Then and Now: The Evolution of Oceanographic Sampling Equipment

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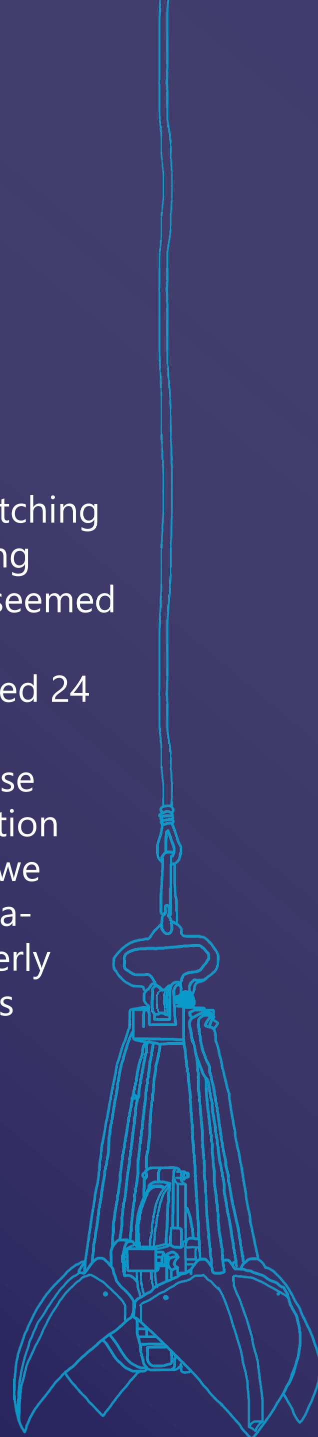
Years ago, I was running Winkler titrations in a tiny shipboard lab, watching the slow drip of reagents into dissolved oxygen samples while getting tossed by Puget Sound. To me (a seasick undergrad volunteer), this all seemed unnecessary – didn't we have an oxygen sensor on the CTD? Why was I spending so much time processing one sample when the sensor captured 24 samples per second?

Today I understand the importance of sensor verification, and those thoughts were nothing more than digital-age naiveté. The Winkler titration method was a groundbreaking development in 1888, and the fact that we still use it today is a testament to its value. Before CTDs, early oceanographers once roamed the high seas with just their wits and whatever cleverly wrought methods and contraptions they could imagine. And these tools set the stage for the innovations that we have today - our growing knowledge is proof of that. But what did early oceanographers use for their research, and what kind of technology have these early tools been replaced with?



Quantifying Currents

Ocean currents are the product of several oceanographic forces and they play a key role in Earth's climate. Oceanographers and those just setting sail for the evening both have a vested interest in the magnitude and direction of ocean currents.

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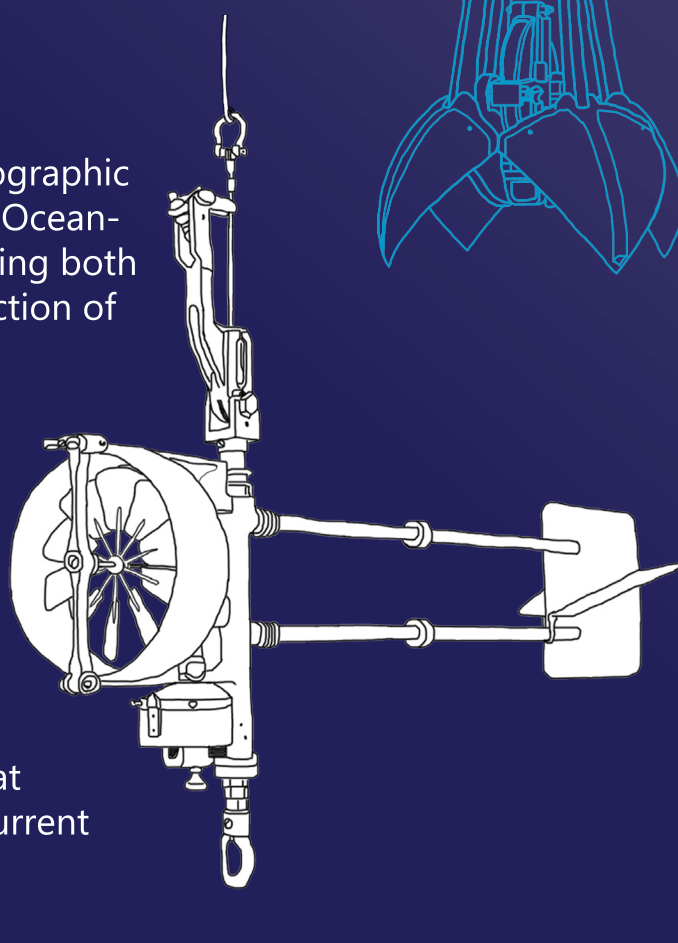
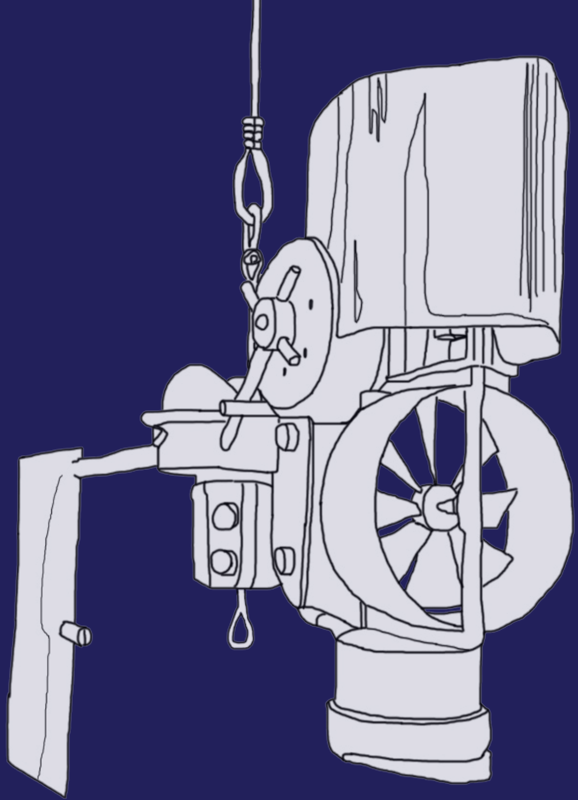
Mechanical flowmeters, such as the Ekman Current Meter, were the preliminary tools for measuring currents. They resembled airplanes with their wings replaced by a rudder - a propeller on the front is spun when faced with an oncoming current while an internal mechanism counts the number of revolutions. Many were equipped with fins and a compass that orient the tool in the direction of the strongest current





and identify which direction it is coming from. Unfortunately for oceanographic pioneers, most were unable to "save" more than one measurement. The scientist had to haul the device back up to the surface, manually record the data, reset the device, then redeploy – a process that makes cataloguing the ocean's currents a daunting task.

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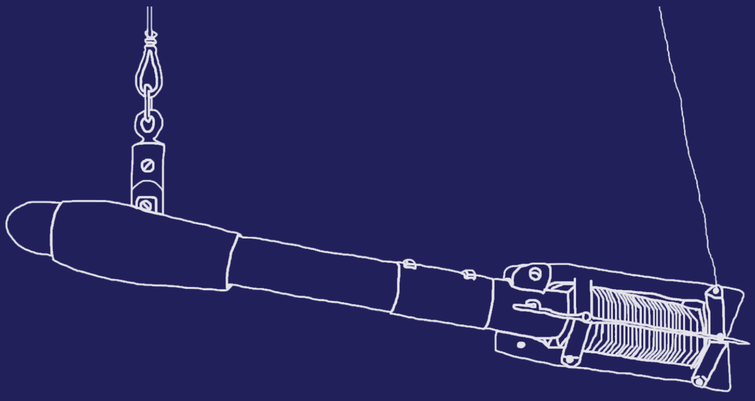
Like most innovations, mechanical current meters have been replaced by electronic tools. The Acoustic Doppler Velocimeter (ADV) and Acoustic Doppler Current Profiler (ADCP) rely on sound to measure currents. Both the ADV and ADCP emid sound waves that are affected by the motion of the water, and calculate current data based on the resulting signal.
Additionally, devices such as the RAFOS and ARGO floats can follow the currents while acoustic or GPS tools track its motion in the water, providing Lagrangian measurements that move along with the current's direction. These sorts of devices are useful for both identifying a current's speed as well as the direction as currents swirl the float around the globe.

Hot or Cold?

Beyond poking a toe into a swimming hole, some pretty impressive devices have been adapted for this measuring water temperature.



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The reversing thermometer worked like a regular mercury thermometer, where a change in temperature causes internal fluid to expand or contract within a capillary. To preserve the temperature reading at depth, inverting the thermometer constricted the capillary, trapping the mercury in a fixed position that doesn't change as the thermometer is pulled back on deck. Chains of these could be strung together like a string of salps to obtain a gradient of temperature descending through the water column.

The mechanical bathythermograph is the analog predecessor to the Expendable Bathythermograph (XBT). Shaped like a torpedo, it had two connected pieces of metal that experienced different rates of expansion from temperature and pressure changes as it descended the water column. The expansion of the metal moved a stylus that scratched a profile of pressure and temperature onto a slide (usually of glass or gold) that could be interpreted upon retrieving the device.

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With the onset of electronic sampling, modern temperature sensors utilize high-accuracy thermistors that change electrical resistance in accordance with temperature. Thermistors provide dramatically improved measurement accuracy and resolution and more convenient sampling – they can respond consistently to extremely small changes in temperature, electronic signals are easier to transmit than a chain of thermometers, and graphing a modern temperature profile with software is a more flexible version of the physical graph drawn by the bathythermograph. Today, sensors like the SBE 3plus are mainstays on state-of-the-art research vessels, providing most of the “T” data in global CTD casts.

Casting a Wide Net

Gaze into a parcel of water and you’re likely to find a thriving community of miniscule critters. Our understanding of the distribution, density, and behavior of tiny marine organisms has evolved over time thanks to the development of some important tools.

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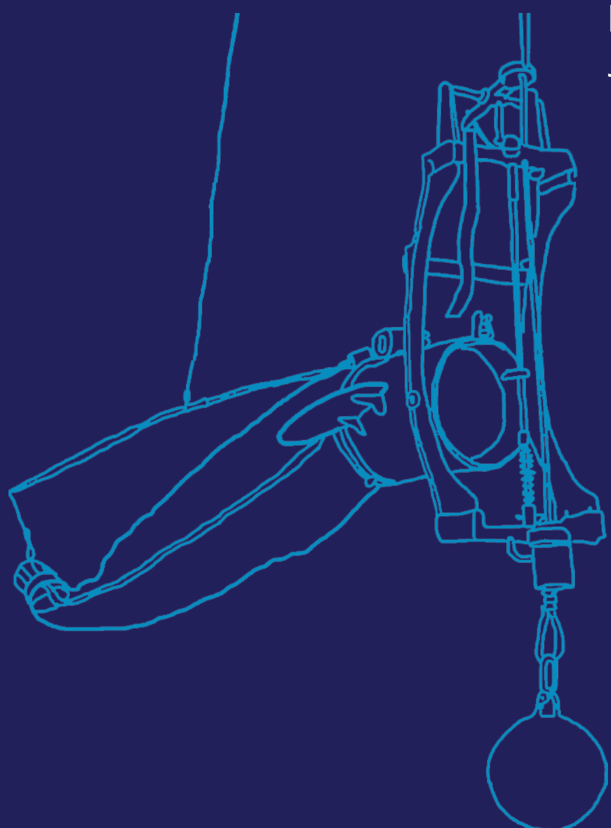
The Hensen net, devised in the late 1800s, facilitated the first quantitative zooplankton studies. German scientist Viktor Hensen’s invention consisted of a mesh net with a bucket on the end to collect its sample, and it could only be towed vertically. Legend has it that in order to conduct his research, Hensen tore down the silk curtains in his house to construct his net.



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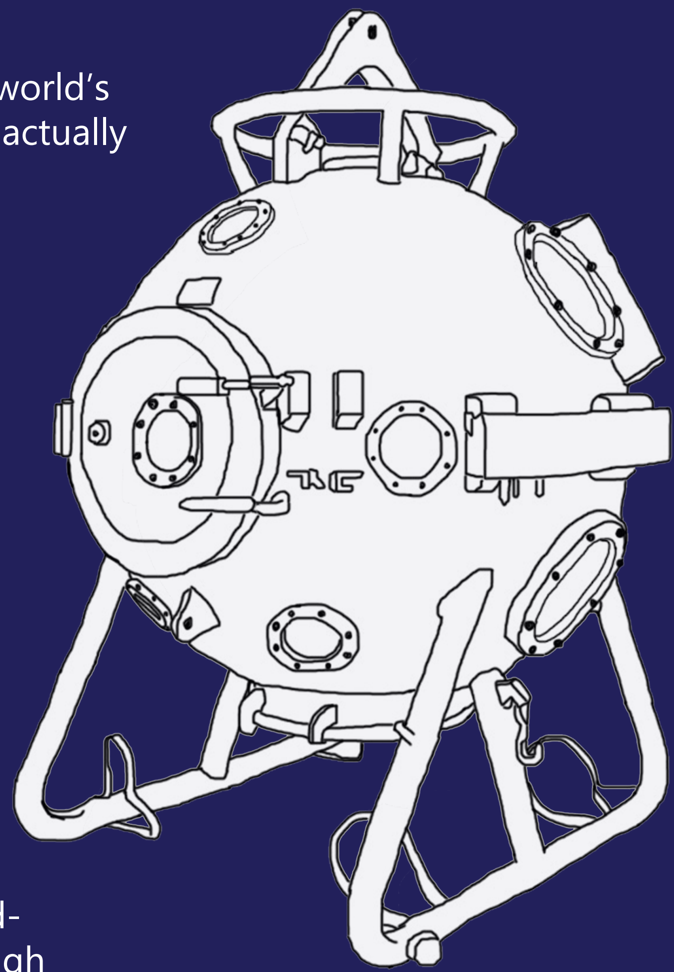
Jumping ahead to the early 1900s, the Nansen net is a tool that is still used to this day. It can close itself while deployed through mechanical means (and later from electrical signals), collapsing at a chosen depth to sample a particular swath of the water column. This capability opened the door for discrete depth sampling and allowed biological oceanographers to explore the vertical distributions of organisms.

We also have the bongo net, a device used for zooplankton sampling. Two 0.5-1 m openings allow for large volumes to be towed, replicate sampling, or multiple mesh sizes to be utilized - sizes that have been calculated and planned out to collect particular organisms. Flow meters and sensors like the 39plus Temperature and Pressure sensor can be attached for additional data collection, providing oceanographers with more quantifiable information to include in their studies.

Undersea Exploration

Sensors can paint a quantifiable picture of the world's oceans, but they can't paint a literal picture. To actually see what's below the waves without undersea cameras, we sent intrepid individuals into the deep ocean.



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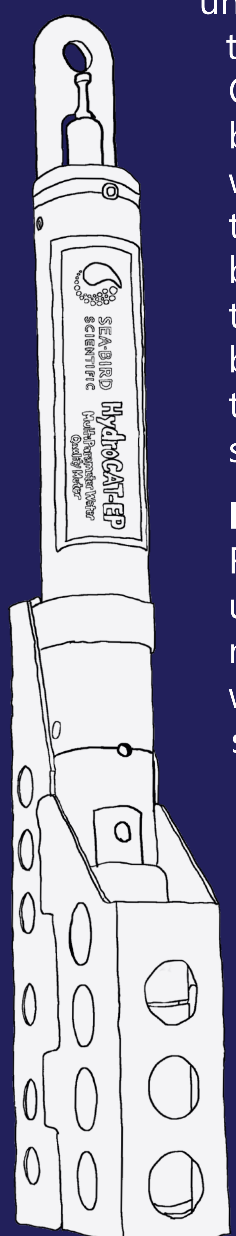
The Bathysphere is an iconic tool in marine science. Shaped like an eye, it's a spherical vessel designed to uncomfortably take a couple of divers to depths beyond the safe limit for traditional diving with a tank and fins. The pressure-tolerant hull had a tiny window for passengers to peer into the bizarre undersea world. Invented in the late 1920's by engineer Otis Barton, he and biologist William Beebe were the first to utilize this creation to conduct record-breaking deep-sea dives. Though this method of descending in a metal bubble may sound limited by today's standards, the Bathysphere opened up the world of deep-sea diving, showing the world how little we know about the ocean.



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ROVs, or Remote Operated Vehicles, can safely handle the task for us. Due to the danger and expenses behind casting our brilliant minds into the void, many studies are opting to utilize robots armed with cameras and compact CTDs such as the SBE 49 FastCAT. These submersible robots are advancing quickly, and are becoming our eyes and hands in the underwater landscape. They come in all different shapes and sizes, and have been engineered for specific purposes.

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