BAYOUS AND BLUE NORTHERS

Understanding the Role of Cold Front Passages in Coastal Ecosystems

By Elizabeth Coleman

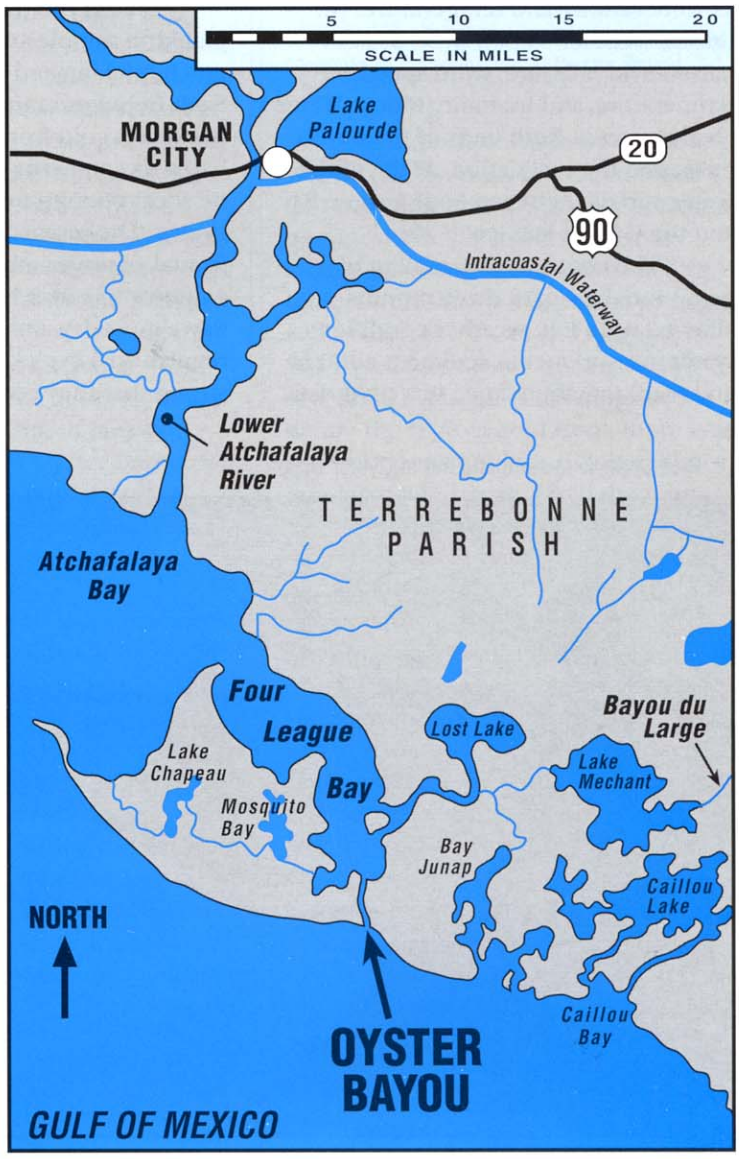
February through April of 1994 was not the kindest season for working in Louisiana's coastal bays and estuaries. The weather was often cold and windy or raining, and boat travel was rocky. Insect pests formed a constant nusiance. Continual vigilance was needed for water moccasins, alligators, and marauding raccoons that pilfered unsecured food. But to researchers from three LSU coastal and marine research groups, who spent these months on Oyster Bayou in lower Terrebonne Parish, it was the perfect season to investigate the role that winter weather processes play in the environmental health and productivity of coastal marshes, bays, and estuaries.

Blue northers—atmospheric cold fronts from the north—are accompanied by winds that push massive amounts of water out of shallow coastal bays, disrupting normal tides. When the cold front passes and the winds return to their normal southerly pattern, they blow gulf water back into the emptied estuaries. With the returning water come the young of winter-spawning species like black drum, gulf menhaden, southern flounder, and brown shrimp. Thus, the scientists hypothesized, blue northers drive the process of recruitment, or the movement of juvenile fish and shellfish from the gulf into the shelter of coastal estuaries where they spend their first few years of life.

"During an earlier project in the Calcasieu area, we noticed that brown shrimp postlarval recruitment to the estuary seemed to increase during these cold front passages," says Dr. Richard Shaw of the Coastal Fisheries Institute. "We thought the fronts could be mechanisms for recruitment, but we didn't have enough data and we wanted to test the hypothesis." Shaw also wanted a better understanding of the relationship among winter spawning, tides, and recruitment to inshore waters. "These fish are spawned offshore, but is their estuarine recruitment enhanced by the strength and frequency of cold front passages? We wanted a measure of estuarine flux. If we saw an increase in newly spawned animals every three to eight days, which is the frequency of cold fronts, we could associate that ingress with some sort of periodicity offshore."

Dr. John Day of the Coastal Ecology Institute and Dr. Larry Rouse, Coastal Studies Institute, were also interested in the effects of blue northers. Day wanted to examine the influence of cold front passages on suspended sediments and nutrient chemistry in estuaries. Rouse wanted to monitor such factors as wind speed and direction, barometric pressure, temperature, humidity, and sea level during cold front passages in order to understand how ecosystems respond to large amounts of water moving into and out of coastal bays and estuaries.

The researchers chose Oyster Bayou as the study site for the Sea Grant-supported project because it forms a pass between the Gulf of Mexico and Four League Bay and funnels massive amounts of water during cold front passages. The bay and bayou are in alignment with prevailing winter winds, which are mainly from a southerly direction but subject to northerly reversals. So that they could continuously sample flood and ebb tides, as well as both day and night conditions, for 90 days, the researchers and assisting graduate students had to live at the site.



All photos courtesy of Brian Perez

They built a small dock as moorage for a rented houseboat that served as living quarters. Laboratory equipment was housed on an aluminum barge called the *Passe Partout*, for which electricity was supplied by generators. "The whole thing was a logistical nightmare," says Shaw. "We had to get permits to put in pilings, and because the bayou is an oyster harvesting area, we had to get approval for an onboard sewerage system. Water, food, and ice all had to be brought to the site by boat."

Two crews of three alternated seven-day shifts, sampling the bayou for plankton and measuring suspended sediments and nutrients every three hours. Plankton nets were used to catch larval fish and postlarval brown shrimp. Bayou current direction and speed at both surface and bottom were recorded with moored current meters, as were salinity and temperature. An on-site weather station provided barometric pressure, wind speed, air temperature, and humidity index. Water level gauges at both ends of the bayou measured the inclination, or tilt, of the water surface between Four League Bay and the Gulf of Mexico.

"The continuous sampling of many variables over three months allowed us to link weather conditions, water measurements, sediment content, and plankton abundance in a tight data package," says Shaw. "We got a valuable time series of data and it's very rare that a researcher can get that."

The researchers built a dock and housed a makeshift laboratory on a barge.

During the three months, 1,440 plankton samples were taken, requiring much "picking and sorting," says Shaw. Such frequent sampling was necessary because a cold front passage lasted only half a day and sampling intervals had to be short enough to cover changing tidal cycles. The researchers found that the frontal passages moved massive amounts of water, blowing Four League Bay almost dry and interfering with regular tidal cycles. "These fronts are so strong that they continue to move water out of the estuary even while the gulf is trying to force a flood tide in. Sometimes the tide is held back for as long as two or three days," says Shaw.

Preliminary analysis of the plankton data reveals that some species enter the bay in large numbers only after the flood tides that follow cold front passages. "These animals are clearly carried into the estuary behind the fronts," says Shaw. "Somehow, they manage to remain inside the estuary, or they move into tributary bayous, so they are not flushed back out by the falling tides."

Changes in temperature and salinity are signals associated with cold front passages that strongly influence recruitment to the estuary, observes Shaw. Most animals respond to cold temperatures with passivity, sinking when water chills. Animals that enter the estuaries after cold fronts may sink during subsequent cold fronts and thus resist being flushed out. When water is warm, animals are far more active and easily transported into the estuary by warmer tidal currents from the gulf.

Salinity, says Shaw, may also be important in cold front recruitment. Some animals are active in the water column during periods of high salinity and more likely to be swept into the estuary with the saline gulf tides that follow frontal passages.

Postlarval shrimp, says Shaw, are carried along the coast by the prevailing current. As they pass openings to the estuaries, they can be

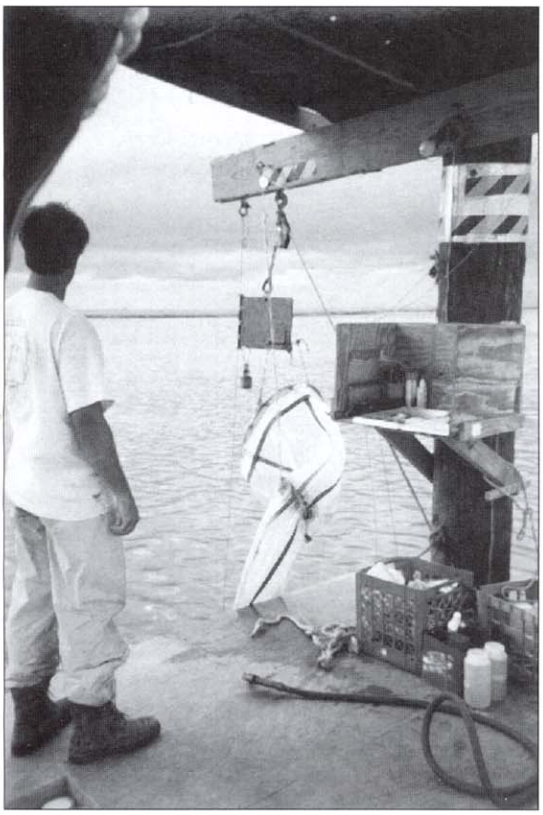
Dr. Rick Shaw with sampling net at Oyster Bayou.

blown in by southerly winds or sucked in by water returning to fill the drained estuaries after cold fronts.

Why is it important to understand event-driven recruitment? Fisheries managers, says Shaw, often use indexes for forecasting annual catch and deciding when to open seasons. These models may be improved if, after the data are analyzed, the number and strength of winter cold fronts are proved to be a driving mechanism in successful estuarine recruitment. In the years that have fewer and weaker cold fronts, pulses of larvae may not propagate the estuaries as abundantly as in the years with strong, numerous fronts. Thus, these may be bad years for catch.

"The negative aspect of cold fronts is that they do chill the water, and that slows growth. Also, Four League Bay is so shallow that a really severe front can kill the fish."

In coastal Louisiana, where marshes starved of sediment and nutrients are crumbling away, cold front passages are helpful in moving sediments to build marsh and carrying nutrients to fertilize plant growth.



Graduate student Brian Perez with sampling equipment.

Rouse and Day found a sequence of events in winter cold-front cycles. In the prefrontal phase, the winds are from the south. The southerly winds over the Gulf of Mexico build up water along the coast that holds back the discharge from the Atchafalaya River and causes widespread marsh flooding from Atchafalaya Bay over to Bayou du Large. (See map of this area on page 9.)

"The water contains suspended sediment and nutrients that build up the marsh and fertilize its growth. That's one reason why you find healthy marshes adjacent to Atchafalaya Bay, even though there's widespread erosion in other parts of the coast," says Day.

In the second phase of the frontal event, thunderstorms, gusty winds, and rain occur. As these pass, the third phase begins with strong, cold winds from the north that push water and suspended sediment out of the shallow-basin wetlands into the nearshore zone. On the way, the nutrient-rich sediment drops out so that the water pulsing out to the continental shelf is reduced in nutrient content. When this phase wanes and the winds become southerly again, sediment-filled water rushes once more into the coastal bays and marshes. "We were interested in measuring the tidal- and front-driven exchanges of sediment and nutrients between Four League Bay and the Gulf of Mexico, through the funnel of Oyster Bayou. We also wanted to know how these processes change as the discharge of the Atchafalaya River rises to its spring peak."

Day found that 70 to 80 percent of the sediment exchange between the bay and the gulf occurred during frontal passages. "Until we were able to take these fine-scale, continuous measurements, we didn't realize what high concentrations of sediments and nutrients are moved during these fronts. Knowing the kinds of events that cause big pulses of sediment into the marsh is important for coastal management. Plans can be designed to enhance the flow, not obstruct it with levees or other structures. If there are water control structures, gates can be opened during these periods to let in water and sediment."

Graduate student Andrew Whitehurst examines contents of sampling net at Oyster Bayou.

An important result of the project will be the development of an index that can indicate the strength of frontal passages. "We'll be able to measure factors like wind speed and direction, temperature, and atmospheric pressure and predict the onset and strength of these passages for the northern Gulf," says Shaw. Though climatologists can define the type of cold front, there is at present no system in the United States for classifying strength and duration.

The researchers are still analyzing data from the project, a long process because of the copious amounts of information. "We had 90 days, sampling eight times day, but it's possible that we could have sampled less over a shorter time and still got the information we needed," says Shaw. The problem interested Dr. Barry Moser of LSU's Department of Experimental Statistics, who will soon begin working with project data to come up with a shorter sampling schedule for such projects. "We may find out that we can get away with sampling the estuary every two or three days, just twice a day," says Shaw. "This is important for future projects with more severe logistical or economic limitations."