Surface Radiocarbon in the Gulf of Mexico and Caribbean as Recorded in Corals

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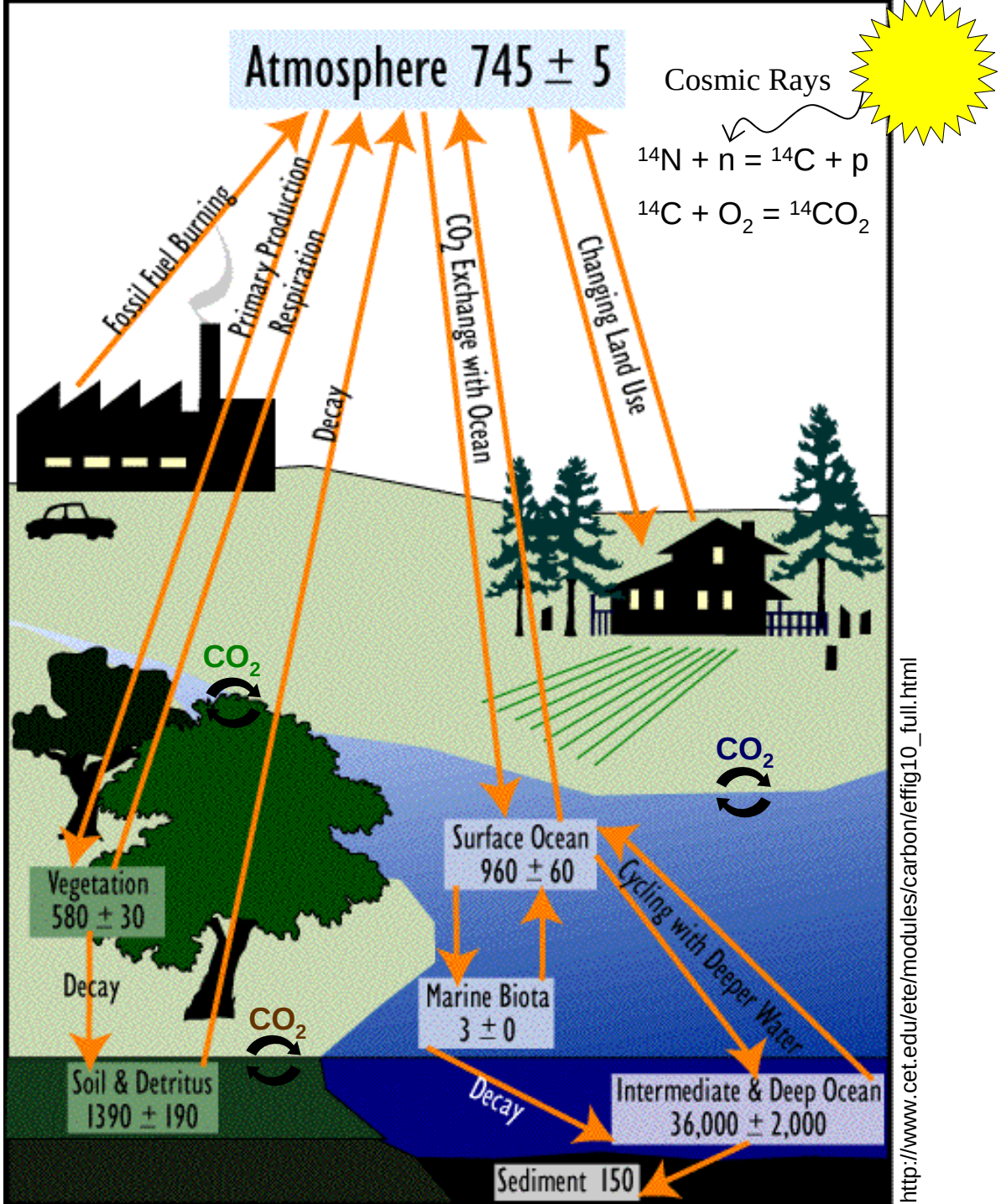
*Currently doing Sea Grant Fellowship with NOAA Climate Program Office

Global Carbon Cycle



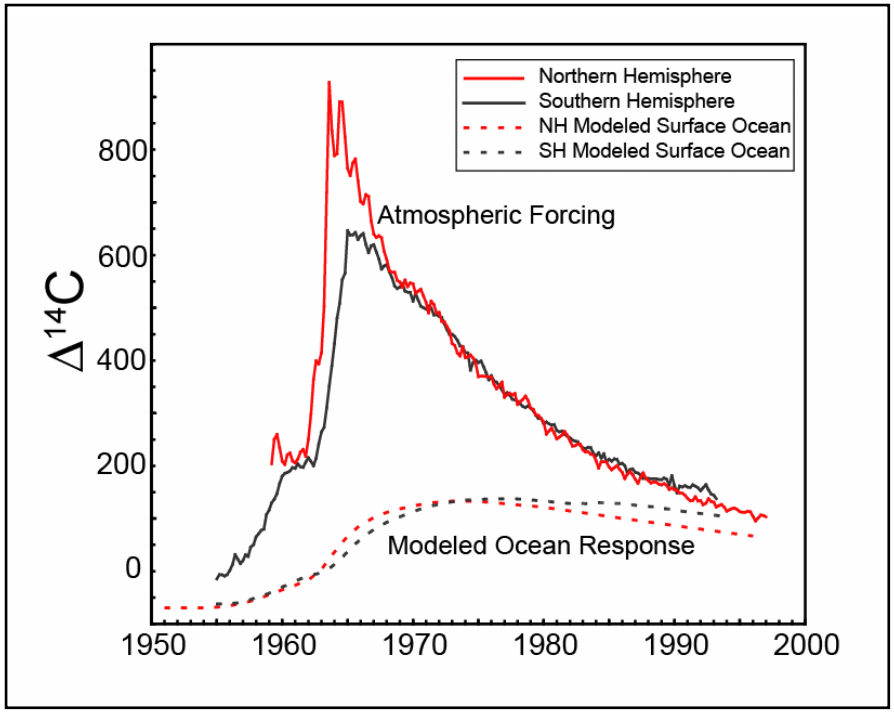
http://www.cet.edu/ete/modules/carbon/effig10_full.html

Carbon Isotopes

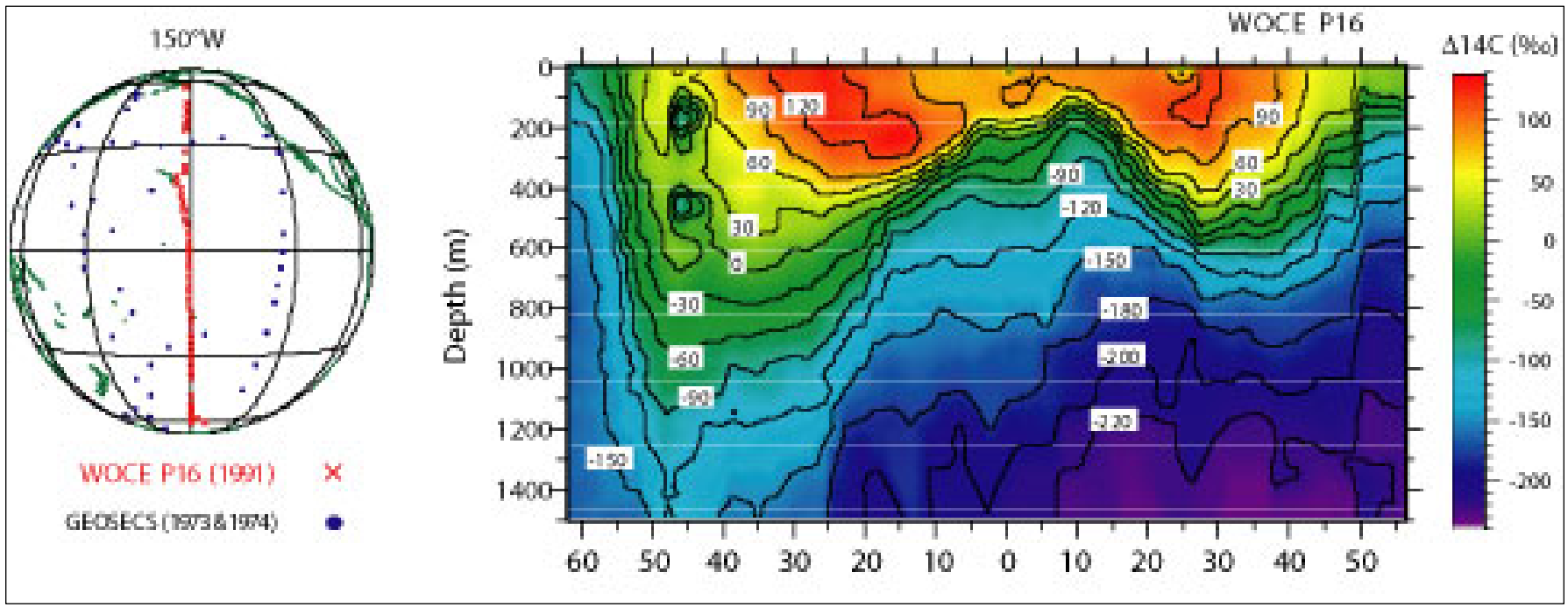
Blue=Protons
Red=Neutrons
Gold=Electrons

- $\delta^{13}C‰$ => ratio of $^{13}C/^{12}C$
- $\Delta^{14}C$ ‰ => ratio of $^{14}C/^{12}C$
  - Naturally occurring and man-made (nuclear bombs)
  - Used to determine age of terrestrial and marine samples

http://encarta.msn.com/media_461535237_761571323_1_1/Isotopes_of_Carbon.html



Radiocarbon in the Atmosphere vs. the Ocean



Some Radiocarbon Terminology

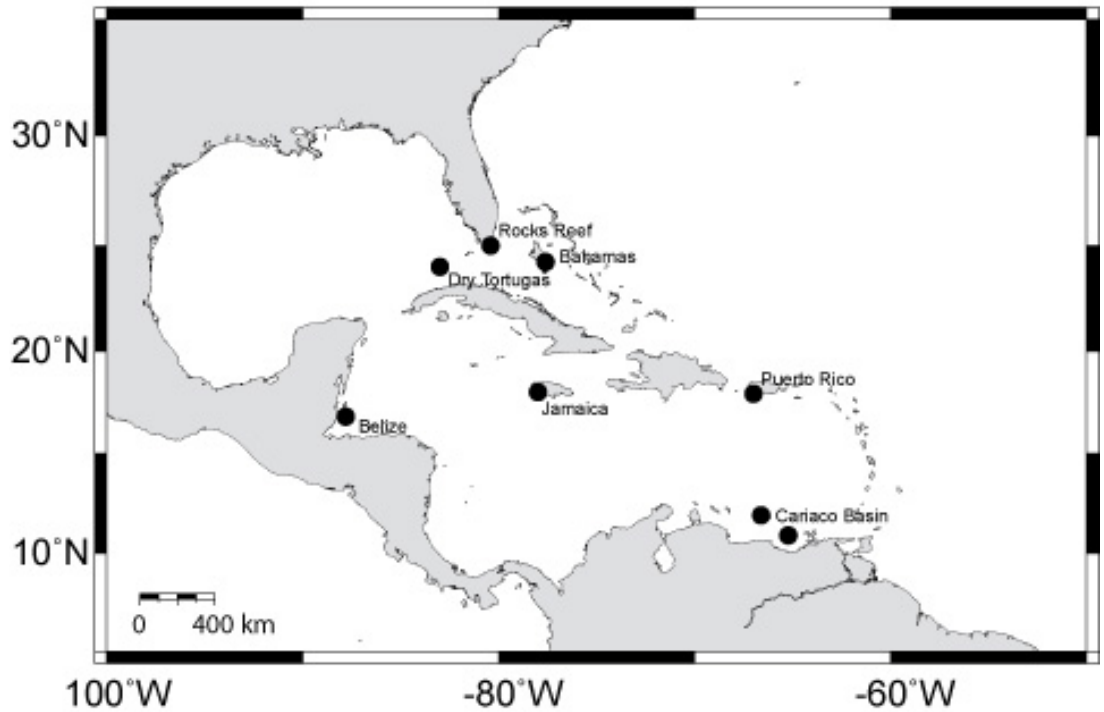
- ^{14}C age BP
  - Conventional radiocarbon age
    => years before 1950
- Reservoir Age
  - Measured marine ^{14}C age – Atmospheric ^{14}C age
- ΔR
  - Difference between the regional and global marine ^{14}C age
  - Measured marine ^{14}C age – marine model ^{14}C age

Why Corals?

- Incorporate geochemical properties of water in which they grow into skeletal material ($CaCO_3$)
- Relatively fast-growing
  - Get high resolution sampling => monthly or greater
- Grow at different rates through the year
  - Annual density bands => assists in determining age of coral
- Not material limited like other oceanic proxies such as forams

The need for more data

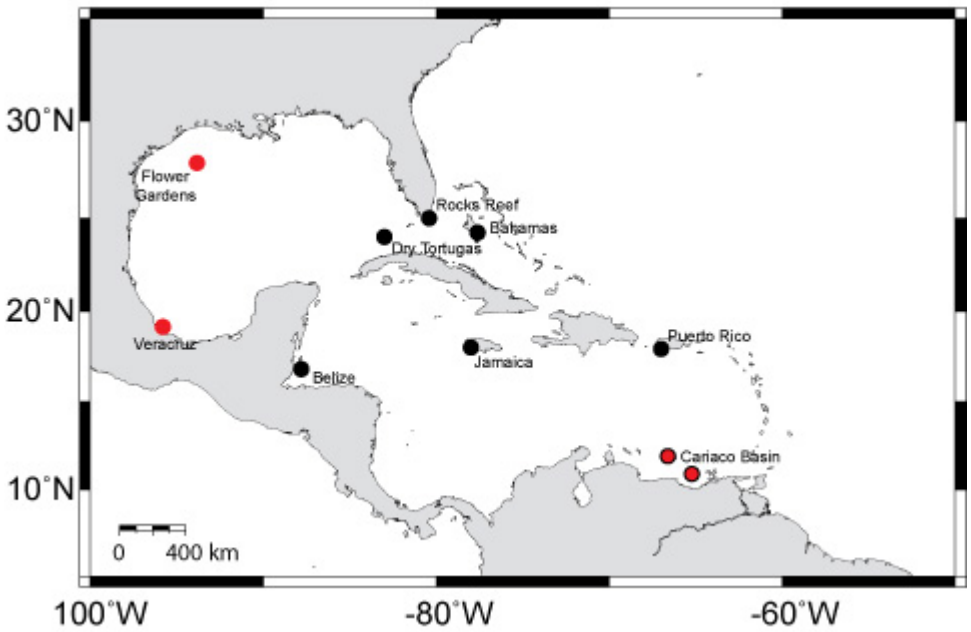
- Relatively few regional measurements in Caribbean
- None in Gulf of Mexico



Sample Sites

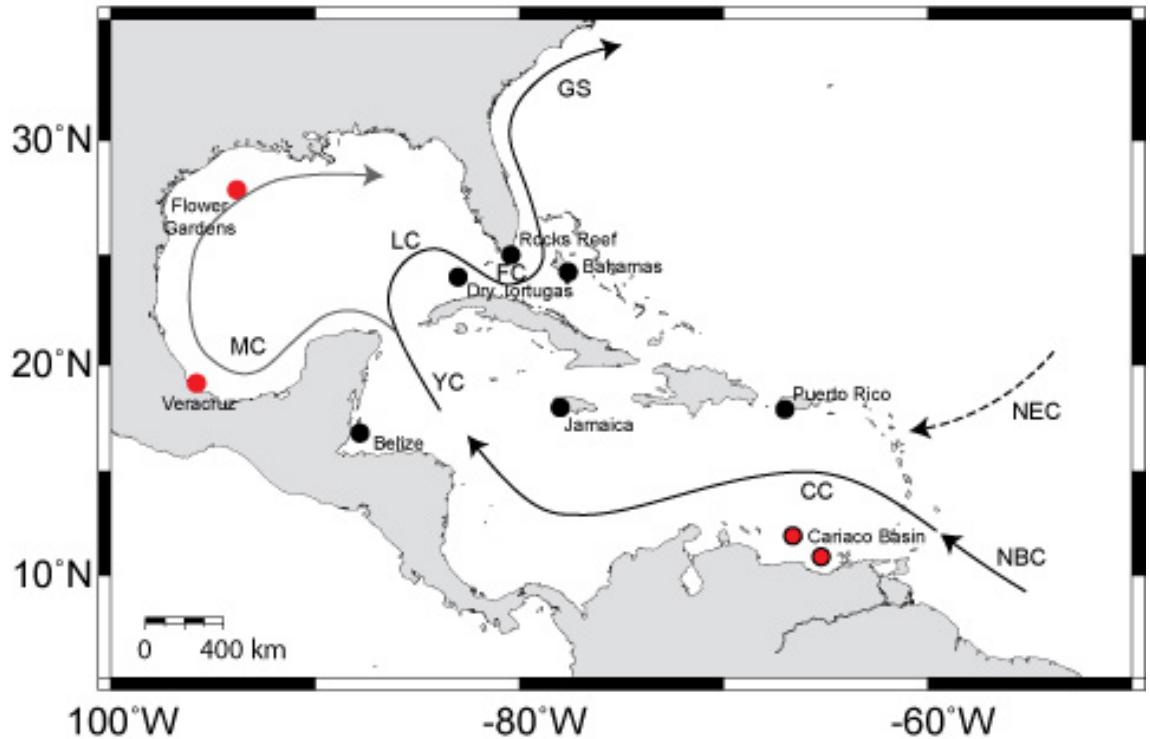
Montastrea faveolata

- *Flower Garden Banks*
  - Northern Gulf of Mexico continental shelf
  - ~20m water depth
  - Collected in 1990
- *Santiaguillo Reef*
  - 20 km off the coast of Veracruz, Mexico
  - ~6 m water depth
  - Collected in 1991
- *Cariaco Basin*
  - Boca de Medio
    - Los Roques archipelago, outside of the Cariaco Basin
    - collected in 1998
  - Isla Tortuga
    - Within Cariaco Basin
    - Collected in 1996



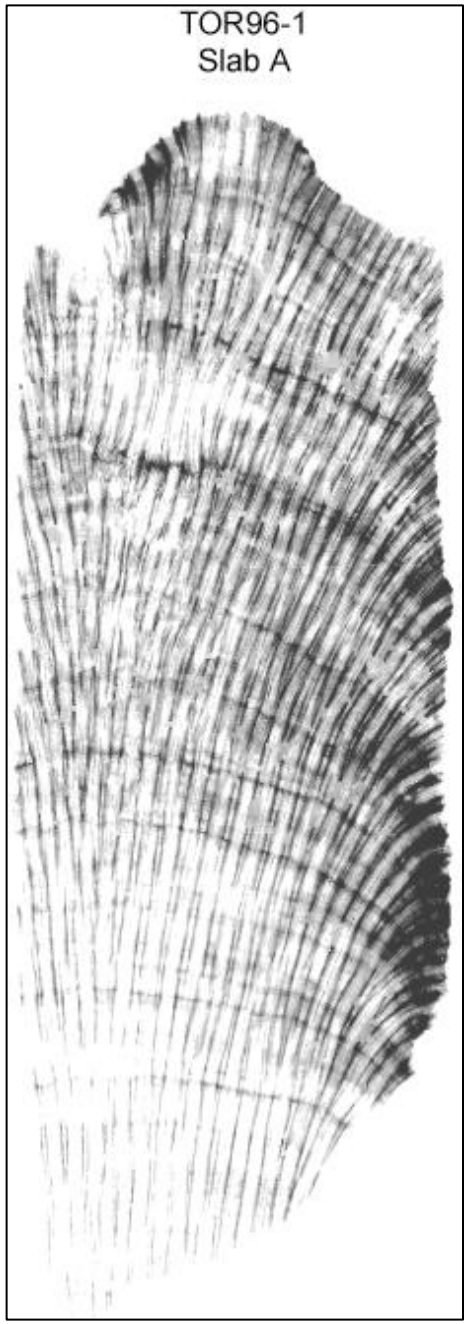
General Surface Oceanography of Region

- Caribbean Sea
  - Surface water enters SE Caribbean and exits through Yucatan Channel
- Gulf of Mexico
  - Enters through Yucatan Channel and exits through Florida Straits



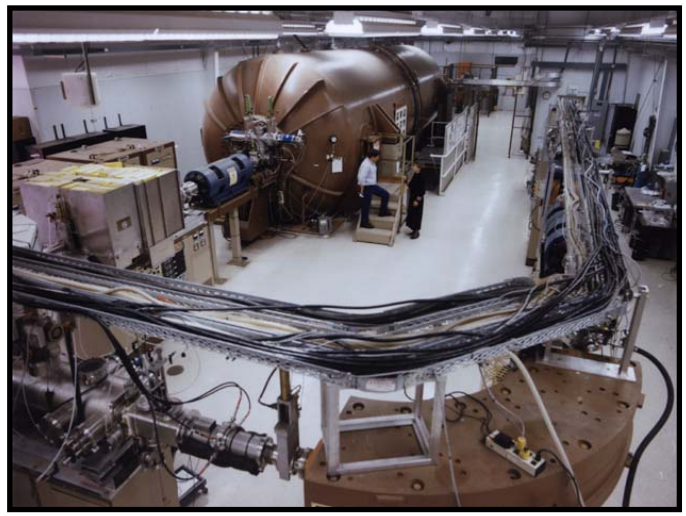
Methods

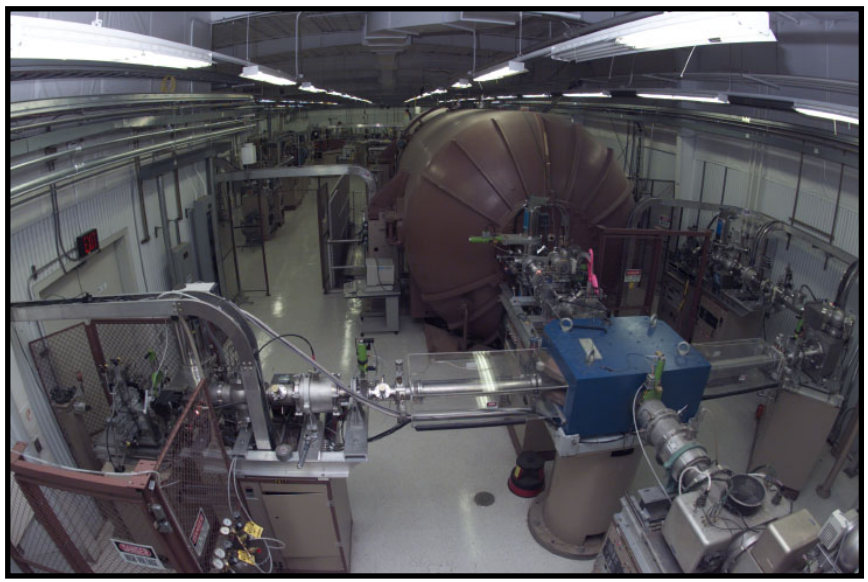
- Cores collected using underwater hydraulic drill
- Ages determined from annual density bands



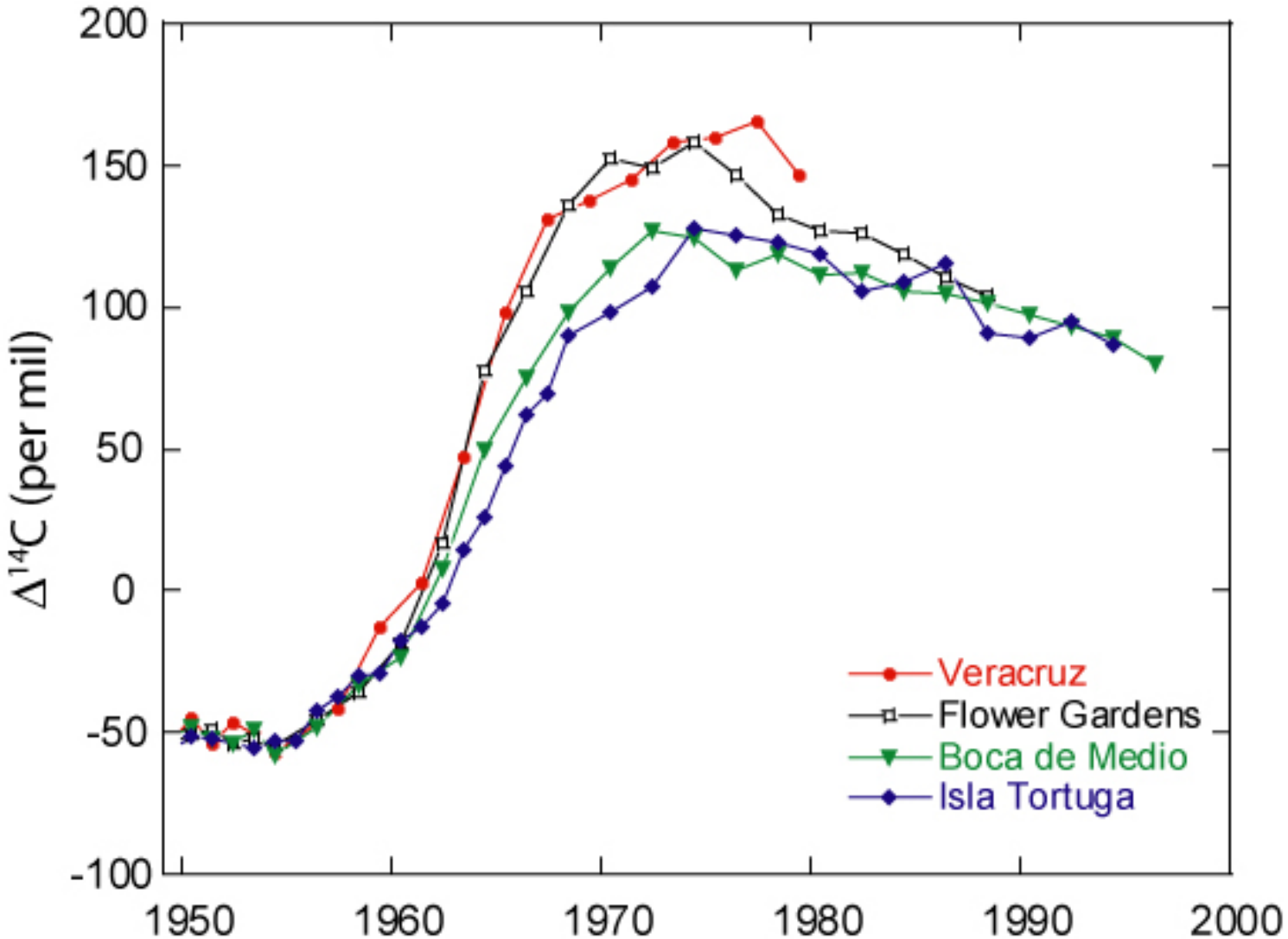
Methods

- Convert ~10mg $CaCO_3$ to graphite for analysis
- ^{14}C analysis at LLNL
  - Center for Accelerator Mass Spectrometry (CAMS)





Results


200
150
100
50
0
-50
-100
Δ14C (per mil)
1950
1960
1970
1980
1990
2000
Veracruz
Flower Gardens
Boca de Medio
Isla Tortuga

Results

Site	Midpoint (year)	Delta ^{14}C (‰) (age corrected)	^{14}C Age conventional	Reservoir Age (years)	ΔR (years)
Flower Garden Banks	1950 (n=9)	-53.2 ± 1.0	439 ± 9	240 ± 13	-30 ± 26
Veracruz, Mexico	1950 (n=10)	-51.9 ± 1.1	428 ± 10	229 ± 13	-41 ± 26
Gulf of Mexico Avg	1950 (n=19)	-52.6 ± 0.7	434 ± 7	235 ± 11	-36 ± 25
Boca de Medio	1950 (n=10)	-53.2 ± 1.0	438 ± 9	239 ± 13	-31 ± 26
Isla Tortugas	1950 (n=3)	-53.9 ± 1.5	447 ± 14	248 ± 17	-22 ± 28
Caribbean Avg	1950 (n=13)	-53.4 ± 0.8	441 ± 8	242 ± 12	-28 ± 25

GoM/Caribbean Average Reservoir Age and ΔR = 238 years and -32 years

Global Atmospheric 14C age = 199 years

Global Average Marine 14C age = 469 years

Comparison with Existing Data

Site	Year	Reservoir Age	ΔR	Reference	Material
Bahamas	1950	229 ± 43	-40 ± 42	(Broecker and Olson 1961)	Gastropod
Bahamas	1885	423 ± 59	56 ± 59	(Broecker and Olson 1961)	Gastropod
The Rocks, FL Keys	1850	405 ± 18	33 ± 16	(Druffel and Linick 1978; Druffel 1982)	Coral
Tortugas, FL	1884	482 ± 52	114 ± 51	(Lighty et al. 1982)	Coral
Golden Cay, Bahamas	1912	493 ± 66	146 ± 66	(Lighty et al. 1982)	Coral
Gulf of Honduras, Belize*	1950	270 ± 54	0 ± 58	(Druffel 1980)	Coral
Jamaica	1884	323 ± 42	-44 ± 41	(Broecker and Olson 1961)	Gastropod
Jamaica	1930	273 ± 43	-30 ± 42	(Broecker and Olson 1961)	Gastropod
Cariaco Basin, Venezuela	1935	336 ± 61	33 ± 60	(Hughen et al. 2004b)	Foraminifera
Cariaco Basin, Venezuela	1910	361 ± 50	12 ± 50	(Hughen et al. 2004b)	Foraminifera
Isla Tortuga, Venezuela	1941	264 ± 41	-22 ± 40	(Guilderson et al. 2005)	Coral
Isla Tortuga, Venezuela	1906	290 ± 41	-70 ± 40	(Guilderson et al. 2005)	Coral
Boca de Medio, Venezuela	1945	256 ± 42	-18 ± 41	(Guilderson et al. 2005)	Coral
Los Testigos, Venezuela	1940	285 ± 43	-1 ± 42	(Guilderson et al. 2005)	Coral

Conclusions

- This study has updated Caribbean reservoir age and ΔR and added Gulf of Mexico information to ^{14}C database
- Caribbean and Gulf of Mexico results within error of each other
- Useful when dating marine samples from this region
  - Only applicable during times of similar oceanographic conditions
  - Could be variable during different oceanographic regimes
- ΔR negative compared to global marine average
- Small ΔR suggests global marine model estimates close for regional

Acknowledgments

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