
# IOP office hours

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# What we are going cover/who asked us questions

1. Pitch trimming

# Pitch trimming - The Basics

Pitch trim (arguably) has the single biggest impact on a Seaglider’s flight.

- Well trimmed vehicles can save more energy then poorly trimmed vehicles (both by getting “clean” flight on both profiles and managing the use of the VBD in maintaining vertical velocity)
- Poorly trimmed vehicles waste energy and sometimes don’t fly at all
- By well trimmed, we ultimately mean the glider takes about as long to dive as climb (depth trace on diveplot is symmetric)
- The basic idea of Seaglider pitch control is that absent changes in the center of buoyancy (changes in VBD), there should be no change in observed pitch for a fixed position of the battery mass.
  - For the dive, the VBD generally doesn’t change outside of the initial bleed (generally confined by $D_NO_BLEED)
  - For the climb, VBD is often used as the primary method to maintain vertical velocity - so the change in pitch is managed by $PITCH_VBD_SHIFT
- https://iopbase3.apl.washington.edu/272?mission=NANOOS_Feb26# - Dive 14 - Pitch regressions and dive plot
- **$C_PITCH** The center (neutral, or flat) position (A/D counts) for pitch.
- **$PITCH_GAIN** The amount of vehicle pitch (degrees) change corresponding to 1 cm movement of the pitch mass.
- **$PITCH_VBD_SHIFT -** parameterizes volume control (VBD) displacement as an equivalent mass shifter displacement. During each GC maneuver, pitch control (cm) is computed as the sum of the pitch desired (in degrees, see the third field in **$MHEAD_RNG_PITCHd_Wd**) divided by pitch gain (**$PITCH_CNV**) plus the VDB control (cc) times **$PITCH_VBD_SHIFT** (cm/cc). Defaults to 0.00167
  - In the past, this has been treated as a constant value that is characteristic of type/setup of the mass shifter
  - I find it better to adjust using the non-linear fit on the pitch regressions

# Pitch Trimming - The "Pitch Adjuster"

- Problem statement: determining an initial $C_PITCH after a glider has had refurb, lead change, sensor changes or is initially built requires one (or more) of the following
    a. Detailed static analysis of the glider (the "trim sheets" of days past)
    b. Trial and error in the field, until the glider flies well enough that the pitch regressions become meaningful.
    c. Some way to get the glider to "fly better" during initial dives so that the pitch regression plots have meaning
- Item (c) - The "Pitch Adjuster" ($PITCH_ADJ_GAIN, $PITCH_ADJ_DBAND):
    - **$PITCH_ADJ_GAIN** enables and adjusts active (closed-loop) control on Seaglider pitch during a dive and climb. The amount of the adjustment is given by (PitchDesired - PitchObserved)***$PITCH_ADJ_GAIN**. (Units of cm/degree) Good place to start is 0.03
    - **$PITCH_ADJ_DBAND** (units degrees) is the deadband for the adjustor to be applied. If the observed pitch deviates from from the desired pitch ($MHEAD_RNG_PITCHd_Wd - third field), run the adjustor. Good place to start is 1.
- A bit of a "heavy handed" approach to pitch control, given the previous slide, but is useful for determining the correct $C_PITCH (or getting closer to it) *if* the glider has changed significantly since last deployment.
- I generally start a mission with the Pitch Adjuster **on,** so the C_PITCH can be established.
    - Once the glider is diving deep and I turn it **off** and see if its still needed (usually, it isn't)
- For some very difficult to trim gliders, running the adjustor for an entire mission (with a light gain) can be a good strategy.
- Typical test dive: [https://iopbase3.apl.washington.edu/254?mission=Shilshole_24Feb26](https://iopbase3.apl.washington.edu/254?mission=Shilshole_24Feb26) Diveplot - Dive 5
- Impact on VBD: [https://sgbasevm.oc.ntu.edu.tw/628?mission=KH_Mar26](https://sgbasevm.oc.ntu.edu.tw/628?mission=KH_Mar26) - Diveplot - Dive 14

# Pitch Trimming - Pitch over VBD or Trimming for Endurance

- Problem statement: while we know that a glider can dive at $C_VBD - $MAX_BUOY to the target depth, and should be able to climb surface at $C_VBD + $MAX_BUOY, the glider would like to see that happen at a consistent rate (to help in consistent sampling).
  - The glider's preferred approach is to pump on the way up.
  - Variations in speed (due to internal waves, strong roll/pitch coupling, gliders flying close to stall, etc) can trigger the speed adjustment. Often, these variations are momentary.
  - https://iopbase3.apl.washington.edu/272?mission=NANOOS_Feb26# Dive 14 Diveplot
  - Down sides - pumping at depth is more expensive the pumping shallow
- "Pitch over VBD" is a solution. The idea is vertical speed can be impacted (to a degree) by adjusting pitch more cheaply (energy wise) then pumping.
- Note: The main effect of this is often to delay

# Pitch Trimming - “Pitch over VBD”

- **$W_ADJ_DBAND** (units: cm/s): Seaglider adjusts its buoyancy to maintain a desired vertical velocity (w). In particular, if the observed w is too low, the glider may attempt to bleed on dives (subject to $D_NO_BLEED and $MAX_BUOY) or pump on climbs. However, in the presence of strong internal waves the glider may appear to slow transiently because of upwelling on the dive or downwelling on the climb, triggering unneeded buoyancy adjustments. This parameter limits active control on VBD changes during a dive and climb. The Seaglider will automatically seek to maintain the desired vertical velocity by changing the VBD when | Wobserved | < | Wdesired | - $W_ADJ_DBAND. Should be positive, and correspond to the typical RMS variance of observed w. A value of 0 ignores internal wave effects. A good typical value is 3.
- **$PITCH_W_DBAND** (units: cm/s): Deadband on pitch adjustments used for vertical speed control. If the observed vertical speed is outside the deadband, but not beyond $W_ADJ_DBAND, the glider will adjust pitch according to $PITCH_W_GAIN try to maintain speed. A good typical value is 0.5.
- **$PITCH_W_GAIN** (unit: cm per m/s): Gain on pitch adjustments used for vertical speed control. If the observed vertical speed is outside $PITCH_W_DBAND, this parameter controls the adjustment made to pitch control to try to maintain desired speed. This parameter is only used during climbs. If this parameter is negative, adjustments will be made to both slow and speed the glider. If positive, adjustments will only be made if the glider is moving too slowly. This parameter cannot be used at the same time as $PITCH_ADJ_GAIN. Interesting values might be in the range 2–10; a good typical value is 3.
- Results: https://iopbase3.apl.washington.edu/272?mission=NANOOS_Feb26# Dive 15 Diveplot
- I generally turn this on after dive 15-20 - once other trimming has been done.