Final Report Summary

In 2002, the severe summer hypoxia (less than 1.0 mg O2/l) in Western Long Island Sound was the worst on record. The suffocation of benthic and pelagic life for the summer months combined with the accumulation of pathogens and heavy metals in the anoxic sediments is an environmental disaster of the first order. The impact on marine life continues to expand and now extends throughout the year. The current regional hypoxia mitigation program centers around nitrogen reduction through wastewater treatment plant discharge regulations. Although a reduction in the total nitrogen input to Long Island Sound has been achieved in the past decade, hypoxia in Western Long Island Sound remains a chronic and growing problem. More than two decades of dissolved oxygen surveys show that hypoxia initiates in the Western Long Island Sound and spreads eastward. Hypoxia mitigation plans have generally focused on reducing the nutrient load of East River water entering the Western Long Island Sound.

In this study, we measured isotope tracers of waters entering Long Island Sound from the East River combined with nitrogen and carbon isotope tracers of organic particles to examine the spread of hypoxia from west to east. Isotope tracers yield important additional information that concentration data and standard oceanographic measurements alone can not provide. Oxygen isotope measurements of Long Island Sound waters show that the low dissolved oxygen in the water column is predominantly due to tidal mixing with the relic hypoxic waters found in four small deep basins in the Western Long Island Sound. The small deep basins contain the densest waters and are natural traps for fine grain sediments rich in organic matter that is delivered to the deep basins through tidal and storm resuspension of sediments from the surrounding shallows throughout the year. The tapered shape of Western Long Island Sound combined with the surrounding shallows results in a natural focus of fine grained sediments to deep basins in the Western Sound.
Our isotopic results indicate that four deep basins act as "hypoxia incubators" on the sea floor of Western Long Island Sound and that they are the immediate or proximate causes of hypoxia throughout the water column. During the stratified summer months the denser waters in the deep basins are out of reach of vigorous tidal mixing and only the occasional summer thunder storm ventilates these deeper depths. However, tidal mixing and local currents progressively mix the low oxygen dense waters found in the deep basins with the ventilated surface layer to produce the observed dissolved oxygen gradients in the water column. Our nitrogen isotope tracers demonstrate clearly that the organic particulates sampled in the deep basins derived their nitrogen almost entirely from waste water effluent. Furthermore, oxygen isotope measurements of Western Long Island Sound water combined with salinity and dissolved oxygen data show unambiguously that the eastward spread of low oxygen waters is due directly to mixing with the extremely low oxygen waters of the four deep basins. In other words, the poorly ventilated deep basins loose oxygen to the oxidation of organic matter derived from waste water effluent and these basins reach severe hypoxic conditions early in the summer. Throughout the summer months, these low oxygen waters are slowly mixed vertically and laterally through tidal and current mixing.

Based on our isotopic and oceanographic measurements in 2001 and 2002, we conclude that nitrogen loading to Western Long Island Sound is grossly in excess of levels needed for severe summer hypoxia and that the vagaries of summer weather patterns control the severity of hypoxia. The extreme summer hypoxia of 2002 was sustained by a stationary high pressure ridge that blocked the occasional summer thunder storms normally responsible for oxygenation of mid-depth waters. The predictability of this weather phenomenon is poor because it is not associated with a normal mode of climate variability for this region, although there is a very weak correlation of the North Atlantic Oscillation (NAO) and climate in the Long Island Sound region.

Oxygen isotope and salinity measurements show that there are four deep basins directly under the East River mixing zone. Nitrogen and carbon isotopes of the particulate organic matter were measured at select stations to measure the contribution of effluent nitrogen sources in the surface waters and deep basins. Nitrogen and carbon isotope measurements of East River particulate matter indicate little

modification by marine organisms in the East River due to the extremely high turbidity leading to very low primary productivity. The carbon and nitrogen isotope results confirm that effluent nitrogen sources are the dominant sources of nitrogen found in the particulate organic matter in the four deep western basins and throughout the water column, and that effluent nitrogen sources are dominantly responsible for the severe hypoxic conditions in the basins. Nitrite is rapidly reduced to background levels as East River Water enters the Western Long Island Sound by Throgs Neck and levels remain low throughout the Western Long Island Sound.

Sediment cores indicate that organic matter has been accumulating at faster rates in the past century than in preanthropogenic times and the nitrogen isotopic composition of the organic matter demonstrates the growing contribution of waste water effluent in supplying the nitrogen sources. Only further research can confirm that there is sufficient organic matter in the modern sediments of the four deep basins to support severe hypoxia in the absence of new sources. Dredging or aeration of the contaminated sediments in the four deep basins are undesirable and costly options, however the small geographic extent of these basins makes capping with clean sands or sediments an option worth consideration and further evaluation. There is reason for optimism with respect to mitigating this blight in Western Long Island Sound because the four basins are small in aerial extent, which means that hypoxia abatement strategies can now be targeted more directly at the immediate source of the problem. Lastly, environmental surveys that only sample the deep western basins over-estimate the aerial extent of severe hypoxia in Western Long Island Sound.