CLIMATE CHANGE
INSTITUTE

14th
J. Louis Agassiz
Symposium

May 11-12, 2006

Sawyer Environmental Laboratory
University of Maine
Orono

14th J. Louis Agassiz Symposium

This volume contains the abstracts for presentations given at the Climate Change Institute's 2006 research symposium. The work described here is global in scope and was performed by graduate and undergraduate students, research staff and faculty associated with the Institute.

This year, we are fortunate to have two guest speakers. Gary Hoyle, formerly of the Maine State Museum, will describe the marriage of science and art in the painting of ice age landscapes. His talk will be followed by the his presentation of a painting ("The Bubbles, Acadia National Park circa 13,000 B.P.") to the Institute.

Our keynote speaker this year is Dr Paul Epstein, Associate Director for the Center for Health and the Global Environment at Harvard Medical School (http://chge.med.harvard.edu/). He is a physician specializing in tropical public health and has served in medical, teaching and research capacities in Africa, Asia and Latin America. He has worked with the Intergovernmental Panel on Climate Change, the National Academy of Sciences, NASA and NOAA to assess the health impacts of climate change, and to develop health applications of climate forecasting and remote sensing. His talk will focus on the Health, Ecological and Economic Dimensions of Climate Instability.

Gordon Hamilton

14th J. Louis Agassiz Symposium – Program

Thursday, May 11

8:00 – Coffee and Pastries

8:25 – **Gordon Hamilton** "Welcome and introduction"

8:30 – **Peter Leach, Daniel Belknap** "Methods for reconstructing paleogeography from two-dimensional seismic profiles in Damariscotta River, Maine, USA"

8:45 – **Alice Kelley** "Archaeological Geology of the Central Penobscot Valley: Where Do We Go From Here?"

9:00 – **Erich Osterberg, Paul Mayewski, David Fisher, Karl Kreutz, Sharon Sneed, Mike Handley, Andrei Kurbatov** "An ice core record of Holocene climate change, trans-Pacific dust flux, and anthropogenic pollution in the North Pacific: Mt. Logan, Yukon, Canada"

9:15 – **Nathan W. Vogan, Karl J. Kreutz, Erich Osterberg, Alan Wanamaker, Cameron Wake, Chris Zdanowicz** "Meteorological Controls on Snow Accumulation and Atmospheric Chemistry in the St. Elias Mountains from the Eclipse Icefield"

9:30 – **Alan Wanamaker, Karl Kreutz, Bernd Schöne, Harold Borns, Douglas Introne, Scott Feindell** "Ocean climate variability in the Gulf of Maine, USA during the late Holocene inferred from isotope profiles and growth histories of the long-lived ocean quahog (*Arctica islandica*)"

9:45 – **Karl Kreutz, Paul Mayewski, Eric Meyerson, Andrei Kurbatov, Sharon Sneed** "Was there a change in Southern Ocean productivity during the LGM?"

10:00 – BREAK

10:30 – **Stephen Norton, Kyle Coolidge, Aria Amirbahman, Jirí Kopácek, Roy Bouchard** "Speciation of Al, Fe, and P in recent sediment of three Maine lakes, USA: Al, Fe, and P dynamics in Maine lakes over the last 500 years"

10:45 – **Brian Robinson** "Fine-Tuning the Bull Brook Artifact Catalog"

11:00 – **Jennifer Ort** "Lithic Analysis and the Bull Brook Settlement Pattern"

11:15 – **Woodrow Thompson, Harold Borns** "Deglaciation chronology, correlation of moraine systems, and the Older Dryas ice margin in southern Maine and northern New Hampshire"

11:30 – **Harold Borns, Brenda Hall, Andrea Nurse** "Is "Bölling, Warming recorded by the Southeastern Margin of the Laurentide Ice Sheet"

11:45 – **Gary Hoyle** "The art and science of reconstructing a landscape of Acadia National Park at 13,000 B.P."

12:00 – LUNCH

1:00 – **Bill Sneed** "Determining surface meltwater pond volume using satellite imagery"

1:15 – **Coen Hofstede** "Exercises in geometry: water pressure ratio, a possible mechanism for ice streams"

1:30 – **Daniel Breton** "Design of a Gamma-ray Density Gauge for Ice and Firn"

1:45 – **Tom Kellogg**, Davida Kellogg "Frozen In Time: The Diatom Record In Ice Cores From Remote Drilling Sites on the Antarctic Ice Sheets"

2:00 – **Joseph Kelley**, Daniel Belknap, Andrew Cooper "Sea-Level Change in Northern Ireland: Looking Closer at the Highstand-Lowstand-Mid-Holocene Highstand"

2:15 – **Terence Hughes** "Variations of Ice-Bed Coupling Beneath Ice Streams"

2:30 – BREAK

3:00 – **Daniel Sandweiss, Kirk Maasch** "Correlating a New Climate Record with Cultural Change in the Lambayeque Valley, Peru"

3:15 – **Christopher Miller** "Geoarcheological Setting of the Sebasticook Lake Fish Weir, Newport, Maine"

3:30 – **Bertrand Pelletier** "Glacial Lake Levels and Paleoindian Settlement at the Munsungun Chert Source, Northern Maine"

3:45 – **Bruce Williamson, Karl Kreutz, Steven Arcone, Erich Osterberg, Beth Bartel, Bjorn Johns, Seth White** "Surface velocities and flow dynamics for the Clark, Commonwealth and Blue Glaciers in southern Victoria Land, Antarctica"

4:00 – **Elena Korotkikh, Gordon Hamilton, Paul Mayewski** "High resolution records of Eemian interglacial from Mount Moulton (Antarctica)"

4:15 – **George Jacobson** "Global climate change: High stakes challenges for international, regional and local science and policy"

4:30 – **Leigh Stearns, Susan Kaspari, Climate Policy Working Group** "Initiating a University of Maine Greenhouse Gas Inventory"

Friday, May 12

8:00 – Coffee and Pastries

8:30 – **Andrea Nurse, Hal Borns, Ann Dieffenbacher, James Fastook** "Geologic and paleoecologic evidence of ice-mass advance in northern Maine during the Younger Dryas cold reversal"

8:45 – **Ann Dieffenbacher-Krall, Marcus Vandergoes, Rewi Newnham, George Denton** "An Inference Model for Mean Summer Temperatures During the Late Glacial Transition in the Southern Alps, New Zealand, Using Subfossil Chironomids"

9:00 – **Leigh Stearns** "Large and rapid ice volume losses from two East Greenland outlet glaciers"

9:15 – **Gordon Oswald** "Subglacial Melt in Northern Greenland"

9:30 – **James Fastook** "Embedded Models: Application to the Ross Sea and Amundsen Sea Sectors, Retreat from LGM"

9:45 – **Gordon Hamilton, Leigh Stearns** "Rapid changes of Kangerdlugssuaq and Helheim glaciers – which came first: acceleration, retreat, or thinning?"

10:00 – BREAK

10:30 – **Kirk Maasch, Paul Mayewski** "Is Recent Global Warming Natural or Human Induced?"

10:45 – **Paul Andrew Mayewski, Gordon Hamilton, Dan Dixon, Susan Kaspari, Leigh Stearns, Sharon Sneed, Kirk Maasch, Ann Zielinski, Mike Handley** "State of the Climate Over West Antarctica: Preparing the Basis for Understanding Past, Present, and Future Climate Change Over Antarctica and Adjacent Southern Ocean"

11:00 – **KEYNOTE SPEAKER: Paul R. Epstein** "Climate Instability: Health, Ecological and Economic Dimensions"

12:00 – LUNCH

1:00 – **Kurt Rademaker, Gordon Bromley, Louis Fortin** "Fire and ice: Volcanic glass, glaciers, and the initial settlement of southern Peru"

1:15 – **Louis Fortin** "The Archaeological Importance of Obsidian and Macusanite **in the Southern Peruvian Highlands"**

1:30 – **Gordon Bromley, Brenda Hall, Kurt Rademaker** "Late Quaternary climate records from Nevados Firura and Coropuna, southern Peru"

1:45 – **Paul Roscoe** "Fish, game and the foundations of complexity in forager society: the evidence from New Guinea"

2:00 – **Kristin Sobolik** "MEBonz: Zooarchaeology Working Group Projects"

2:15 – **Andrei Kurbatov, Paul Mayewski, Bashar Abdul Jawad** "Update on Ice Core Dating Software"

2:30 – BREAK

3:00 – **Daniel A. Dixon, Paul Andrew Mayewski, Susan Kaspari, Sharon Sneed, Mike Handley, Kirk Maasch, Karl Kreutz, Gordon Hamilton, Andrew Carleton** "Major Ion, Trace Element And Water Isotope Measurements From The 2002 And 2003 US ITASE Traverses"

3:15 – **Susan Kaspari, Paul Mayewski, Shichang Kang, Sharon Sneed, Karl Kreutz, Douglas Introne, Roger Hooke, Kirk Maasch, Dahe Qin** "Weakening of the South Asian Monsoon Since 1400 A.D. from a Mt. Everest Ice Core"

3:30 – **Bjorn Grigholm, Paul Mayewski, Susan Kaspari, Sharon Sneed, and Michael Handley, Vladimir Aizen, Elena Aizen, Daniel Joswiak, Arzhan Surazakov, John Marshall, Michael Krachler** "Seasonal stable isotope and trace element records from Fedchenko Glacier, Central Asia"

3:45 – **Sean Birkel, George Denton, James Fastook, David Battisti** "Could the Orographic Influence of the Laurentide Ice Sheet have Triggered "Jet Jumps" across the Northern Hemisphere?"

4:00 – **Daniel Belknap, Joseph Kelley** "Deglaciation to modern stratigraphy and evolution of Maine lakes"

4:15 – **Audrey Bamberg** "Geologic and biologic proxy records for paleoclimate in the Antarctic"

4:30 – **Brenda Hall, Charles Porter** "Late Holocene ice fluctuations in the Cordillera Darwin, Chile"

Keynote Speaker

CLIMATE INSTABILITY: HEALTH, ECOLOGICAL AND ECONOMIC DIMENSIONS

Paul R. Epstein, M.D., M.P.H., Harvard Medical School, paul_epstein@hms.harvard.edu

Climate change has multiple direct and indirect consequences for human health. Heatwaves are the most direct and are projected to take an increasing toll in developed and underdeveloped nations. The 2003 summer heatwave in Europe, with 35,000 excess deaths in five nations, extensive wildfires and widespread crop failures demonstrates that climate change and the magnitude of its impacts may be surprisingly non-linear.

Climate also restricts the range of infectious diseases, while weather affects the timing and intensity of outbreaks. The ranges of several key diseases or their vectors are already changing in mountainous regions, along with upward shifts in plant communities, the rapid retreat of alpine glaciers and an upward shift in the freezing isotherm (the level at which temperatures remain below freezing all year).

Deep ocean warming is accelerating the hydrological cycle and the associated extreme weather events (EWEs) can create conditions conducive to outbreaks of infectious diseases. Heavy rains can leave insect breeding sites, drive rodents from burrows and contaminate clean water systems. Conversely, drought can spread fungal spores, spark fires (and respiratory illness) and is statistically associated with large outbreaks of West Nile virus and St Louis encephalitis, a disease with a similar life cycle.

Sequences of extremes can destabilize predator/prey relationships, leading to population explosions of opportunistic, disease-carrying organisms (e.g., rodents and mosquitoes). The 1997/98 El Niño-related extreme weather events spawned "clusters" of disease outbreaks in many regions of the globe.

In the marine environment, ocean warming – along with eutrophication and loss of filtering wetlands -- is contributing to harmful algal blooms that can cause shellfish poisoning, provide a reservoir for cholera and other bacteria, and can lead to hypoxia and "dead zones".

Excess carbon dioxide itself has consequences for organisms. Ragweed grown in elevated carbon dioxide levels produces a lot of pollen. Opportunistic, weedy plants take advantage by allocating CO2 to reproduction - the male parts - whereby they spread and prosper. Pioneering trees that spread quickly - like maples, pines, birches, and poplars - also appear to be boosting their seeds, cones, and pollen.

The impacts of EWEs also have economic consequences. Yearly losses increased from $4 billion annually in the 1980s to $40 billion in the 1990s; reached $55 billion in 2002 ($11 billion insured) and $60 billion ($15 billion insured) in 2003. The United Nations Environmental Programme estimates that annual losses from extreme weather events could reach $150 billion by the end of this decade if current trends continue; sending shockwaves through the insurance and reinsurance sectors.

Advances in climate forecasting and health early warning systems can help catalyze timely, environmentally-friendly public health interventions. If climate change continues to be associated with more volatile and severe weather, we have begun to see the profound consequences climate change can have for public health and the international economy.

Abstracts appear in the order of presentation

METHODS FOR RECONSTRUCTING PALEOGEOGRAPHY FROM TWO-DIMENSIONAL SEISMIC PROFILES IN DAMARISCOTTA RIVER, MAINE, USA

Peter Leach, Daniel Belknap

Human populations occupy dynamic landscapes modified by a suite of geologic processes. Early Holocene archaeological sites in the Gulf of Maine have been submerged by rising sea-levels, to the point that the oldest known sites on the present coastline date to roughly 5000 BP. We are developing a means of locating these sites in Dodge Basin, Damariscotta River, through geologic, geophysical, and archaeological methods in concert. To efficiently predict submerged archaeological site locations it is essential to accurately reconstruct paleogeography. Prior research in Dodge Basin located a relict oyster bioherm, dated to at least 4800 BP, which we consider to be an initial means of refining our search. We collected 65 km of seismic reflection profiles, as well as 9 vibrocores from one to six meters in length, to accomplish this goal. Major reflectors (estuarine fill, oyster bioherm, glaciomarine mud, bedrock) were digitized from georeferenced seismic profiles and exported as x-y-z data points. These points were imported into ArcGis with z (depth) values visually labeled, and superimposed on a 2D polygon of the study area. Bathymetric and structure contour maps were created by hand-contouring the labeled points in one-meter contour-intervals. Next, a color-ramped Triangulated Irregular Network (TIN) file was built from the x-y-z data in ArcMap. Finally, the TIN file was converted to 3D in ArcScene and color-ramped to approximate the pre-transgressed (6300 BP) shoreline of the study area, as well as the 5000 BP and 4000 BP shorelines. Application of archaeological site potential models to our first-order reconstruction identifies high-potential areas of submerged prehistoric site locations in Dodge Basin. These methods are possible due to a multidisciplinary research design and availability of geophysical and desktop GIS software capable of accurate, high-resolution mapping.

ARCHAEOLOGICAL GEOLOGY OF THE CENTRAL PENOBSCOT VALLEY: WHERE DO WE GO FROM HERE?

Alice R. Kelley

The completion of a detailed study of the archaeological geology of the central Penobscot Valley marks the beginning, rather than the end of investigations in the region. In the realm of archaeological geology, site location models await to be tested in the field. Refining the postglacial development of the Penobscot River Valley will make an important contribution to Maine Quaternary geology, as well as the general understanding of how river systems are established following deglaciation. The low-relief central Penobscot Valley provides an ideal location to examine the timing and effects of a migrating postglacial forebulge. Work of this nature has the potential to supply field data for new models of the visco-elastic response of the Earth's crust to glacial loading and unloading. One study has come to an end...but many more remain.

AN ICE CORE RECORD OF HOLOCENE CLIMATE CHANGE, TRANS-PACIFIC DUST FLUX, AND ANTHROPOGENIC POLLUTION IN THE NORTH PACIFIC: MT. LOGAN, YUKON, CANADA

Erich Osterberg, Paul Mayewski, David Fisher, Karl Kreutz, Sharon Sneed, Mike Handley, and Andrei Kurbatov

A >12,000 year-long ice core record from the summit plateau (5300 m asl) of Mt. Logan, Yukon, Canada, reveals large fluctuations in North Pacific climate throughout the Holocene with a 1-2 ky periodicity interpreted as advances and retreats of the polar front. Cold periods associated with a southern displacement of the polar front are marked by low dust concentrations in the North Pacific atmosphere, while warmer periods (more northern polar front) are associated with enhanced trans-Pacific dust flux from Asia to Mt. Logan. The latest climate transition in the early 19th century was a shift to a more northerly polar front position (modern conditions). The early 20th century was the dustiest period in the last 500 years on Mt. Logan, with a steady decline in trans-Pacific dust flux since then. Sea salt aerosol (Na+) concentrations on Mt. Logan have a statistically significant correlation with the strength of the Aleutian Low pressure center in the Gulf of Alaska, and reveal a steady intensification of the Aleutian Low from ~1100 AD to present. The same trend is seen in the Siple Dome ice core from the Pacific sector of Antarctica, suggesting a global-scale intensification of atmospheric circulation. These records are compared to paleoclimate and climate forcing records from GISP2 and other sites to explore regional variations in climate patterns and their controlling forces. Continuous trace metal data spanning the Holocene reveal an unprecedented rise in lead, bismuth and arsenic concentrations on Mt. Logan since the early 1970s, interpreted as Asian anthropogenic pollution from rapidly expanding industrial activity.

METEOROLOGICAL CONTROLS ON SNOW ACCUMULATION AND ATMOSPHERIC CHEMISTRY IN THE ST. ELIAS MOUNTAINS FROM THE ECLIPSE ICEFIELD

Nathan W. Vogan, Karl J. Kreutz, Erich Osterberg, Alan Wanamaker, Cameron Wake (University of New Hampshire), Chris Zdanowicz (Geological Survey of Canada)

A new ice core (343 m) was collected from the Eclipse Icefield (~30 km northeast of the Logan Massif, 3017 masl) in the St. Elias Mountains by the University of New Hampshire and the University of Maine in 2001-02. Previous work on snow samples and an ice core recovered in 1980 from Mt. Logan (5345 masl) has shown that major discontinuities in the variation of the water stable isotope ratios exist with altitude, which are believed to be derived from a multilayered atmosphere during precipitation events on high altitude glacier sites. To properly interpret the glaciochemical records developed from the new Eclipse Icefield ice cores, calibration of snow properties with meteorological data (temperature, precipitation, and sea level pressure) is critical. At the Divide Site (2800 masl), two automatic weather stations (AWS) have been operating since 2002, collecting snow depth as well as standard meteorological data. From the AWS data we are currently developing detailed time series of snow accumulation, temperature, and sea level pressure to be used in comparison to time series of major ions (Na+, NH4+, K+, Mg2+, Ca2+, Cl-, NO3-, SO42-), stable water isotopes (^{18}O, D), and trace elements (Zn, Pb, Hg, Cd, Cu, V, Mn, Ni, As, Al, Fe, Se, and REEs) developed from snowpit samples. The primary goal of this research is to constrain the meteorological controls on snow accumulation and atmospheric chemistry on a subannual resolution for the Eclipse Icefield, and then apply these controls to the ice core climate proxy record.

OCEAN CLIMATE VARIABILITY IN THE GULF OF MAINE, USA DURING THE LATE HOLOCENE INFERRED FROM ISOTOPE PROFILES AND GROWTH HISTORIES OF THE LONG-LIVED OCEAN QUAHOG (*ARCTICA ISLANDICA*)

Alan D. Wanamaker, Karl J. Kreutz, Bernd R. Schöne (Univ Frankfurt), Harold W. Borns, Douglas Introne, and Scott Feindell (Darling Marine Center)

To investigate ocean climate variability during the late Holocene in the Gulf of Maine, USA, a 142-year old bivalve shell (Arctica islandica) was collected alive in 2004 from Casco Bay in 30 meters of water. In addition, fossil A. islandica bivalve shells of the late Medieval Warm Period (MWP) and the Little Ice Age (LIA) were collected via a vibracore in Casco Bay in 1996 from approximately 39 meters of water. Each sample was prepared for isotopic analysis and digital imaging for growth histories, and microsampled to produce high-resolution (seasonal to interannual) isotopic profiles that reflect ambient growing conditions. Annual growth lines are recorded in the shell of the animal, which allows for the development of an absolute chronological record during its life span, if the collection date is known. Information recorded in these annual shell layers includes a geochemical signature of water properties (temperature and salinity), and morphological characteristics (thickness of annual bands) that may reflect ambient conditions such as water temperature and/or food supply. Because of these relationships, it is possible to use isotopic and growth data from A. islandica to reveal long-term trends in bottom temperatures, ocean circulation changes, or food availability. Standardized growth indices (SGIs) and isotopic profiles from each animal were compared to assess interannual to decadal ocean climate variability, and reveals whether or not the MWP is an appropriate analog to the modern ocean climate in the Gulf of Maine. Further, isotopic profiles from the fossil shells provide regional insights as to the timing and magnitude of both late Holocene climate anomalies. Consistent with modern instrumental sea surface temperature records for the gulf, there is substantial interannual variability in shell chemistry for all bivalves. Further, decadal to multi-decadal oscillations in shell chemistry are evident in the 142-year old modern shell, which appear to be related to observed basin-scale circulation changes in the North Atlantic Ocean (e.g., Thermohaline Circulation [THC]; Atlantic Multi-decadal Oscillation [AMO]). The longevity and geographic distribution of the bivalve A. islandica, and its utility as an ocean climate proxy offers significant advances in climate studies, especially in the development of high-resolution ocean temperature records for mid-to-high latitudes.

WAS THERE A CHANGE IN SOUTHERN OCEAN PRODUCTIVITY DURING THE LGM?

Karl Kreutz, Paul Mayewski, Eric Meyerson, Andrei Kurbatov, and Sharon Sneed

Establishing the lead/lag relationships among climate, atmospheric aerosol properties, ocean biogeochemistry, and greenhouse gases on several timescales remains a fundamental problem in paleoclimatology, and is of particular interest in the Southern Hemisphere where in-situ experiments demonstrate a direct relationship between marine productivity and inputs of aolian iron. Increases in sulfur-bearing chemical (methylsulfonate; MSA) concentrations during the Last Glacial Maximum in the Vostok ice core were originally interpreted as reflecting enhanced marine emissions of dimethylsulfide, and therefore in part responsible for atmospheric CO2 drawdown. However, recent publication of new chemistry data from the EPICA-Dome C deep ice core recovered from interior East Antarctica, as well as re-interpretation of data from the Vostok ice core, suggest that Southern Ocean marine biological emissions have changed little with climate over the past 740,000 years. These results, if valid, appear to contradict hypotheses that link climate, dust flux, Southern Ocean productivity, and atmospheric carbon dioxide concentrations on glacial/interglacial timescales. Here we present and discuss sulfur chemistry data (sulfate and

MSA) from two additional Antarctic deep ice cores (Taylor Dome and Siple Dome) that primarily reflect South Pacific conditions, and address possible spatial heterogeneity in Southern Ocean productivity and/or climate conditions during the LGM.

Al, Fe, AND P DYNAMICS IN MAINE LAKES OVER THE LAST 500 YEARS

Stephen A. Norton, Kyle Coolidge, Woodard and Curran, Aria Amirbahaman, Department of Civil Engineering, Jicí Kopácek, Czech Hydrobiological Institute, Roy Bouchard, Maine Department of Environmental Protection

Samples from dated sediment cores from three Maine lakes were sequentially extracted yielding 5 chemical fractions: exchangeable (NH4Cl), reducible (BD), NaOH-soluble at 25oC, acid (HCl) soluble, and NaOH-soluble at 85oC. Concentrations of total extractable Al range from 800 to 1000 µmoles/g for oligotrophic (OT) lakes and are about 600 in the eutrophic (ET) lake sediment. 80-90% of the Al is in the two NaOH fractions and most of the rest is in the HCl fraction. Concentrations of total extractable Fe range from 100 to 200 µmoles/g for OT lakes and are <100 in the ET lake. Extractable Fe is dominated by the BD and HCl fractions. Total extractable P is 40 to 60 µmoles/g for the OT lakes, and is only 20 to 30 for the ET lake. More than 80% of extractable P in the OT lakes is in the 25oC NaOH fraction, and thus strongly associated with the 25oC NaOH-extractable Al; the (NH4Cl + BD + HCl) P fractions are less than 10%. For the ET lake, BD P ranges up to 35% of total extractable P, the maximum occurring in the surface Fe enrichment zone. The HCl P fraction ranges from 20 to 30%. The NH4Cl fraction of Al, Fe, and P is trivial. P is thus associated with Al in the OT lakes, supporting the hypothesis that their trophic status is controlled by Al(OH)3 adsorption of P, at some point. The ET lake has a larger % of P in the BD fraction which can be mobilized during anoxia, leading to recycling of P and higher primary productivity.

FINE-TUNING THE BULL BROOK ARTIFACT CATALOG

Brian S. Robinson

Recent research on the Bull Brook Paleoindian site in Ipswich Massachusetts is directed toward understanding the large circular pattern of artifact concentrations (or house sites) covering and area 600 feet in diameter. After 50 years of intermittent research we are sorting and compiling the records, translating still photos and home movies into GIS coordinates. The combined sources of information, including the original excavators valuable memories, are now being integrated to check the existing catalog of 9000 artifacts. This process involves careful evaluation of original field records and modern memories to increase the accuracy of artifact distributions and the next stage of analysis.

LITHIC ANALYSIS AND THE BULL BROOK SETTLEMENT PATTERN

Jennifer Ort

The circular pattern of 42 loci at the Bull Brook site in Ipswich Massachusetts may represent the largest gathering of Late Pleistocene hunter gatherers in North America. Ongoing research by multiple investigators involves refinement of the map, defining site formation processes, and lithic

source material analysis. My role in the project is the analysis of the lithic artifacts. Goals of the analysis include interpreting the distribution of tool types, lithic technologies and material between loci and across the site. Today's presentation will focus on theoretical issues and observations made at this early stage of analysis.

DEGLACIATION CHRONOLOGY, CORRELATION OF MORAINE SYSTEMS, AND THE OLDER DRYAS ICE MARGIN IN SOUTHERN MAINE AND NORTHERN NEW HAMPSHIRE

Woodrow B. Thompson, Maine Geological Survey, Harold W. Borns

Many of the radiocarbon ages obtained from late-glacial organic materials in southern Maine are suspect due to the uncertain magnitude of the marine reservoir effect and other variables. Comparison with the varve chronology in western New England suggests that recently published deglaciation chronologies for southern Maine are too old, and that a correction exceeding -600 years is needed for marine fossil ages. A related problem is the dating and correlation of end moraines across Maine, to establish synchronous ice-margin positions and possible climatic controls on the deposition of major moraine systems. The westward continuation of the Pineo Ridge moraine in southeastern Maine has long been uncertain. The authors propose that this moraine system bends to the southwest at the Pineo Ridge delta, and that it can be traced across southwestern Maine to the Waldoboro moraine and other prominent moraine clusters in the zone of late-glacial marine submergence. Our suggested extrapolation of Pineo Ridge moraine coincides with the southern termini of major esker systems, and with marine and lacustrine deltas along a line extending west through Gray and Sebago Lake to the vicinity of Conway, NH. A reservoir correction of -1000 yrs would date the Pineo Ridge moraine system to ~ 12.6 14C ka BP (14.9 cal ka). This hypothesis would reduce or eliminate the discrepancy between the southern Maine dates and New England varve chronology. In northern New Hampshire, studies by several workers indicate an age of ~ 14 cal ka for the Littleton-Bethlehem moraine system and a correlation with the Middlesex Readvance in adjacent Vermont. The Littleton-Bethlehem moraines have been traced east to Randolph, NH, and they are thought to have resulted from a glacial stillstand or slight readvance during the Older Dryas cooling. We suggest two possible extrapolations of the Older Dryas ice margin into Maine. One model would extend it along the northwest flank of the Mahoosuc Range, coincident with the Success Pond moraine. Alternatively, the Older Dryas margin may have curved farther to the north, crossing the Kennebago Lake and Flagstaff Lake areas. The authors have found a possibly correlative swarm of minor moraines recording northeastward ice recession in the South Branch Dead River valley between Rangeley and Stratton. Ongoing field work and precise dating is expected to more clearly define the extensions of both the Pineo Ridge moraine system and the Older Dryas ice margin.

IS "BÖLLING, WARMING RECORDED BY THE SOUTHEASTERN MARGIN OF THE LAURENTIDE ICE SHEET

H.W. Borns, B. Hall and Andrea Nurse

The deglacial record from coastal Maine is imperfectly known. However, on going glacial and ecological research to refine the history suggests that much of the record in Maine correlates with the classic European late-glacial record, now found to be also correlative with events in the southern hemisphere. The emergent glacial-marine record from eastern coastal Maine indicates ice marginal recession from 14,000 14C yr B.P. to about 13,900 14C yr B.P. marked by

numerous end moraines and which was followed by a short readvance to the Pineo Ridge Moraine System at about 13,500 14C yr B.P. North of this line of readvance the landscape is dominated by extensive deposits of stratified drift, including eskers, but no end moraines.

This distribution of deposits and chronology appears to replicate the European record of ice recession during Oldest Dryas time, and the short-lived cold reversal and ice readvance followed by the abrupt onset of the Bölling warm interval.

THE ART AND SCIENCE OF RECONSTRUCTING A LANDSCAPE OF ACADIA NATIONAL PARK 13,000 B.P.

Gary B. Hoyle,Curator Emeritus, Maine State Museum

Within the history of the natural sciences, the collaboration of researchers and illustrators has often been essential in portraying specimens in accurate, lifelike detail. This relationship has also been important in the reconstructions of ancient life forms, most of which resulted in illustrations of megafauna dominating a simple representation of the appropriate landscape. However, the painting "The Bubbles, Acadia National Park circa 13,000 B.P." presented at this symposium represents a break from this tradition. The focus of the picture is on the overall environment shaped by the receding ice sheet with a limited representation of available plant life.

DETERMINING SURFACE MELTWATER POND VOLUME USING SATELLITE IMAGERY

William Sneed, Climate Change Institute

Ponded surface meltwater on ice caps and ice sheets is an important glaciological and climatological characteristic. Changes in the distribution and amount of ponds with time represent changes in the surface climate conditions controlling melting. The availability of large volumes of ponded surface water raises the possibility of sudden drainage to the bed, a change in basal lubrication, and a rapid increase in ice velocity. While the problem of calculating the areal extent of meltwater ponds using satellite imagery is fairly straightforward, determining the depth (and thus the volume) is not. We propose a method for deriving the depth of meltwater ponds using 15 m resolution ASTER imagery. The method involves making some reasonable assumptions about the albedo of the bottom surface of the ponds and the optical attenuation characteristics of ASTER bands VNIR1 and VNIR2 through the ponded meltwater. We have applied the technique to estimating surface water volume on Austfonna (Svalbard) and the portions of the Greenland Ice Sheet. The method is well-suited to the near-optically-clear melt ponds of ice sheets and ice caps, but not to the turbid ponds of alpine glaciers.

EXERCISES IN GEOMETRY: WATER PRESSURE RATIO, A POSSIBLE MECHANISM FOR ICE STREAMS

Coen Hofstede

Increased melt on major ice sheets will lead to increasing sea level. The two major ice masses on Earth, Greenland and Antarctica, seem to react faster to global warming than originally was thought by increased draining of ice in sea. Most of the draining takes place through fast moving glaciers called ice streams. A not well understood condition for ice streams to occur is the

presence of water. We present a possible draining mechanism for ice stream draining by introducing a force balance that uses water pressure ratio in a 2D flow line model. We will show that the water pressure ratio is really an uncoupling ratio of the ice mass from the bed. Two extreme situations occur when implementing an uncoupling ratio. In one case, the ice mass is completely uncoupled which will result in an ice shelf profile. In the second case, the ice mass is completely coupled which will result in a parabolic shaped ice sheet. The beauty of the mechanism lies in the fact that it is simple and thus quick and that the water pressure ratio provides a gradual transition from ice sheet to shelf flow, representing an ice stream. We will first present a case in which the water pressure ratio is known along a flowline, leading to a certain ice sheet profile. To see if our ratio makes any sense, we will than use the produced ice profile to see if we can reproduce our water pressure ratio. Finally, to see if our model makes any sense in the real world, the thus developed model will than be used on a field data set, the Whillans Ice Stream.

DESIGN OF A GAMMA-RAY DENSITY GAUGE FOR ICE AND FIRN

Daniel J. Breton

We present the design, technical drawings, performance and uncertainty estimates for an automated gamma-ray density gauging system to be used in Antarctica for the 2006-2007 International Trans-Antarctic Scientic Expedition and for subsequent eld and laboratory use. Source and collimator designs are covered in detail, along with calculations for exposure and dose due to both direct exposure to radiation beam and to radiation scattered from the sample. Basic operating, casualty and wipe testing procedures are also provided.

FROZEN IN TIME: THE DIATOM RECORD IN ICE CORES FROM REMOTE DRILLING SITES ON THE ANTARCTIC ICE SHEETS

Davida E. Kellogg and Thomas B. Kellogg

Diatoms are single-celled plants belonging to the Bacillariophyta, or golden-brown algae. Their two-piece silica frustules, resembling petri dishes in basic structure and distinguished by species-specific markings, pores, and spines, make them objects of beauty. The resistance of those silica frustules to dissolution in cold waters, the long geologic history and widespread distribution of the class, and the varying ecologic tolerances and consequent geographic provinciality, and limited stratigraphic ranges of many species render them tailor-made for paleoclimate research in the polar regions. Delicate as they may appear, diatoms live and prosper in both marine and the entire range of non-marine environments, from super-saline through brackish to fresh waters, and at temperatures ranging from those prevailing in hot springs at Yellowstone Park to those in the interstices of pack ice in polar seas.

The oldest known diatoms are marine species from the Cretaceous. Fresh-water species do not seem to have appeared until the Miocene, although the range of one species, Aulacosira granulata, may extend from the Recent all the way back into the Oligocene. Most marine species are relatively short-lived, making their stratigraphic ranges a standard tool of oil geologists and other stratigraphers. Fossil diatomaceous deposits occur on all continents including Antarctica. The same species-specific ecological tolerances and provenances that allow forensic pathologists to reconstruct the scene of a drowning allow paleoclimatologists to reconstruct climate change. The first multi-institution paleoclimate reconstruction effort, the CLIMAP project of the 1970s, made extensive use of marine diatoms in sediment cores. The discovery of diatoms in

ice cores from the polar ice sheets is a much more recent development, but one which may turn out to be of equal importance for paleoclimatology.

In this paper, we first review the history of diatom finds in polar ice cores and then discuss their paleoclimatological significance and uses for both current and future research. Finally, we demonstrate how diatoms in Antarctic ice cores may serve as proxies for fluctuations in atmospheric circulation.

SEA-LEVEL CHANGE IN NORTHERN IRELAND: LOOKING CLOSER AT THE HIGHSTAND-LOWSTAND-MID-HOLOCENE HIGHSTAND

Joseph T. Kelley, Daniel F. Belknap, Andrew Cooper (University of Ulster)

Like Maine, northeastern Northern Ireland experienced a high stand of sea level during deglaciation. The time of deglaciation is poorly constrained by a foram date from marine sediment of 14.2 cal. ka B.P. The marine sediment is associated with a raised shoreline at 20 m nearby, although numerical models of sea-level change cannot replicate the post-glacial drowning. We have recently established the time/depth of the lowstand of sea level at 13.3 cal. ka B.P. at 30 m below present sea level in Belfast Lough. Three consistent radiocarbon dates on marine shells from cores through a lowstand shoreline complex identified from seismic reflection profiles establish confidence in the time/depth of the lowstand. Despite these observations, numerical models of sea level change do not accommodate a 5-6 cm/yr isostatic uplift at this time. Sea level rise to an elevation 2-6 m higher than present 4-6 ka is inferred from numerous raised shoreline features, although selection of the precise shoreline position and establishment of its time of formation remains a work in progress. We have used ground-penetrating radar to reconstruct a raised shoreline complex and have obtained numerous samples of peat and shells for dating from this deposit.

VARIATIONS OF ICE-BED COUPLING BENEATH ICE STREAMS

Terence Hughes

Ice-bed coupling can be quantified as the ratio of basal water pressure P_W to ice overburden pressure PI. Maximum coupling occurs where $P_W/P_i = 0$ and maximum uncoupling occurs when $P_W/P_i = 1$. Intermediate coupling, such as P_W/PI = 0.7 occurs when PW/PI $\approx$ 0 over 30 percent and $P_W/P_i \approx 1$ over 70 percent of a given basal area. This allows transitions from sheet flow to stream flow to shelf flow to be expressed in terms of basal shear, side shear, longitudinal tension, and the longitudinal force gradient using P_W/P_i as a direct measure of ice-bed coupling. the cause of P_W/P_i at any point along an ice stream is the downstream resistance to stream flow that can be represented by a compressive back stress at every point. Perturbations in this resistance cause ice velocities and thinning or thickening rates to change rapidly along the whole length of an ice stream upstream from where the perturbations occurred.

CORRELATING A NEW CLIMATE RECORD WITH CULTURAL CHANGE IN THE LAMBAYEQUE VALLEY, PERU

Dan Sandweiss, Kirk Maasch

Last year, Rein et al. (2005 in Paleoceanography) published a new 20,000 year, high-resoluition marine sediment record from a core taken from the continental shelf some 80 km southwest of Lima, Peru (~12° S). This record is a proxy for El Niño activity in central Peru. Lithic concentrations track changes in coastal zone precipitation, which is largely a function of El Niño activity. Recently, spurred by a request from the BBC, we compared this record to the last 2000 years of cultural development in the Lambayeque Valley of northern coastal Peru (~6° S). There, a series of advanced cultures rose and fell, dramatically. From 600-750 AD, the largest site of the late Moche culture was Pampa Grande, inland near the valley neck. Between 700-750 AD, this site was abandoned and the pyramids burned. Construction soon began at the Sicán Culture's Batán Grande Religious-Funerary Precinct, a complex of pyramids and burials north and west of Pampa Grande. Most of the Peruvian gold in the world's museums comes from the Middle Sicán (900-1100 AD) occupation of the Precinct. Between 1050-1100 AD, the Batan Grande pyramids were burned and abandoned. At this time, construction began at the site of Túcume, some 10 km south-southwest of Batan Grande. Túcume has the greatest number of pyramids of any site in ancient South America. Almost immediately after the Spanish Conquest of Peru in 1532 AD, Túcume was abandoned and the pyramids burnt. In this talk, we compare the Rein et al. El Niño proxy record and the Lambayeque cultureal record to identify and consider where correlations do and do not exist.

GEOARCHAEOLOGICAL SETTING OF THE SEBASTICOOK LAKE FISH WEIR, NEWPORT, MAINE

Christopher E. Miller

The Sebasticook Lake fish weir is located on the northeastern shore of Sebasticook Lake on an inlet of the East Branch of the Sebasticook River. The Sebasticook River is within the major Kennebec River drainage system of Central Maine. The weir is not a single structure, but rather a complex of emplaced wooden stakes, representing several periods of use. Anoxic conditions of the inlet environment have preserved organic material and artifacts, making the site unusual in Northeastern prehistory. Radiocarbon dates of the weir stakes suggest use of the weir between 5820-1760 BP (Late Archaic-Early Woodland period), making it one of the oldest dated fish weirs in North America. The earliest dates may be controlled more by preservation and lake-level change than by cultural use.

Preliminary geophysical investigations of the Sebasticook Lake basin revealed several submerged, wave-eroded terraces, interpreted as evidence of a lake-level lowstand approximately 9m below present. As a continuation of the initial survey, this project has two goals. First, a more comprehensive geophysical survey using sidescan sonar (SSS) and seismic reflection profiling (SRP) along with coring of the lake basin was employed to investigate the location, nature and depth of the paleo-shorelines and associated lake-level lowstand. Second, a more detailed GPR survey of the site proper allowed a clearer understanding of site-formation processes and the relationship between lake-level change and utilization of the fish weir. The results of this research have direct bearing on our understanding of prehistoric occupation of the Northeast and how human populations lived in and had influence on a dynamic landscape.

GLACIAL LAKE LEVELS AND PALEOINDIAN SETTLEMENT AT THE MUNSUNGUN CHERT SOURCE, NORTHERN MAINE

Bertrand Gilman Pelletier Jr.

This presentation will report the results of recent field work from Munsungan Lake in Piscataquis County, Maine. Previous research has documented a re-advance of glacial ice at Oxbow, Maine during the Younger Dryas period (11, 000 -10, 000 radio-carbon years ago). This glacial ice is close to Munsungan Lake and would have been active during the Paleoindian exploitation of the chert source. If glacial ice existed in other parts of the region contemporaneously with humans, would raised channels and stagnation moraines at Munsungan Lake be active during the earliest human quarrying episodes? Geologic evidence documents dynamic lake level changes near the Munsungun chert source, a known human focal point. Relict shorelines, prehistoric channels and 'perched deltas' suggest an ice dammed lake located near Paleoindian sites at Munsungan Lake. Stagnation moraines are present in the lake basin and may have acted as an ice cored moraine dam, controlling lake levels. When an ice cored moraine dam melts the structure deflates and collapses, triggering catastrophic outburst floods. Higher Pleistocene lake levels would have affected site selection and could explain the lack of Paleoindian sites on modern shorelines. Until recently, these landforms were thought to predate the presence of humans in the region. Research will continue to focus on understanding the relationship between changing lake levels and the distribution of archaeological sites at Munsungan Lake.

SURFACE VELOCITIES AND FLOW DYNAMICS FOR THE CLARK, COMMONWEALTH AND BLUE GLACIERS IN SOUTHERN VICTORIA LAND, ANTARCTICA

Bruce Williamson, Karl Kreutz, Steven Arcone, Erich Osterberg, Beth Bartel, Bjorn Johns, Seth White

Ice dynamics data is critical in selecting the most appropriate ice core sites for development of climate records, while also independently providing evidence regarding climate change. At Taylor Dome, for example, near the eastern edge of the East Antarctic Ice Sheet, radar stratigraphy was used to demonstrate a likely change in storm trajectory from a northern source during the late ice age period to the southern source witnessed today . At the Clark, Commonwealth, and Blue Glaciers, ground penetrating radar surveys yielding surface stratigraphy data and a view of the ice-rock interface were conducted in November 2003 as part of site selection activities for medium-depth ice core collection in the McMurdo Dry Valleys. In addition, high-resolution GPS surveys of mass balance pole networks at the Clark and Commonwealth Glaciers during the 2004 and 2005 seasons provide surface velocity data. As a result of these activities, the Blue Glacier was found unsuitable as a site for developing an ice core record, and the most promising sites were identified at the Clark and Commonwealth Glaciers. The Clark Glacier showed the least complex ice flow, offering the fewest constraints on site selection. The site at the Commonwealth was chosen in response to ice dynamics factors developed through these surveys.

HIGH RESOLUTION RECORDS OF EEMIAN INTERGLACIAL FROM MOUNT MOULTON (ANTARCTICA)

Elena Korotkikh, Gordon Hamilton, Paul Mayewski

The Mount Moulton blue ice area, in West Antarctica provides a unique opportunity to obtain ages of englacial tephra layers using $^{40}Ar/^{39}Ar$ method. During the 1999/2000 field season a horizontal ice core was collected by N.W. Dunbar (New Mexico Tech) and G. Zielinski (CCI). The core covers the period from 15,000 to 500,000 years ago. Preliminary ice chemistry records from this core demonstrates that sodium values are similar to Vostok. Additional field work conducted by CCI in 2004 demonstrated that some part of the record may be disturbed. Nevertheless the Eemian section appears to be well preserved based on methane measurements by Sowers (Penn State University). The Eemian interglacial is the most recent analog for the present Holocene interglacial, therefore it may be useful to predict future climate change. The goal for this research is to conduct high resolution sampling for stable isotopes, major ions, and trace elements from trench A of horizontal ice core collected in 1999/2000 to investigate in more detail the West Antarctic climatic conditions during the Eemian interglacial.

GLOBAL CLIMATE CHANGE: HIGH STAKES CHALLENTGES FOR INTERNATIONAL, REGIONAL, AND LOCAL SCIENCE AND POLICY

George L. Jacobson

Since its inception in 1972 as the Institute for Quaternary Studies, the Climate Change Institute has engaged in international science designed to provide global perspectives on complex earth systems. Our research initiatives have frequently involved productive collaborations with scientists from many other nations, and we take for granted the importance of working with others to achieve our scientific goals. Among other things, this research has solidified our appreciation for the importance of reducing anthropogenic emissions of greenhouse gases. Despite more than a decade of international attempts to effect policy changes that would dampen the acceleration of carbon emissions, the actual global response has thus far been negligible. Citizen-driven initiatives may be more successful at local and regional scales, and the Institute has played a role in some important recent examples. The long-term and very difficult challenge is to find ways for local policy successes to stimulate global responses.

CLIMATE POLICY GROUP: INITIATING A UNIVERSITY OF MAINE GREENHOUSE GAS INVENTORY

Leigh Stearns, Susan Kaspari, Sean Birkel, Dan Dixon, Gordon Hamilton, George Jacobson

In the past five years, the University of Maine's energy consumption has risen dramatically. Campus's consumption of electricity rose by ~40% between 2000-2005, and our energy bill has doubled. Even given a slight rise in student population and campus footprint (the addition of new buildings), our energy consumption is out-pacing any obvious explanation. In an effort to account for the University of Maine's greenhouse gas emissions, several Climate Change Institute graduate students are spearheading a study into UMaine's energy use.

The CCI's Climate Policy Group is committed to improving sustainability efforts on campus. In order for the administration to initiate energy improvements on campus, we need to demonstrate that such measures are economically and environmentally beneficial. We are

currently working with Clean Air – Cool Planet, a non-profit organization, to audit and reduce the campus's greenhouse gas footprint.

FRIDAY, MAY 12

GEOLOGIC AND PALEOECOLOGIC EVIDENCE OF ICE-MASS ADVANCE IN NORTHERN MAINE DURING THE YOUNGER DRYAS COLD REVERSAL

Andrea Nurse, Harold Borns, Ann Dieffenbacher-Krall, and James Fastook

Following the Late Wisconsinan deglaciation, masses of residual, wasting ice persisted through the Younger Dryas chronozone in northern Maine. During this 1000-year period of significantly lower atmospheric temperatures, the southern margin of one ice mass advanced to override and deform frontal sand and gravel exposed at Oxbow, Maine. The advancing ice margin continued southeastward beyond the Oxbow exposure for another kilometer, where several moraine segments mark the termination of the readvance. In the Oxbow stratigraphic section, below the basal till of the readvance, the sand and gravel unit contains deformed peat with four samples dating to an average of 10,500 14C yr B.P.

Lake sediment cores from northern and eastern Maine demonstrate a climate change signal characterized by a unique magnetic susceptibility pattern, an associated sharp reduction in organic content, an increase in spruce pollen and Dryas leaves, and chironomid assemblages consistent with colder summer temperatures. This zone has been well-dated to the Younger Dryas chronozone. Along the ice-flow line of the re-advance, this Younger Dryas signal is present in lake sediments 5 km south of the termination of the re-advance, but absent in Cranberry Pond sediments, 1.2 km east of the Oxbow exposure and in Perch Pond in the Deboullie highlands northeast of the Oxbow site. High carbonate influx peaks following Younger Dryas sediment deposition at Pennington Pond and Little Machias Lake in northern Maine suggest carbonate leaching from recently deposited, ice-transported tills.

Chironomid-derived temperature estimates for northern Maine and geologic evidence of Younger Dryas ice margin advance will be applied to northern Maine ice cap model. Together, these types of data will better define the Younger Dryas climate in northeastern North America.

AN INFERENCE MODEL FOR MEAN SUMMER TEMPERATURES DURING THE LATE GLACIAL TRANSITION IN THE SOUTHERN ALPS, NEW ZEALAND, USING SUBFOSSIL CHIRONOMIDS

Ann Dieffenbacher-Krall, Marcus Vandergoes (NZ Geological and Nuclear Sciences), Rewi Newnham (Plymouth Univ.), and George Denton

The origin of Southern Hemisphere millennial-scale climate events during the Late Glacial Transition remains a central issue of paleoclimate studies. The specific details of an in or out-of-phase relationship could support either Northern Hemisphere forcing or a Southern Hemisphere driver for thermohaline switches. Southern New Zealand, in the mid-latitudes of the southwest Pacific, is a prime location for establishing inter-hemispheric relationships and for testing models of abrupt climate change.

Surface sample chironomid assemblages from 60 lakes from the Southern Alps of New Zealand are used to reconstruct mean (austral) summer temperatures during the Late Glacial

Transition. The inference model is based on Weight Averaging Partial Least Squares regression, leave-one-out (jack-knifing) cross-validation. The model has a root mean square error of prediction (RMSEPjack) of 1.16 °C, an r2jack of 0.83, and a maximum biasjack of 1.44 °C. A 3-component WA-PLS model provides a reduction in RMSEP of 11.9% over a 2-component model and 21.4% over a 1-component model.

We applied the model to chironomid percentage data (square root transformed) from Boundary Stream Tarn, a kettle-hole lake located in the climatically sensitive eastern margin of the Southern Alps. Sediment from this lake provides a continuous, isotopically dated record of deglacial climate fluctuations since 18,000 cal yrs BP. Principal changes in Late Glacial/Interglacial Transition lithostratigraphy and pollen, notably the expansion of alpine grasses and herb taxa between c. 14,300 and 13,000 cal BP, are indicative of climate reversal and cooling that corresponds in time with the Antarctic Cold Reversal (ACR). Chironomid analysis reveals increasing mean summer temperatures from 9.5 to 11 °C during the period from 17,000 to 14,300 cal yrs BP. Temperatures increased to 12 °C until 14,000 cal yrs BP. Chironomid types indicative of cold temperatures dominated assemblages from 14,000 to 13,300, when temperatures dropped by as much as 3 °C. Subsequently, summer temperatures climbed to 11.5-12 °C and remained at these levels until at least 9500 cal yrs BP. Temperatures fluctuated by as much as 1 °C, averaging around 12 °C, from 13,000 to about 11,500 cal yrs BP.

These results confirm a mid-ACR period of cooler temperatures, and indicate that the Younger Dryas chronozone was a period with fluctuating temperatures similar to those of the early Holocene. These sequences further distinguish the coupling mechanisms by comparing terrestrial changes in southern New Zealand with Antarctic records and help clarify the relationship between the hemispheres.

LARGE AND RAPID ICE VOLUME LOSSES FROM TWO EAST GREENLAND OUTLET GLACIERS

Leigh Stearns

Kangerdlugssuaq and Helheim glaciers draining the southeastern portion of the Greenland Ice Sheet began a series of dynamic changes in ~2002. These changes include calving front retreat, ice flow acceleration, and surface lowering. The rapid onset of the changes has implications for the future behavior of the Greenland Ice Sheet and its contribution to sea level rise and ocean freshening. Here we quantify the rate of ice volume loss from each glacier. The results are derived from an analysis of repeat digital elevation models extracted from stereo satellite imagery.

The lower portions of both glaciers thinned, on average, by 70-90 m between 2002 and 2005. These thickness changes correspond to volume losses of ~18 km^3 for Kangerdlugssuaq Glacier and ~14 km^3 for Helheim Glacier. We emphasize that these are minimum amounts, because our satellite data are restricted to the lower portions of both glaciers. The combined volume loss from thinning alone – approximately 32 km^3 over three years (for comparison, Lake Mead holds about 35 km^3 of water) – represents a significant mass unloading of Earth's crust.

SUBGLACIAL MELT IN NORTHERN GREENLAND

Gordon Oswald

The surface and basal topography of the major ice sheets has been surveyed extensively using airborne Radio Echo Sounding. NASA's PARCA program has generated radar profiles of the

Greenland Ice Sheet, yielding topographic data essential for ice sheet models such as UMISM. Radio echoes from ice sheets, ice streams and glaciers also reveal characteristics of surface crevassing and of trends in internal layering.

However, researchers have hesitated to report evidence of melting at the ice-rock interface, due to a number of unknown influences on the intensity of the reflection. The existence of subglacial water is a key boundary condition for ice sheet models, directly affecting their stability.

In the work to be described, additional echo characteristics, and also a range of prior knowledge about the interface, are introduced to provide a basis for analysis of spatial changes in the interface that indicate the presence of water. Data provided by Kansas University Radar and Remote Sensing Laboratory are analysed and a topographic map is generated of the occurrence of subglacial meltwater in Northern Greenland.

EMBEDDED MODELS: APPLICATION TO THE ROSS SEA AND AMUNDSEN SEA SECTORS, RETREAT FROM LGM

James L. Fastook

Modeling ice sheets such as Antarctica is an important scientific activity for a number of reasons: 1) ice sheets are an integral part of the world's climate system, both as a mechanism defining climate and as an indicator of change; 2) modeling allows us to test our understanding of the fundamental physical processes that control the behavior of ice sheets and their response to changing climate; 3) modeling provides a virtual laboratory where we can investigate the possible changes that will occur.

Physics-based modeling of Ice sheets suffers from the same deficiencies that other fields such as global climate modeling (GCM) have encountered. This deficiency involves the need for higher resolution than current computers are able to provide with reasonable runtime and memory requirements.

Climate modelers overcome this deficiency by designing mesoscale models which run inside their global climate models. This allows them to use higher resolution in a smaller domain which is driven by the output of the lower-resolution, global-domain model. These mesoscale models, since they run at higher resolution, can also improve on the physics used in the GCM, they can be specifically tuned to work in particular regions, they can examine the interaction between processes operating at different scales, they can look at the effects of processes originating outside their domain, and at processes too small to be picked up in the full GCM.

We have followed the climate modelers' lead and developed an embedded ice sheet model, one where a section of the ice sheet (mesoscale) is modeled either at higher resolution with the same physics or at the same resolution with better physics. This embedded model is driven by output from a low-resolution model of the entire ice sheet (global model). By this approach we either obtain higher-resolution results, better able to capture the behavior of small-scale features such as ice streams, or we can include processes such as longitudinal stresses, which are impossible to calculate within the constraints of the shallow-ice approximation.

We apply the embedded technique to the Ross and Amundsen Sea sectors, focusing on the period from LGM to the present. A sequence of nested grids allows us to go from a continental view at low resolution, to a regional view at intermediate resolution, and finally to an ice-stream-specific view at the full resolution of the BEDMAP data set. Fast flow regions of wet bed, as predicted by the UMISM basal water component, are compared with known ice streams.

RAPID CHANGES OF KANGERDLUGSSUAQ AND HELHEIM GLACIERS – WHICH CAME FIRST: ACCLERATION, RETREAT, OR THINNING?

Gordon Hamilton, Leigh Stearns

Kangerdlugssuaq and Helheim glaciers are two of the largest outlet glaciers in East Greenland. New field and satellite remote sensing measurements show that both glaciers underwent a series of changes beginning in 2001. Between June 2001 and August 2005, both glaciers accelerated 40-300%, retreated >5 km, and thinned >100 meters. The rapidity of the change in ice dynamics raises concerns that other outlet glaciers in Greenland might undergo similar changes. Here, we seek to determine the order of events and gain insight into the mechanism triggering the changes of Kangerdlugssuaq and Helheim glaciers.

Ice velocity, calving front position and surface topography were determined for multiple epochs during 2001-2005 using a series of Landsat ETM+ and ASTER images and field measurements. Our results show that both glaciers began to thin and accelerate between June 2001 and July 2003, apparently triggering retreat. Increased flow speeds and thinning caused the glaciers to lift off their terminal point, where they had maintained stable positions from 1972-2001. Both glaciers steadily thinned and accelerated until the summer of 2005, when both processes increased rapidly.

We speculate that the positive feedback of acceleration, thinning and retreat was initiated by strong regional summer warming. Data from the nearest available weather station indicates that regional warming began in the late 1990s, with record warming occurring in 2003 and 2004. We hypothesize that accelerated ice flow resulted from enhanced lubrication caused by more surface meltwater reaching the bed. This process has been observed on the inland ice sheet in west Greenland (the so-called 'Zwally effect'). The new observations and the hypothesized mechanism highlight the sensitivity of large outlet glaciers to regional climate change, and have implications for ice sheet mass balance and sea level rise predictions.

IS RECENT GLOBAL WARMING NATURAL OR HUMAN INDUCED?

Kirk Allen Maasch and Paul Andrew Mayewski

During the last 2000 years two primary climate events have impacted the middle to high latitudes. These are commonly referred to as the Medieval Warm Period and the Little Ice Age. Detailed reconstruction of climate change for this time span are made by calibrating geochemical and biological proxies with instrument records of meteorological variables. Quantitative analysis of changes in both temperature and atmospheric circulation reveals the following.

The earliest major warming of the last 2000 years in the Southern Hemisphere is ~AD500 and for the Northern Hemisphere ~AD800. Southern Hemisphere atmospheric circulation weakens as of ~AD300. Northern Hemisphere atmospheric circulation weakens by AD400. Major cooling occurs in the Southern Hemisphere ~AD1000. In the Northern Hemisphere cooling onset is ~AD1400. Southern Hemisphere atmospheric circulation intensifies by AD800-1000 while Northern Hemisphere circulation intensifies just before the AD1400. In summary, atmospheric circulation changes in both hemispheres precede or are coincident with temperature change and temperature change is first in the Southern Hemisphere.

For the last few decades the average Northern Hemisphere temperature has risen to the highest levels of the last 2000 years. In the Southern Hemisphere that does not appear to be the case as average temperature remains within the observed variability of the last 2000 years. In both hemispheres, the patterns of middle to high latitude atmospheric circulation are still within the range of variability of the last 6-10 centuries.

From the natural analog for the phasing of warming and circulation change, temperature

increase over the last few decades should follow change in atmospheric circulation and should also precede in the Southern Hemisphere. Instead recent temperature change precedes change in atmospheric circulation and occurs first in the Northern Hemisphere. These findings imply that recent rise in temperature is inconsistent with natural climate variability and is most likely related to anthropogenic activity in the form of enhanced greenhouse gases.

STATE OF THE CLIMATE OVER WEST ANTARCTICA – PREPARING THE BASIS FOR UNDERSTANDING PAST, PRESENT, AND FUTURE CLIMATE CHANGE OVER ANTARCTICA AND ADJACENT SOUTHERN OCEAN

Paul Andrew Mayewski, Gordon Hamilton, Dan Dixon, Susan Kaspari, Leigh Stearns, Sharon Sneed, Kirk Maasch, Ann Zielinski and Mike Handley

Climate model predictions for greenhouse gas induced warming over the Arctic are now a reality as is warming in the northern portions of the Antarctic Peninsula and Tierra del Fuego. These predictions suggest a warming of several degrees over the next few decades over much of Antarctica and the Southern Ocean. However, instrumented records of climate are sparsely distributed over these regions and barely extend back a few decades. To fully assess current and detect future climate change over Antarctica requires climate records that are significantly longer than the instrumented record.

The International Trans Antarctic Scientific Expedition (ITASE) is a 20-nation oversnow traverse consortium that is developing a continent-wide array of annually resolved, instrumentally calibrated records of past climate (temperature, net mass balance, atmospheric circulation, chemistry of the atmosphere, and forcing) covering the last 200-1000 years. The Climate Change Institute is the lead institution for ITASE. The US component of ITASE concentrated on West Antarctica from 1999-2004 and during the 2006-2008 austral field seasons will extend its traverses into East Antarctica.

US ITASE climate reconstructions for West Antarctica provide a basis for assessing current and detecting future climate change utilizing instrumentally calibrated ice core records covering the last 200+ years. Based on this reconstruction the state of West Antarctic climate can be summarized as follows. Temperatures are still within the range of natural variability of the last 200 years, exclusive of the Antarctic Peninsula, and are closely associated with changes in major atmospheric circulation patterns. Mass balance variability is primarily controlled by surface/bed topography with significant variability in regions displaying large gradients in topography. Initial phases of the inland migration of marine air masses can be detected along the Amundsen Sea coast. A significant portion of the natural variability in the strength of the westerlies surrounding Antarctica is attributed to decadal and longer scales of solar variability that impact production of ozone and as a consequence the thermal gradient over Antarctica and the Southern Ocean. This finding verifies previous research that suggested such circulation systems are sensitive to change as a consequence of anthropogenically forced ozone depletion. Examination of the last 2000 years of climate over West Antarctica suggests that a period of intensified atmospheric circulation began ~AD1100, almost 300 years before the ~AD1400 intensification of atmospheric circulation marking the onset of the Little Ice Age in the Northern Hemisphere. Lagged response to greenhouse gas warming in the high latitudes of the Southern Hemisphere is likely controlled, as previously suggested, in response to the thermal capacity of the vast Southern Ocean, and as indicated by US ITASE research as a consequence of underpinning by the naturally more intense "Little Ice Age" state of the atmosphere over these latitudes.

KEYNOTE SPEAKER: Paul R. Epstein "Climate Instability: Health, Ecological and Economic Dimensions" *SEE PAGE 6*

FIRE AND ICE: VOLCANIC GLASS, GLACIERS, AND THE INITIAL SETTLEMENT OF SOUTHERN PERU

Kurt Rademaker, Gordon Bromley, and Louis Fortin

We present preliminary results from 2005 Churchill Expedition-funded interdisciplinary work at the highland Alca obsidian source and the Nevado Firura ice cap in southern Peru. In the late Pleistocene, high elevation paleogeography of this region was considerably different than it is today. Highland sites that appear contemporary with the well-dated coastal occupation at Quebrada Jaguay suggest that early foragers occupied the periglacial zone. Determining the timing and spatial extent of glacial advances and retreats is the first step in modeling other elements of Andean highland paleoenvironments to refine the search for early human settlements in this and other coast-highland corridors.

THE ARCHAEOLOGICAL IMPORTANCE OF OBSIDIAN AND MACUSANITE IN THE SOUTHERN PERUVIAN HIGHLANDS

Louis Fortin

Obsidian characterization studies have been used in many parts of the world to investigate prehistoric interaction and exchange. However, it was not until the 1970s that such research was conducted for the Andean area of South America. Since then, sourcing obsidian has grown considerably in allowing us to understand more completely the patterns of procurement and exchange in Peru. Nonetheless, there are still chemical types of obsidian that come from yet unlocated geologic deposits of volcanic glass. Macusanite, a little known glassy peraluminous rock found in the south eastern highlands of Peru, may be one of these unlocated geologic deposits. Further research will have to be done in pinpointing a macusanite source in SE Peru, along with sampling it and then comparing it regionally to locations that have obsidian with no known geologic deposit.

LATE QUATERNARY CLIMATE RECORDS FROM NEVADOS FIRURA AND COROPUNA, SOUTHERN PERU

Gordon Bromley, Brenda Hall, Kurt Rademaker

The Nevado Firura ice cap in southern Peru fluctuated greatly in size in response to late Quaternary climate change. At its most extensive the ice cap, which today is restricted to the summit of Nevado Firura (5499 m), covered more than 570 km2 and descended down to ~4500 m elevation. Subsequent recession and readvance of the ice margin has resulted in a complex sequence of glacial landforms being deposited on the plateau surrounding Nevado Firura. In 2005 we carried out glacial geologic fieldwork in this area as part of an integrated geologic-archaeologic project aimed at exploring relationships between climate change, glaciation, and the land-use behaviour of the first Americans. I will be presenting a geomorphic map of the 2005 field area and discussing the climatic implications of our initial data. In addition, I will describe the next step in this research and our plans to extract a palaeoclimate record from neighbouring Nevado Coropuna this summer.

FISH, GAME, AND THE FOUNDATIONS OF COMPLEXITY IN FORAGER SOCIETY: THE EVIDENCE FROM NEW GUINEA

Paul Roscoe

Drawing ethnographic data from the foraging communities of New Guinea - an under-utilized resource in hunter-gatherer research - this paper will examine the relationship between subsistence form and four aspects of cultural complexity - density, settlement size, settlement form, and settlement permanence. Based on global data, it is commonly proposed that, in forager communities, these characteristics are directly related to the degree of dependence on aquatic resources. For serendipitous reasons, the New Guinea data allow these propositions to be assessed with some precision, and the results strongly corroborate them. The implications of these findings for understanding the generation of complexity in forager societies are briefly discussed.

MEBONZ: ZOOARCHAEOLOGY WORKING GROUP PROJECTS

Kristin Sobolik

For this presentation, I will review the projects undertaken by a faunal working group of Maine zooarchaeologists working on Maine projects. The projects discussed will include: 1) the Zoogeography of Maine, which involves consolidating the faunal data accumulated from Maine archaeological sites with the intent of analyzing animal movements through time and across space; 2) an analysis of faunal remains from Indiantown Island, an archaeological site located in the Sheepscot River estuary; and 3) analyses of dog remains from northeastern archaeological sites.

UPDATE ON ICE CORE DATING SOFTWARE

Andrei V. Kurbatov, Paul A. Mayewski, Bashar Abdul Jawad (Department of Computer Science)

We developed interactive computer software, Ice core Dating (ICD) program that helps to identify and record the depth of annual signals using stable isotopes, glaciochemistry, ECM (electrical conductivity), DEP (dielectric properties) and particle counter data.

ICD is programmed in Java, and licensed under the terms of GNU GPL public license. Features include:

- Runs on any operating system that supports Java programming language
- Input text data files are automatically checked for consistency (Zero values, negative values, correct format...)
- Working sessions can be saved and accessed later
- Import, save and export generated time scales as text files
- Flexible number of parameters could be loaded and plotted
- Log and normal scales are available
- Ability to zoom, pan the chart, and add comments during the sessions
- Ability to interactively edit annual mark lines

ICD is thoroughly documented and comes with a technical reference and cookbook that explains the purpose of the software and its many features, and provides examples to help new users quickly become familiar with the operation and philosophy of the software.

ICD is available as a free download from the Climate Change Institute web site: (http://www.climatechange.umaine.edu/Research/software/index.html).

We would like to thank Climate Change Institute members: Daniel Dixon, Susan Kaspari, Erich Osterberg, Ann Zielinski for helpful suggestions on program design and functionality. The software development was supported by the University of Maine and National Science Foundation.

MAJOR ION, TRACE ELEMENT AND WATER ISOTOPE MEASUREMENTS FROM THE 2002 AND 2003 US ITASE TRAVERSES

Daniel A. Dixon, Paul Andrew Mayewski, Susan Kaspari, Sharon Sneed, Mike Handley, Kirk Maasch, Karl Kreutz, Gordon Hamilton, Andrew Carleton (Penn State Univ)

Over-snow traverses, such as those conducted by the International Trans-Antarctic Scientific Expedition (ITASE), provide us with the data needed, at a high enough spatial and temporal resolution, to form a more accurate assessment of the regional climate differences between deep core sites. This study focuses on a collection of cores and surface snow samples collected along the 2002/03 (ITASE-02) and 2003/04 (ITASE-03) US ITASE traverses. The ITASE-02 traverse started from Byrd Station, West Antarctica, and progressed southward, ultimately ending at the South Pole. The ITASE-03 traverse began at the South Pole and proceeded over the interior of East Antarctica to the Automated Geophysical Observatory number 4 (AGO4). From AGO4 the traverse travelled northward along the Transantarctic Mountain seismic sensor line, passing through the area known as Megadunes, and finishing up at Taylor Dome. Fifteen shallow ice cores and several snowpits were collected along the traverses. Surface snow samples were also collected every ~30-50 km along both traverses. All samples were analysed using an ion chromatograph for their soluble major ion content (Na, K, Mg, Ca, Cl, NO3, SO4). The surface snow samples are additionally analysed for their delta-O18, H/D, and trace element content (Sr, Cd, Sb, Cs, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Pb, Bi, U, As, Tl, Al, S, Ca, Ti, V, Cr, Mn, Fe, Co, Cu, Zn) using inductively coupled plasma-mass spectrometry. Core top data indicate summer concentration values for most of the surface snow samples. The seasonality of the surface snow samples is most uncertain between AGO4 and the Megadunes. Summer concentrations of many trace elements in West Antarctica are generally below detection limits. There are high particle concentrations around the South Pole and Megadunes areas. This may be a consequence of chemical and/or precipitation differences between the two traverse years. The surface around the Megadunes area is most likely composed of redistributed or reworked (probably through ablation processes) snow. The process of surface ablation has the effect of concentrating chemistry on the surface.

WEAKENING OF THE SOUTH ASIAN MONSOON SINCE 1400 A.D. FROM A MT EVEREST ICE CORE

S. Kaspari, P. Mayewski, S. Kang (Chinese Academy of Sciences), S. Sneed, K. Kreutz, D. Introne, R. Hooke, K. Maasch, D. Qin, S. Hou, J. Ren (Chinese Academy of Sciences)

Analysis of a 108m high-resolution ice core drilled to bedrock from Mt. Everest covering the last 1500 years indicates a weakening of the Asian monsoon since ~1400 A.D. Empirical orthogonal function (EOF) analysis on the major ion (Na+, K+, Mg2+, Ca2+, Cl-, NO3-, SO42-) and D time series demonstrates that the Everest site is influenced by continental air masses associated with the Asian high pressure system and marine air masses associated with the South Asian

monsoon. Everest Ca2+ (Cl-) is positively (negatively) correlated with NCEP surface pressure from May-September over central Asia from 1948-2001, indicating that when pressure is relatively higher (lower) over central Asia more continental (marine) air masses penetrate the Everest site. An inverse correlation of Everest D and June-September NCEP precipitation rate from 1948-2001 confirms the results of previous studies that the amount effect is the primary seasonal control on D in the Everest region (Kang et al., 2002, Tian et al., 2001; 2003), however temperature and changes in moisture source also may affect D. Increased continental and decreased marine air masses since ~1400 suggests higher pressure over central Asia, and a weakening of the monsoon in the Everest region. Increasing D and decreasing net mass balance further supports this weakening. Proxy records from low elevation sites south of the Himalayas indicate a strengthening over the same time period (Anderson et al. 2002; von Rad et al., 1999; Wang et al., 2005). These regional differences are associated with higher pressure over Asia during summer and a southward shift in the mean summer position of the Intertropical Convergence Zone, as supported by a reduction in seasonal differences of insolation. The change in monsoon strength at ~1400 is synchronous with other large perturbations of the climate system associated with the onset of the Little Ice Age.

SEASONAL STABLE ISOTOPE AND TRACE ELEMENT RECORDS FROM FEDCHENKO GLACIER, CENTRAL ASIA

Bjorn Grigholm, Paul A. Mayewski, Susan Kaspari, Sharon Sneed, Michael Handley, Vladimir Aizen, Elena Aizen, Daniel Joswiak, Arzhan Surazakov, John Marshall, and Robert Brander (Univ Idaho), Michael Krachler (Univ. Heidelberg)

As reconnaissance for the Central Asia Deep Ice-coring Project (CADIP) two shallow ice cores (9 and 12m) were retrieved from Fedchenko Glacier (5280m and 5650m a.s.l) in the Pamir Mountains (Tajikistan) during the summer of 2005 to determine the presence and quality of annually preserved chemical signals. The ice cores were processed and analyzed at ~10cm resolution for stable isotopes (δ18O, δD), soluble ions (Na^+, $K+$, Mg_2^+, Ca_2^+, Cl^-, NO_3^-, SO_4^{2-}), and trace elements (Al, Fe, Zn, Pb, Cd, Cu, Co, Ti, Ba, Cr, Sr, V, U, Cs, Mn, As, Se, and REE). Isotope and trace element time-series exhibit clear annual signals reflecting seasonal precipitation patterns and dust storm events and allow accurate dating of the ice cores. Stable isotope values display large amplitude oscillations between summer and winter, with more depleted values corresponding to colder winter precipitation. Large trace element peaks are associated with the spring/summer increase of dust activity in central Asia. Results of clear inter-annual chemistry are very encouraging for the eventual retrieval of deep ice cores. Past research suggests that Fedchenko Glacier may be 1,000m in thickness and could potentially provide an ice core record spanning 100,000 years. The primary scientific objective of CADIP is to develop glaciochemical and isotope time-series to investigate natural and anthropogenic inter-annual/decadal to centennial/millennial scale climate and environmental variability of north-central Asia through the Holocene. Special thanks to Dan and Betty Churchill for their generous Churchill scholarship, which allowed for student participation on this expedition.

COULD THE OROGRAPHIC INFLUENCE OF THE LAURENTIDE ICE SHEET HAVE TRIGGERED "JET JUMPS" ACROSS THE NORTHERN HEMISPHERE?

Sean Birkel, George Denton, James Fastook and David Battisti (University of Washington)

Paleoclimate records show that the North Atlantic region and many other parts of the Northern

Hemisphere were affected by abrupt climate changes during the mid to late Pleistocene. These so-called Dansgaard-Oeschger (D-O) events encompassed both changes in thermohaline circulation and the position of the polar jet. Typical D-O events, characterized by a rapid warming followed by a slow cooldown, were most dominant when Northern Hemisphere ice sheets were "medium" size. Abrupt changes were infrequent near the Last Glacial Maximum when the ice sheets were at their largest. In addition, D-O events are not known to have occurred during the Holocene or when the Northern Hemisphere ice sheets were small. One idea explains the apparent link between ice sheet size and abrupt climate shifts by considering orographic effects on atmospheric circulation. "Jet jumps," or semi-permanent flips in the polar front, might occur when ice sheets such as the Laurentide grow to some critical height and lateral extent. A joint effort between the University of Maine and the University of Washington will use glaciological and atmospheric models to explore the physical plausibility of jet jumps. We will reconstruct the Laurentide Ice Sheet at various times based on known glacial geology and then test under what circumstances it is (or is not) possible to flip the polar jet between warm and cold modes of flow over the North Atlantic.

DEGLACIATION TO MODERN STRATIGRAPHY AND EVOLUTION OF MAINE LAKES

Daniel F. Belknap and Joseph T. Kelley

Maine's more than 6000 lakes and ponds were primarily created by glacial scour and deglacial damming. These range from high mountain tarns, to bedrock-controlled lakes and river drainage, and to drift-dammed lakes. Local and regional paleoecological studies (e.g., Deiffenbacher-Krall and Nurse, 2005) of pollen and vegetation macrofossils in lakes and ponds document wet and dry cycles, lake-level changes, and vegetation changes. Some coastal lowland lakes are isolation basins, recording a change from deglacial marine to isostatically rebounded freshwater settings. We have studied eight lakes in reconnaissance and detailed investigations using seismic profiling, sidescan sonar, and core sampling. Moosehead Lake, the largest in Maine, shows distinct bedrock control of initial glacial scouring of basins. It is above the marine limit, and contains submerged eskers, glaciolacustrine, and postglacial lacustrine sediments. It is large enough that regional isostatic tilt is recognized in uplifted and submerged shorelines. Lobster Lake in north-central Maine formed around a prominent kettle hole basin, and today receives input from springtime flow from the flooding West Branch Penobscot River, forming a reverse-flow delta at its outlet. Sebago Lake straddles the mapped inland postglacial marine limit, and contains a stratigraphic record of glaciomarine, glaciolacustrine, and proglacial delta deposits. Deep basins in Sebago Lake record extensive slides, slumps and basinal run-out deposits, suggesting instability in early post-glacial times, but possibly of much more recent activity. We are studying Rangeley and Mooselookmegunticook Lakes in NW Maine to characterize their fishing habitats, stratigraphy, and potential isostatic tilt record. Sebasticook Lake occurs below the inland marine limit, and contains an eskers, moraines, kettleholes, and a transition from glaciomarine to glaciolacustrine sediments indicative of an isolation basin. Sebasticook is notable for geoarchaeological studies of a mid-Holocene fishing weir site and low lake-level shorelines. Finally, Pemaquid Lake and Biscay Pond are coastal lakes with a record of glaciomarine sedimentation followed by emergence and isolation by uplift. They form analogues for the nearby Damariscotta River estuary, which saw a similar isolation, but then was subsequently resubmerged by the Holocene transgression. Many Maine lakes and ponds record an early Holocene low-lake level recorded in lowstand shorelines and wave-abrasion platforms (8-12 m in Moosehead, Sebago, Sebasticook, and other studies) that is an important link to paleoecological climate indicators, as well as a potential record of regional isostatic tilting, valuable for evaluation of the passage of a glacial forebulge.

GEOLOGIC AND BIOLOGIC PROXY RECORDS FOR PALEOCLIMATE IN THE ANTARCTIC

Audrey Bamberg

This presentation will report the initial findings of an interdisciplinary research project focused on investigating Holocene distributions of adélie penquins and elephant seals on the raised beaches of Victoria Land Coast, Antarctica. In order for seal colonies to have existed in this area, the coast must have been continuously ice free for at least three to five months. Adélie penguins on the other hand require some sea ice but not as much as present conditions, which places their occupation of the coast at different times than the elephant seals. Because of the excellent preservation of elephant seal and adelie penguin remains we are able to reconstruct when these animals were present on the raised beaches along the coast and thus infer past sea ice extent and climate. As part of this multidisciplinary approach, my research goals are to examine the geology and sedimentology of the beaches that formed during the Holocene as a result of glacial isostatic rebound. This investigation will enable me to determine whether the beaches were formed by ice push (characteristic of the present cold environment) or during long or short periods of open water. Together the biologic and geologic data will provide an important multi-proxy climate record for the Antarctic.

LATE HOLOCENE ICE FLUCTUATIONS IN THE CORDILLERA DARWIN, CHILE

B. Hall, C. Porter (Patagonian Research Foundation)

We report here preliminary results of a study to examine late Holocene glacier fluctuations in the Cordillera Darwin of southern Chile. We delineated glacier extent during the "Little Ice Age" using field mapping, dendrochronology, and historical photographs. Our evidence indicates a significant ice advance in the 1940s that reached, in some cases, within a hundred meters of the maximum Little Ice Age position. Evidence for the large meltdown and retreat that typically occurred after A.D. 1850-1870 elsewhere in the world appears to be lacking in the Cordillera Darwin. With a few notable exceptions, most glaciers seem to be at the same location seen in photographs from the early 1900s and within one kilometer of the A.D. 1945 readvance position. In addition, we have documented evidence of present-day, ongoing ice advance. At six sites examined so far, ice is advancing into trees that, in at least one case, are about 100 years old. Although preliminary, all data gathered to date suggest that ice fluctuations in the Cordillera Darwin differ from the "typical" Little Ice Age records seen elsewhere, particularly in the Northern Hemisphere.