Final Report

New Molecular Tools to Examine Paleo-phylogeographic Responses to Climate Change: Ancient Coral Migrations in the North Atlantic

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Introduction

The biodiversity of seamounts and, in particular, the fragility of deep-sea coral populations has received heightened media and scientific attention in recent years. Their ability to harbor a vast array of associated fauna (many endemic), including commercially important fish species, makes them of immediate interest to conservationists, managers and scientists. Yet our understanding of the history, biology and ecology of these habitat creating structures is still in its infancy. Hard corals (Scleractinians) have been present throughout the world's oceans for millions of years, and so have experienced many climatic changes and extinction events. The most recent glaciation, 40 million years ago, saw the major rise of the Scleractinia. These deep-sea corals build skeletons that incorporate chemical traces indicative of conditions in the surrounding sea water. Sub-fossil solitary corals (not embedded in rock) collected from NW Atlantic seamounts (Fig. 1) have been used to define major changes in intermediate and deep ocean circulation that coincide with large swings in atmospheric climate since the Last Glacial Maximum. These sub-fossil corals are found in abundance at depths below the thermocline, yet the phylogeographic relationships between, and the effect climate change has had upon these populations, had been unexplored.

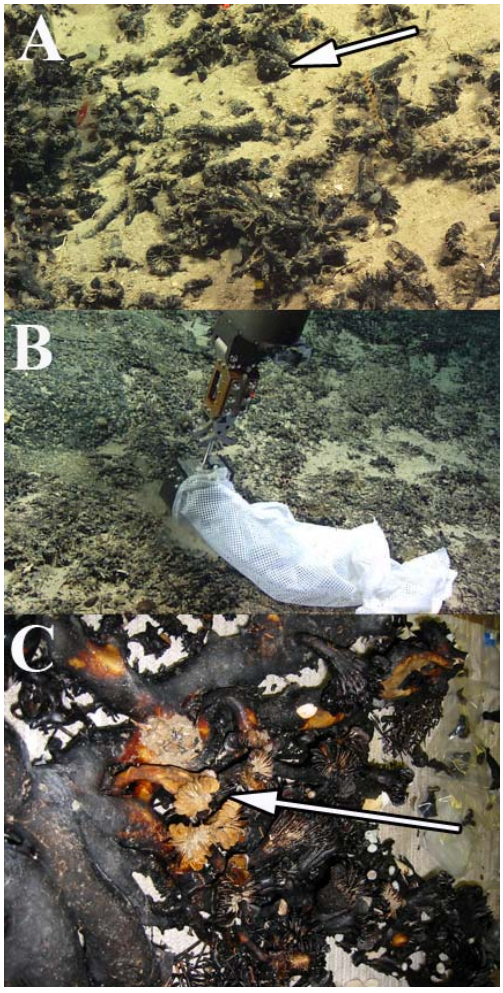

Figure 1. A, Sub-fossil *D. dianthus in situ* on the seafloor at Manning Seamount; B, Using scoops with the ROV *Hercules* on the Corner Rise Seamounts to collect sub-fossil corals; C, A single *D. dianthus* from Manning Seamount ready for processing.
Scale bars – A, ~10cm; B, ~50cm; C, ~1cm

With funding from the Ocean Life and Ocean Climate Change Institutes, we proposed to pursue techniques to investigate ancient deep-water coral migration patterns from NW Atlantic Seamounts through the development of new molecular genetic techniques for extraction of ancient DNA from sub-fossilized coral. Though the use of ancient DNA techniques have bloomed in recent years, their application in marine invertebrates is virtually unexplored, yet could provide unique insights into population dynamics of benthic fauna in relation to past climate affects, and thus help us to form models to predict what will happen to these populations in the future.

Objective

The primary goal of this research project was to develop ancient DNA extraction techniques in order to address fundamental questions on historical migration of deep-sea scleractinian corals from the NW Atlantic. DNA sequence data, specifically nuclear Internal Transcribed Spacer (ITS) regions, from sub-fossilized *Desmophyllum dianthus* and *Lophelia pertusa* would be used to assess the feasibility of utilizing fossil to examine past population migrations.

Results

We successfully developed techniques to extract DNA from sub-fossil coral material, as well as building close collaborations with the PaleoDNA Laboratory in Canada. Through the Institute funding we have assessed that ancient DNA techniques are both viable and valuable tools to look at past-population questions unanswerable by usual molecular techniques (Fig. 2). We have demonstrated that these techniques work on deep-water scleractinians (Waller et al, in press) and are continuing to show their ability to answer questions of past population migrations in tandem with climate change effects. With these findings in hand, we successfully secured funding for

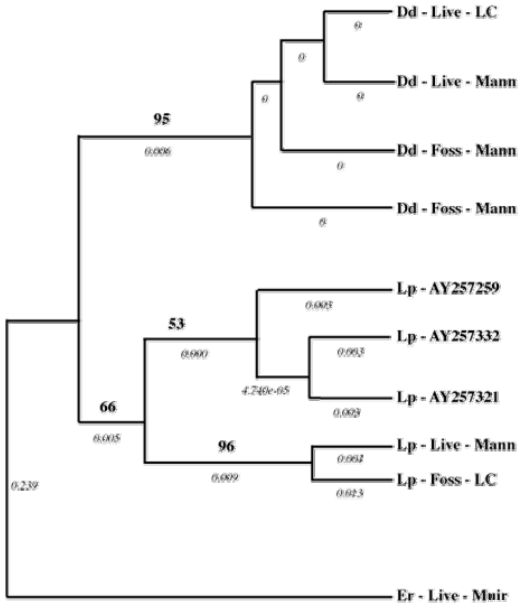

Figure 2. Neighbor-joining distance tree based on 351bp of the ITS2 region of fossil and live *D. dianthus* (Dd) and *L. pertusa* (Lp) and live *E. rostrata* (Er) as the outgroup. Fossil extractions and PCR have been repeated twice and yielded identical sequences. Bold numbers are bootstrap values, numbers in italics are substitutions per site. Mann – Manning Seamount, LC – Lost City. Bootstrap values are after 500 replicates, K2P.

further ancient DNA studies including fossil corals and past climate change associated the Mediterranean. In addition, we are continuing to process samples and data from the New England Seamounts for the combined genetic, climatalogical, and physical oceanographic analysis that we predict to be complete by 2009. We are also initiating the application of these approaches and techniques to recently-deceased corals in both shallow and deep-water habitats for multiple purposes (e.g., assessing the role of colonization/ extinction events, El Nino effects, population analysis, evolutionary processes), as well as with octocorals and the fossil shells of hydrothermal vent clams and mussels.

Outcomes

Publications (Peer-reviewed and non peer-reviewed)

Waller, RG; Adkins, J; Robinson, L & **Shank, TM**. (In Press) Ancient DNA techniques and their utility in deep-water coral research. *Bulletin of Marine Science*

Robinson, LF; Adkins, JF; Scheirer; DS, Fernandez, DF; Gagnon, A & **Waller RG** (In Press) Deep-sea scleractinian coral age and depth distributions in the NW Atlantic for the last 225 thousand years. *Bulletin of Marine Science*

What other tales can coral skeletons tell? Oceanus, Nov 06

Abstracts and Talks

Waller, RG; Shank, TM; Adkins, J & Robinson, L. Fossil Scleractinians from the New England Seamounts: Ancient DNA Techniques Give New Insights Into Past Climate Change – Preliminary Data. Abtract, 3rd Deep Sea Coral Symposium, Miami, September 2005

Waller RG & Shank TM. Ancient DNA Techniques in Deep-Water Corals. Talk, Ocean Climate Change Institute, Woods Hole, MA, October 2006

Waller RG. Deep Water Corals; Past, Present and Future. Talk**,** Hawaii Institute of Marine Biology, University of Hawaii, February 2007

Waller RG. Deep Water Corals; Past, Present and Future. Talk**,** School of Ocean and Earth Sciences, University of Hawaii, February 2007

Funded Proposals

NSF Biological Oceanography - *Paleogenetics of Pleistocene Deep-Water Corals from the Mediterranean Sea: The Rise and Fall of Coral Populations within the Basin*. Waller & Shank - $207,221- OCE 0647612 – 2007-2010

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