Radioisotopes and coastal research in the Great Barrier Reef (Featured Speaker)

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Radioisotopes are efficient tracers of coastal processes on various spatial and temporal scales. The isotopes of radon and radium are particularly useful tools to understand hydrological land-ocean interaction because (a) activities of these isotopes are elevated in groundwater by two to three orders of magnitude in comparison with seawater, and (b) these isotopes have half-lives similar to the time scales of coastal hydrological processes such as river and groundwater discharge to the ocean, as well as coastal ocean mixing (or residence) time.

The application of these isotopes to studies of land-ocean interaction in the central Great Barrier Reef region (Townsville to Cooktown) is illustrated in three recent studies: (1) coastal mapping of radon on a regional scale improves the understanding of the spatial variability of river and groundwater fluxes to the Great Barrier Reef lagoon; (2) quantification of tidal water exchange between mangrove forests and creeks demonstrates the significant contributions this process makes to water flux and associated geochemical fluxes along tropical coastlines; (3) estimates of coastal water residence time contribute to the understanding of the fate of land-derived solutes in the Great Barrier Reef Lagoon.

Concurrent mapping of ^{222}Rn (half-life 3.8 days) and salinity allows an efficient qualitative assessment of land–ocean interaction on various spatial and temporal scales. From shore-parallel transects along the Central Great Barrier Reef coastline with a surface-towed and continuously recording multi-detector system, numerous locations of elevated radon activities can be identified as terrestrially-derived submarine groundwater discharge, riverine sources, and the recirculation of seawater through crustacean burrows in mangrove forests. Variations in the inverse relationship of ^{222}Rn and salinity in different tropical wet seasons reveal 'timing' aspects of large-scale freshwater input during the tropical wet season into the lagoon.

Subsequently, ^{222}Rn was used together with radium isotopes to quantify the tidal water exchange between a mangrove forest on Hinchinbrook Island and the ocean. Significant export of these radio-nuclides from the forest into a tidal creek indicates continuous tidally-driven circulation through animal burrows in the forest. The forest floor is efficiently flushed, with water flux of about

30 L m^{-2} day^{-1} of forest floor, which is equivalent to about 10% of the total burrow volume in the forest per tidal cycle. This work illustrates the physical process which supports export of organic and inorganic matter from mangrove forests to the coastal zone. Importantly, annual average circulation fluxes through mangrove forest floors are of the same order as annual river discharge in the central GBR.

Finally, an improved understanding of the fate of land-derived waters is of great importance to current discussions about water quality management in the Great Barrier Reef. The mixing of coastal waters is an important parameter influencing the health of these ecosystems. Time constants associated with the decay of four naturally-occurring isotopes of radium span large time scales; ^{224}Ra, ^{223}Ra, ^{228}Ra and ^{226}Ra have half-lives of 4 days, 11 days, 6 years and 1620 years respectively. The radium quartet has been used to determine time scales of mixing of near-shore water and deep ocean water. This study demonstrates that central GBR water within 20 km of the coast is flushed with outer lagoon water on a timescale of 18–45 days, with the flushing time increasing northward. This difference likely reflects the different reef matrix density in the two zones, affecting exchange with offshore Coral Sea water.