of SG195 for reference (left). Schematic of dive of glider with communication to satellites (right).

This mission will utilize SG175, SG194, and SG195 (Figure 6). All three gliders collect conductivity and temperature data via CT sails. Only SG194 and SG195 have optode and wetlab sensors installed. See the table below for more information:

Glider:		**SG175**	**SG194**	**SG195**
Appx Length		1.2 m	1.2 m	1.2 m
Total Mass:		51735g	53536g	53778g
CT Sail	*last calibrated*	2013 (unknown)	1-Aug-20	14-Aug-19
	SN	(unknown)	236	325
Aanderaa Optode	*last calibrated*	N/A	2013 (unknown)	2013 (unknown)
	SN	N/A		

Wetlabs	*last calibrated*	N/A	28-Dec-12	3-Jan-13
	SN	N/A	BB2FM6 386	BB2FLBMT 174

The gliders are set to sample every 5 seconds for the first 20 meters and then every 10 seconds at any depth below 20 meters for all sensors (CT sail, optodes, and wetlabs) for both dives and climbs. After the glider completes the dive, it will sit at the surface for approximately two minutes to transmit data to the basestation via satellites (Figure 6).

Hand CTD

At the deployment and recovery sites of the gliders, the field team will cast over a hand CTD down to the full water depth (~100 m) for validation in analyzing data. The instrument that will be used to perform the CTD casts will be a YSI Exo sonde that collects conductivity, temperature, depth, and oxygen data. The YSI Exo sonde has a depth reading of up to 250 m. More information can be found at www.ysi.com/exo2.

Figure 7. Photo of hand CTD for reference.

Mission Targets

Figure 7. Map of target waypoints for each glider. SG194 will travel west of Blake Island following the blue track. SG175 will take the most direct path out of Colvos Passage out into the main basin following the green path. SG195 will profile within the main basin. The deployment location is at the respective starting target waypoints.

Figure 8. Bathymetric map (NOAA 2004) with target waypoints idnetified.

Target Locations (plotted in Figure 7)

SG194			SG175			SG195		
Name	Lat (º)	Lon (º)	Name	Lat (º)	Lon (º)	Name	Lat (º)	Lon (º)
start_194	47.4967	-122.49	**start_175**	47.4967	-122.49	**north_195**	47.55	-122.46
1_194	47.50975	-122.48458	**1_175**	47.50975	-122.48458	**south_195**	47.51	-122.45
2_194	47.53335	-122.50578	**2_175**	47.53335	-122.47477			
3_194	47.5530833	-122.51783	**end_175**	47.54879	-122.40946			
end_194	47.5638333	-122.47477						

All three gliders will be deployed during the flood between high-low and low-low tides, so water will push the glider northward from “start” to “1” and then through the ferry travel paths (Figure 7). The gliders should be just north of the “1” waypoint and start to split around noon when the flood will have ceased, and the tides will start to retreat. The gliders will go out with the tides and be going with the retreating water until they are recovered. By deploying the gliders at 8:00 and recovering at 16:00, we will have covered the high-low, low-high, and low-low of a tide allowing us the best chance to follow the northward flowing water (which is our objective).

SG194 and SG195 are fully equipped with the ability to measure oxygen and fluorescence alongside conductivity and temperature, so they will be traversing what are seemingly the more interesting routes. SG175 will be collecting more of a ‘control’ transect of conductivity and temperature out into the deeper basin. SG175 will also traverse a sill (Figure 8) which will likely sample highly mixed water columns while the glider will be difficult to control. For crossing the sill, we will set a target depth (i.e., D_TGT in the cmdfile) to 20 m. This way we are not relying on the accuracy of the on board bathymetric maps or the altimeter (which both may be faulty). Instead, by using a target depth shallower than what we expect, we will reduce chances of hitting the sill.

The total mission is expected to take 10 hours to complete (8:00 to 16:00). This will be approximately 10 complete dives averaging 50-60 minutes a dive given a depth of 100 m.

Field Logistics

Pre-mission

SSC students have ballasted the seagliders for approximate density changes at Shilshole Marina. Previous missions within Colvos Passage have shown that the gliders are properly ballasted for the Puget Sound vertical density changes (including Colvos Passage, the focus of this study). The gliders were trimmed during a pilot teaching day on 05 April 2024.

Transportation (personnel and equipment)

Figure 9. UW Weelander to transport and deploy SG195 (left). Private boat (“Daddliest Catch”) from UW employee to transport and deploy SG194 and SG175 (right).

Field team will be transported via trucks with boat trailers to Don Armeni Boat Ramp (West Seattle; Figure 7) about 20 minutes from Ocean Science Building (OSB). The UW Weelander (Cap. Dave) and private boat (Cap. Andrew) will transport and deploy three gliders to the northern end of Colvos Passage. SG194 and SG175 will be deployed off of the private boat, and SG195 will be deployed off of the Weelander (Figure 9). A more detailed schedule is outlined below:

Field Schedule	

5:30	Depart OSB (Weelander: SG195, Private Boat: SG175&SG194)
6:30	Arrive at Point Defiance, perform self-test and sea launch SG194, SG195 test prior to leaving port
7:00	Leave port and transit to Colvos Passage (as transiting, run self-test and sea launch on SG175)
7:40	Deploy SG194 (Private Boat) & SG195 (Weelander) (@ 47.4960ºN, -122.495ºW *Deploy* in Figure 1)
8:00	Deploy SG175 (Private Boat)
8:10	Perform hand CTD cast from Private Boat
8:20-16:30	Wait for recovery (at either Blake Island or Boat Launch, at discretion of boat captain)
16:30-17:30	Recover Gliders (Weelander: SG195, Private Boat: SG175&SG194) with CTD cast before each recovery (@ *end* waypoints in Figure 1)
18:10	Return to Point Defiance Boat Launch
18:30	Depart from Point Defiance Boat Launch and return to OSB

In the event an emergency recovery is necessary, both boats plan to dock at Blake Island, WA at a public dock during the duration of the mission.

Figure 10. Satellite image of Blake Island, WA. Public boat launch is at the northeastern most corner.

<u>Communication</u>

Communication will primarily be between the pilot room and field team via telephones. The two boats in the field will communicate via radios.

Glider Deployment Instructions

Field Checklist

Instrumentation	Notes

Glider(s) with cradle(s) - SG175 - SG194 - SG195	- Panels are attached all screws are screwed in - The rudder is somewhere safe, plastic box works - If 194/195 make sure Shorting plug is attached, 170s make sure you have a couple of wands - The antenna is by glider's side tucked into ratchet strap (make sure rachet strap does not dig into the antenna or the glider to much - The Glider is secured to cradle via ratchet strap plus upper and lower straps if cradle has them
Glider toolbox - Specific to each glider	- Screwdriver (need 1, preferably have 2) - Rudder screw (need 2, preferably have 4) - Electrical tape
Field laptop (x2)	
Deckbox	Specific Frequencies for - SG194: Int 12.5 Hz; Rply 13.5 Hz - SG195: Int 14.0 Hz; Rply 10.5 Hz

Self-Test

Prior to Starting Self-Test:

1. Secure glider: Make sure the Glider is propped up against the rail and secure. May need to use ratchet straps if unstable.
2. Attach Antenna: Make sure the side of the antenna with holes on it is between the rudder and holes of glider fairing. Slide rudder into slot (may need adjusting around wires). Hand tighten screws to secure rudder & antenna.
3. Connect to the glider: Set up laptop in dry/protected area. Plug comms cable into computer via USB. Open terminal (ensure that minicom is not already open!) and open minicom by typing 'minicom' in terminal. Press **ctrl + A**, release then **L** to open the capture file. Name capture file "SG###Data_LastNameofUser_inserttask (ie. deployment).txt". Connect the other end of comms to **yellow** plug on antenna of glider
4. Turn on glider: Turn on glider with Shorting plug (attached on glider for SG194 and SG195) or wand for (SG175). Within a minute of turning the glider on, talk to the glider (via terminal) or else the glider will go to sleep.
5. Check internal pressure and battery readings in terminal: Check internal pressure (should be around 8.5-9.15 PSI), if not notify the pilot. Check battery gauges (should be around 24 W), if not notify the pilot.

Start Self-Test:

1. In the terminal, go to the last option on the menu. Select autonomous self-test (if it prompts for phone numbers, press *enter*). Alert pilot that self-test has started & wait.
2. Once the self-test is completed, you will get notification whether or not the self-test has passed. If not passed, re-run and alert the pilot.

3. Look at warnings and errors (i.e., common errors are iridium registration, SMS, and bathymaps and are O.K., just alert the pilot). Other errors will need to be cleared before continuing.
4. Alert pilot that self-test in complete
    1. Anything else let science know and call Ellie or Caleb or Charlie/science
5. When Selftest is done, alert pilot, and wait for the go ahead to start Sea-Launch

Start Sealaunch:

1. Once pilot gives go ahead to start sealaunch, go back to main menu then go into last option again. Click Sealaunch option. Hit enter for phone options that show up.
2. Wait until it asks you if the pilot has given the go ahead for sea launch.
3. Ask pilots if its O.K. to say yes. THIS IS TRANSFER OF COMMUNICATION TO PILOT.
4. Type yes or just Y and hit enter when the pilot gives O.K.

Disconnect from Glider:

1. DO NOT DISCONNECT SHORTING (clear) PLUG!!
2. Disconnect Comms cable from **yellow** plug. Plug the black dummy plug into the yellow plug (the one that is hanging on the antenna).
3. Remove all three sensor caps (2 on the CTD and 1 on the Optode). Remove the ratchet strap. Get the go ahead from the pilot to deploy.

Deploy Glider by slowly lowering glider & cradle into water. Check to make sure it is buoyant, and the antenna is out of water (should be sitting at ~45 degree angle to water surface).

Personnel/Pilot Schedule

Each glider will have an undergraduate student giving the glider parameters to fly smoothly. Katie Kohlman will assist the pilots in setting the parameters and piloting the gliders while also acting as the main communication point between the pilot room and field team. The Ocean Tech Center (OTC) will act as the piloting room and the undergraduate students will follow the schedule below:

<table>
<tr><th>31-May</th><th>Pilot SG175</th><th>Pilot SG194</th><th>Pilot SG195</th><th>Field WELANDER</th><th>Field PRIVATE</th></tr>
<tr><td>7:00</td><td rowspan="6">Lydia Kelley</td><td rowspan="3">Xavier Giomi</td><td rowspan="4">Annabella Andre</td><td rowspan="6">Captain: Dave Ellie Brosius, ZiggyAvetisyan</td><td rowspan="6">Captain: Andrew Caleb Flaim, Nadia Martynenko</td></tr>
<tr><td>8:00</td></tr>
<tr><td>9:00</td></tr>
<tr><td>10:00</td><td>Zachary Levitan</td></tr>
<tr><td>11:00</td><td rowspan="2">Maddy Chriest</td><td>Jackson Page-Roth</td></tr>
<tr><td>12:00</td><td>Zachary Levitan</td></tr>
</table>

13:00			Jackson Page-Roth		
14:00					
15:00			Angela Yang		
16:00					
17:00		Xavier Giomi	Sydney Schumacher		
18:00					

Budget
Day rate of Weelander: $1000
Day rate of Private boat: $750
Transportation to and from boat launch is included in day rate.

Total Day cost: $1750
Funds will use SSC's budget.

Diversity, Equity, and Inclusion Goals
The purpose of the SSC is to train undergraduate students to become familiar with ocean technology (specifically gliders) and to better understand how in situ data is collected. This mission will serve as a teaching tool to allow more students to learn how to pilot and gain ample amounts of experience sitting in the "hot seat" and increase their communication skills. Students in the field will learn how to "talk" to the gliders via ethernet cables, deployment techniques, and communication skills. As this is an undergraduate lab, the turnover rate is quite rapid. All seniors are gaining experience teaching the younger undergraduates to pass on skills so that the lab can continue to grow.

Safety
Safety is the most important goal of the field team. The undergraduate teams consist of one student with experience and one student learning. The procedure to deploy and recover a seaglider requires students to handle ~120 lbs of the glider using a deployment cradle in and out of the water.

Small boat operations
The two captains of the small boats have the appropriate training experience as documented by a WA state boater card(http:/www.boat-ed.com/washington). Personal floatation devices will be worn by field team members at all times.

In an event that the glider is in the path of a ferry or vessel of any kind and the field team notices, under no circumstances should the field team attempt a recovery.

Incident response
Each boat is equipped with first aid for minor injuries (i.e., cuts or scrapes). In the event of an emergency, the field team will immediately communicate to shore via VHF radios. If

transportation to a medical site is required, the small boats can transit to downtown Seattle and transit via land to Kindred Hospital Seattle. 911 service is available in the region.