



Proxies and Chronologies

North American TRACES Workshop

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Proxy Development in Paleoceanography

- 1) Chronology or age model development
- 2) Replication of the proxy within different samples.
- 3) Clear link between proxy and environmental signal.



Art work by Terry Kirby -- HURL Expedition Leader

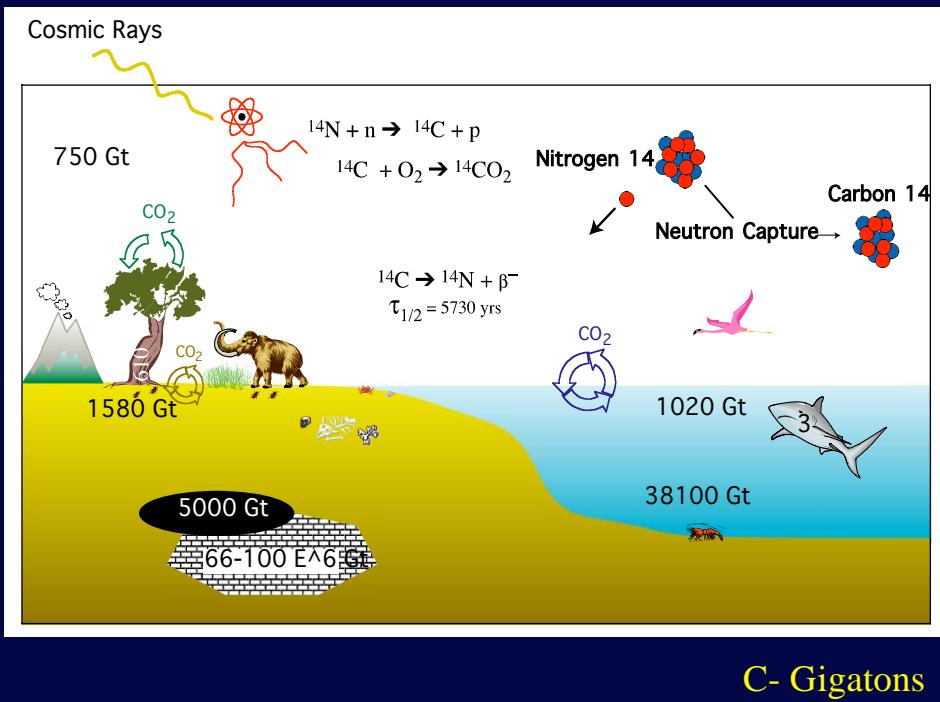
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Age Dating Methods

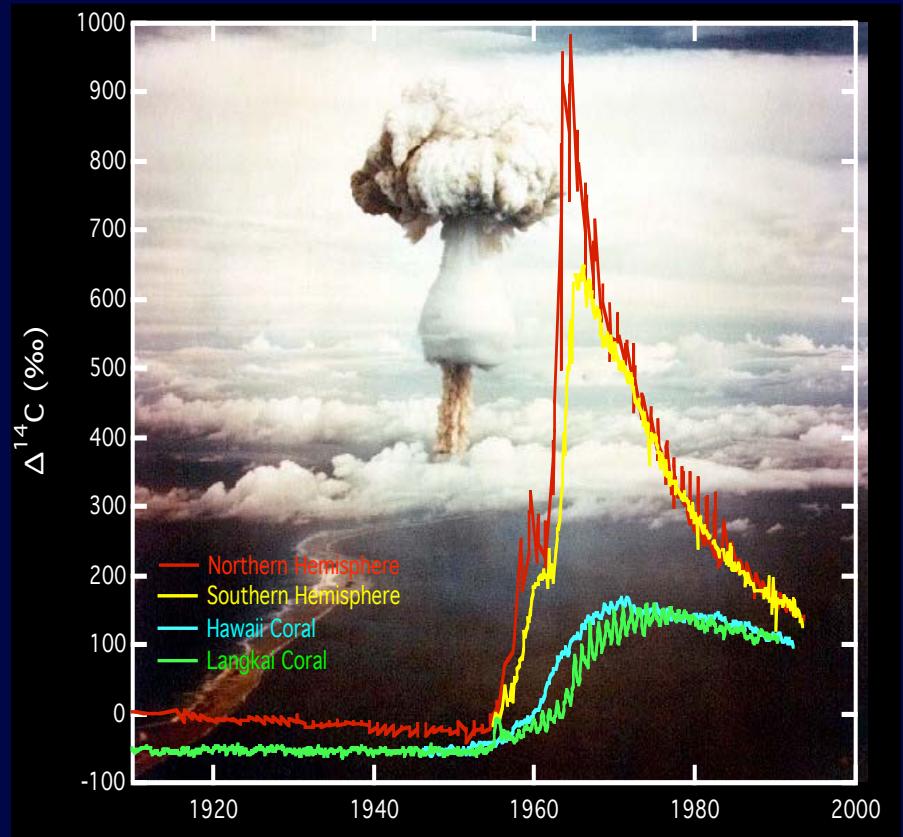
- Dendrochronology
 - high resolution -- needs validation
- Lead 210 (^{210}Pb) dating
 - ~ 200 years max, relatively large sample size
- Radiocarbon (^{14}C)
 - ~ 50,000 years, last few hundreds years reasonably invariant, requires calibration.
- U-Series
 - up to ~100,000 years, no calibration, typically larger uncertainties on younger material.
- Amino Acid Dating
- $^{87}\text{Sr}/^{86}\text{Sr}$

Radiocarbon in the Environment

‘Natural’ ^{14}C



Anthropogenic ^{14}C



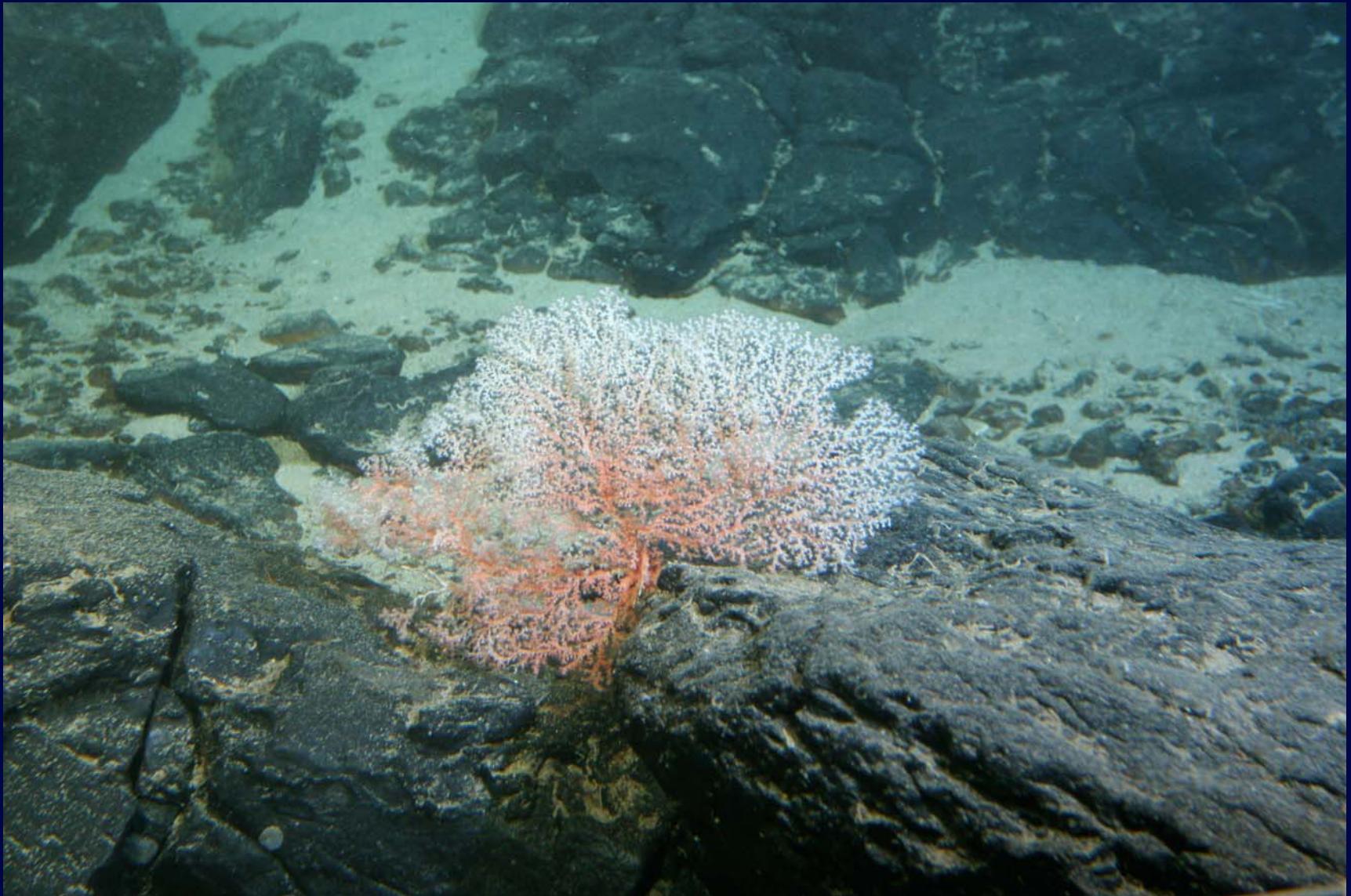
We can use radiocarbon (^{14}C) as a “conventional dating technique” or use the bomb-spike as a unique marker in the instrumental period.

**1 -- Age and growth rate results of the
most promising DSC**

**2 -- Example of age and growth rates in
the development of proxies**

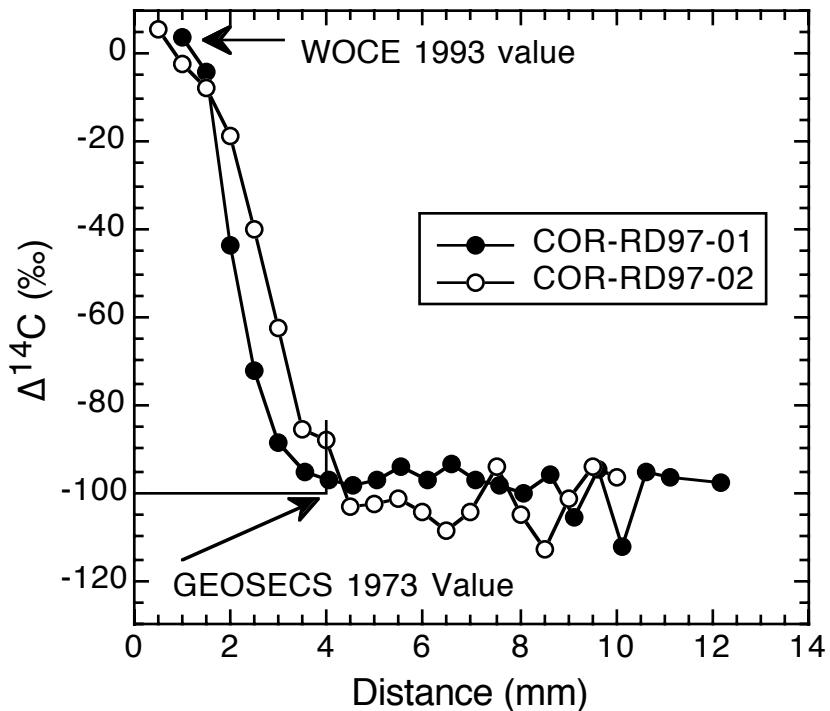


Corallium sp.



Corallium sp.

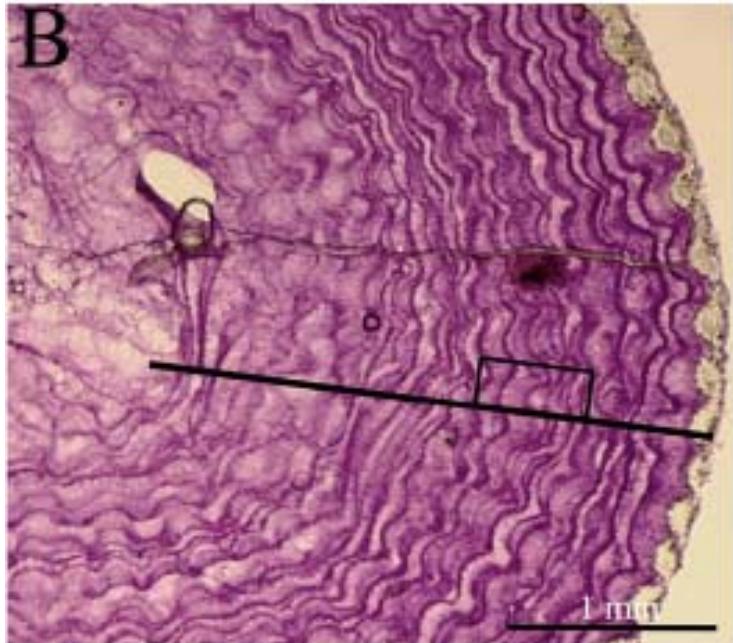
Corallium secundum, 400m



Roark et al., 2006 MEPS

- Corresponding radial “growth rate” is $\sim 170 \mu\text{m}/\text{year}$ ~ 70 years old.
- GEOSECS data is used to set our initial time-marker and assigned a $\Delta^{14}\text{C}$ value of $\sim -100\text{\textperthousand}$ to be no later than 1973.

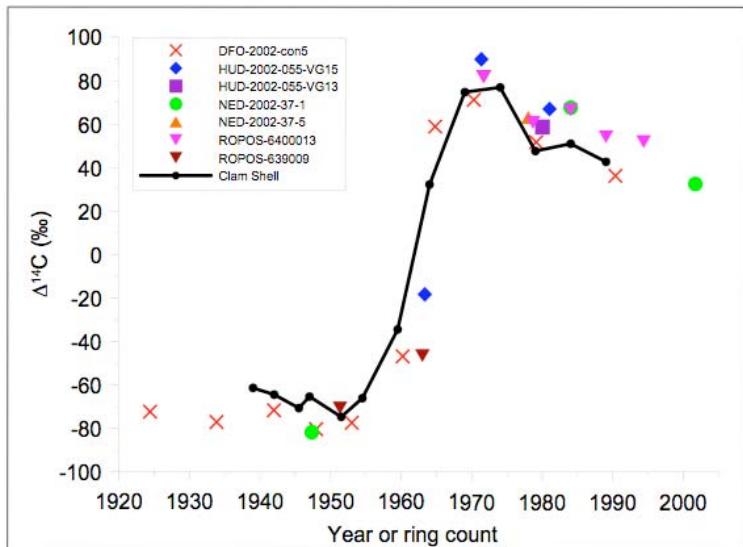
Corallium rubrum ~27m



Marschal et al., 2004 Coral Reefs

- $350 \pm 150 \mu\text{m}/\text{year}$ based on staining of organic growth bands of known age samples.
- *C. niobe* 600 m from Little Bahama Bank
 $110 \pm 20 \mu\text{m}/\text{year}$ Age = $180 \pm 20 \mu\text{m}/\text{year}$
 ^{210}Pb Dating by Druffel et al., 1990 GCA

Primnoa resedaeformis



Depth 250-475 m Nova Scotia

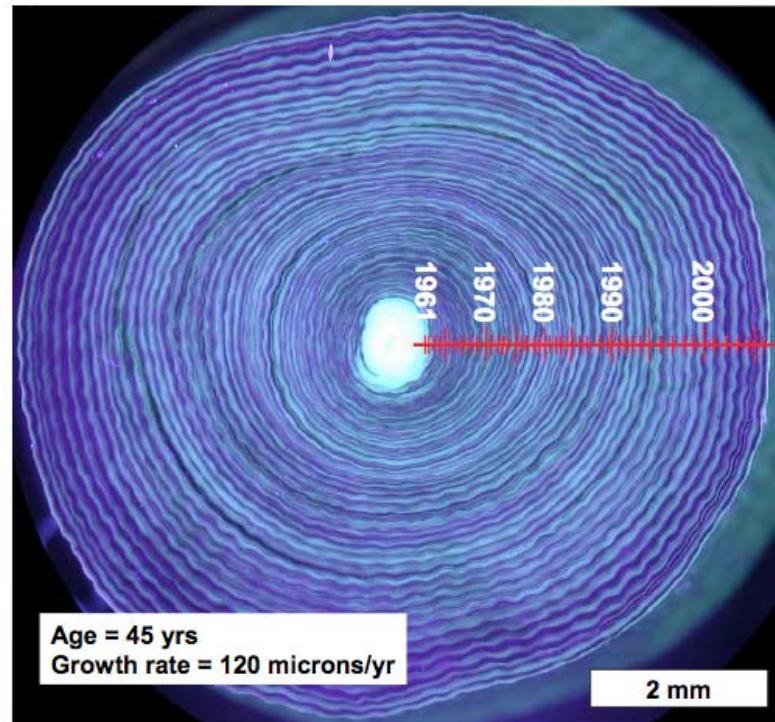
Sherwood et al. (2005)

Max age 78 years

~120 $\mu\text{m}/\text{year}$

Sherwood et al., 2005 MPES

Growth rings in *Primnoa*



^{210}Pb Studies

Location/Depth

Max age

Radial growth rate

Williams et al., 2007 MEPS

Gulf of Alaska/110-429 m

195 to 52 years

Andrews et al., 2002 Hydrobiologia

SE Alaska

~100 years

~360 $\mu\text{m}/\text{year}$

Climate Studies $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ -- Sherwood et al., 2005 and Williams et al., 2007
Sub-Fossil ~2600 year old specimen with life span of ~300 year Risk et al., 2002

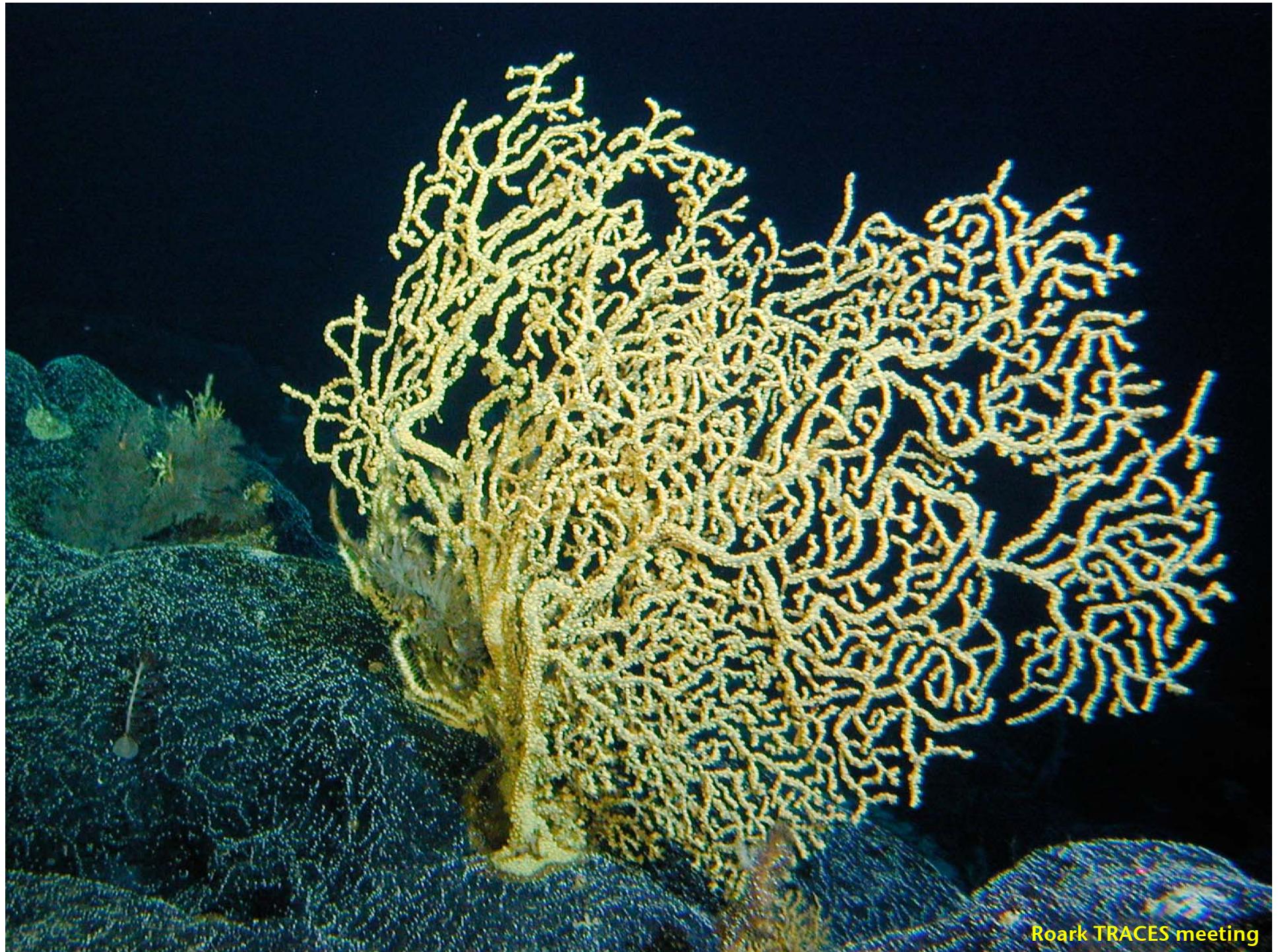
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Enallapsammia rostrata

^{226}Ra - ^{210}Pb North Bermuda 1410 m -- Adkins et al., 2005 EPSL
Radial growth rate 70 $\mu\text{m}/\text{year}$, ~210 years old

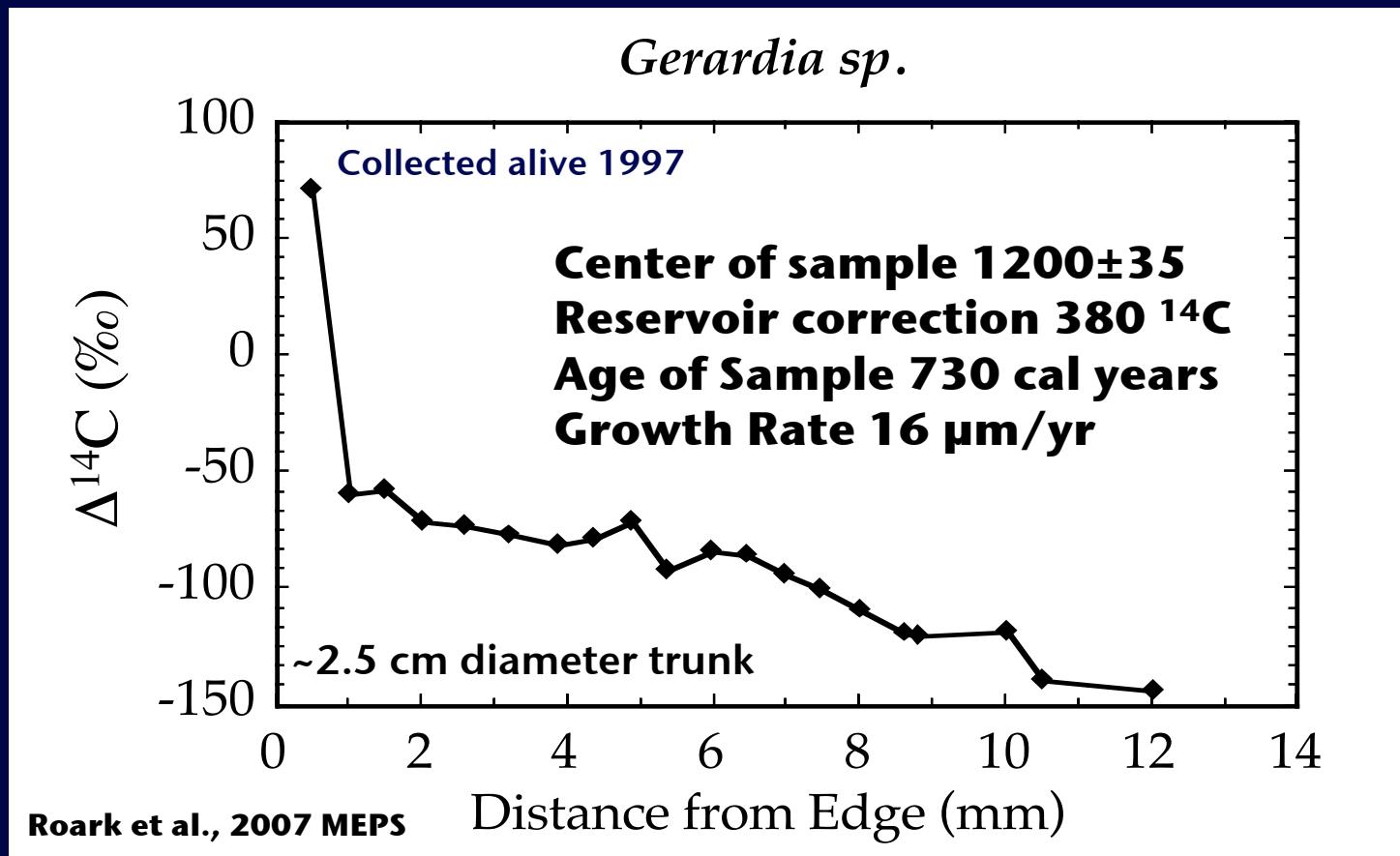
U/Th dating
Line Islands 480-700 m
5 colonies 214 \pm 5 to 607 \pm 6 lifespan ~40-70 $\mu\text{m}/\text{year}$
Houlbrèque et al., in prep

Either method paired with ^{14}C --> Ventilation records



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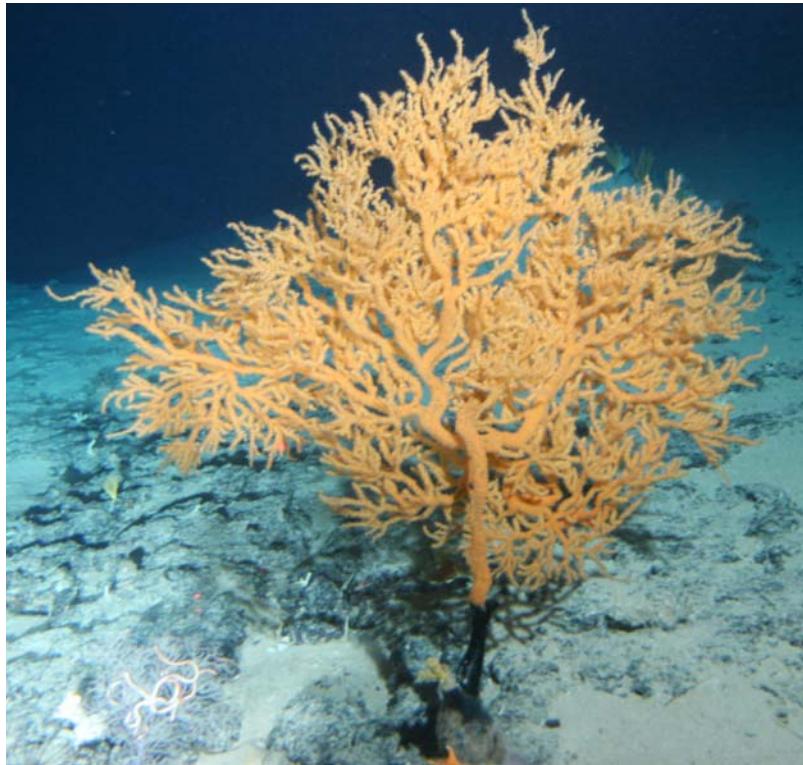
Ancient Deep-Sea Corals?



Atlantic *Gerardia sp.* 1800 ± 300 (Druffel et al., 1995)

Amino Acid Dating 250 ± 70 years (Goodfriend, 1997)

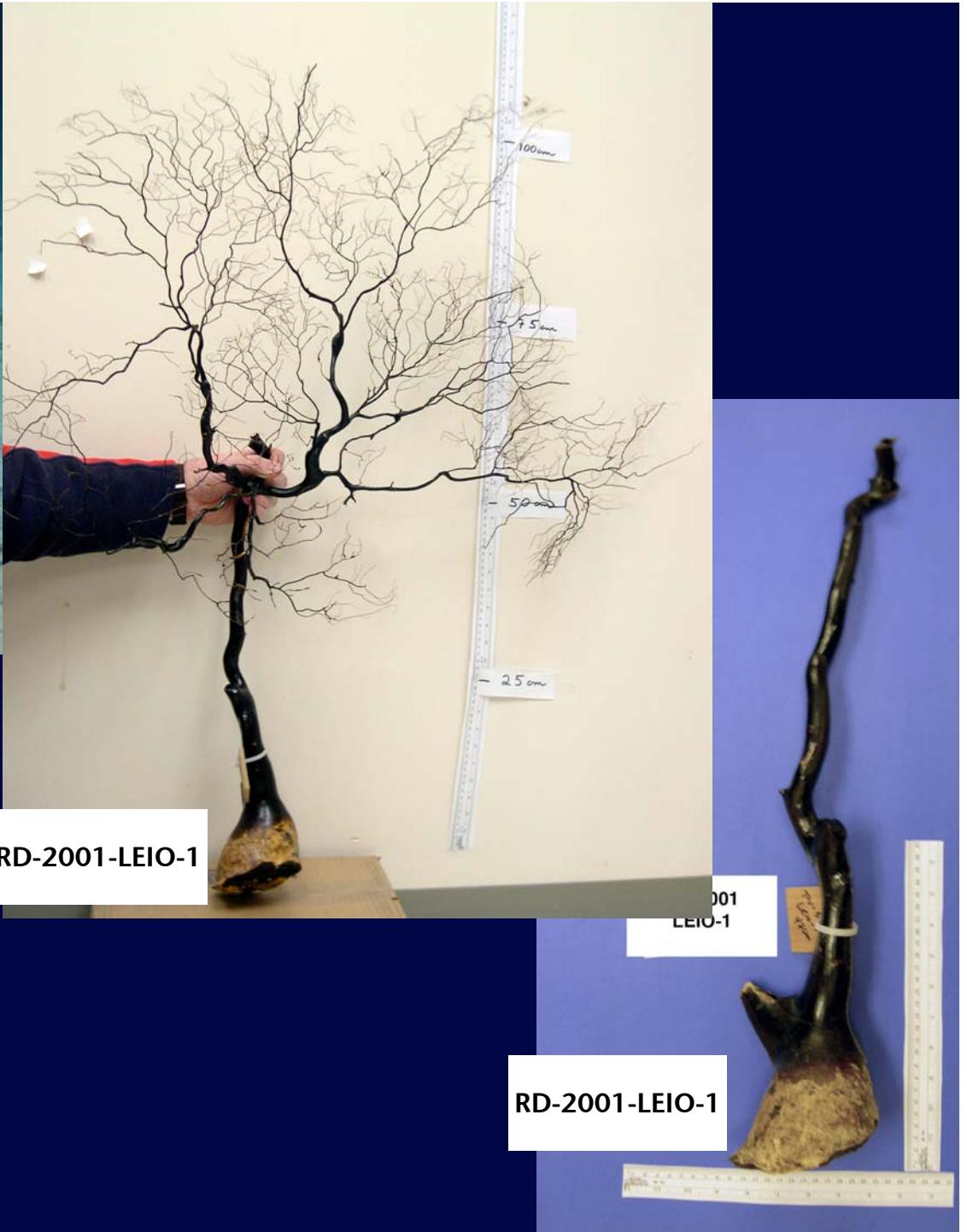
Hawaii -- radial growth 1.07 mm/yr ,
Maximum age 70 years (Grigg 2002)



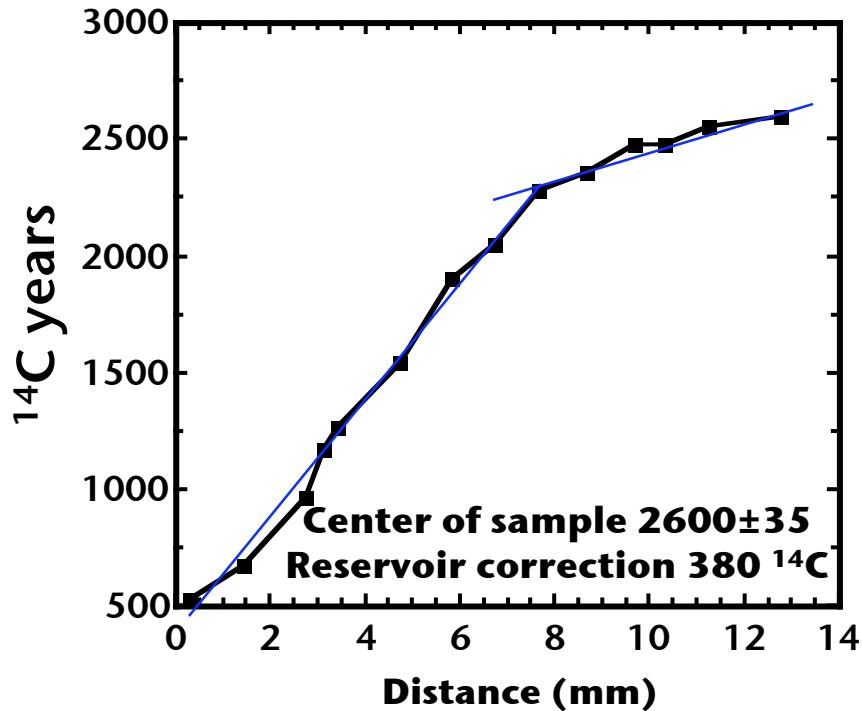
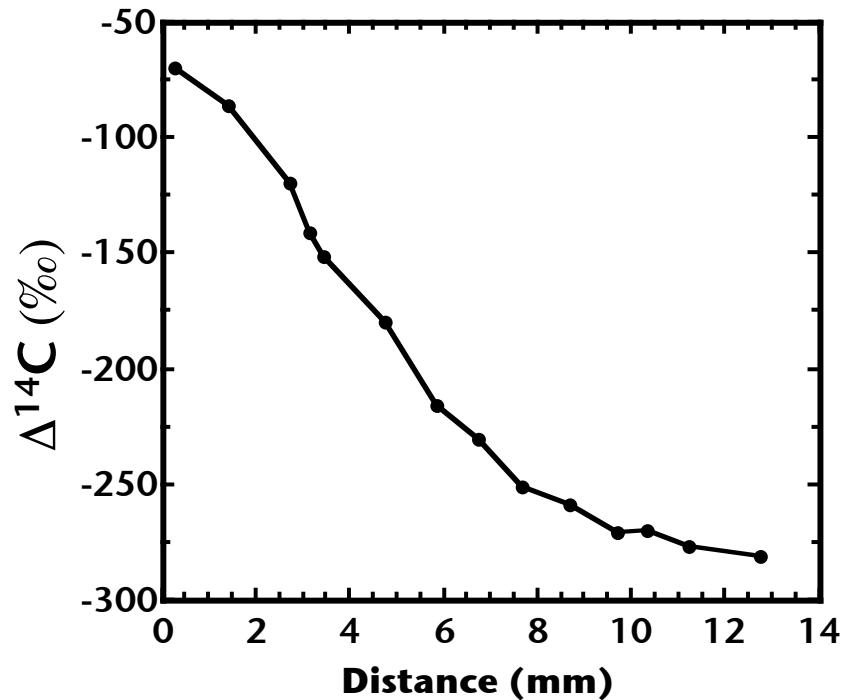
Leiopathes glaberrina

(RD-2001-LEIO1)

470 m depth
1.1 m height



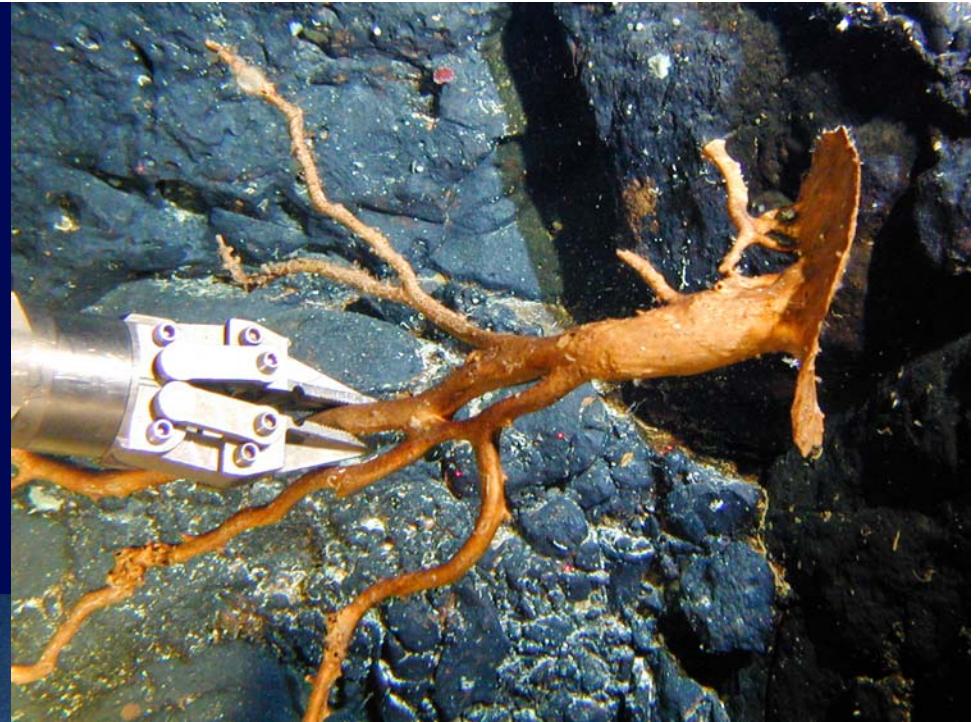
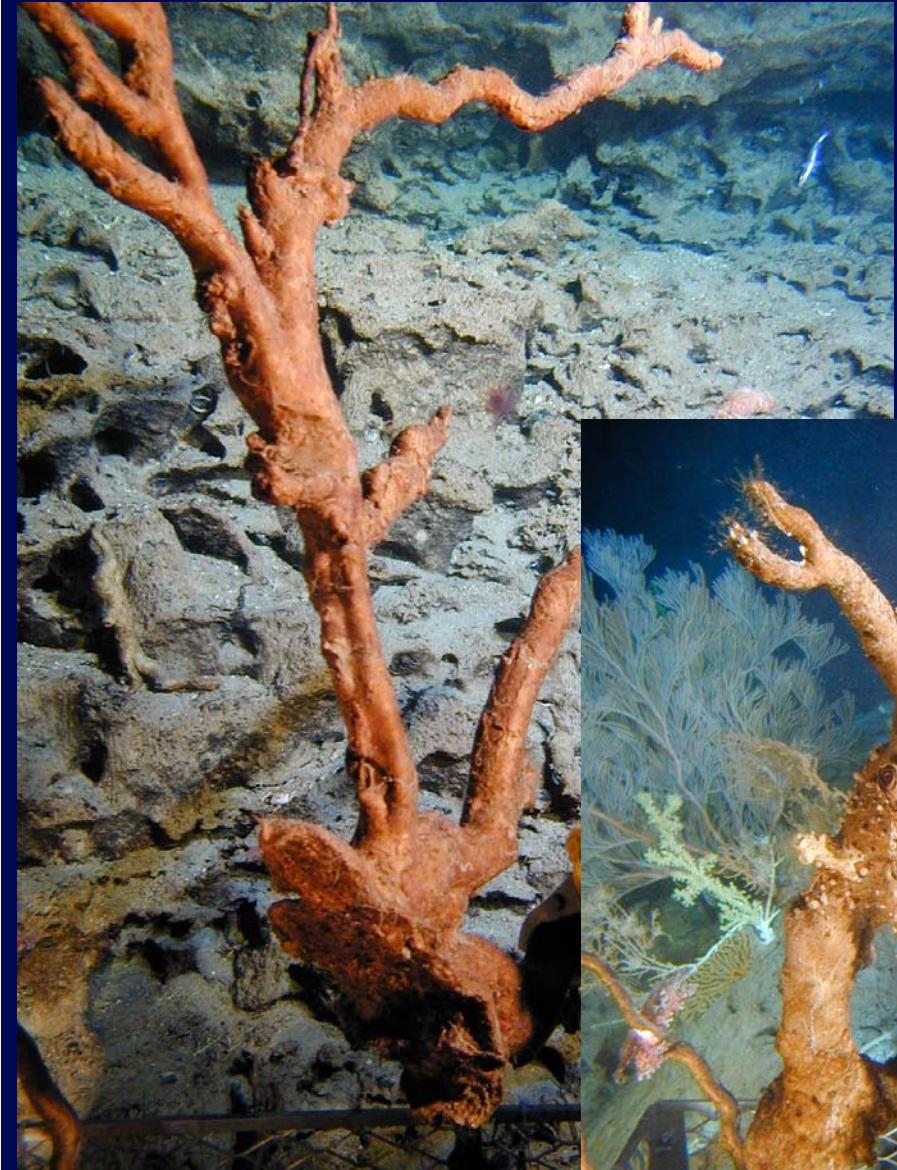
Ancient Deep-Sea Corals?



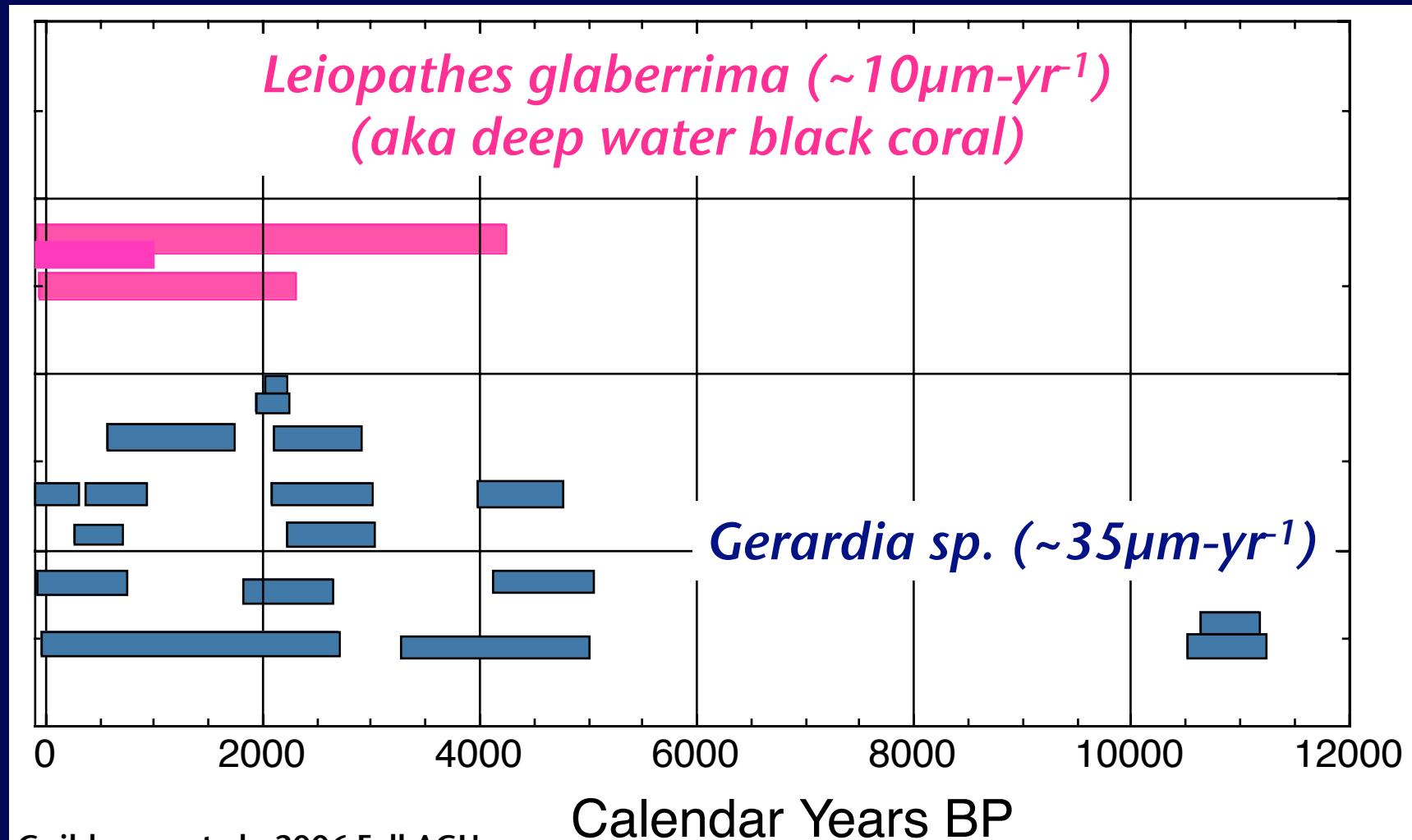
Roark et al., 2007 MEPS

- Black Corals *Leiopathes glaberrima* (BC#5)
- 400 m
- Growth rate $\sim 5\mu\text{m}/\text{yr}$
- $\sim 2320 \pm 15$ years old

Sub-fossil *Gerardia*



Protinaceous Deep-Sea Corals



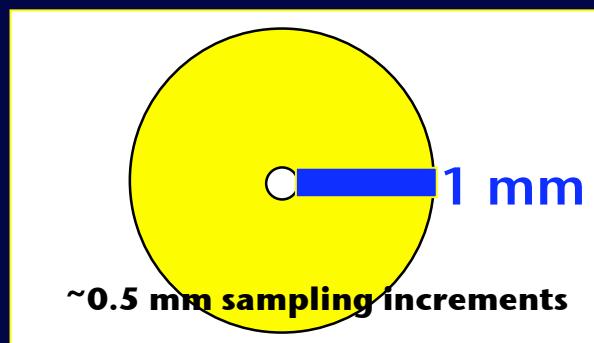
Climate Studies $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ records at decadal resolution over the Holocene



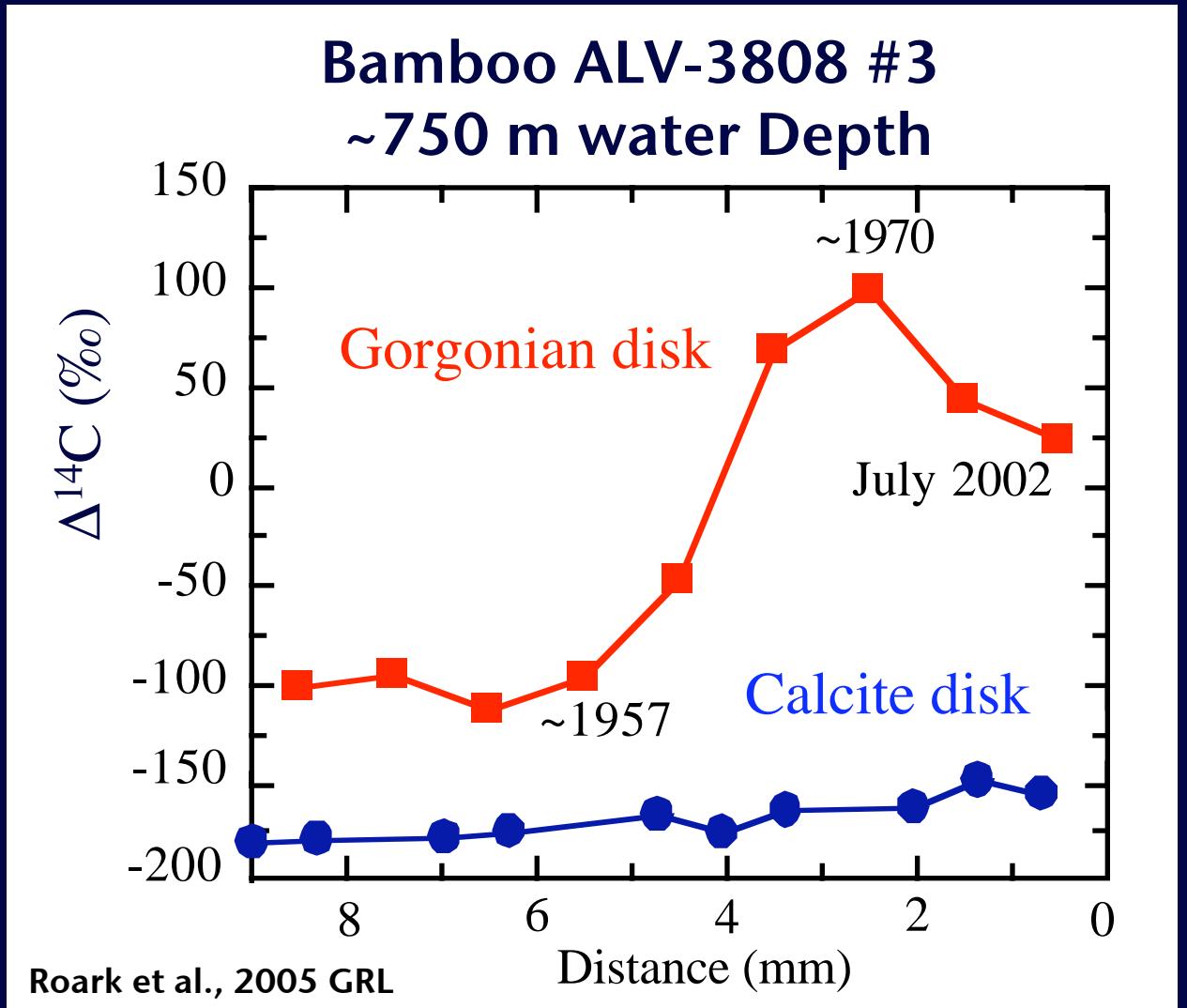
“Bamboo Coral” *Isididae*



Roark TRACES meeting

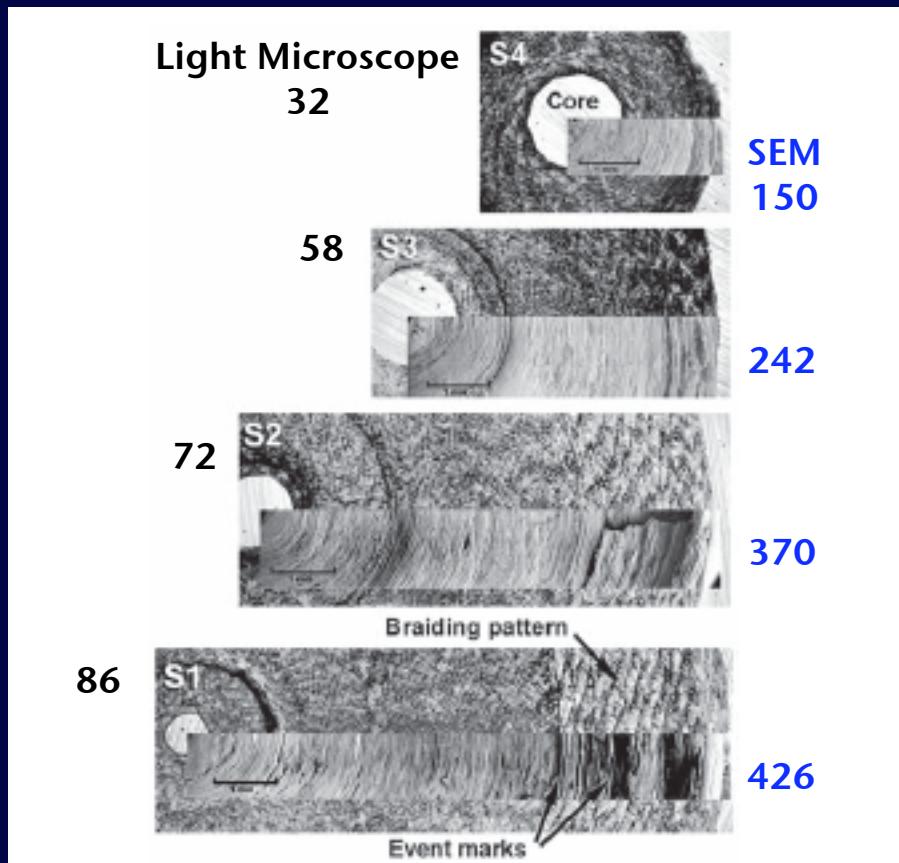


Warwick Seamount



- Corresponding linear “growth rate” is ~120 $\mu\text{m}/\text{year}$. Sample is ~75 years old.

New Zealand and Australian Bamboo Corals



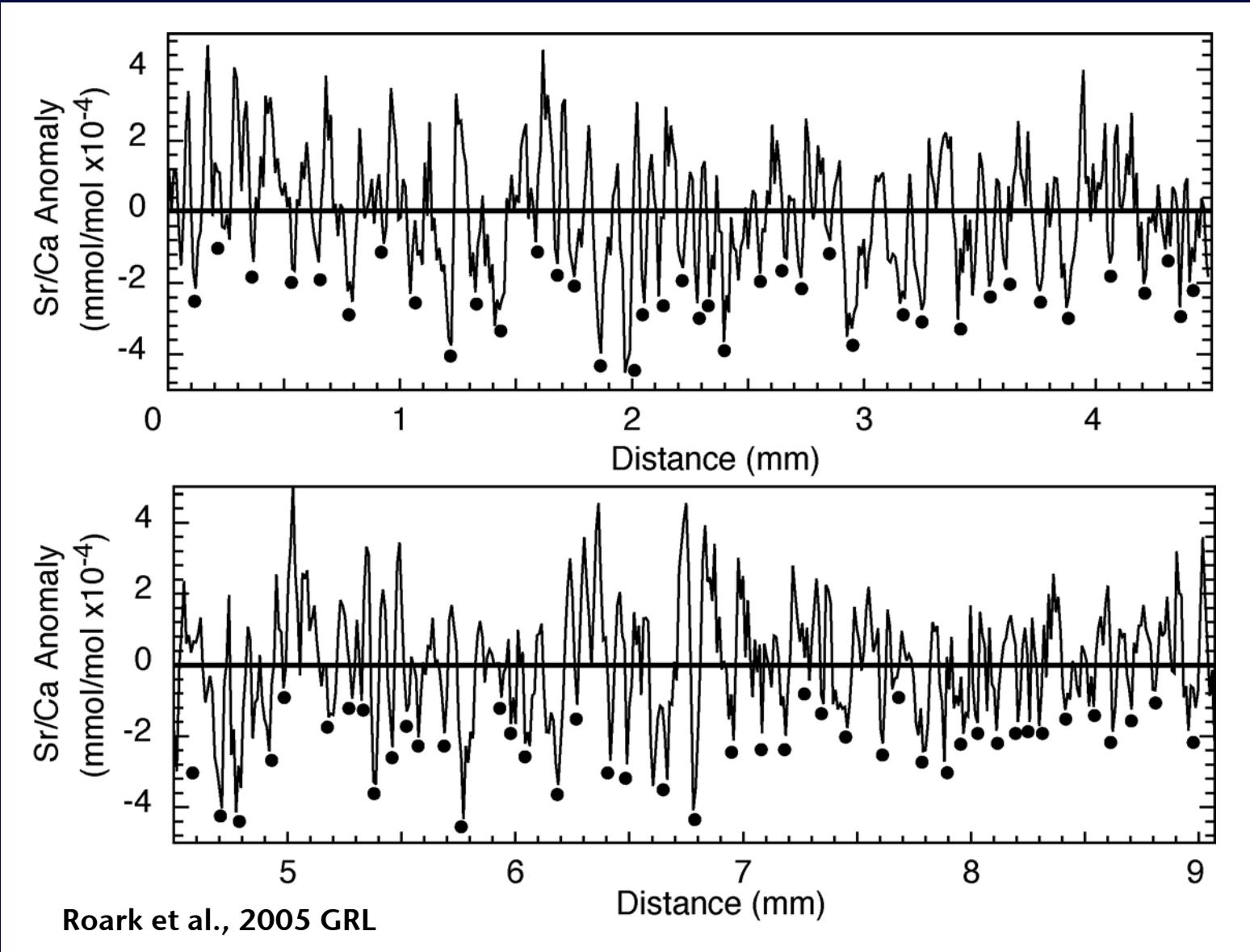
Tracey et al., 2007 Bull. Marine Science

Lepidisis
 $^{210}\text{Pb} = 43 \pm 18 \text{ years old}$
130-290 $\mu\text{m}/\text{year}$

Keratoisis spp and Lepidisis spp

- Study assessing reliability and reproducibility of ontogenetic variability using electron probe microanalysis -- Thresher et al., 2007 Bull Marine Science
- Mg/Ca may be controlled by environmental variable - - temperature?
- Sr/Ca was more problematic with these methods

Sub-Fossil specimens
 $3680 \pm 35 \text{ year old}$
Life span $305 \pm 35 \text{ years}$



84 Sr/Ca cycles --> annual?

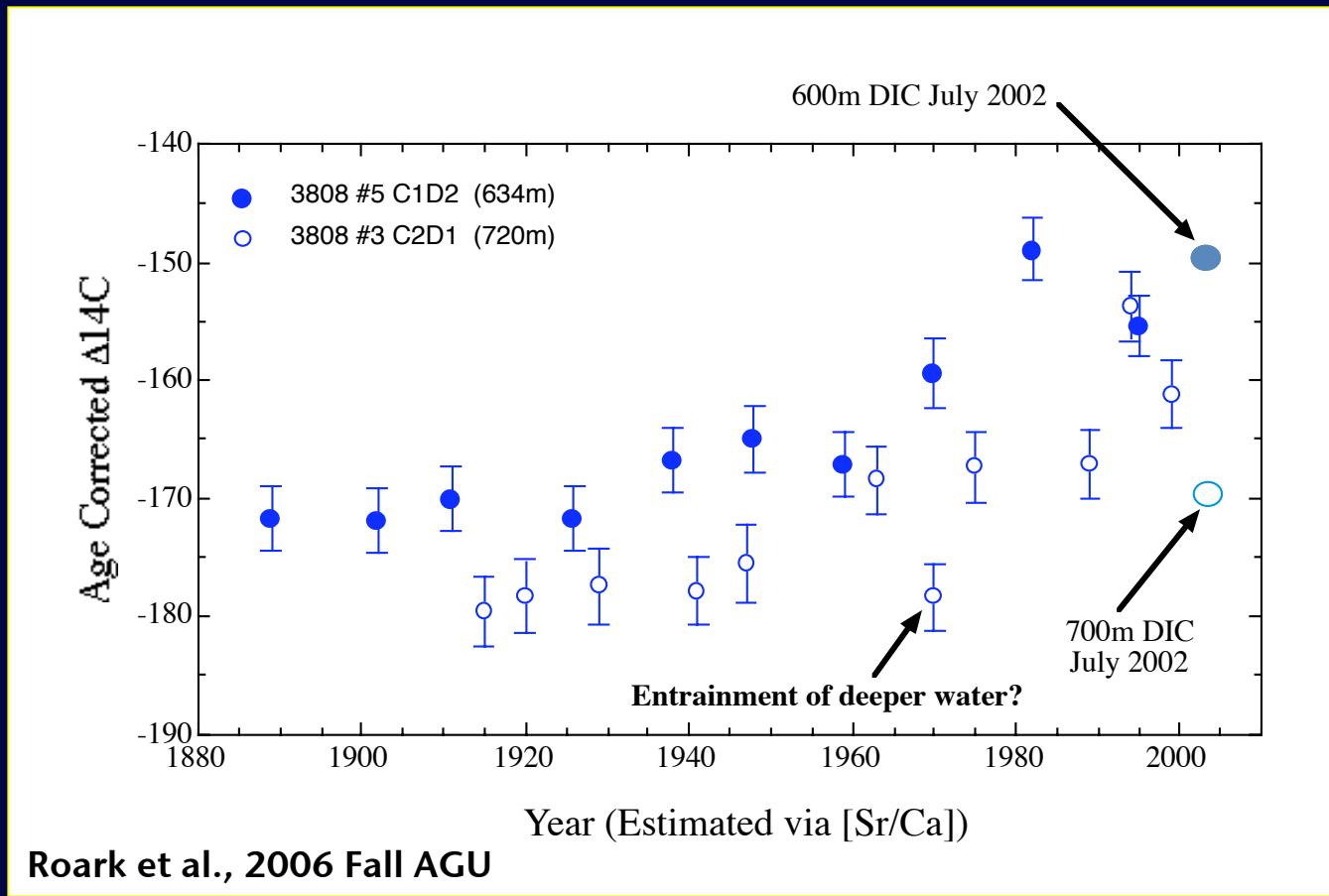
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Bamboo Chronology Replication

ALV- 3808	Bamboo #4	Bamboo #3	Bamboo #5
Radius	5.7 mm	9 mm	20 mm
Growth rate	72 $\mu\text{m}/\text{yr}$	120 $\mu\text{m}/\text{yr}$	160 $\mu\text{m}/\text{yr}$
^{14}C age	64 ± 4 years	75 ± 5 years	126 ± 8 years
Sr/Ca cycles	78	84	139

Roark et al., 2006 Fall AGU

Mid-depth ^{14}C History, Warwick Seamount



Bomb Radiocarbon as an Oceanographic Tracer

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Research Questions

- Highly resolved chronologies and ^{14}C independent chronologies
 - link between proxy and environmental signals (instrumental records)
 - use ^{14}C as a tracer -- ventilation and carbon cycle studies
- Continue proxy development!
 - Multiple analyses and techniques
 - Comparision of techniques and analytical tools
- Climate studies
 - Carbon cycle and ventilation studies
 - Subsurface temperature