# Glider Ballasting

## Step 1: Weight Inventory

1. Label ballast sheet with glider, date, preparers, and mission.
2. The main section of the ballast sheet pertains to vehicle weights. These weights are tracked for 2 reasons:
   1. Record keeping
      1. In the event a glider is shipped away for long term
      2. Used in conjunction with another glider and parts may be swapped
      3. Allows for swapping of parts without a scale or means of obtaining a weight
   2. Exact ballast (calculated volume)
      1. Knowing the exact volume of the vehicle aids in ballasting accuracy
      2. When deploying new instruments, strap on (external riding) instruments, etc.; it is helpful and safe to find the total vehicle package volume
3. Clean and disassemble the vehicle to be worked on. Separate out main ballast bottles, batteries, and sections of vehicle.
4. Carefully record weights of the parts. Be sure to not leave parts out that are normally installed during flight (ie: power on/off plug, flash cards). Defaults are noted, but note any exceptions. Be careful not to double weigh parts as well (ie: nose batteries installed in fore section)

## Step 2: Ballast Considerations / Target Density

1. Determine
   1. Day 0 (start of deployment)
      1. Surface Temperature
      2. Surface Density
      3. Bottom temperature
      4. Bottom Density
   2. Day X (end of deployment) (x days later)
      1. Surface Temperature
      2. Surface Density
      3. Bottom Temperature
      4. Bottom Density
2. The above data can be obtained from following sources
   1. Recent CTD casts, cruises, live datasets including gliders, observatories
   2. Historical records from similar time periods of previous years from sources similar to above
   3. Ocean models
   4. If no good data is available, it is best to take a guess and ballast light. Proceed to deploy with a CTD sensors on hand, to make adjustments at the last minute. This is important for freshwater areas, or brand new uncertain zones.
3. Decide on a target density and temperature and enter these on the ballast sheets
4. If you have a previous volume measurement, enter that as starting point

How to pick the right density is beyond the scope of this article, but as a reminder for a trained individual, we have included the following information below:

* Priority in ballasting
  + Lowest surface density across deployment span
    1. Ballast no more than 2.5 sigma units higher than this (expert users disregard)
  + Coldest surface water across deployment span
    1. Glider will lose volume at surface, thus inhibiting surfacing. We must account for the coldest water in the ballasting decisions
  + Densest bottom water across deployment span
    1. Obtaining full dataset from top to bottom is important, but not as important as being able to surface. Coastal gliders may hit ranges they cannot operate to full depth in. Often bottom is given up in lieu of surfacing reliability.

## Step 3: Ballasting

1. Be sure tank is thoroughly mixed and the water is less dense than your target density
2. Be sure glider is in ballast mode
3. Submerge glider equally from CG point of glider
4. Make judgment call on whether this dunk will be valid as a ‘volume’ dunk. This means is the glider close enough to obtain a highly accurate weight in tank for it to be used in the calculation of the glider’s density. In other words:
   1. If it is hundreds of grams out of trim, fix first
   2. If it is hundreds to thousands too light or heavy, fix first (get it to more ballpark)
5. If glider is not the above, then proceed with highly accurate density dunk
6. Hang glider from scales, use weights as needed to submerge
7. Prepare external CTD for measurements and place in tank while glider settles
8. Record
   1. Scale weight, fore and aft
      1. Log any external weight locations
   2. External CTD Temp
   3. External CTD Cond
   4. External CTD density
9. Remove from scales, record:
   1. Log external weight values
   2. Glider CTD Temp
   3. Glider CTD Cond
10. Get glider to barely submerge via:
    1. Remove wings if way too heavy
    2. Use ballast pump to obtain +- ~ 200g
    3. While glider is hovering, barely submerged, obtain roll value of vehicle
11. Proceed with H-Moment calculation if new glider, new payload, or new configuration with external instrument. (not this document)
12. Remove vehicle from tank

## Step 4: Ballasting Predictions / Corrections

1. Enter information from the dunk on the ballasting spreadsheet. The outputs from the dunk will be in the purple sections. Take note that ‘Weight in Tank’ = ‘Scales’ – ‘External weight added’
   1. Calculated Glider Volume
      1. This is the volume of the vehicle, given the weights above in air are accurate as well as the tank density, temperature and weight of the vehicle in the tank.
   2. Glider Density 2, 3
      1. This is the density in target water, using the entered and calculated volume.
2. Dunk sanity check
   1. As a general rule of thumb, 50 g ~ 1 sigma unit. In other words if the glider pulls on the scales by 300 g in a tank of 1020 water, your glider is about 1026 density. Use that to make sure your entered values are within spec.
      1. Coastal volume is 50-51 L
      2. Deep volume is 55-60L
3. Finalize the dunk
   1. Enter the ‘Calculated Glider Volume’ as ‘Entered Volume’ if you trust the measurement and it makes sense
4. Print out the sheet and label Iteration 1
5. Make ballast adjustments by the pink section
6. Large changes should be logged in the weights section (payload bay, etc). Smaller changes (just bottles) can be logged on the iterations sheet as well as reflected in the weights section.
7. Be sure to add Trim corrections to the adjustment (out of scope of this document).