GROUNDWATER INPUTS TO THE COASTAL ZONE

Burnett, W.C.

Department of Oceanography, Florida State University, Tallahassee, FL 32306, USA,

Both terrestrial and marine forces drive underground fluid flows in the coastal zone. Hydraulic gradients on land result in groundwater seepage near shore and may contribute to flows further out on the shelf from confined aquifers. Marine processes such as tidal pumping and current-induced topographic flow may occur anywhere on the shelf where permeable sediments are present. The terrestrial and oceanic forces overlap spatially and thus measured fluid flow through coastal sediments may be a result of composite forcing. We thus define "submarine groundwater discharge" (SGD) as any flow out across the seabed, regardless of composition or driving force. This process is often characterized by low specific flow rates that make detection and quantification difficult. However, because such flows (both recharge and discharge) occur over large areas, the total flux is significant. "Groundwater" is thus an important source of biogeochemically important constituents to coastal waters. When derived from land, groundwater-seawater interactions represent a pathway for new material fluxes to the coastal zone and may result in diffuse pollution in areas where contaminated groundwaters occur.

One of the main objectives of the Yellow River Project is to quantify the exchange between the river and the Bo-Hai Sea. An important parameter in such an effort is to characterize the mixing between the estuary and the oceanic waters. This can be done by analysis of natural radium isotopes, especially ^{223}Ra and ^{224}Ra that have half-lives (3.66 d and 11.4 d, respectively) on the same time scale as mixing rates in many near-shore environments. This approach works because there are sources of the isotopes in the near-shore waters from the river and possibly from SGD and there should be almost none in the open sea away from these sources (**Fig. 1**).

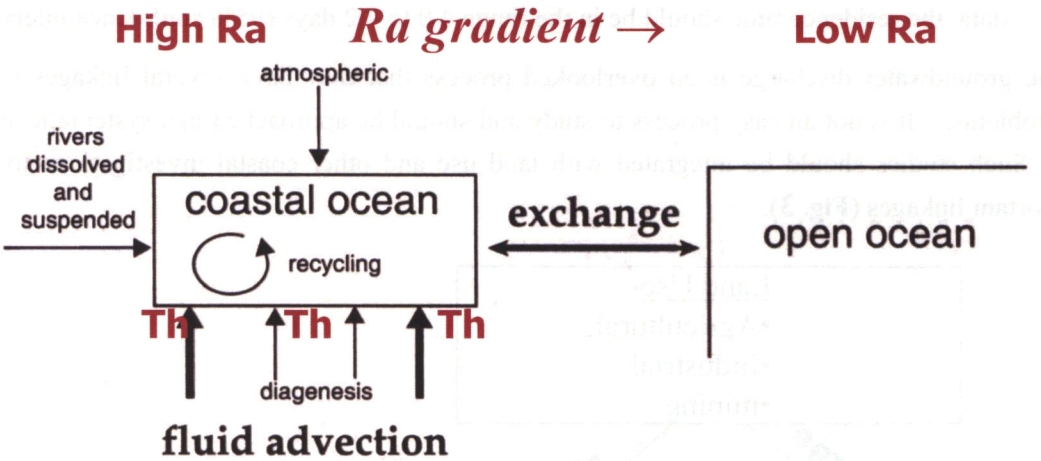

Figure 1. Diagrammatic view of how natural short-lived radium isotopes (daughters of thorium isotopes concentrated in the sediment) can be used to quantify mixing between coastal and offshore waters.

A residence time (average length of time the water remains in the system) may be calculated if the initial isotopic composition is known and assumed to be constant. In practice, the sampling usually consists of a transect or a series of transects extending from the river end-member (0 $^{o}/_{oo}$ salinity) out to sea to cover the

entire salinity profile. Because of the highly seasonal discharge of the Yellow River, the length of such a transect will vary tremendously. Once the samples are collected and the measurements made, a residence time can be estimated from the following equation:

$$^{224}Ra_{obs} = {}^{223}Ra_{obs}\left(\frac{^{224}Ra}{^{223}Ra}\right)_i \bullet \frac{e^{-\lambda_{224}T}}{e^{-\lambda_{223}T}}$$

where T is the residence time in days, $(^{224}Ra/^{223}Ra)_i$ is the initial isotopic ratio, and $_{224}$ and $_{223}$ are the decay constants of the respective isotopes of radium. To illustrate this approach, a data set from a sampling off eastern Long Island (New York) is shown below (**Fig. 2**).

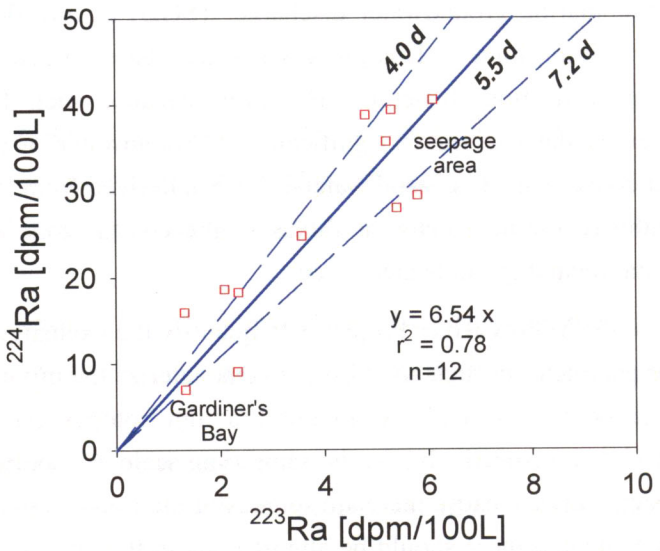

Figure 2. Activity of ^{224}Ra versus ^{223}Ra for 12 samples collected in a line away from an area of activity groundwater seepage near Shelter Island, eastern Long Island, NY. Based on the trend in the data, the residence time should be in the range 4.0 to 7.2 days (95% confidence interval).

Submarine groundwater discharge is an overlooked process that may have several linkages to real-world coastal problems. It is not an easy process to study and should be approached in a systematic, concentrated manner. Such studies should be integrated with land use and other coastal investigations to discern the most important linkages (**Fig. 3**).

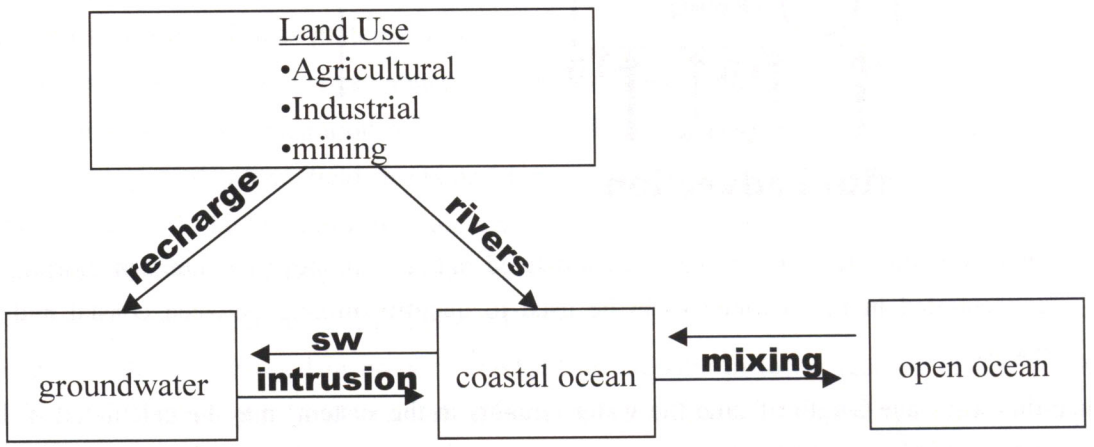

Figure 3. Linkages between land use, coastal aquifers, and the ocean. Effects measured in the

ocean may be consequence of activities in the interior with a groundwater pathway.

An IUGG Inter-Association Commission on "Groundwater-Seawater Interactions" combining scientific talents from the International Association of the Physical Sciences of the Ocean (IAPSO) and the International Association of Hydrological Sciences (IAHS) was formally organized in 2001 to help facilitate and coordinate research in this highly interdisciplinary subject. The joint commission plans to coordinate activities relating to this subject, organize workshops and symposia, participate in the planning and execution of various types of research, and actively engage scientists from developing countries.