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Woods Hole Sea Grant: 2002-2004 Projects

Development of a Carbon Isotopic Method for Quantifying Groundwater Inputs to Estuaries

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The contribution of groundwater to the coastal ocean and to estuaries is not well understood, primarily due to the difficulties associated with identifying and distinguishing between groundwater inputs and other freshwater inputs, such as surface river flow and surface runoff. In the first year of this project, investigators developed a carbon isotope-based method for estimating groundwater inputs to estuaries and applied the method to field sites in coastal North and South Carolina. Current sampling methods for estimating submarine groundwater discharge along the coast include seep meters and piezometers and geochemical tracers such as radium, radon and 14C. This project, now in its second year, will attempt to use dissolved inorganic carbon (DIC) isotopes to distinguish between two freshwater sources—groundwater and tidal inputs—to the North Inlet in SC. Investigators have also sampled the surface waters and groundwaters in the region to document the range of carbon isotopic compositions; this will provide essential context for upcoming studies. Results to date have shown that in the NC/SC study region, the DIC in groundwater from confined aquifers is characterized by low radiocarbon content (low ?14C values), while the DIC in both surface seawater and surface freshwater (rivers, streams, and water table or surficial aquifer) has high ?14C values. Isotopic analyses of groundwater in the same areas and of the known DIC sources to these tidal creeks (seawater, stream water, and CO2 from salt marsh decomposition processes), show that confined aquifers are the only significant low ?14C source to these estuaries. Using carbon isotopic tracers to identify and quantify groundwater inputs to coastal and estuarine systems will help to show the influence such inputs have on water quality and the transport of nutrients from land-based sources. This project, combined with R/M-46 (described below), could provide important tools with which to estimate groundwater fluxes—and the associated fluxes of nutrients and contaminants—in a variety of settings. (R/M-47)

Application of Radium Isotopic Approach for Water Mass Age: Implications for Estuarine Phytoplankton Blooms

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Building on previous Sea Grant-supported projects that looked at biological and chemical processes in Waquoit Bay (Cape Cod, Massachusetts), this project will use radium isotopes as tracers of water residence times (Tr) in estuaries to understand the relationship between residence times and phytoplankton bloom dynamics. The key question guiding this research is “How is it possible to have phytoplankton blooms in shallow estuaries if water residence times are of similar duration to planktonic cell division rates?” Water residence times are important to the ecological, chemical, and biological processes of shallow water estuaries. In Waquoit Bay, the residence time has been reported to be relatively short (less than two days) and it has been shown that phytoplankton respond to local nutrient conditions. These results imply either calculation of whole system water residence time is in error, or that different water parcels within the estuary differ sufficiently in age to allow blooms to develop. To address this, researchers will use radium isotopes to determine (1) whether the whole estuary Tr truly represents water age, and (2) if Tr for specific parcels of water have sufficiently different water ages. To obtain evidence of the plankton response to both differences in Tr and nitrogen (N) loads, investigators will assess the composition and structure of phytoplankton in the water parcels of the Waquoit Bay estuarine system. Investigators hypothesize that in estuaries with high N loads but short residence times, phytoplankton populations will shift toward taxa with short generation times, thus allowing them to take advantage of the nutrient enrichment. This shift in phytoplankton community structure could be the mechanism allowing the significant differences in biomass and production previously measured in the Waquoit system. Where N loads are low, the hypothesis is that the phytoplankton community merely reflects the composition, biomass, and production of the itinerant assemblage that enters and leaves the estuary via tidal exchange. Understanding more about how land-derived nutrient inputs and water renewal rates interact within a system has useful implications for coastal zone managers who need information about the relationship between nutrient concentrations and biological changes. (R/M-46)

Effects of Anthropogenic Nitrogen Loads on Commercially Important Bivalves

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In many coastal regions, land-derived nitrogen loads have increased as a result of increased wastewater associated with residential sprawl. This often leads to eutrophication and can alter the features of the receiving estuarine ecosystems. Commercially important bivalves that grow in shallow coastal habitats are susceptible to the effects of nitrogen enrichment, including changes in food quantity and quality and habitat degradation. In some areas, abundance of commercially important bivalves appears to have decreased in recent years as anthropogenic nutrient enrichment has increased. In this project, investigators will quantitatively define how land-derived nitrogen loads alter food supply and benthic habitats used by shellfish and how populations of shellfish are affected by these changes. By looking at eight Cape Cod, Massachusetts estuaries with varying nitrogen loads investigators will determine the potential food supply for bivalves (specifically, quahogs, Mercenaria mercenaria; soft-shell clams, Mya arenaria, and bay scallops, Argopecten irradians), measure changes in sediment properties due to eutrophication-related processes, measure the growth and survival of shellfish, directly link changes in shellfish growth and survival to amounts and sources of anthropogenic nitrogen load, and characterize food processing by bivalves to determine how eutrophication-related changes in food quantity and quality may affect their growth and survival. By providing a quantitative understanding of the relationships between nitrogen loading rates to estuaries and bivalve growth and survival, project results will be useful to coastal managers and policy-makers as they manage areas of promising habitat for commercial and recreational shellfishing and practices such as harvesting, seeding, or relaying shellfish. (R/M-51-PD)

Effects of Varying Freshwater Discharge on Nitrogen Dynamics in the Oligohaline Regions of Estuaries

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This field and laboratory-based project will examine how changes in salinity alter nitrogen processing and release from sediments. Previous work by the investigators looked at how salinity affected nitrogen dynamics in subtidal sediments in the oligohaline, or low salinity, zone of estuaries. They found that, while subtidal benthic nitrogen fluxes are important in controlling productivity in the overlying water, the surrounding fresh and brackish water tidal marshes may be equally important. Because of evapotranspiration and less frequent flooding, marshes tend to experience greater changes in salinity compared to subtidal sediments. Investigators hypothesize that although

marshes may be considered a net sink for nitrogen due to denitrification and burial, they may act as a source of nitrogen in summer. In spring, large amounts of nitrogen entering a system during spring runoff may be stored in sediments and marsh plants. In summer, when river discharge is low, elevated sediment salinities may cause the marsh to release part of its stored nitrogen back to the estuary, thereby contributing to the mid-summer algal bloom observed in the oligohaline zone in many estuaries. Marshes occupy greater than 10 times the area relative to the subtidal sediments sampled in previous work. This project will continue the sampling of subtidal sediments while also moving into the intertidal marsh to assess the effects of fluctuating salinity on the whole estuarine ecosystem and to accurately model the system's nitrogen dynamics. (R/M-50)

The Recycling of Anthropogenic Metals in Massachusetts Bay Sediments: Assessing the Impact of the New Outfall (Phase II)

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This project begins its second phase by examining the behavior of a suite of trace metals in surface sediments in Massachusetts Bay. Sewage discharge can be an important source of metals to the coastal environment. In 2000, sewage discharge into Boston Harbor was rerouted to a site 14 km offshore in Massachusetts Bay. The effect of the change is to decrease organic matter and nutrient loading in Boston Harbor and increase it in the vicinity of the new sewage outfall. These changes affect the input of organic matter and metals in sediments at both locations. Once released, metals are persistent, since they neither decay nor decompose. Thus, their residence time in coastal waters is determined largely by their association with particulate phases and by particle transport processes. In the initial phase of this study, begun in 2000, investigators looked at trace metal behavior at a site of fine-grained sediment accumulation near the new outfall site just as the site became operational. This study phase will look at the effect of the recent increase in sewage output on metal accumulation in local sediments. Investigators will examine the processes that determine whether anthropogenic metals that rain to the seafloor with organic matter and iron and manganese oxides are either returned to the water column via remineralization reactions or sequestered in the sediment column. This project will benefit from related studies, by the investigators and others, of sewage inputs at another site—Inner Harbor in Hull Bay, Massachusetts, where sewage inputs have recently decreased. This will allow investigators to study the potential release of metals from sediments accumulated earlier (Hull) as well as those arriving at the sediments now (Massachusetts Bay). The sites also offer contrasting chemical characteristics that may play a role in metal cycling. A key characteristic of coastal sediments is strong seasonal variability in remineralization reactions as well as solid phase and solution phase transport by bioturbation, driven by variability in organic matter inputs and water temperature. To distinguish long-term trends due to changes in human activities from natural, seasonal variability, investigators will measure benthic fluxes and porewater profiles over the duration of the project. (R/B-164)

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