# Measuring Water Current Velocity

*Water current* is the movement of water from one location to another. Ocean water currents are driven by wind, tides, and differences in water temperature and density from sea surface to seafloor. Since water current will impact what you can grow and how you grow it (i.e. your farm designs) ocean farmers need to pay careful attention to water currents while evaluating the suitability of potential farm sites.

Ocean currents are typically measured in knots, a measure of distance over time. One knot is equal to one nautical mile per hour (slightly more than a standard mile per hour).

1 nautical mile = 1.15 miles = 1.85 kilometers
1 knot = 1 nautical mile per hour = 1.15 miles per hour
1 knot = 20.251969 inches per second = 51.44 centimeters per second

Different crops tolerate different current velocities and exposure conditions. In general, ocean farmers growing a mix of seaweed and shellfish should seek sites with currents that reach 1-2 knots during peak tide stages in areas with moderate protection from prevailing winds and waves.

Typically, ocean farms are arranged either parallel or perpendicular to currents—with the general recommendation to orient lines parallel to current flow. Longlines that are oriented perpendicular to current are subject to greater drag than longlines that are oriented parallel to current. Exact orientation should also account for prevailing wind and waves.

There are lots of ways to glean information about average water currents on or near your farm site before stepping foot on a boat. Regional tide and current data is available through the National Oceanic and Atmospheric Administration (NOAA) website. NOAA's Tides & Currents map (https://tidesandcurrents.noaa.gov/) and DeepZoom.com use data collected from weather buoys and tide gauges to plot tide and current data across the country. Explore these resources to get a sense of regional tide and current information before heading out to collect site-specific data.

When you are ready to measure water current on your site, there are a few different approaches that you can take—ranging from measuring surface currents with simple tools to collecting detailed profiles of the current speed and direction from sea surface to seafloor. The more detail that you need, the higher the cost of the equipment and analysis.

The cheapest and simplest way to measure surface current on your site is to measure the time it takes for a floating object to move between two fixed points. The floating object (also called a *drifter)* could be your boat and the two fixed points could be landmarks or buoys. Or, with your boat anchored in place from the bow, you could drop a small buoy, orange, or other floating object into the water at the bow of your boat and measure the amount of time it takes the object to reach the stern (and then retrieve the object, of course, and repeat as needed). This method requires a floating object, a timing device, and at least one observer to drop and retrieve the object into the water and record its travel time between the two points. Then, using the equation *speed = distance / time*, you can calculate the current speed by dividing the distance the object traveled by the travel time.

For example:
If you drop a small buoy off of the bow of a 32' boat and it takes 40 seconds for the buoy to reach the stern, your current speed is approximately 0.5 knots.

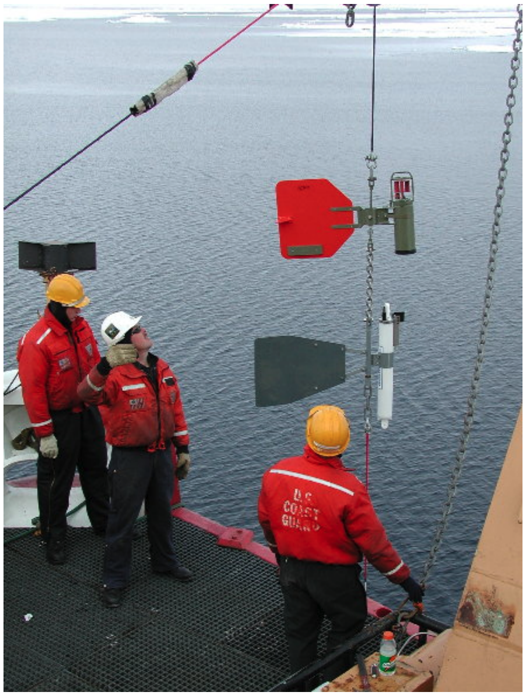
Speed = 32 feet / 38.4 seconds
= (32 feet * 12 inches/foot) / 40 seconds
= 384 inches / 40 seconds
= 9.6 inches / second
= (10 inches / second) / (20.251969 inches / second)
Speed = 0.474028 knots

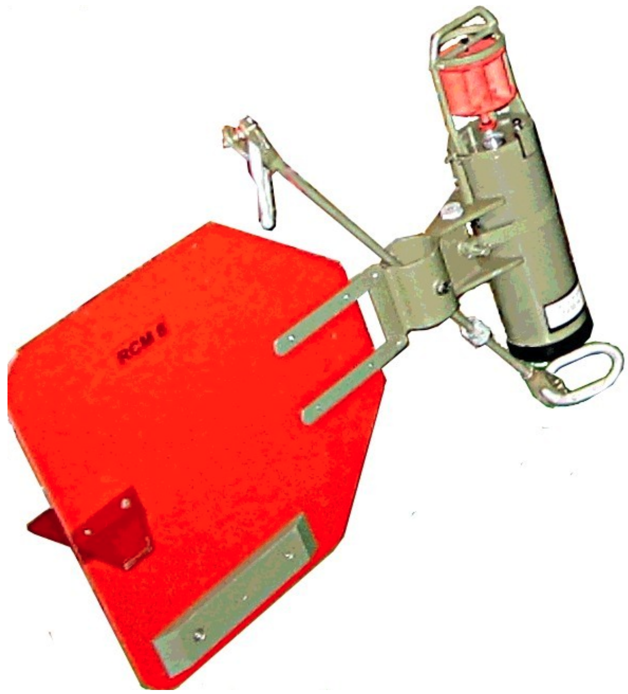
This observer-object method is good for quick current measurements, but is limited in that it only provides data for a specific point in time. When using this method, be sure to record the date, time, and tide stage; collect on different days and different tide stages, and then compare your results.

If you are interested in continuous current measurements over an extended period of time, consider using a mechanical current meter, a tilt current meter, or an Acoustic Doppler Current Profiler, explained in detail below.

A mechanical current meter measures current from a fixed position within the water column. Generally, a mechanical current meter consists of a propeller (to detect current velocity), a vane (to determine the direction of flow), a clock, and a recording unit to log currents over time. This type of meter works best when attached to an anchored object, such as a buoy or boat.

There are lots of different models of mechanical meters, which come in different sizes and range in cost from a few hundred to a few thousand dollars. Before purchasing, make sure the mechanical meter is calibrated to read ocean currents (and has a sensitivity range that is suitable for your site conditions).



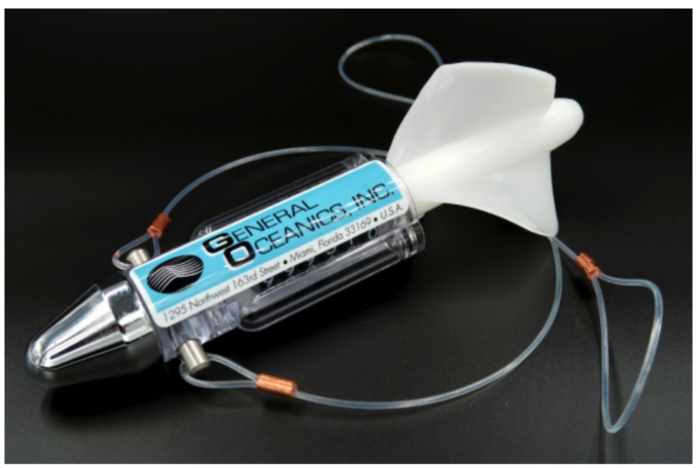




Image: Crewmembers on the USCGC Polar Star deploying monitoring devices; the current meter has the red vane (top L).[1] Detail of rotor current meter (top R).[2] The General Oceanics flowmeter is much smaller than the RCM, just under 9” long (bottom).[3]

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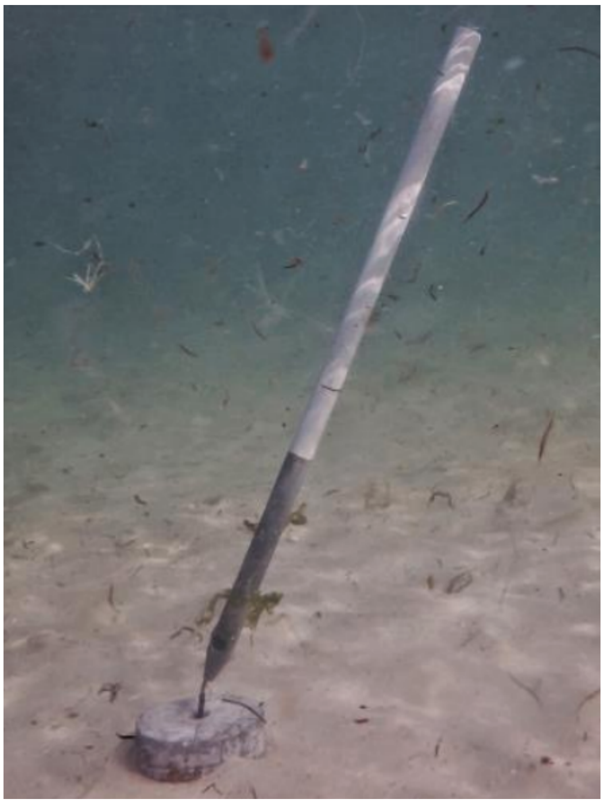
[1] USCGC Polar Star WAGB-10 (nd) Chukchi Borderland Project: Daily Updates from our Teacher at Sea. August 23: Mooring Deployment. Photograph of crewmembers deploying an SBE-16 (bottom) and current meter (red vane, top).
[2] Detail of current meter Wikipedia.org (2012) Rotor current meter RCM 8 with red vane and Savonius-rotor. Retrieved online 6/22/2020 https://en.wikipedia.org/wiki/Current_meter.
[3] Environmental XPRT (nd) General Oceanics Model 2030R Flowmeter, Current Meter, Digital, Mechanical, w/ Standard Rotor. Retrieved online 06/22/2020 https://www.environmental-expert.com/products/general-oceanics-model-2030r-flowmeter-current-meter-digital-mechanical-w-standard-rotor-568623

A tilt current meter is a simple tool consisting of a meter and data logger housed in a vertical PVC pipe that is tethered to a ballast fixed in position on the seafloor. The PVC pipe bends in the direction of current flow, and the meter measures and logs tilt (angle) and direction (or bearing) using the *drag-tilt principle*.[4] Tilt current meters are typically deployed and retrieved by divers. But, in addition to anchoring a tilt current meter to the seafloor, ocean farmers have attached tilt meters to growlines to better understand current at the depth that crops are planted. The TCM-1 Tilt Current Meter is one type of current meter that has been deployed on ocean farms. TCM-1 models range in cost from $1000-$1500 each.[5]



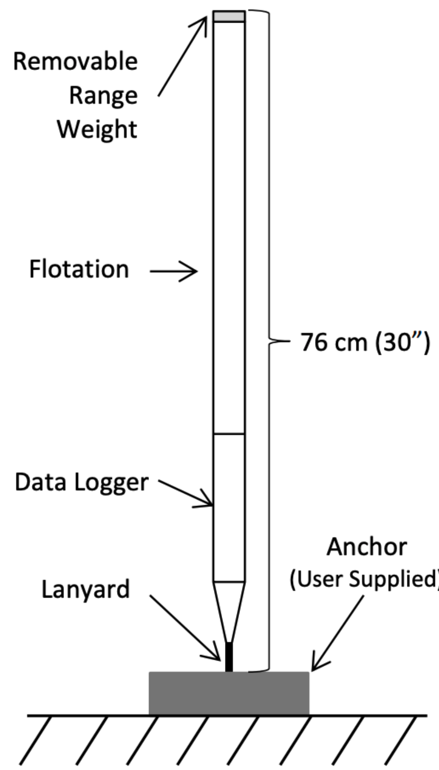



Image: Current tilt meter on the seafloor (L), diagram (R)[6]

[4] “Within a stationary current flow, a tethered object will experience a tilt induced by the force balance of buoyancy, drag, and mooring tension.” Anarde, K. and Figlus, J. (2017) Tilt Current Meters in the Surf Zone: Benchmarking Utility in High-Frequency Oscillatory Flow. *Coastal Dynamics*. Paper No. 050 pp.923-932. Retrieved online 06/22/2020
https://coastaldynamics2017.dk/onewebmedia/050_Anarde_Katherine.pdf
[5] Lowell Instruments LLC TCM-1 Tilt Current Meter
https://lowellinstruments.com/products/tcm-1-tilt-current-meter/#:~:text=The%20TCM%2D1%20Tilt%20Current%20Meter%20measures%20current%20using%20the,for%20measuring%20tilt%20and%20bearing.
[6] Lowell Instruments, LLC (2019) TCM-1 Current Meter Product Data Sheet, Version 10, October 2019.
https://lowellinstruments.com/download_files/TCM-1_Data_Sheet.pdf

An Acoustic Doppler Current Profiler (or ADCP) uses the *Doppler shift principle* to measure speed and direction of ocean currents.[7] The Doppler shift or Doppler effect is used to describe the change in frequency of a sound or light wave in relation to an observer. Think of how the pitch of a fire truck siren increases as it approaches you and then lowers after it passes: this is the Doppler shift.

An ADCP emits high-frequency sounds in the water and measures the way that the frequency changes as it scatters off of particles in the water. Since the particles are moving at the same speed as the water, the frequency shift is proportional to the current.[3] An ADCP is also able to use its transducers to determine the direction of current, and can measure current speed and direction from sea surface to seafloor (or a profile of the current throughout the water column).

ADCPs come in different shapes and sizes. Some are designed to be mounted to the hull of a boat, others anchored to the seafloor, attached to ROVs, or rigged to be towed by a boat through a body of water. In general, an ADCP consists of a few main parts: an amplifier, a receiver, a clock, a compass, a temperature sensor, and a pitch-roll sensor.

[7] NOAA (2013) Acoustic Doppler Current Profiler. https://oceanexplorer.noaa.gov/technology/tools/acoust_doppler/acoust_doppler.html

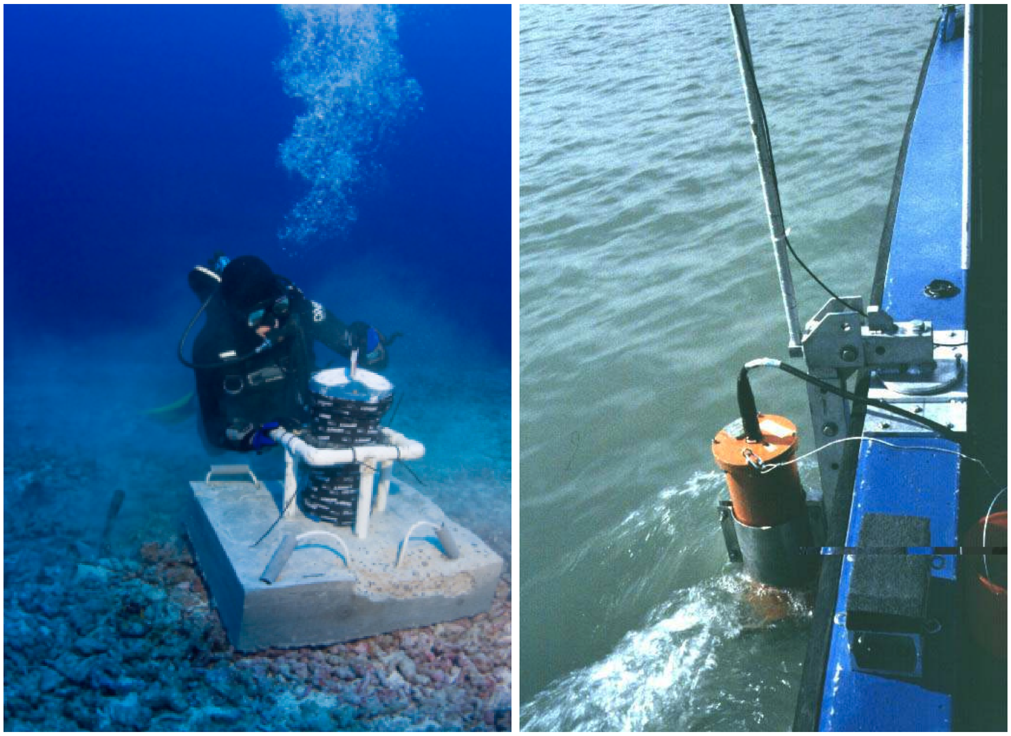


Image: Example of ADCP units (top).[8] An ADCP anchored to the seafloor (bottom L).[9] An ADCP mounted to the side of a boat (bottom R).[10]

Use an ADCP to measure current on your site if you need to map differences in flow from surface to seafloor across the entirety of your site. The cost of renting an ADCP unit ranges from $600/day to $6000/month depending on the type and supplier.

[8] Teledyne Marine (2020) RD Instruments Sentinel V ADCP. http://www.teledynemarine.com/sentinel-v-adcp
[9] NOAA Acoustic Doppler Current Profiler https://oceanexplorer.noaa.gov/technology/tools/acoust_doppler/acoust_doppler.html
[10] USGS Software Deployment Photos (nd) ADCP Mount https://hydroacoustics.usgs.gov/software/deployment_photos/