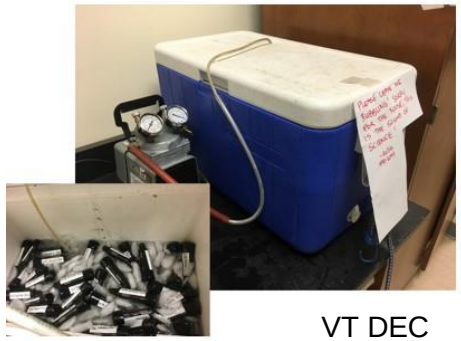
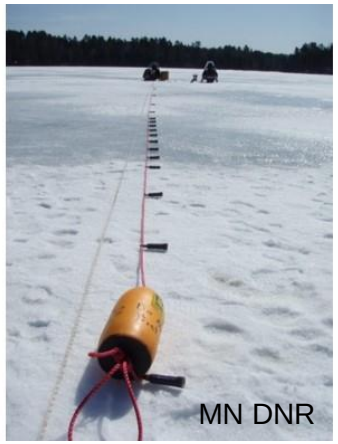
Lake Sensor Arrays: Assembly and Deployment

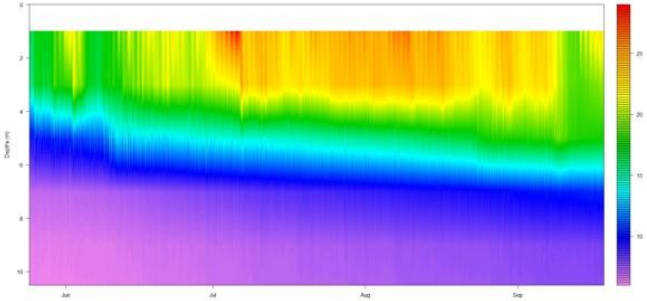


VT DEC



MN DNR

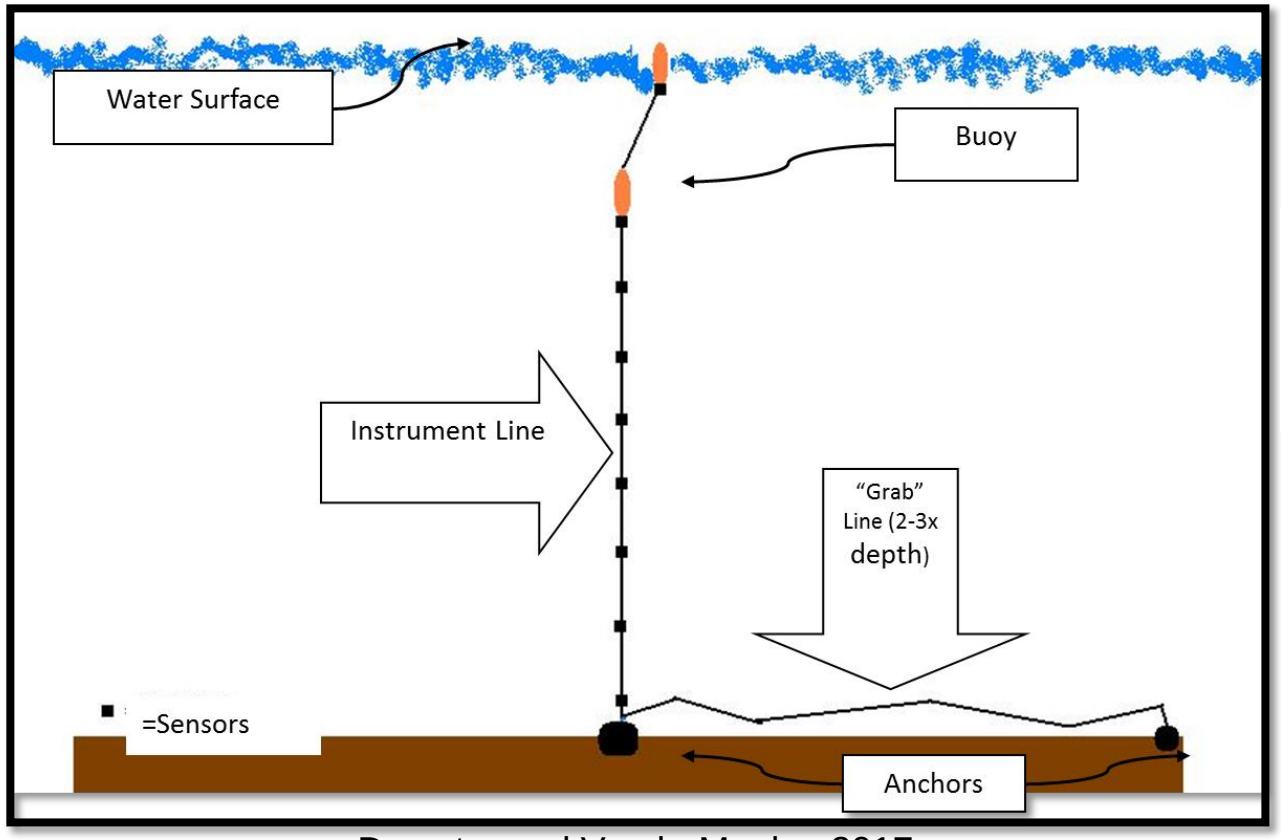
QC



November 14, 2022
NALMS Workshop

Challenging to develop guidance due to the many potential permutations…

Variables – parameters, sensors (brands and models), depth intervals, time intervals, IT support, level of expertise, and more…



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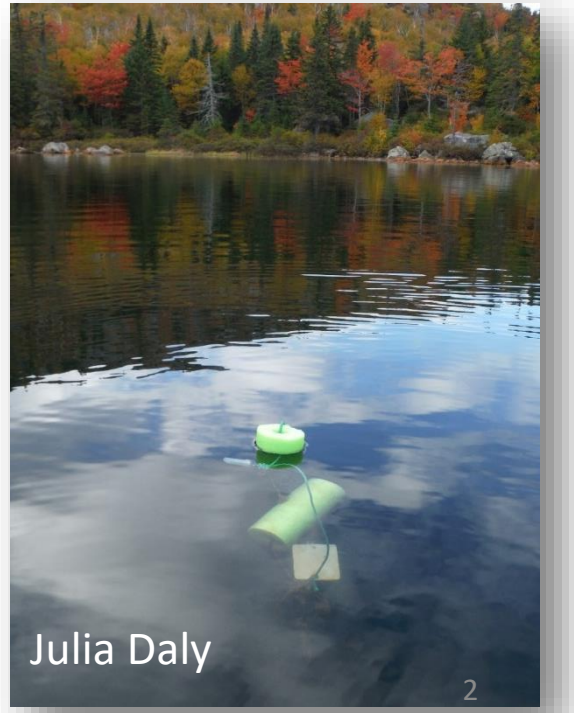
Commonly used equipment at RMN lakes. Not an endorsement!



Fixed moored arrays of continuous sensors for vertical profile measurements in lakes

Information was derived from the following 3 draft SOPs -

- Damstra, R., and D. D. VanderMeulen. 2017. Standard operating procedure #14: Moored temperature arrays, version 1.0. In J. E. Elias, R. Axler, E. Ruzycki, and D. VanderMeulen. 2017. Water quality monitoring protocol for inland lakes: Great Lakes Inventory and Monitoring Network, version 1.2. Natural Resource Report NPS/GLKN/NRR—2017/XXX. National Park Service, Fort Collins, Colorado.

- Casey W. Schoenebeck, C.W. and T.J. Martin. 2017. Standard Operating Procedures for the Deployment, Retrieval and Data Processing of Continuous Water Temperature Loggers for the Sentinel Lakes Program. Minnesota Department of Natural Resources

- Bowe, S. 2017. Dissolved Oxygen and Temperature Continuous Monitoring Buoy SOP. Red Lake Band. Red Lake Band of Chippewa Indians.

Also – thank you Julia Daly! And GLEON researchers

Site Reconnaissance

- Depth
- Mixing pattern
- Boat traffic
- Rules and regulations
- Accessibility
- Bottom substrate
- Water level fluctuations
- Prevailing windspeed and direction

Equipment

- Continuous sensors (and associated data download devices & software)
  - Temperature
    - Stratified lakes:
      - Spaced 1m apart in the epi- and metalimnion
      - Geometrically increasing intervals in the hypolimnion (1, 2, 3 ,4, then 5 m intervals to the bottom).
    - Polymictic lakes:
      - One logger per chain
      - 2 chains recommended
      - Ideally, the logger should be located > 0.5 m off the bottom and >1 m below the surface.
- Rope for instrument line & grab line (and recovery loop at the top)
- Floats (primary & secondary)
- Anchors for instrument line & grab line
- ~~Heavy-duty zip ties~~ paracord

Additional

1. GPS
2. Retrieval equipment (usually a tool to grab the loop such as a pole with a hook sometimes called a boat hook or decoy retriever)
3. Hand brush
4. Meter stick or reel tape
5. Computer or tablet with Hoboware software http://www.onsetcomp.com/hoboware-free-download
6. Hobo Shuttle and coupler with USB cord
7. Gloves, especially if working in a zebra mussel infested lake
8. Extra data loggers in case one needs to be replaced
9. Side scanning sonar (optional but useful)

Where to put the DO sensors? Depends on the purpose and how many you're able to purchase…
It helps to have discrete profile measurements to help inform the initial placement

meters	Temperature	DO
0		
1	Logger	DO
2		
3	Logger	
4		
5	Logger	
6		
7	Logger	
8		
9	Logger	
10		
11	Logger	
12		
13		
14	Logger	
15		
16		
17	Logger	
18		
19		
20		
21	Logger	
22		
23		
24		
25	Logger	DO
26		

Concerned about possible internal P loading events?

Concentrating the loggers around the bottom may be the best idea (starting at 1-m above the bottom).

A number of RMN partners are also putting them 1-m below the surface to compare the bottom measurement(s) to.

meters	Temperature	DO
0		
1	Logger	
2		
3	Logger	
4		
5	Logger	
6		
7	Logger	
8		DO
9	Logger	
10		DO
11	Logger	
12		DO
13		
14	Logger	
15		DO
16		
17	Logger	
18		
19		
20		
21	Logger	
22		
23		
24		
25	Logger	
26		

Concerned about fish habitat?

Concentrating the loggers around the middle thermal layer boundaries may be the best idea.

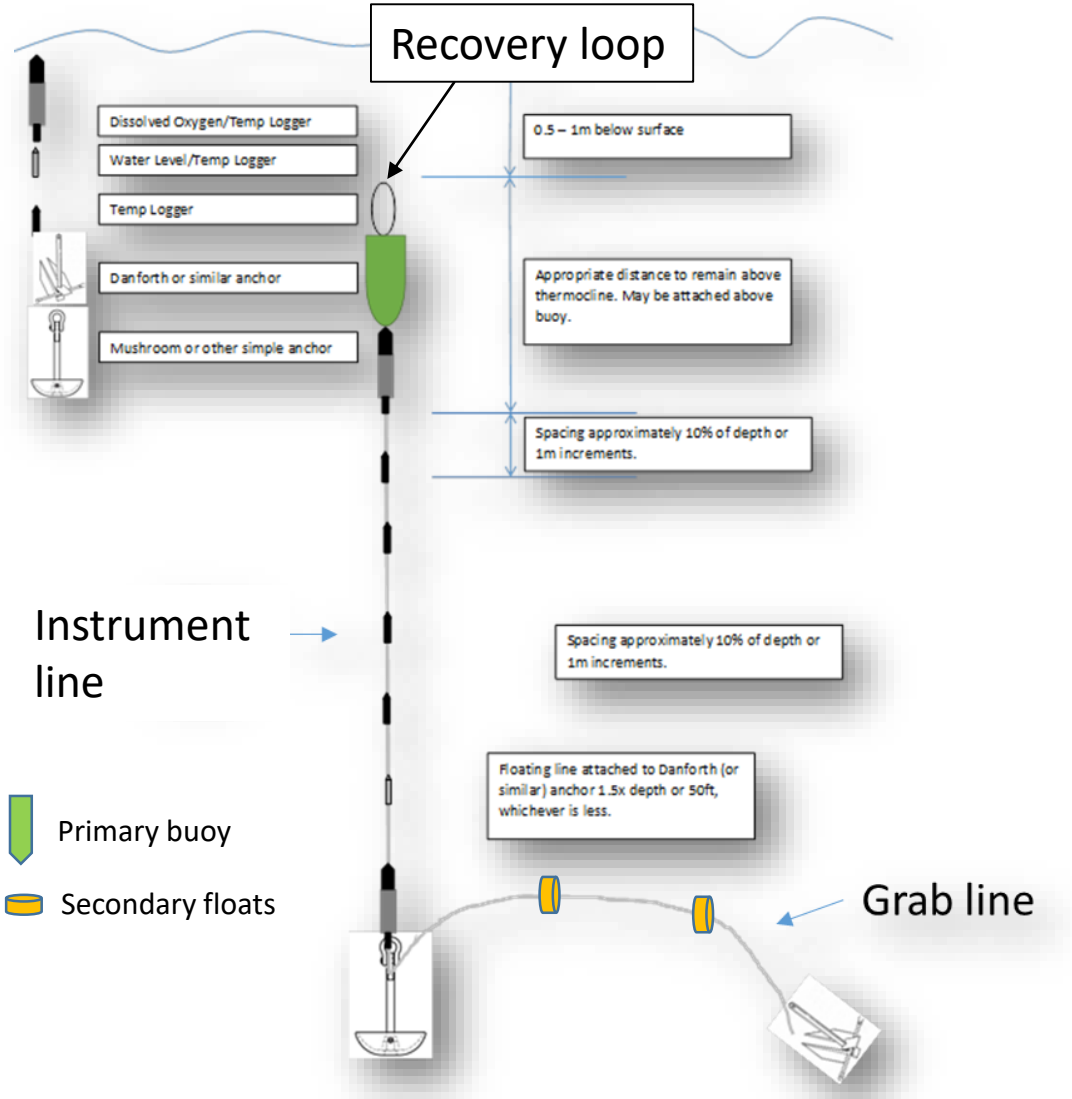
You can assume that the deeper you go in the water column, the less likely the DO will be within fish requirements.

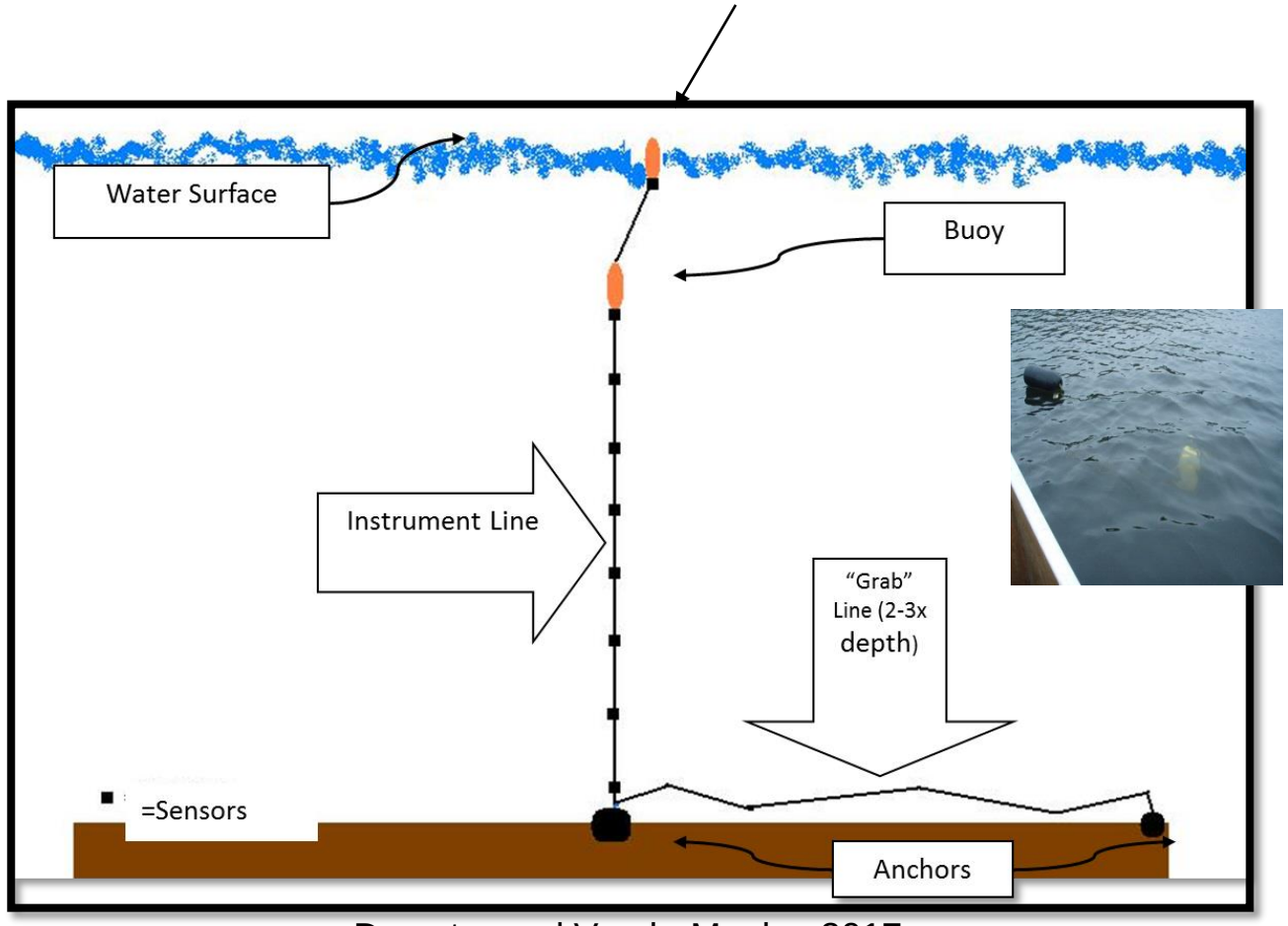
Consider placing the bottom logger around where you estimate DO to fall below a critical threshold (e.g., 3 or 4 mg/l)

Schematics

Many potential permutations! These are just two possibilities.
In some situations, people put their top buoy/sensor below the surface. In other situations, the top buoy is placed at the surface. There is no right or wrong way to do this – it will vary across sites and is up to your discretion.

This top buoy/sensor is detachable (this makes it easy to remove from the rest of the line if you want to take it out for the winter). Having two buoys has other advantages as well (see next slide).





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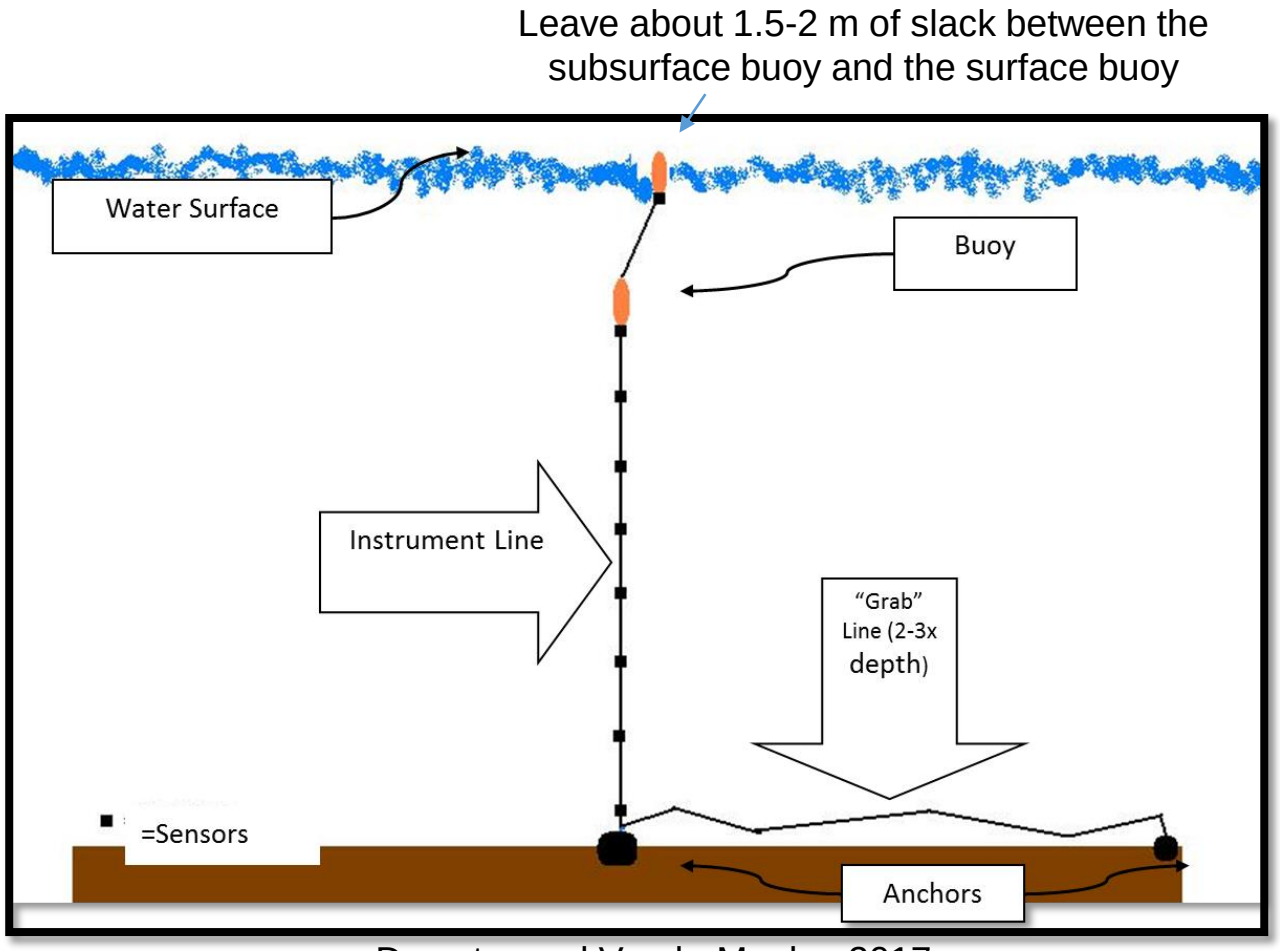
Two-buoy system

Advantages of a ‘two buoy’ system (where a second buoy is placed roughly 1-m below the first buoy)

- The surface buoy is detachable (you could potentially remove it during the winter).
- It accommodates unexpected water level changes (that may cause the instrument line to sag if water levels go down).
- It helps keep the line straight when the wind blows.
- It gives you a little flexibility in the deployment depth.
- It is easier to get arrays positioned (with a surface buoy only, it can be a struggle – you may have to submerge the buoy or end up with too much slack in the line).



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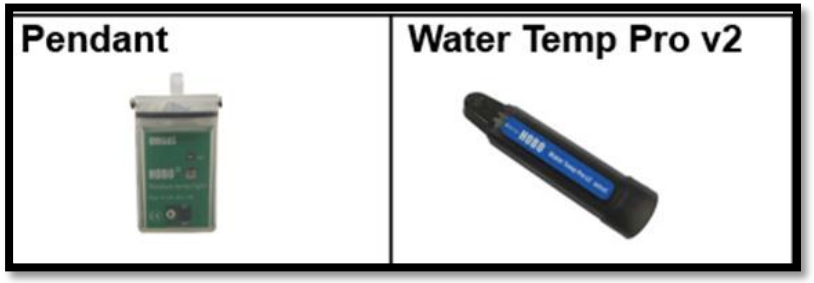
HOBO Water Temperature Loggers

	Pendant	Water Temp Pro v2
Temperature Range (in water)	-20 to 50C	-40 to 50C
Accuracy (0 to 50°C)	0.54°C	0.2°C
Depth Rating	30m	120m
Battery	User-replaceable	Factory-replaceable
Typical use battery life*	1 year	6 years
Special Features	Also includes either a relative light sensor or alarm indication	Protective boot available
Price	$42 - 47 for 6.5k $64 for 52k	$129

*1 minute or greater logging interval

Battery life is affected by temperature & logging interval (extremely cold or hot temperatures and logging intervals faster than one minute may significantly reduce battery life)



60-minute logging intervals

Pendants are cheaper and have relative light sensors, but require more maintenance

- Replace batteries 1X/year – (CR2032 batteries)
- Light sensors are prone to fouling (depends on the lake)

If you use the Pendant, we recommend the 52K version (it has enough memory to record at 60-minute intervals for a year)

HOBO Pro v2 Water Temperature Logger

Note: these stop recording temperature when the DO cap expires

HOBO Dissolved Oxygen Logger Overview

$1,350

$125 sensor cap replacement

- Records **Dissolved Oxygen Concentration** and **Temperature**
- The DO Assistant in HOBOware Pro is used to get **Salinity-Adjusted DO Concentration** and **DO Percent Saturation**
- **Uses RDO Basic Sensor from In-Situ – Optical DO Sensor with easy-to-replace, 6-month sensor cap**
- Part of the HOBO water logger family: Optic USB interface & waterproof shuttle for reliable data offload in wet environments; HOBOware ease-of-use and data integration.
- Durable Delrin and PVC housing
- CE compliant
- Accuracy: 0.2 mg/L up to 8 mg/L; 0.5 mg/L from 8 to 20 mg/L
- 21,700 DO/temp measurements

DO Calibration

Lab Calibration - recommended after new DO sensor cap is installed

- 100% calibration with included calibration boot or in an air-saturated water bath; barometric pressure reading required.
- 0% calibration recommended if DO readings may be less than 4.0 mg/L. (use optional Sodium Sulfite solution)

DO Calibration

Field Calibration – use to compensate for fouling or to calibrate data instead of lab calibration…meh..

- Take precise readings at the start and end of each deployment – after stablization
- Use both start & end points to compensate for fouling.
- A single-point calibration can be done with a reading from any time within the deployment.

Field Calibration Options

Field Meter/Sonde (Recommended) – Fastest method at around 5 minutes and logger can remain in the water

- Lake profiles – We are using .25m profiles for QC

100% saturation method (Better than nothing) – useful if a field meter is not available

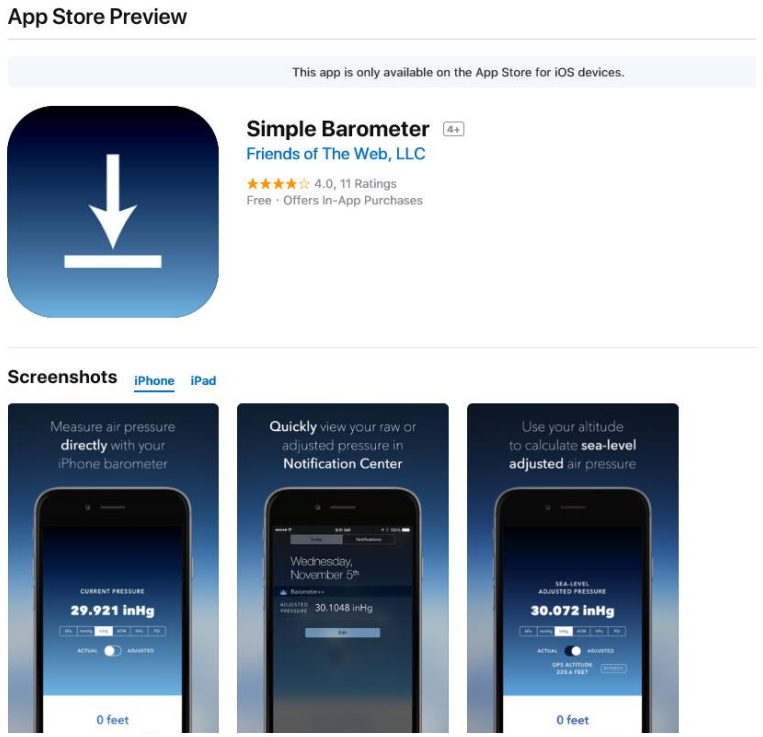
- Use Calibration Boot with freshwater for sponge.
- Allow time for air in boot to reach saturation and for logger to reach temperature equilibrium with surrounding air (time depends on temperature difference from where it was)
- Requires barometric pressure – use meter, U20 Water Level logger or nearby weather station.

DO Calibration tips from VT DEC

“Hey guys,
Just getting ready to prep the DO/Temp sensors for deployment and going through Jen’s ppt which recommends calibrating to zero as well as 100% saturation. I don’t have time to buy the sodium sulfite solution from Fisher and no one has any nitrogen I can use to bubble the water to get it to zero….but I found this from in situ’s website and I’m going to try it. Thought I’d share it with you guys in case you find yourselves in the same boat as me.”

https://in-situ.com/wp-content/uploads/2015/01/RDO-Sensor-Two-Point-Dissolved-Oxygen-Calibration-Using-Yeast-Tech-Note.pdf

Separate note: there is a free 'simple barometer' app. For folks carrying a smartphone around with them they can use this app to get the barometric pressure. I've been testing it against the barometers installed in our Hyddrolab Surveyor units for calibrating DO and I find it very reliable. Certainly better than trying to use what you can find from a closest weather station.



PME mini-dot DO sensors

Logger is ~$1000 (without bulk discount)

Don’t have to change out a sensor cap every 6 months

They take lithium-ion AA batteries that can be bought in the store. Check them at least once a year and change them as needed.

No proprietary software

MN has been using them for almost 3 years and so far haven’t noticed any significant wear or other issues.

Worried about algal growth?
They have anti-fouling copper kits ($50)

If the lake has zebra mussels or somethings similar, would recommend wipers on loggers above the thermocline
Logger + miniWIPER = $1725

HOBO Water Level Loggers

- Two series:
  - **U20** - highest performance, choice of stainless steel or titanium housings, with 0.05% accuracy ($495 and $595)
  - **U20L -** lowest price in the industry ($299)
- Self-contained, non-vented loggers for easy deployment.
- Optic USB interface allows fully sealed housing with no mechanical connectors to fail.
- Durable ceramic sensor can withstand being frozen.
- Batteries – factory-replaceable; 5-year battery life under typical use*
- Need HOBOware Pro software to generate water level (based on the data from the air and water sensors)

*varies based on logging interval, temperature and other factors

HOBO Water Level Loggers

- Non-vented
- Two at each site, one in the air* and one in the water
  - RMN partners typically deploy the **U20 in water** (requires greater accuracy) and the **U20L on land**
- Air sensor measures barometric (atmospheric) pressure. This is needed because atmospheric pressure changes with weather; failure to compensate for these variations could result in errors in the water level measurements.

*in some situations, data from a nearby weather station may be used but on-site deployments are generally preferred at RMN sites

2 sensors -

1 in the water

1 on land

HOBO Water Level Loggers

End cap

Pressure is measured by a ceramic diaphragm.

Optics for data transfer

Air sensor/barometric pressure logger

Tip: drill holes in bottom of PVC or mount sensor upside down to prevent water from collecting in the bottom (which would affect the sensor readings)

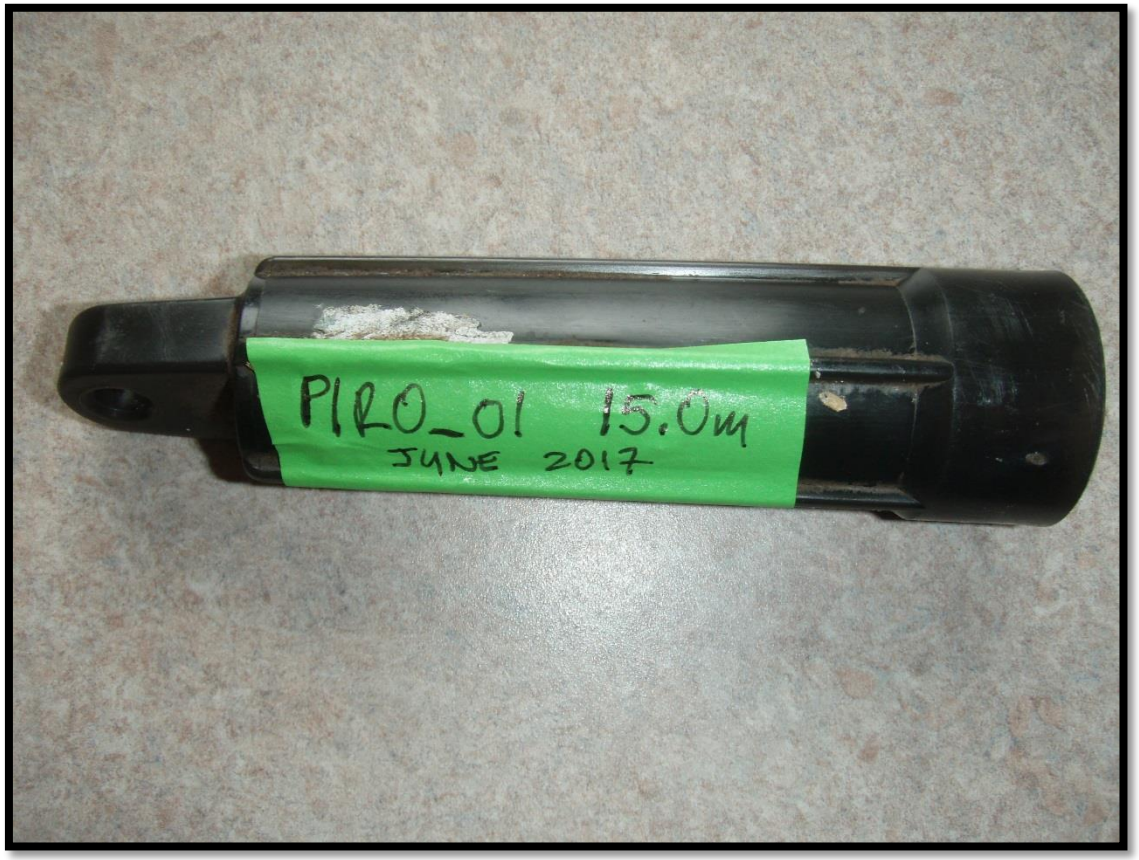
- RMN protocols -
  - On-site installations are preferred
  - Mount in a shaded area, to minimize temperature variations
  - Mount as close as possible to the water sensor
- Easiest to use data from a HOBO logger (another U20 or U20L logger, or a HOBO weather station)
- To be consistent with typical meteorological air temperature observations, sensors should be placed at a height of approximately 4-6 feet off the ground

Couplers

- Come with the base station and waterproof shuttle

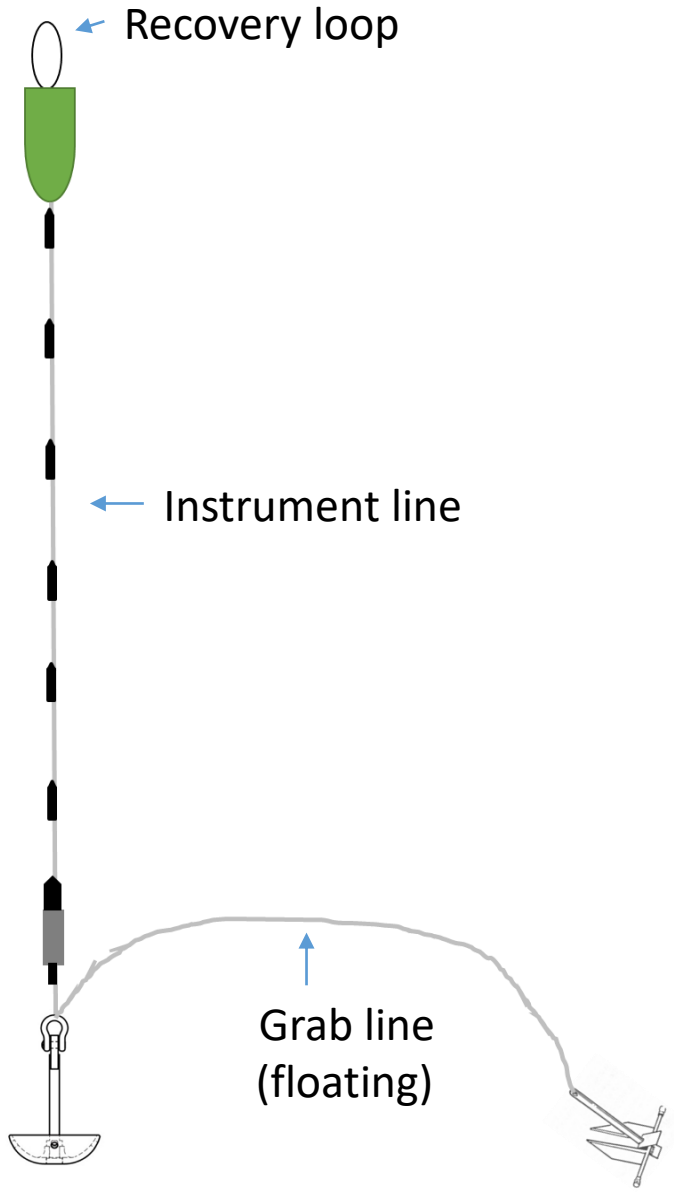
- Allow you to use the base station and waterproof shuttle with all of the HOBO optic loggers

Clearly label outside of logger with sensor name



Rope

- Most entities prefer rope over cable or chains (cable rusts if it is not stainless steel or coated, and is likely to cause more damage if it gets tangled up in a prop)
- Instrument line – several possibilities (it is up to your discretion; each have pros and cons, as described in the next slides; each of these options has been used successfully by the entities listed on slide 1)
  - 1/4” Solid braided polyester rope
  - 1/2” Braided poly rope
  - 3/8” Potwarp
- Important: monitor the condition of the instrument line carefully. It will degrade over time due to UV; how fast it degrades varies depending on the type of rope you use and local conditions.
- A grab line is recommended. It is best to use floating line supplemented with secondary floats (see slide 14).
- A recovery loop can be either floating or non-floating line (your discretion). Do not skimp on the length of it! Make the loop big enough to easily grab. You may even consider having two loops.
- The instrument and grab line can be the same line (where you run one line throughout); or you can have separate instrument and grab lines. As described on slide 2, you may want to set up your instrument line so that the upper 1-m separates/easily detaches from the rest of the instrument line.



½” Braided poly rope

½” is the preferred diameter (don’t go smaller)
Expect to change it every 2-4 years.

Pros: floats, easy to handle, easy to attach loggers to (you can weave parachute cord and/zip tie them into the rope - see photos on right), strong

Cons: may degrade faster than the other two options (monitor its condition closely)

Braided Poly Rope, 1/2 in. by 600 ft., Yellow

Write a Review

Stock Number: BP161Y

$83.95

1 ADD TO CART

DESCRIPTION | REVIEWS | Q&A

This Size #16 Yellow Poly line carries a 2,500 lb. test rating.
This diamond or hollow braided polypropylene is tightly braided with 12 mil mono fibers.
It's our most popular line.
The extra firmness helps to keep the leads and floats from "falling through" the netting.
The braiding gives the surface extra texture so that the net ties tend to stay in place better.
Lead inserts can be used with this #16 size.

https://www.memphisnet.net/product/4976/rope-braided-polypropylene-poly-yellow

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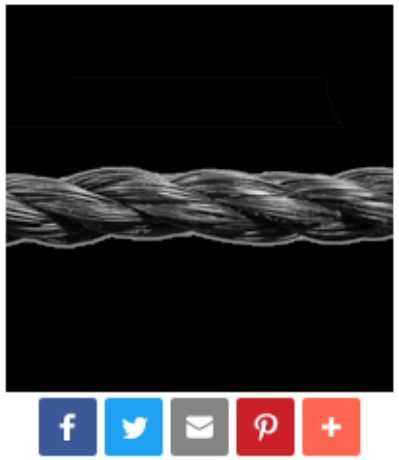
3/8” Potwarp

- Combination of polypropylene and polyethylene
- May have higher resistance to UV rays than the braided poly rope

Don’t go smaller than 3/8” diameter.
Expect to change it every 3-5 years.

Pros: floats, easy to handle, easy to attach loggers to (you can weave parachute cord and/zip tie them into the rope - see photos on right), strong

Cons: may degrade faster than polyester



Potwarp, 3/8 in. by 1,200 ft.

Write a Review

Stock Number: WARP6

$110.45

1 ADD TO CART

DESCRIPTION | REVIEWS | Q&A

A combination of polypropylene and polyethylene.
For both power or hand lifting of traps.
This rope has a test strength of approximately 2,300 lbs.
Black color for high resistance to sun's ultraviolet rays.

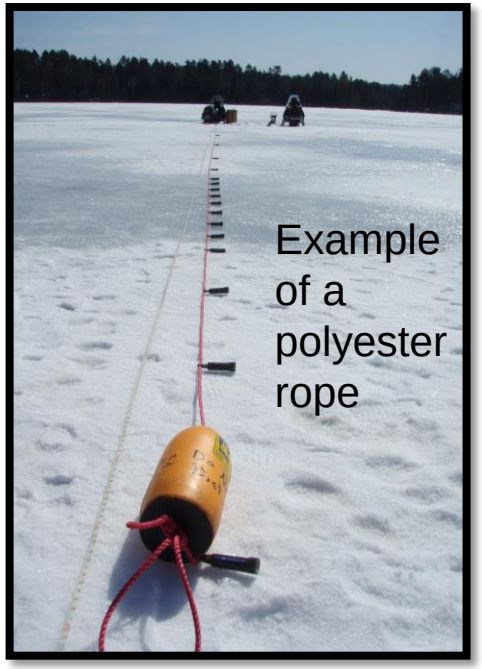
https://www.memphisnet.net/product/1980/rope-twisted-potwarp

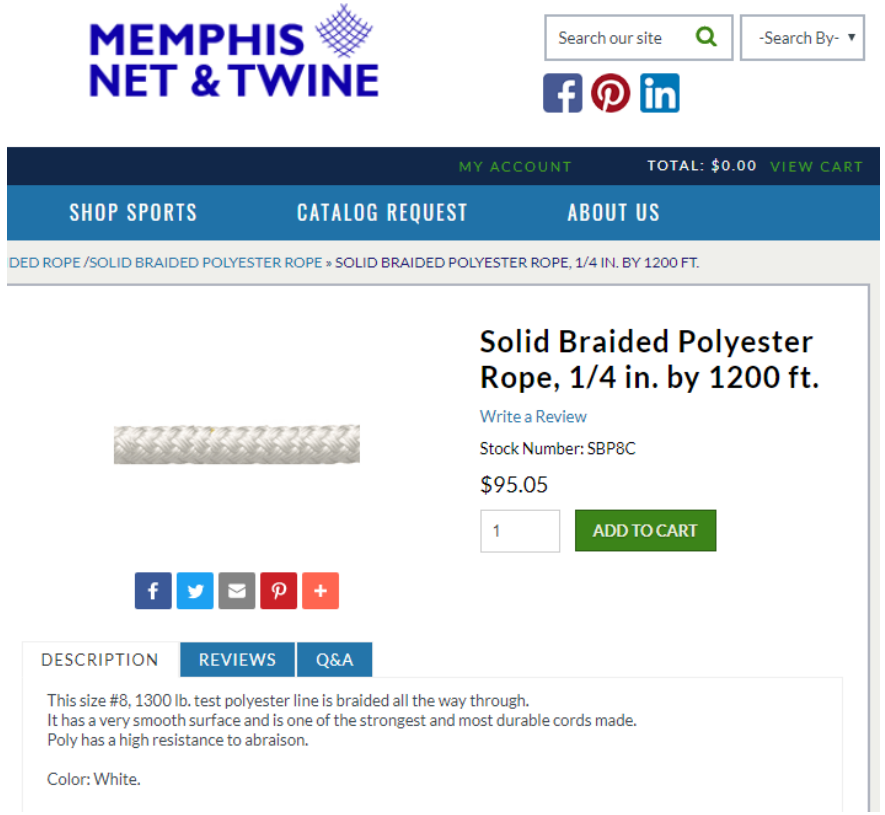
1/4” Solid braided polyester rope

¼” will fit through holes in the proV2 sensors (don’t go smaller diameter than ¼”)
Make sure it is *solid* (not hollow)

Pros: very strong, lasts longest (> 5 yrs), may stretch less, can run the line through the holes in the proV2 loggers.
Cons: doesn’t float, not as easy to handle as the larger diameter rope, more expensive than poly if you go with a ½” diameter line, can’t weave/zip tie the loggers into the rope.

¼” polyester rope fits through this hole





https://www.memphisnet.net/product/6020/rope-solid-braided-polyester

Attaching loggers to the instrument line

Poly rope or potwarp –

- You can run **zip ties** through the weave of the rope and connect them to the temperature logger. **Use two zip ties. Make sure they are heavy duty and UV resistant**.
- Another option is **parachute cord** (see photo below)
- Clips and carabiners are *not* recommended (some people have tried these and found it was hard to find clips that would attach to the loggers (they were mostly too big or too small)) and also had corrosion problems).

The parachute cords should be woven into the instrument line braid, and tied with an overhand or figure eight knot to secure the parachute cord to the line. Next, slide the instrument onto the parachute cord and tie an overhand or figure eight knot into the cord to keep the instrument in place on the line. Next, the parachute cord is woven into the instrument line again, and a clove hitch with several half-hitches can be used to lock the parachute cord to the line

Attaching loggers to the instrument line

¼” Polyester rope –

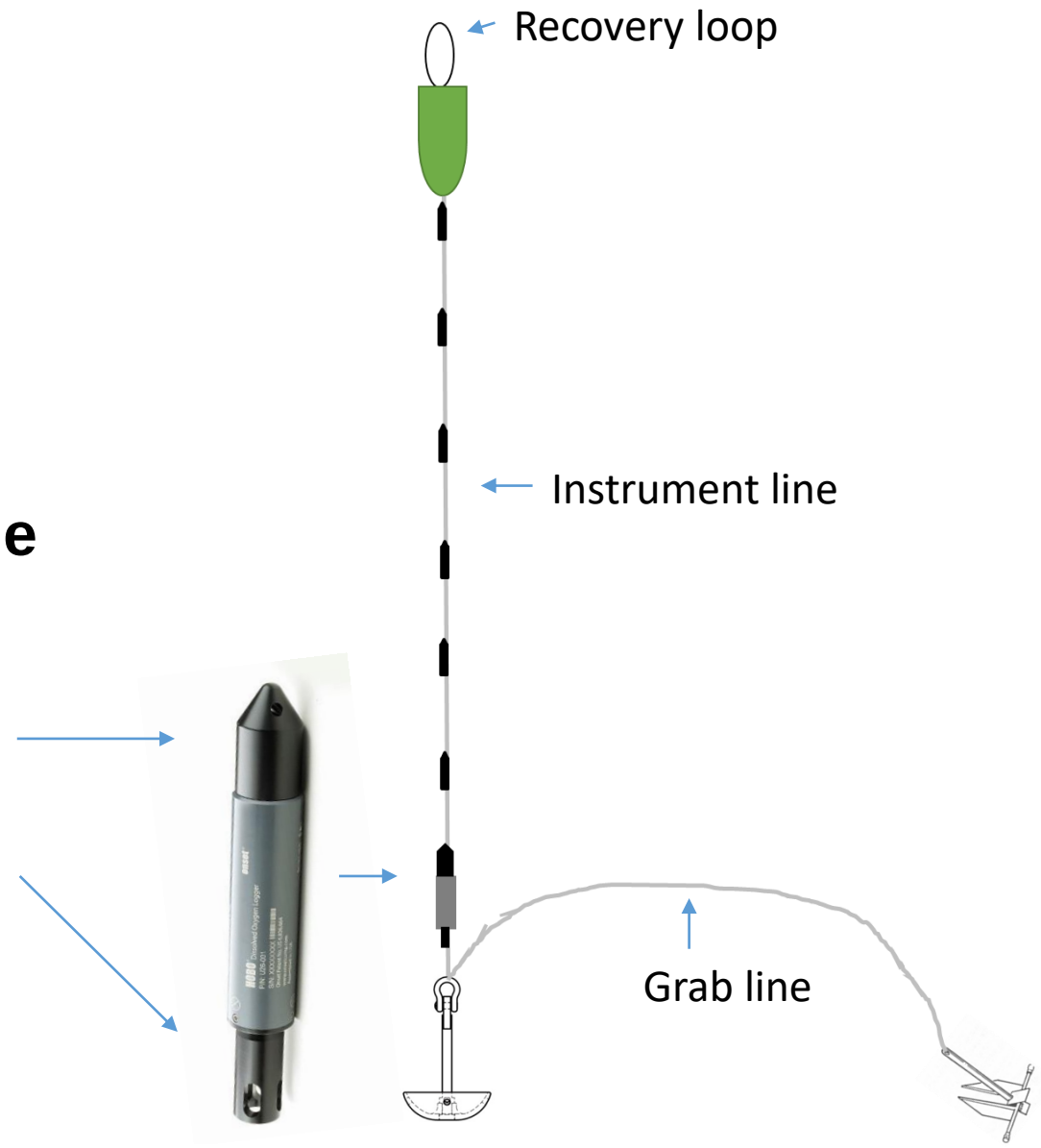
- You can run the rope through the holes in the proV2 sensors and secure them with zip ties (put zip ties above and below them), supplemented with electrical tape.
- If you run the line through the holes in the proV2s and end up needing to replace an individual logger, you may have to pull off all the other loggers to get to it (depending on where it is positioned)

¼” polyester rope fits through this hole

Attaching DO sensors to the instrument line

If you are using DO loggers, use two tie points, one at the top and another at the bottom to keep the logger in line with the rope to keep it from changing its depth in windy conditions.

(this isn't an issue with the proV2 temperature sensors because the sensors are near the attachment/pivot point)




WARRANTY VOID IF SCREWS ARE REMOVED.
Do not open. Damage will result.
WARNING: Fire, explosion, and severe burn hazard.
Do not recharge, disassemble, heat above 100° C,
incinerate or expose internal battery to water.

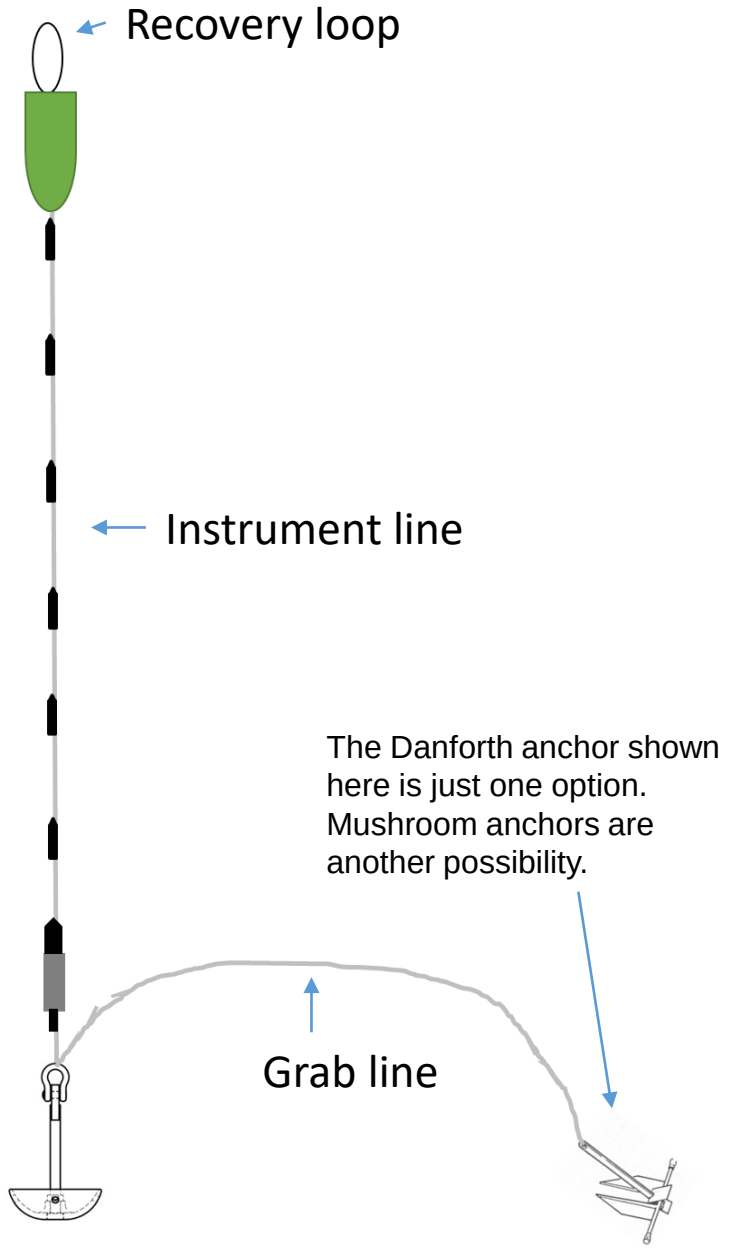
Grab line

Strongly recommended!
The line needs to float off the bottom enough to allow it to be snagged by a grappling hook.

Recommendations -

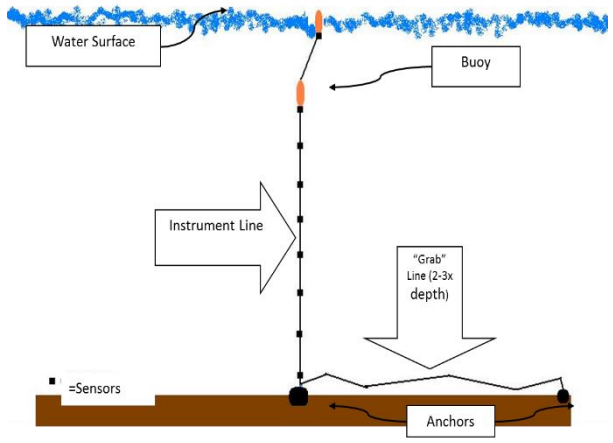
- Use floating line (poly or potwarp).
- Supplement the floating line with small gillnet-type floats (see slide 14; how many you need depends on the length of the grab line, the weight of the rope, and the placement of the anchor).

People have had success snagging the grab line with a grapple hook.



Primary floats/buoys

- Should be closed cell, not hollow plastic
- Go big (e.g., 14” instead of 10”) if you can
- Consider using two (see slide 3)
- Clearly mark/label – e.g., write “Do Not Disturb, Research Buoy”



Float, "Buoy Style" PVC, 6 in. dia. by 14 in., White

Rated 5.0 out of 5, based on 3 reviews
Read Reviews | Write a Review

Stock Number: MB6XXW

$10.48

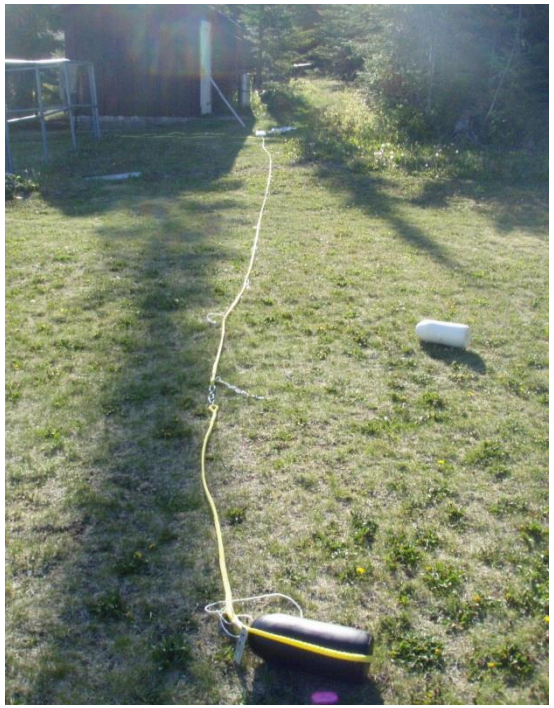
Buy 1 or more for $10.48 each
Buy 25 or more for $8.95 each

1 ADD TO CART

DESCRIPTION | REVIEWS | Q&A

This float has a 6 in. outside diameter and is 14 in. in length.
It has a 1 in. hole diameter and has approximately 170 oz. buoyancy.

https://www.memphisnet.net/product/3784/floats-pvc-buoy



Examples of two-buoy deployments

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Primary floats/buoys

If risk of vandalism or disturbance is high and more discrete buoys are necessary, options to consider include:

- Painting the top of the float black
- Using a smaller float
- Placing the top buoy below the surface
    - Set float at depth that will not freeze in the ice or be hit with a propeller (> 1 m) but will still be visible and reachable for retrieval

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Regulations in some place do not allow sub-surface deployments. In these situations you may want to make the buoys very visible.

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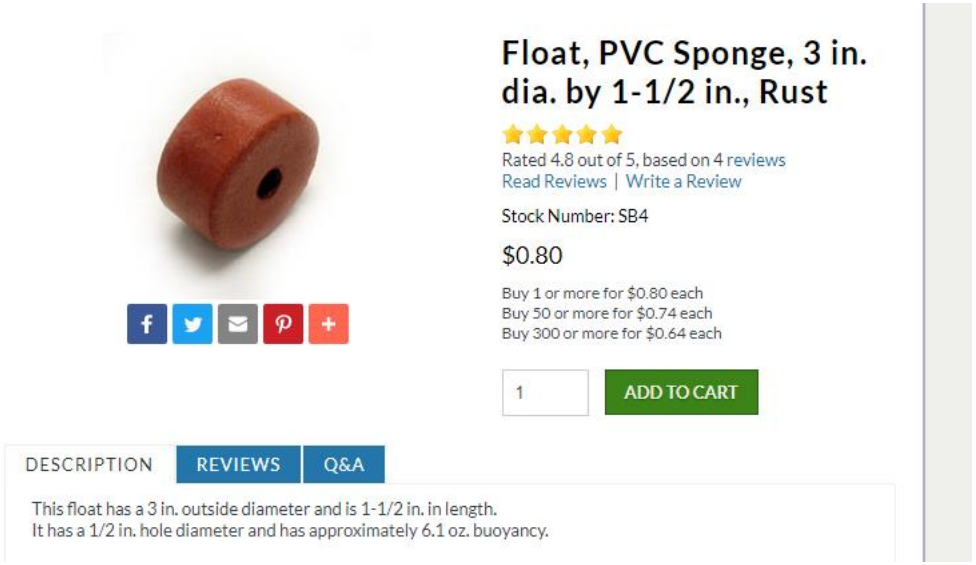
Secondary floats

- Small gillnet-type floats (many options – below is just one)
- We recommend adding these to the instrument line (e.g., between loggers) and grab line. They are cheap and can only help!



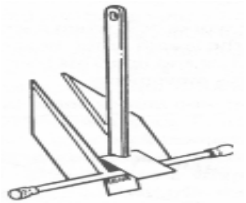
https://www.memphisnet.net/product/3769/floats-pvc

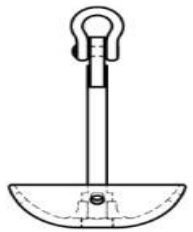
https://www.memphisnet.net/category/floats

Anchors

Many potential options!

- Mushroom anchors
- Concrete blocks (one is typically 25-30 lbs)
- Homemade concrete anchors with bent rebar (sometimes people put these in plastic coffee cans to make them easier to handle)
- Danforth anchors
- Steel plates
- Mesh bags with rocks for remote areas





How heavy? It depends. Considerations include -

- How long is your instrument line? (the longer the line, the heavier the weight)
- Do you have a surface buoy only? If so, it may be more prone to movement due to wind, so you may need a heavier weight
- How heavy a weight can you lift? In most cases you will need to pull the anchor up in order to download the data.
- How much boat activity is there? The biggest danger may be from people accidentally (or purposefully) catching and dragging the line. In busy areas, you may want to use a heavier weight to make it harder to drag.

Note: the concrete anchors are abrasive. Don't tie rope directly around them. Use chains or cable that you then tie the rope around.

Two concrete blocks = 50 lbs

Anchors

Many potential options!

- Mushroom anchors
- Concrete blocks (one is typically 25-30 lbs)
- Homemade concrete anchors with bent rebar (sometimes people put these in plastic coffee cans to make them easier to handle)
- Danforth anchors
- Steel plates
- Mesh bags with rocks for remote areas

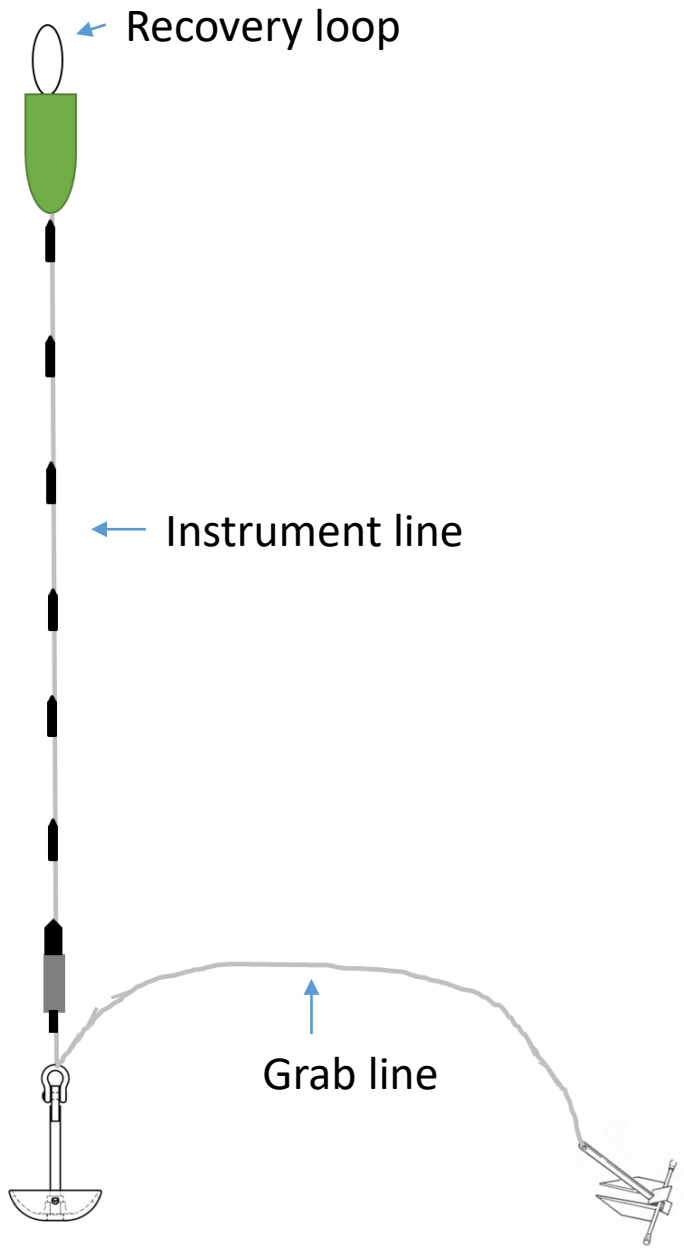
Tips

Don’t skimp!

Don’t skimp on the recovery loop!
Bigger is better

Err on the side of excess anchors
and excess buoyancy

Secure the loggers with ~~heavy duty zip ties~~
paracord and electrical tape to act as a
bobber stop




PICK-SIX SAMPLER
Choose five beers from the flagship menu and one beer from the specialty menu.
Coconut Porter
Reserve BB Scotch
Reserve BB Stout
Barley Wine


Questions?