**What is ADCP used for?**

An acoustic Doppler current profiler, or ADCP, is a device that uses sound waves to measure the speed and direction of currents throughout the water column. Understanding how water in the ocean moves provides important information about biological, chemical, and physical properties of the ocean.

### **How Does It Work?**

The ADCP uses the Doppler effect by transmitting “pings” of sound using a sequence of consistent rapid pulses that ricochet off particles suspended in moving water and reflect back to the instrument. Particles moving toward the instrument return waves with a higher frequency (or pitch), while particles moving away produce a lower-frequency return. Since the particles move at the same speed as the water that carries them, the difference in frequency between the sound waves the profiler sends out and the sound waves it receives can be used to calculate how fast the particle and the water around it are moving. The system tracks when each of the pings is returned; as pings that travel further (lower) will return later, this translates to current data across a variety of depths.

ADCPs use a series of acoustic transducers that emit and receive pings from different directions. The instrument can be mounted directly on a stationary object like a mooring buoy or even directly on the seafloor. They can also be mounted to a moving vehicle, such as ships or unmanned underwater and surface vehicles. On large research vessels, the ADCP is permanently mounted on the bottom of the ship’s outer hull.

As with other types of sonars, ADCPs are available in different frequencies. Higher frequencies, for example 300 kiloHertz (kHz), are useful in providing high-resolution data near the surface to a depth range of around 70 meters (230 feet). Lower frequency ADCPs, such as 38 kHz, will provide lower-resolution data to a depth range of up to 1,300 meters (4,265 feet), depending on surrounding noise levels in the ocean.

### **Why Is It Important?**

Measuring currents is a fundamental practice of physical oceanographers. By determining how ocean water moves, scientists can determine how organisms, nutrients, and other biological and chemical constituents are transported throughout the ocean. Because of its high resolution and ability to gather data deep within the ocean interior, the ADCP is an efficient tool for sampling a large section of the ocean in a limited amount of time.

Ocean waters have varied temperatures and in places like the warm Gulf Stream, the movement of water means the movement of heat. Heat transport in the ocean is a critical component of the global heat budget and thus plays an important role in Earth’s global climate. Nutrient transport is important for biological studies such as biomass concentrations, and sediment transport is important for geological studies such as river and beach changes over time. ADCPs can only measure temperature at the transducer (so at the transducer face, on the ship’s hull), but when used in conjunction with other measurements, the combination of temperature and currents is a powerful tool for study.

On a smaller scale, ADCPs are useful for helping to characterize the physical oceanography of a specific area and assessing currents near remotely operated vehicle (ROV) dive locations. Data collected from an ADCP can be used to inform dive planning and [ensure safe ROV deployment and recovery operations](https://oceanexplorer.noaa.gov/okeanos/explorations/ex1907/logs/nov18/nov18.html).

**How does ADCP work?**

The ADCP works by transmitting "pings" of sound at a constant frequency into the water. (The pings are so highly pitched that humans and even dolphins can't hear them.) As the sound waves travel, they ricochet off particles suspended in the moving water, and reflect back to the instrument.

## **Working principle**

ADCPs contain [piezoelectric](https://en.wikipedia.org/wiki/Piezoelectricity) transducers to transmit and receive sound signals. The traveling time of sound waves gives an estimate of the distance. The frequency shift of the echo is proportional to the water velocity along the acoustic path. To measure 3D velocities, at least three beams are required. In rivers, only the 2D velocity is relevant and ADCPs typically have two beams. In recent years, more functionality has been added to ADCPs (notably wave and turbulence measurements) and systems can be found with 2,3,4,5 or even 9 beams.

Further components of an ADCP are an [electronic amplifier](https://en.wikipedia.org/wiki/Electronic_amplifier), a [receiver](https://en.wikipedia.org/wiki/Receiver_(radio)), a clock to measure the traveling time, a [temperature sensor](https://en.wikipedia.org/wiki/Temperature_sensor), a compass to know the heading, and a pitch/roll sensor to know the orientation. An [analog-to-digital converter](https://en.wikipedia.org/wiki/Analog-to-digital_converter) and a [digital signal processor](https://en.wikipedia.org/wiki/Digital_signal_processor) are required to sample the returning signal in order to determine the [Doppler shift](https://en.wikipedia.org/wiki/Doppler_shift). A [temperature](https://en.wikipedia.org/wiki/Micro_processor) sensor is used to estimate the [sound velocity](https://en.wikipedia.org/wiki/Sound_velocity) at the instrument position using the [seawater equation of state](https://en.wikipedia.org/wiki/Speed_of_sound" \l "Seawater), and uses this to estimate scale the frequency shift to water velocities. This procedure assumes that the [salinity](https://en.wikipedia.org/wiki/Salinity) has a preconfigured constant value. Finally, the results are saved to internal memory or output online to an external display software.

**Processing methods**

Three common methods are used to calculate the Doppler shift and thus the water velocity along the acoustic beams. The first method uses a monochromatic transmit pulse and is referred to as "[incoherent](https://en.wikipedia.org/wiki/Coherence_(physics))" or "[narrowband](https://en.wikipedia.org/wiki/Narrowband)". The method is robust and provides good quality mean current profiles but has limited space-time resolution. When the transmit pulse consists of coded elements that are repeated, the method is referred to as "repeat sequence coding"[[1]](https://en.wikipedia.org/wiki/Acoustic_Doppler_current_profiler" \l "cite_note-1) or "broadband". This method improves the space-time resolution by a factor of 5 (typical). Commercially, this method was protected by US patent[[2]](https://en.wikipedia.org/wiki/Acoustic_Doppler_current_profiler" \l "cite_note-2) 5615173 until 2011. The pulse-to-pulse coherent method[[3]](https://en.wikipedia.org/wiki/Acoustic_Doppler_current_profiler" \l "cite_note-3) relies on a sequence of transmit pulses where the echo from subsequent pulses are assumed not to interfere with each other. This method is only applicable for very short profiling ranges but the corresponding improvement in space time resolution is of order 1000.

## **Applications**

Depending on the mounting, one can distinguish between side-looking, downward- and upward-looking ADCPs. A bottom-mounted ADCP can measure the speed and direction of currents at equal intervals all the way to the surface. Mounted sideways on a wall or bridge piling in rivers or canals, it can measure the current profile from bank to bank. In very deep water they can be lowered on cables from the surface.

The primary usage is for [oceanography](https://en.wikipedia.org/wiki/Oceanography).[[4]](https://en.wikipedia.org/wiki/Acoustic_Doppler_current_profiler" \l "cite_note-4) The instruments can also be used in [rivers](https://en.wikipedia.org/wiki/River) and [canals](https://en.wikipedia.org/wiki/Canal) to continuously measure the [discharge](https://en.wikipedia.org/wiki/Discharge_(hydrology)).

Mounted on [moorings](https://en.wikipedia.org/wiki/Mooring_(oceanography)) within the water column or directly at the seabed, water current and wave studies may be performed. They can stay underwater for years at a time, the limiting factor is the lifetime of the battery pack. Depending on the nature of the deployment the instrument usually has the ability to be powered from shore, using the same [umbilical cable](https://en.wikipedia.org/wiki/Umbilical_cable) for data communication. Deployment duration can be extended by a factor of three by substituting [lithium battery packs](https://en.wikipedia.org/wiki/High_capacity_oceanographic_lithium_battery_pack) for the standard alkaline packs.