



Residence Time in St. Andrew Bay, Florida

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Why Residence Time??

- Length of time required for a parcel of water to enter and exit a water body
- Important to health of ecosystem
- Basin geometry is influential
- Not a constant variable



Radium Isotopes

- Naturally present in the Earth's crust
- Soluble in saline water, but not in freshwater

- ^{223}Ra , $t_{1/2} = 11$ days

- ^{224}Ra , $t_{1/2} = 3.6$ days

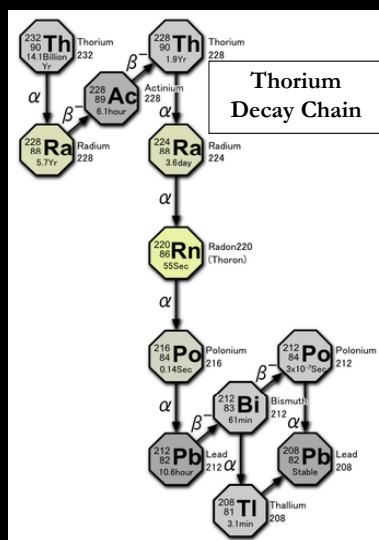
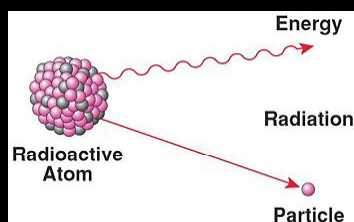
short-lived

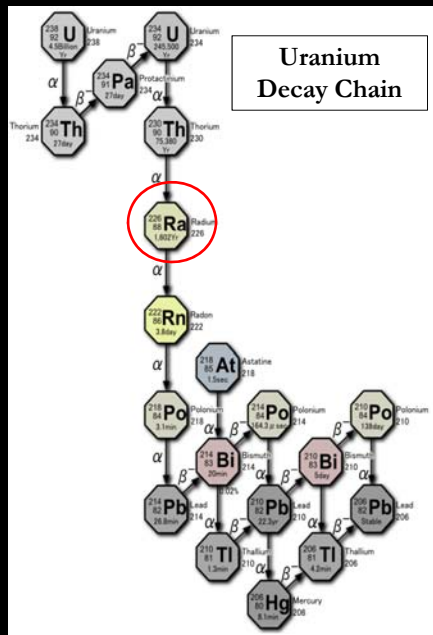
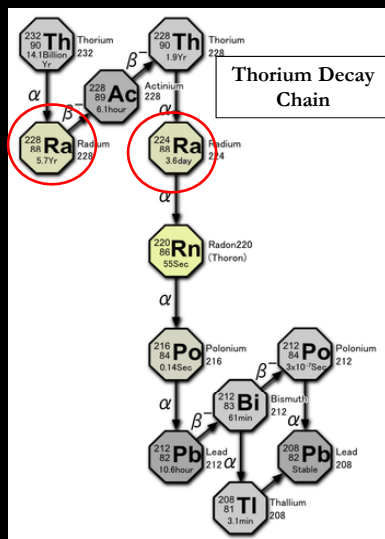
long-lived

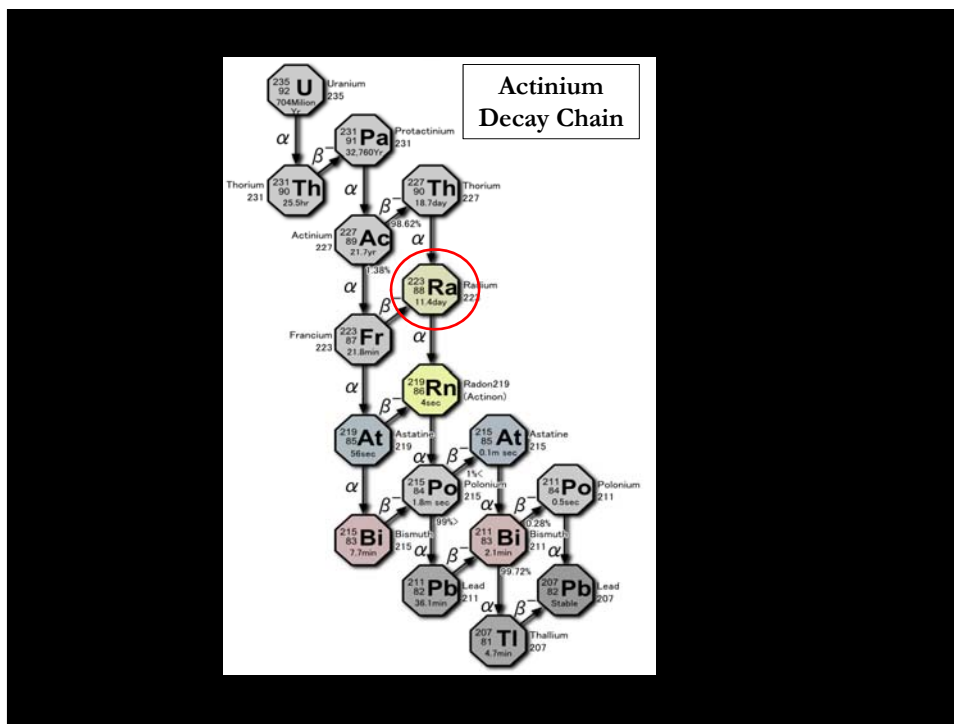
- ^{226}Ra , $t_{1/2} = 1600$ years

- ^{228}Ra , $t_{1/2} = 5.8$ years

Radium Isotopes: Decay







Study Area St. Andrew Bay, FL



- 4 estuaries: North Bay, West Bay, East Bay and St. Andrew Bay
- 280 km², 998x10⁶ m³
 - NB: 27 km², 68x10⁶ m³
 - WB: 71 km², 170x10⁶ m³
- Deer Point Lake
 - 22 km²
 - 13-22 m³/sec over dam

Grab Sampling

- “snap-shot” of conditions at the moment of sampling
- Collect 60-70 liters per sample
- Pass water over manganese-oxide fibers



Stationary Moorings

- Deployed for approximately a tidal cycle
- 2-3 sets of fibers per mooring
- Results are an average conditions over the deployment period
- Approach successfully used in Apalachicola Bay by H. Dulaiova

Analytical Methods

- Short-lived Ra isotopes
 - ^{224}Ra , $t_{1/2} = 3.6$ days and ^{223}Ra , $t_{1/2} = 11$ days
 - Radium Delayed Coincidence Counter (RaDeCC)
 - ^{224}Ra excess correction (ex^{224}Ra)
- ^{226}Ra
 - $t_{1/2} = 1600$ years
 - Rn line
 - ^{226}Ra excess correction (ex^{226}Ra)

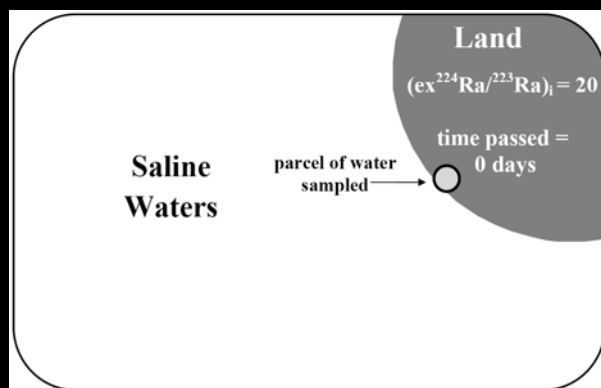
Residence Time via Radium Isotopes

$$\left[\frac{\text{ex}^{224}\text{Ra}}{^{223}\text{Ra}} \right]_{obs} = \left[\frac{\text{ex}^{224}\text{Ra}}{^{223}\text{Ra}} \right]_i \frac{e^{(-\lambda_{224})t}}{e^{(-\lambda_{223})t}}$$

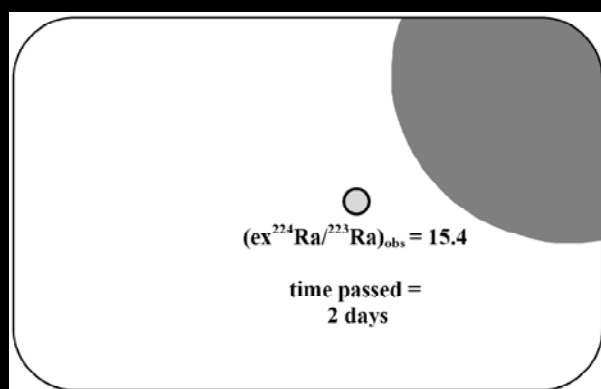
- Radium isotope source from groundwater and river inputs
- Determine age of water parcel assuming...
 - Only one source of radium
 - Loss of radium is due to either decay or dilution by mixing
 - Any offshore source does not influence activities

Moore 2000

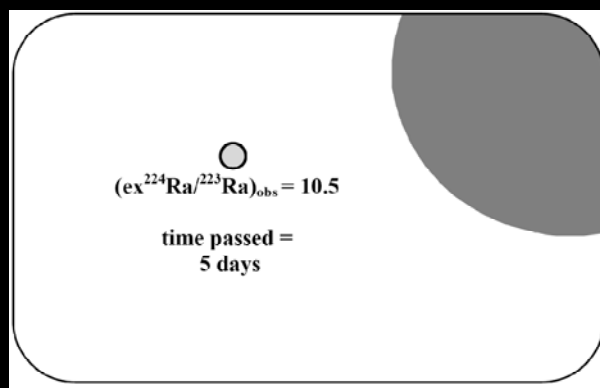
Residence Time via Radium Isotopes



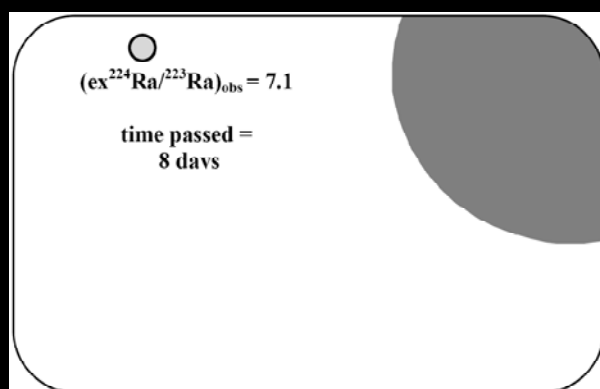
Residence Time via Radium Isotopes



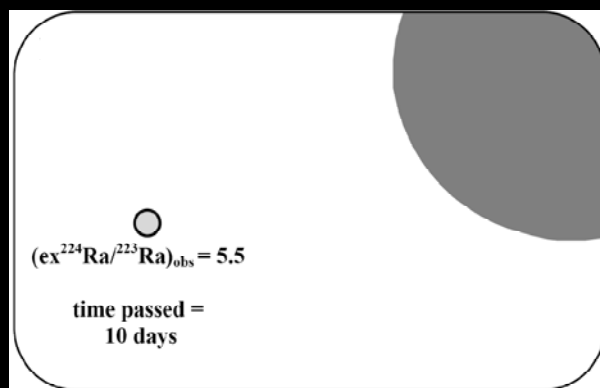
Residence Time via Radium Isotopes



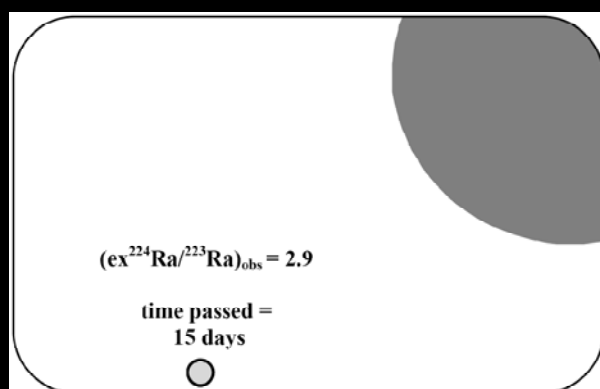
Residence Time via Radium Isotopes



Residence Time via Radium Isotopes



Residence Time via Radium Isotopes



DETERMINATION OF RESIDENCE TIME

6 Sampling Trips:

February 2009

July 2009

April 2009

October 2009

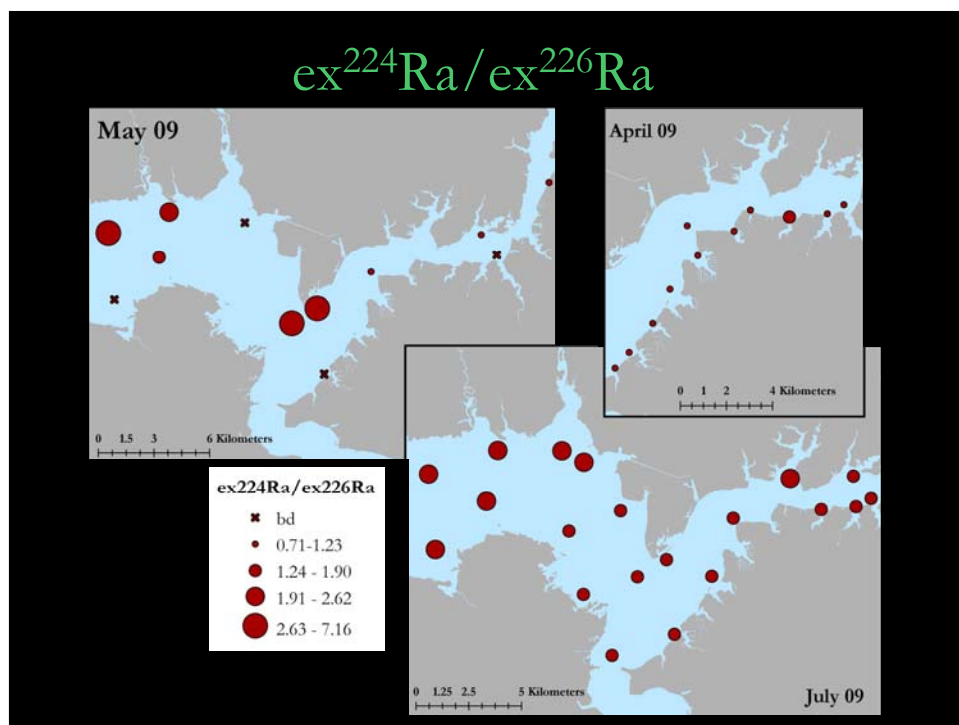
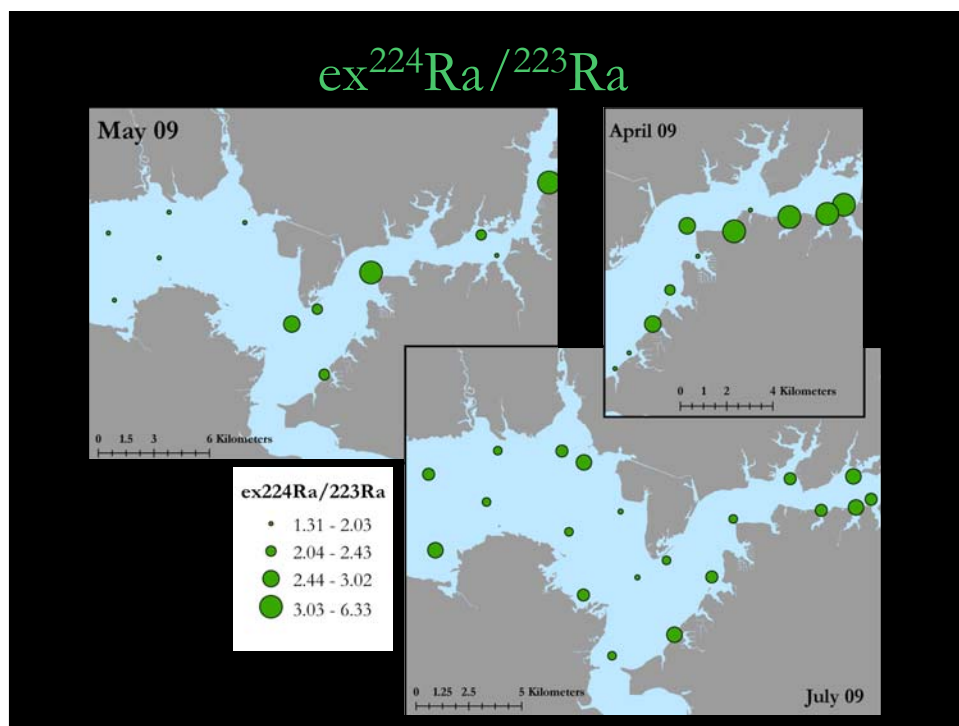
May 2009


April 2010

Sample Collection



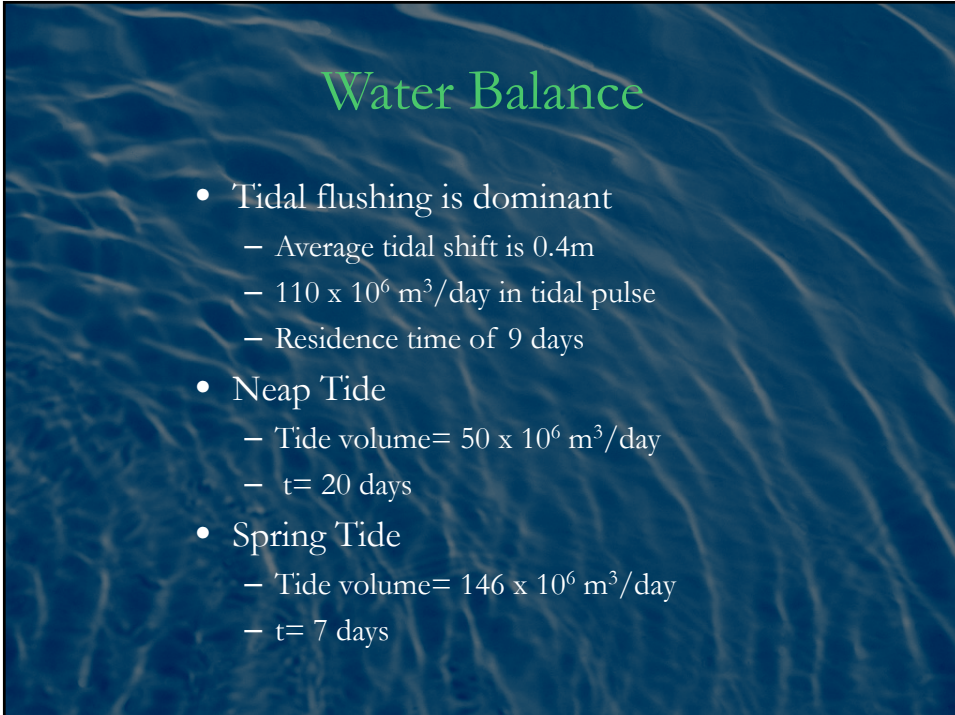
- Combination of grab and mooring samples





AR Residence Time Estimates

- Average AR for each site
- $ex^{224}\text{Ra}/^{223}\text{Ra}$
 - Deer Point Lake is the largest freshwater source to North Bay
 - Highest measured ratio of 9.38
 - $\tau = 10$ days
- $ex^{224}\text{Ra}/ex^{226}\text{Ra}$
 - Highest average AR at site WB06 of 6.15
 - Deer Point Lake AR excluded
 - $\tau = 9-10$ days



Water Balance

- Tidal flushing is dominant
 - Average tidal shift is 0.4m
 - $110 \times 10^6 \text{ m}^3/\text{day}$ in tidal pulse
 - Residence time of 9 days
- Neap Tide
 - Tide volume = $50 \times 10^6 \text{ m}^3/\text{day}$
 - $\tau = 20$ days
- Spring Tide
 - Tide volume = $146 \times 10^6 \text{ m}^3/\text{day}$
 - $\tau = 7$ days

Water Balance (cont.)

$$T_f = \frac{VT}{(1-b)P}$$

Variable	Definition	St. Andrew Bay value
T_f	Flushing parameter	10-11 days
V	Volume of bay	$1.0 \times 10^9 \text{ m}^3$
T	Tidal period	24.8 hours
b	Return flow factor (fraction of bay water returning with each flood tide)	0.1-0.2
P	Difference in water volume between high and low tide	$110 \times 10^6 \text{ m}^3$

Monsen et al. 2000

Conclusions

- Residence time of northern St. Andrew Bay between 7 and 20 days
 - ARs approach: average of 10 days
 - Water Balance: average of 11 days
- No dominant radium source
- Multiple local sources
- St. Andrew Bay is a healthy environment
 - Continued monitoring necessary!!



Acknowledgements



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Questions??