Using acoustics to understand Texas-Louisiana shelf circulation

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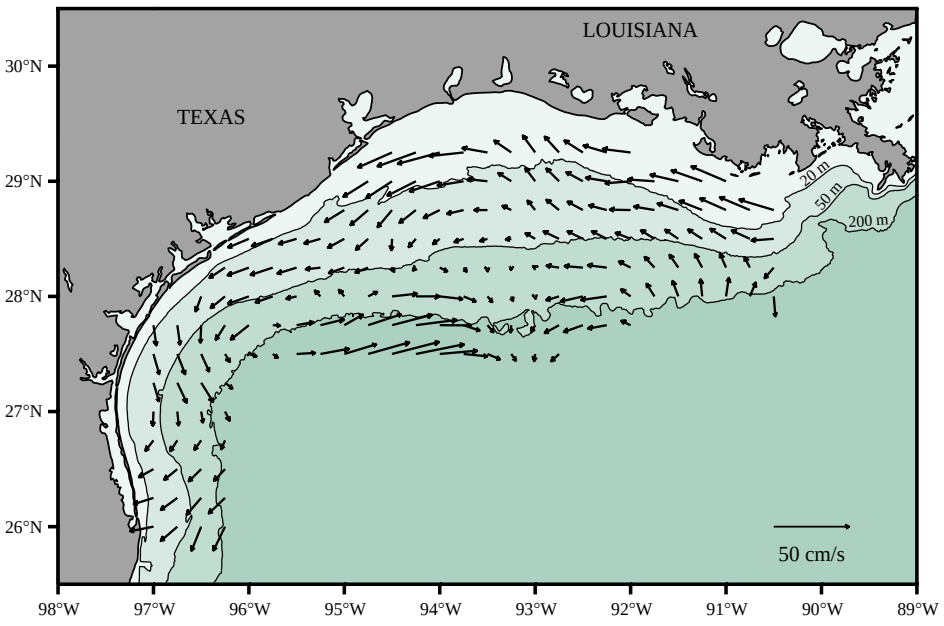
Over the outer Texas-Louisiana continental shelf, there are many oil and gas operations. The exploration, production, and transport of petroleum and other chemical products pose potential risks to the coastal environment when spillage occurs. In order to reduce risks to the environment and to marine resources, we must understand the physical processes and the circulation of the shelf water that may influence the stability of oil platforms, the transport of pollutants (such as from oil spills or discharge of drilling fluids), and the ecosystems of regions that may be affected by oil and gas operations. I addressed the variability and structure of currents over the Texas-Louisiana continental shelf in my dissertation.



The surface flow field derived from ADCP measurements at ten-meter depths during a November 1993 cruise in the Gulf of Mexico.

Acoustical technology has been extensively applied to many aspects of oceanographic studies. One of the tools for measurement of ocean currents is Acoustic Doppler Current Profilers (ADCPs). The ADCP can provide profiles of ocean currents with spatial coverage and resolution not practically attainable with conventional current meters. In addition, ADCPs can resolve sharp vertical velocity gradients and complicated vertical current structure. With a shipboard ADCP, the measurements can also be compared and contrasted with the hydrographic data. My dissertation research is based mainly on the measurements collected by the shipboard ADCP instruments.

To describe the prevailing circulation pattern, I analyzed the surface-current velocity data measured by the shipboard ADCP during February, July, and November 1993. Previous studies have inferred that the circulation pattern over this shelf region takes the form of a cyclonic (counter-clockwise) gyre from September to May and an anti-cyclonic (clockwise) gyre during the summer months. There was no direct evidence to support this conclusion, however. One of my research objectives was to supplement and refine this conceptual circulation pattern via direct measurements of currents.

First, to derive the prevailing, or low-frequency current from the measurements, I applied the statistical optimal estimation technique to rid the data of possible measurement noise and other high-frequency components of currents which are not of interest. The results agreed very well with those from other data sources and analyses. I also computed the spatial-correlation scales of currents, the distances by which the currents must be separated to flow independently of one another, which are perfectly consistent with the scales derived from the hydrographic data.

ADCP measurements provide high-resolution vertical profiles of current velocity, so I also used the data to study the vertical structure of currents. I used the "empirical orthogonal function" (EOF) technique or "principal component analysis" for this part of my investigation. By means of this technique, the principal component of the currents through the water column was derived and discussed for the data collected along the 50-meter and 200-meter isobaths in the shelf region. The results were consistent with the dynamic interpretations of shelf currents.

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Editor's Note: Hsien-Wen Chen is currently a postdoctoral research associate in the LATEX program. He continues to research the physical oceanography of the Texas-Louisiana shelf in order to better understand its circulation.