

Lecture #14: Background

Lecture 14 deals with acoustical measurement techniques. As with all technology, things change quickly – some technologies endure and get expanded on (e.g., telephones, TV) and some get superseded and fade away (e.g. horse transportation, printed newspapers and books). In this lecture, we will look at both some older and newer (workable) acoustic technologies, and see visibly how things change.

The first topic is “Ocean Acoustic Tomography,” following a chapter in Medwin (Editor) written by Bob Spindel. This is a very clear and simple paper, and also has good basic technical detail. Note in particular Eq. (18.17) and the development leading up to it – this is a very clear example of doing the ocean inverse problem with acoustics! By and large, tomography finds its best usage in ocean thermometry these days – global warming is an ever more serious issue, and tomography has some good advantages for temperature measurement.

A very successful ocean technology is “float technology” in which a neutrally buoyant drifter is dragged along with the ocean currents. If one can track where the drifters are over time, one then can map the currents that produced the drift. This has been accomplished by having three or more large, lower frequency acoustic sources transmit to small drifting floats with (cheap enough) acoustic receivers in them. By measuring travel times of pulses from three or more sources, the floats can be triangulated. This is called RAFOS float system, and is described in basics in a small Wikipedia article (why not?). In a newer development, a global system of profiling floats (which bob up and down doing T, S, etc. profiling, rather than staying at a constant pressure surface) called ARGOS has been implemented, and there are many thousand of these floats deployed worldwide. Also, since there is now global GPS, the “acoustic position fix” for these profilers becomes less critical – the floats can get a GPS fix each time they surface. Just as GPS superseded coastal (radar based) LORAN-C fixes for navigation, it is displacing acoustics for fixes for floats and gliders *if* they can access the surface (winter in the Arctic, anyone? But summer might be ice free soon, alas.)

An interesting historical variant on the RAFOS float, used to track vertical current profiles (not horizontal) was the PEGASUS instrument, in which one dropped a free falling hydrophone package into the water, and then did a fix on it using a (three or more instrument) bottom acoustic transponder web. This is a cute concept, it worked – and now has been completely superseded by the Doppler Current Profiler technology! But please browse the article – it is a very interesting look at acoustic tracking, for one thing!

The next three instruments to be discussed are all based on acoustic backscatter – and all do very different things!

The inverted echo sounder (IES) is simply a bottom mounted pinger that looks at the travel time of pulse reflections from the ocean surface (which you can assume flat, to start). If the ocean is a 2-layer fluid (warm over cold) in which the top layer moves up and down (thickens and thins), then the travel time of the pulse changes with the movement. This type of ocean layer movement is called “First mode” movement, and the IES tracks it nicely! The article by Watts and Rossby is a classic PO article (at research level in JPO), but is easy enough to read. I would note that the IES technology is still very useful today – it just added a pressure sensor and is called PIES. It is cheap, easy, and efficient.

The next technology, the acoustic Doppler current profiler (ADCP), is an insanely successful one. It simply uses the Doppler shift one gets in backscattered returns from “neutrally drifting” particulates carried by ocean currents to measure those currents. There are four “JANUS faced” transducers looking out in different directions in a typical ADCP, and the difference between the dopplers in the different directions gives u , v , and w – the ocean current components. The devil is in the details, but for the basics of these instruments, the manuals on the vendor websites (a typical one is shown for the course) are plenty good. ADCP’s are being routinely attached to every mooring, AUV, and other platform in the ocean, as they provide beautiful vertical (or even horizontal) current profiles.

The final contestant in the backscatter device beauty contest is the simple backscatter imaging sonar. A nice article in Medwin (Editor) written by Dave Palmer about hydrothermal vent imaging is assigned as a reading in the course, as it is a “typical” usage. However, sidescan and multi-beam sonars for imaging the bottom, multi-frequency backscatter sonars for zooplankton quantification, and higher frequency imaging sonars for fish schools are just a few more examples of the many, many uses of backscatter sonars to measure the ocean, its biology, and the seabed. Numerous books exist on backscatter sonars, sonar imaging and its applications.

To conclude, we’ve just looked at a “taster’s sample” of acoustical oceanography devices. As mentioned before, a good scientist/engineer will be aware of all of these, as well as their non-acoustic competitors!!

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