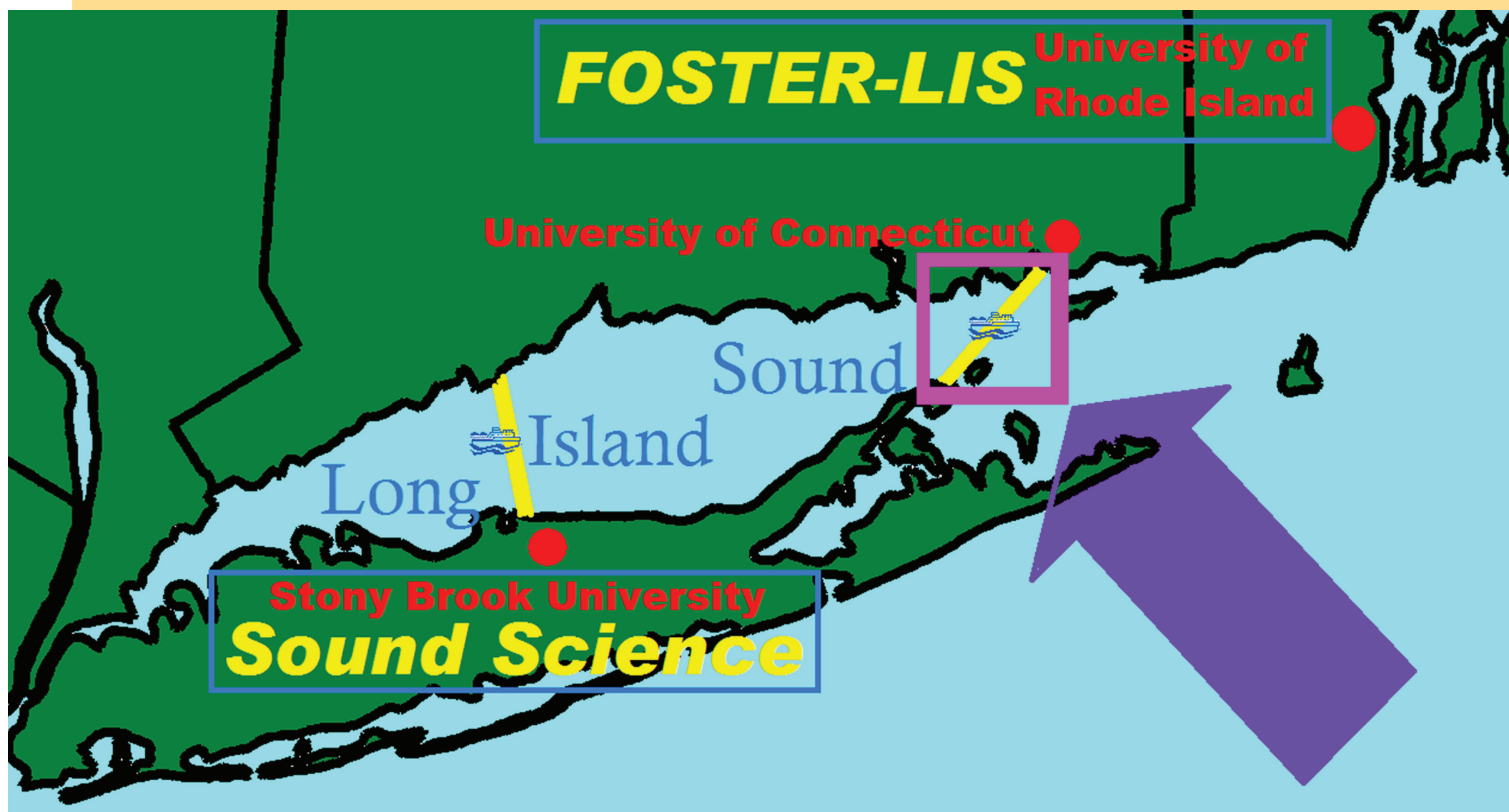


# Ferry-based Observations for Science Targeting Estuarine Research in Long Island Sound



## Importance of water quality in Long Island Sound

- Long Island Sound (LIS) is an estuary, a semi-enclosed body of water in which fresh water from rivers mixes with sea water from the coastal ocean.
- LIS serves many functions critical to the regional economy, provides unique habitat to diverse species of aquatic and bird life, and is a recreational haven for people living along its densely populated shores.
- To preserve and protect these assets, effort is concentrated on maintaining good water quality. This includes managing the impacts of human activities.

## Why focus on currents and water property distributions? How are they investigated?

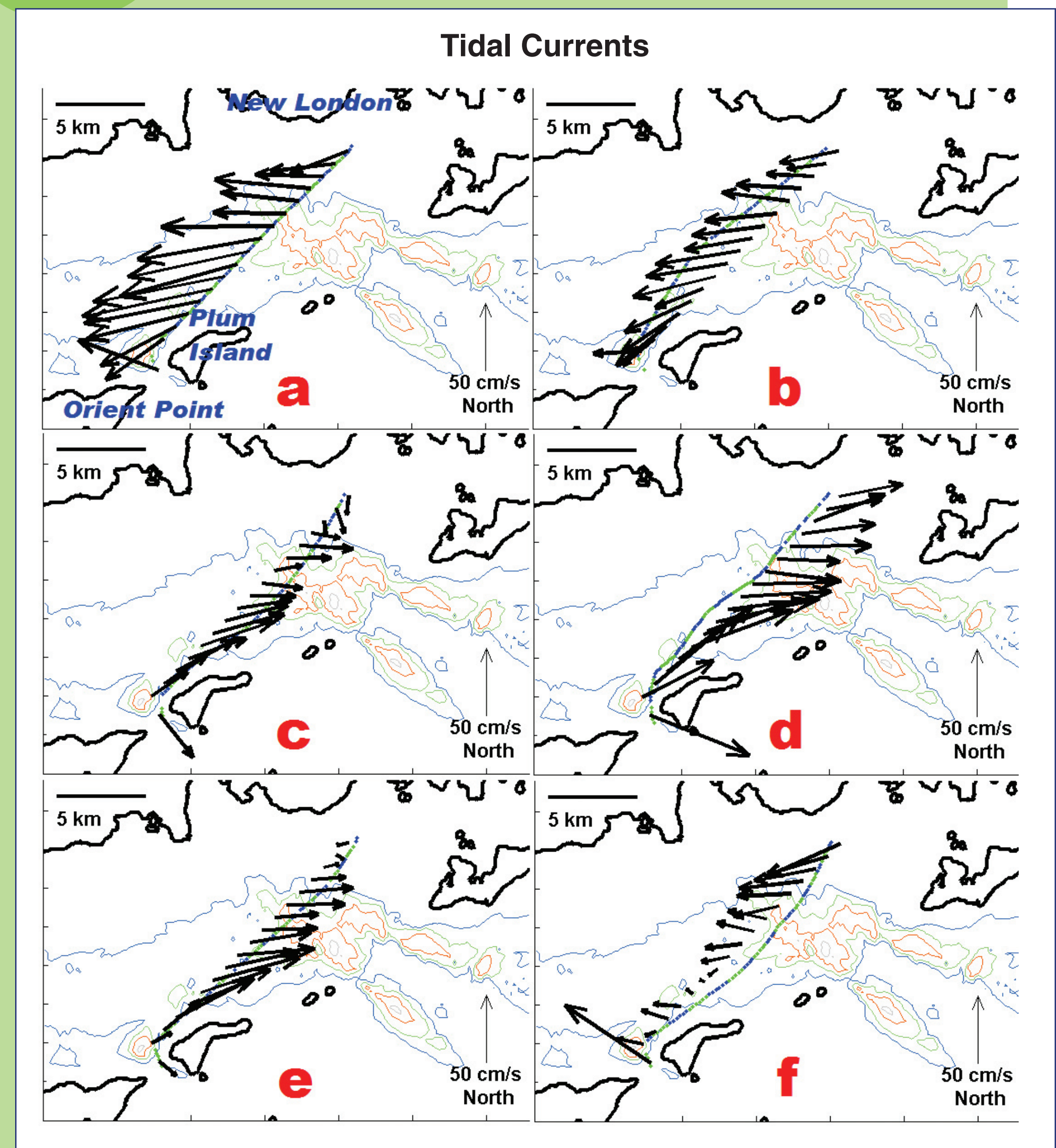
- Major influences on LIS water quality are
  - water circulation such as tidal flow, persistent currents, and eddies
  - distributions of water properties like salinity and temperature, and of waterborne materials like chlorophyll from phytoplankton (single-celled microscopic algae)
- Currents and water property distributions in estuaries result from complex processes undergoing active research, particularly in physical oceanography, the study of ocean fluid dynamics.
- Two main research techniques to investigate water quality and circulation in estuaries and coastal areas are (a) computer simulations, and (b) collection and analysis of field observations.

## Why collect oceanographic observations from a ferry?

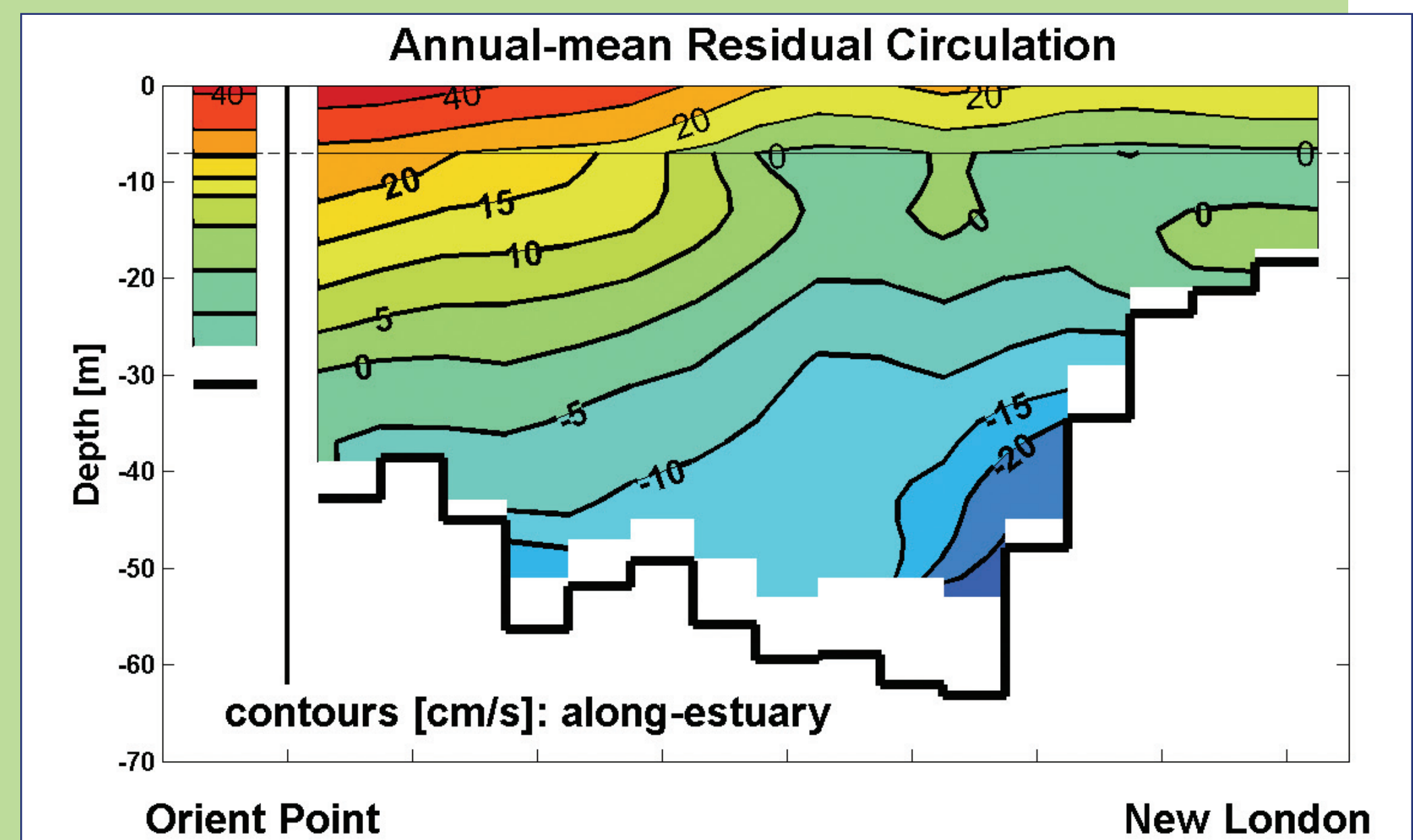
- This project is motivated by the limited amount of observations that have been made in LIS, a result of the high expense of operating research vessels.
- In FOSTER-LIS, measurements are collected from a ferry, the MV John H. This is a very cost-effective means to gather field data. The vessel is operated by Cross Sound Ferries, Inc. (CSF), which generously provides the research team access.
- Collecting measurements in ongoing field programs such as this is a high priority because computer simulations must be validated against observations.
- The ferry travels where the dominant exchanges of water from within and outside LIS occur, in eastern LIS between New London, CT and Orient Point, NY. The measurements improve understanding of rates and pathways for water replenishment in LIS.
- FOSTER-LIS is part of a joint effort. In the SoundScience project, Stony Brook University collects data between Bridgeport CT and Port Jefferson NY using a ferry in central LIS (<http://www.stonybrook.edu/soundscience>).

## What have we learned from FOSTER-LIS so far?

- Tidal currents in eastern LIS negotiate complex coastline geometry and seafloor topography. They are
  - swift, about 80-100 centimeters per second (nearly 2.2 miles per hour)
  - oriented along the estuary axis nearly east-west
  - generally strongest in the deepest central portion of the estuary and in Plum Gut, the narrow gap between Orient Point and Plum Island



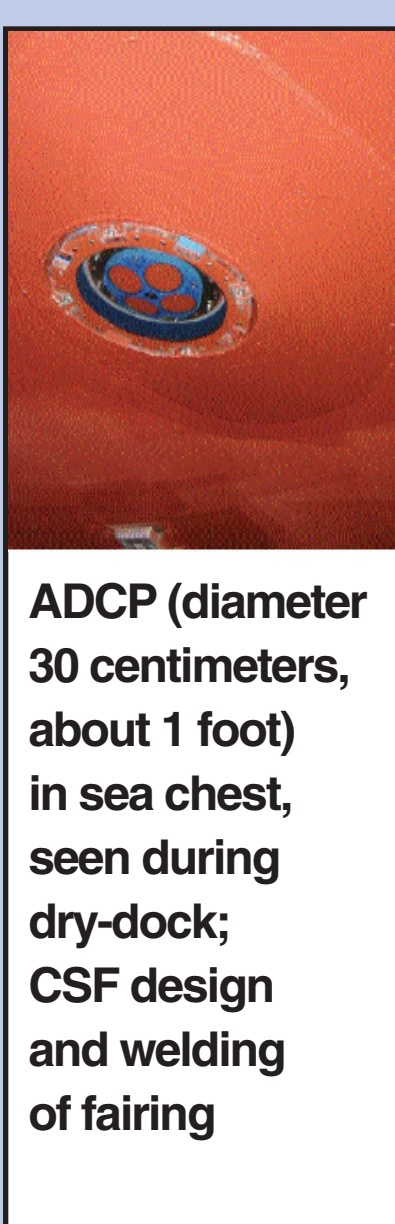
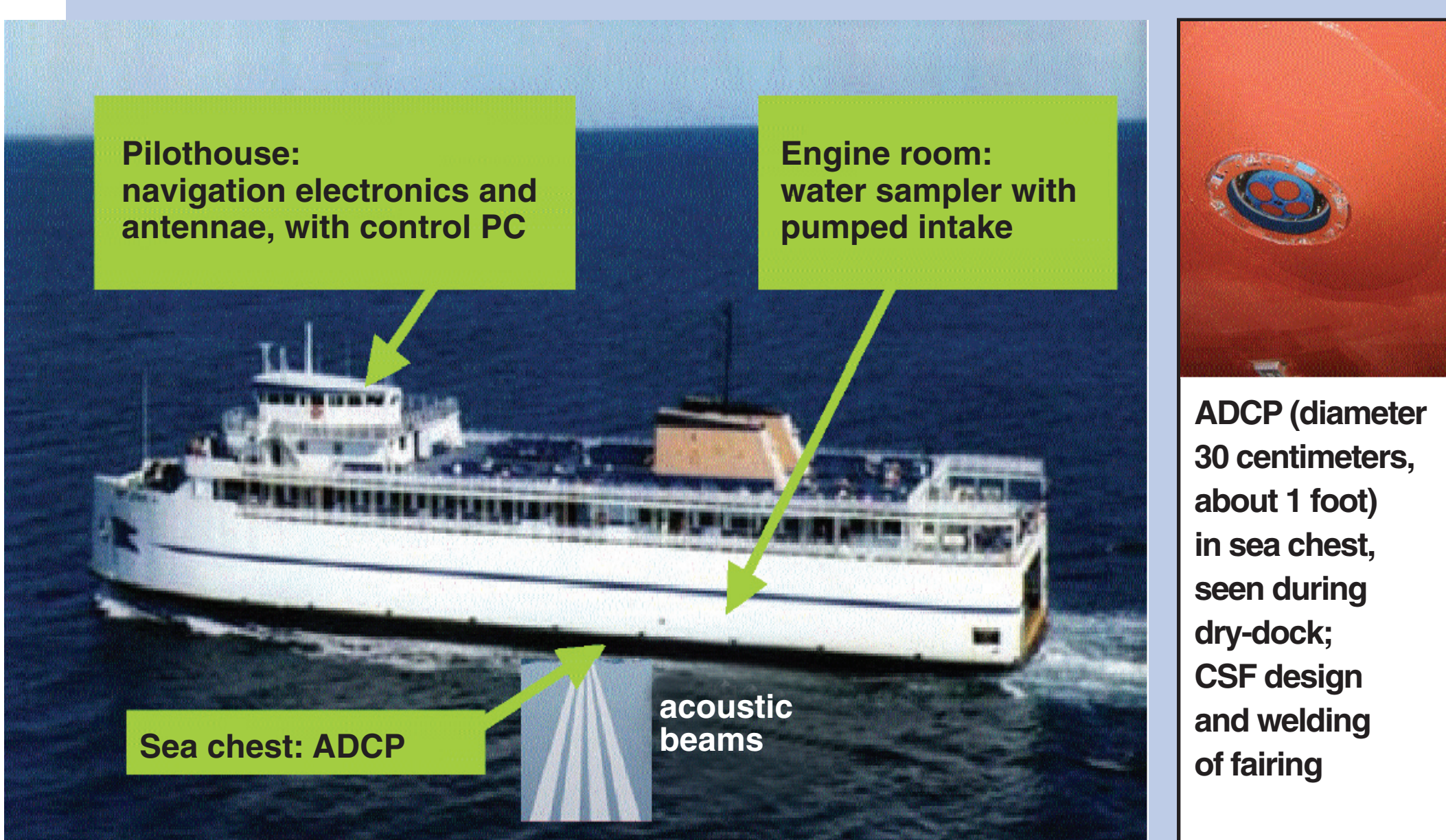
Observed flow over a tidal cycle. Currents are averaged vertically using all sampled depths. Six non-sequential crossings were selected, from a period of many days, to nearly uniformly span a 12.4-hour tidal cycle: delay relative to most recent high tide is about (a) 0, (b) 2, (c) 4, (d) 6, (e) 8, and (f) 10 hours. Purple-green hatch line is ferry path. Colored lines are constant-depth contours (blue 20 m, red 40 m, etc.) to show seafloor depth variations.



Residual currents are non-tidal net drift, an average over at least several tidal cycles—in this case, about 2500 ferry crossings spanning two years. Currents in the along-estuary (roughly east-west) direction are shown, more red where directed eastward out of the estuary and more blue where directed westward in to the estuary. Currents shallower than 7 meters deep are not measured by the ferry and have been inferred by assuming the simplest spatial structure and matching total inward and outward flow to conserve volume. An across-estuary vertical slice from Orient Point at left to New London at right is seen, looking westward, with the black vertical line at Plum Island.

## Residual flow

- Residual flow in eastern LIS was poorly known previously. Isolating it requires sampling multiple times daily, for many days or weeks, in order to average out stronger alternating tidal motion. Ferry-based measurements are uniquely suited to accomplish this.
- Observed residual currents peak at about 30-60 cm/s. Eastward flow exits LIS concentrated along the north shore of Long Island near the surface. Westward flow enters LIS concentrated along the bottom near the Connecticut side.
- The volume of inward and outward flows in this “estuarine exchange flow” is roughly 20 times the annual-mean river inputs to LIS.
- The left-right asymmetry results from the Coriolis effect, due to the rotation of earth about its axis. Because LIS is in the Northern hemisphere, each limb of the exchange is shifted to the right of its direction of flow.
- These observations provide a new perspective on pathways and rates of water replenishment affecting LIS water quality. They can help validate computer simulations used in water quality management decisions.



## How does it work?

- Horizontally-directed currents are measured in a vertical profile, from near the sea surface to near the seafloor, many times each minute by an acoustic Doppler current profiler (ADCP) mounted in a sea chest (flush cavity) in the vessel hull.
- The ADCP sends and receives sound pulses to measure water movement relative to the ship. This information is combined with accurate vessel navigation data to determine the speed and direction of water, relative to land, in each depth layer.
- Near-surface water is pumped past sensors in the engine room where its temperature, salinity, and chlorophyll concentration are measured.
- Data are relayed by cable to a control computer located in the ferry pilot house. The real-time observations are presented on a monitor in the ferry passenger area.
- A cellular modem is used to operate the control computer remotely from shore, and to transfer data to shore for processing and archiving.
- Data processing includes creation of gridded data products for use in validating computer simulations. Archived gridded data are available for inspection and download at the project website, [www.gso.uri.edu/foster](http://www.gso.uri.edu/foster).