

**Paleoenvironmental Reconstruction and Landscape Interactions
in Lake Clark and other Southwest Alaska Lake Systems,
Southwest Alaska Inventory and Monitoring Network**

Annual Report

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EXECUTIVE SUMMARY

In order to fully understand the dynamics of any ecosystem, it is important to have some knowledge of how that ecosystem developed through time, how it has changed in the past, and how it may change in the future. Landscape history studies such as the timing of deglaciation, location and timing of hydrologic connections or barriers, and the history of lake level change will provide a framework for understanding salmon population dynamics in terms of colonization, isolation, and bottleneck effects, as well as for the ongoing efforts to locate and date early human settlements in the area. Paleoenvironmental reconstruction using pollen and other indicators from lake sediment cores will provide a history of ecological succession and vegetation change since the last ice age. Volcanic history, also obtained from lake sediment cores, will allow us to construct a regional tephra stratigraphy useful for dating inorganic lake sediments, landforms, and archeological sites. The potential effects of ash fall into different lake systems can also be investigated through the study of such events in the sedimentary record.

The first year of this study included lake coring, associated field work and lab analyses which is still underway. Results to date include:

- Glaciers retreated from Lake Clark valley by ~15,000 yBP.
- A preliminary lake level history indicates that lake level lowering occurred early (probably prior to ~11,000 yBP) and took several thousand years.
- At least 6 tephras have been identified and dated, ranging in age from ~7,500 to 1,900 yBP.
- Exploratory research (funded by the U. of Illinois) into using microbial DNA as sensitive indicators of environmental change in lake sediments shows initial success with the identification of 5 distinct microbial communities extracted from 5 different sediment facies.
- Distinct sediments rich in magnetite, iron oxide, and clay minerals suggest different drainage pattern and/or complex early lake history in the Lake Clark Valley.

Plans for 2004 include additional lake coring through the ice in March on Kontrashibuna, and small lakes around Lake Clark. Summer coring efforts in 2004 will move to lakes in Katmai National Park. Detailed study of lake level change will be conducted in Lake Clark (beach ridge profiles, lake elevation measurements). Lab work is continuing on all aspects of this study and will continue into the summer of 2004.

ABSTRACT

In order to fully understand the dynamics of any ecosystem, it is important to have some knowledge of how that ecosystem developed through time, how it has changed in the past, and how it may change in the future. This study aims to reconstruct the deglacial history, lake level history, ecologic succession and volcanic history of lakes in Southwest Network Parks. The first year on this project focused on Lake Clark National Park where a number of lakes were cored during the summer of 2003. Results to date suggest: 1) Glaciers retreated from Lake Clark valley by ~15,000 yBP. 2) A preliminary lake level history indicates that lake level lowering occurred early (probably prior to ~11,000 yBP) and took several thousand years. 3) At least 6 tephras have been identified and dated, ranging in age from ~7,500 to 1,900 yBP. 4) Exploratory research into using microbial DNA as sensitive indicators of environmental change in lake sediments shows initial success with the identification of 5 distinct microbial communities extracted from 5 different sediment facies. Work is continuing on all aspects of this study and will expand into Katmai lakes in the summer of 2004.

INTRODUCTION

Field work within Lake Clark National Park and Preserve (LCNPP) was conducted from May 2003 through August 2003. The focus of field efforts for 2003 consisted of three parts: (1) Air and land reconnaissance for selection of appropriate sampling locations. (2) Extraction of sediment cores obtained from kettle ponds located within the paleo-shorelines of Lake Clark. (3) Examination and sampling of exposed sections of laminated lake sediments likely deposited by a higher, glacial-fed 'paleo Lake Clark' along the Newhalen and Tazimina Rivers. Laboratory analyses of the lake sediments is in progress and our results to date are reported here.

One lake, informally named Olga's Pond and located near the mouth of Dice Bay, was cored and sampled in the field for microbes and microbial DNA that may be present in ancient lake sediments. It is hoped that this exploratory method will yield paleo-DNA and potentially provide a new way to determine microbial presence and function in lake sediments, reconstruct lake histories, and improve our understanding of ecosystem dynamics and nutrient cycling.

The small lakes, ponds, and bogs act as 'isolation basins' recording the change from a larger, higher, glacial-fed lake to small isolated systems as the lake level recedes below its threshold (Figure 1). Field survey data and initial laboratory analysis have demonstrated positive results for reconstructing the paleo extent of Lake Clark and the timing of deglaciation within the Lake Clark watershed.



Figure 1. Lake shorelines surround small kettle pond (Lily Dean Lake) near outlet of Lake Clark (Ann Maglio photo)



Figure 2. Tephra layers are traceable between cores and between lakes (Ann Maglio photo)

Radiocarbon dating combined with excellent tephra stratigraphy is being used to determine the timing, rate, and synchronicity of lake level changes. The record preserved within the lake sediments will illustrate lake dynamics in historic and pre-historic periods and provide baseline data on past responses to the potential cause(s) of lake level change (e.g. isostasy, climate, and tectonics). The baseline data set may also be applied as an index of water balance and changes in precipitation and evaporation.

Methods:

Determination of paleo and historic lake levels is an iterative and continuous process because the location of suitable sites does not occur along a consistent elevation gradient. Therefore when ancient glacial lake sediments are observed in a sediment core of a small pond, the elevation and location in reference to contemporary Lake Clark must be considered both spatially and temporally. The transition from glacial lake sediments to isolation pond sediments provide two valuable sources of information (1) confirmation of the paleo-extent of Lake Clark (2) The date for lake level regression past a certain elevation. Once glacial lake sediments are recovered from a site, the objective is to move incrementally higher in elevation to locate the historical extent of Lake Clark by determining the approximate maximum elevation of the shoreline. The location of sample sites is restricted by logistics (transportation, ability to move ~600 lbs of gear to site, etc.) and the availability of an appropriate site (lake, pond, or bog) that contains an obtainable sediment record, in the right area, and at the desired elevation. If glacial lake sediments are not found in cores where expected, it is then necessary to: 1) consider geomorphologic processes that may have “erased” the sedimentary record, or 2) assume that the extent of Lake Clark did not reach that site. These no-lake sites provide valuable information on the extent of glaciers that may have existed during, or after, the existence of ‘Paleo Lake Clark’.

Open water ponds were cored from a platform mounted on a 16 ft pontoon river raft anchored over the deepest or most suitable area of the pond. Bog cores were obtained from the surface. A 5 cm (2 in) diameter Livingston square-rod piston coring device was used to extract sediment from lakes, ponds, and bogs. Cores were extracted in 1 m (3.28 ft) increments and extruded into 5 cm diameter x 1m length PVC casing for transport and storage. Cores are stored under refrigeration at the University of Alaska Anchorage.

Summary of Field Activities

Sediment cores were extracted from eleven sites along the periphery of Lake Clark (see Figure 3 and Table 1.). The approximate volume of material removed from LCNPP was 0.076 cu. m (2.7 cu. ft). The volume of material retained from each site was dependant on total core length and the number of cores taken (e.g. for duplication and correlation).

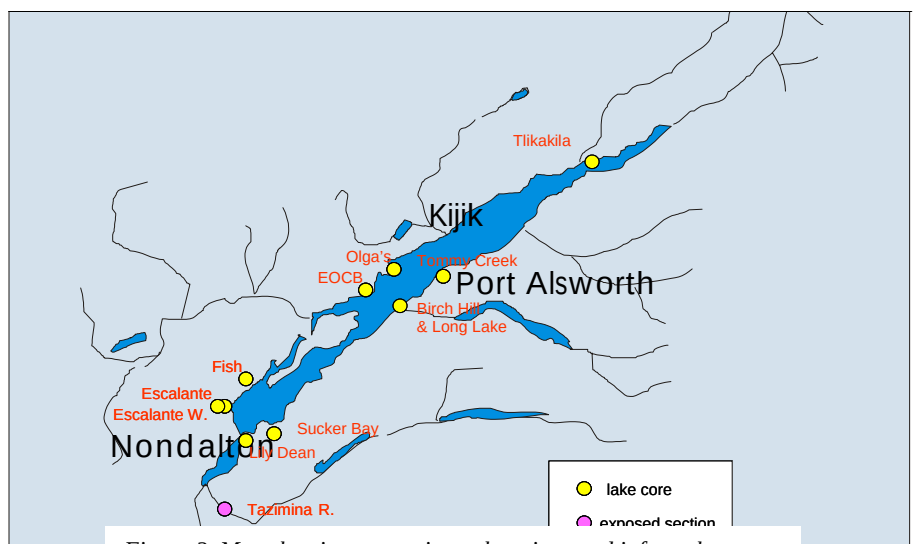


Figure 3. Map showing approximate locations and informal names of core sites.

Table 1. Location and Total Volume of Sediment Retained by site

Date(s) 2003	Informal Name	Latitude	Longitude	Elevation (m)	Volume Retained m ³ (ft ³)	Maximum core length (m)
03/01	Birch Hill Pond	NA	NA	83	0.003 (0.11)	1.5
03/02	Long Lake	NA	NA	82	0.004 (0.12)	1
06/07, 06/08	Tommy Creek Lake	60°14.541'	154°14.500'	101	0.018 (0.64)	5
06/09, 06/29	Olga's Pond	60°14.250'	154°23.203'	79	0.018 (0.64)	4.5
06/11	EOCB	60°12.677'	154°26.551'	89	0.003 (0.11)	1
08/03	Lily Dean Pond	60°01.155'	154°44.858'	80	0.007 (0.26)	3
	Kijik Bog	NA	NA	NA	hit ice	
08/08	Suckers Bay Bog	60°01.765'	154°39.779'	81	0.004 (0.12)	3.2
08/10	Escalante	60°03.806'	154°47.399'	90	0.005 (0.16)	2.5
08/11	Escalante West	60°03.806'	154°47.399'	92	0.002 (0.06)	1
08/13, 8/14	Fish Lake	60°06.227'	154°42.259'	98	0.012 (0.42)	5
				Total	0.076 (2.7)	

Note: Table is sorted by date

Sites located along the Newhalen and Tazimina Rivers provided excellent exposures of lake and delta/fan sediments in stratigraphic section. These were described and sampled for sediment, tephra, and radiocarbon analyses. Tephra and sediments were collected in Whirl Pack® bags for transport and storage.

Figure 4. Student Ann Maglio stands by exposure along Tazimina River.



Results and Ongoing Activities:

The summer coring season was extremely successful. Nearly all lakes cored contained valuable and usable sediment records. The exposed sections along the Newhalen and up the Tazimina River are going to provide excellent sites for the study of lake sediments over a greater horizontal distance (opposed to a 5 cm diameter core).

Analyses of the cores and sediments are in progress at UAA and at the University of Illinois. A suite of ten initial radiocarbon dates has been obtained and a framework for the timing of deglaciation and lake level change is being constructed. The following sections report our results to date.

Radiocarbon Dating of Ice Retreat and Lake Level Change

Radiocarbon samples obtained from the base of sediment cores (bottom-most organics) are used to determine a “limiting age” for the retreat of glacial ice and commencement of organic deposition into kettle lakes. By “limiting age” it is meant that ice retreated at some time PRIOR to the radiocarbon age of the sample. Basal dates obtained from numerous cores suggest that ice retreated out of the valley by about 15,000 years before present (yBP). All dates, unless otherwise noted are in CALIBRATED years. That is, dates are corrected for changes in the ^{14}C production through time, in order to reflect actual years before present.

With the exception of the Tommy Lake core, all other kettle lakes surrounding Lake Clark contain lacustrine sediments likely deposited in a larger, and higher elevation Lake Clark. The threshold elevation of Tommy Lake is probably higher than any Paleo Lake Clark elevation and therefore did not receive sediments from the large glacial lake that occupied the valley (Figure 5). The Tommy Lake core represents the oldest core obtained in the valley, and the dominantly organic content throughout makes it an excellent candidate for pollen analysis. A split of this core is being sent to Nancy Bigelow at Univ. Alaska Fairbanks for the extraction and counting of pollen. Additionally, at least 6 tephras are recorded in the Tommy Lake core. Three of these distinct tephras range in age from ~6500 yBP to ~2500 yBP. Textural, morphologic, mineralogic and geochemical analyses of these ashes is under way (topic of M.S. Thesis for graduate student Matthew Bowes).

Radiocarbon dates obtained from sediments marking the transition of (relatively) inorganic glacial lake clays to organic lake bottom marks the transition from large glacial lake sedimentation to isolated small pond sedimentation that occurred as the larger lake level transgressed below the threshold of the small pond being cored. At present, we have only estimates of the elevation of pond thresholds; detailed surveys of beach ridges, pond thresholds, and abandoned river channels will be completed during summer of 2004 as part of graduate student Ann Maglio’s M.S. thesis. Hand level estimates and estimates from topographic maps suggest that lake level drop occurred relatively quickly (over several thousand years) and relatively soon after deglaciation. Olga Pond and Lily Pond, two of the lowest elevation kettles, show the transition occurring prior to ~11,000 yBP.

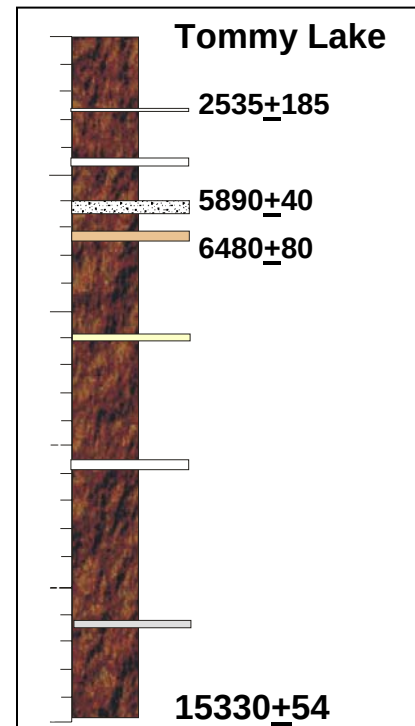


Figure 5. Tommy Lake core.

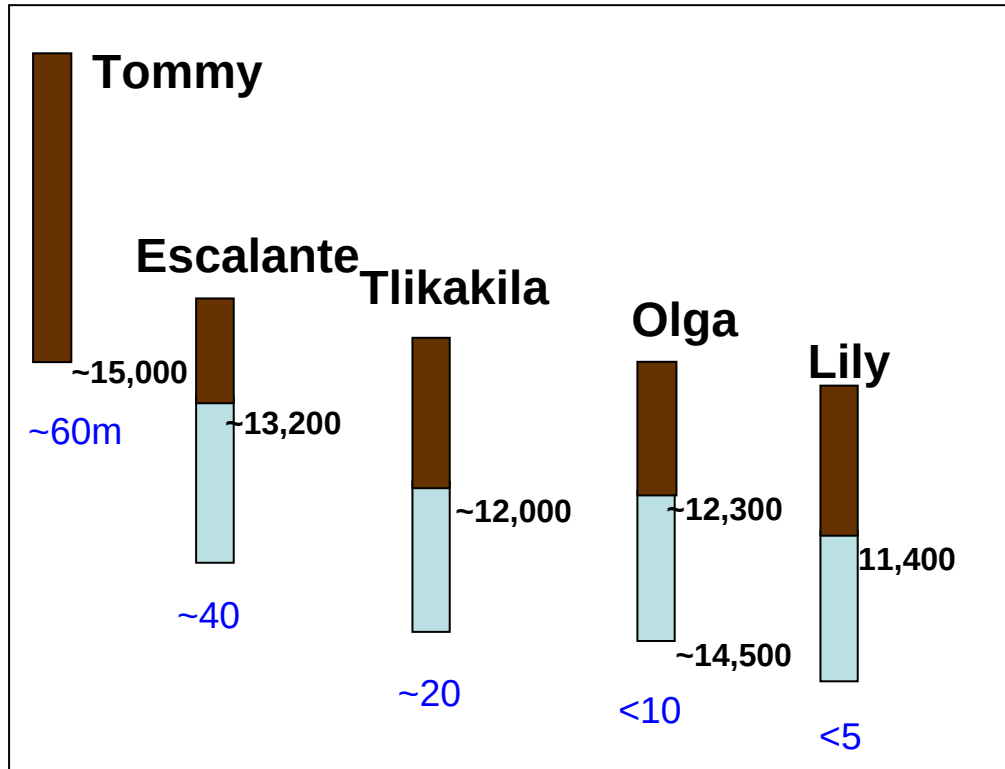


Figure 6. Five kettle lakes that surround Lake Clark date the transition from glacial lake sedimentation to isolated pond sedimentation. Numbers at bottom are estimated elevation above present lake level (meters).

Note: Tlikakila Bog was cored as part of an earlier study.

Lake Sediment Analyses

Analysis of organic content, grain size, clay mineralogy, carbonate content and magnetic susceptibility are ongoing and overall results are not yet complete. Initial studies of some cores show interesting patterns that warrant further investigation. Sediments obtained from Escalante Lake, and the sections along the Tazimina River and Newhalen River (see Figure 3 for locations) show distinctly different sediments than lake sediments obtained from cores “up lake”. The bottom of Tazimina and Newhalen sections, and the entire Escalante core are characterized by rhythmite bands containing strong iron staining and very fine clay laminations (Figure 7). The magnetic susceptibility of these sediments is nearly two orders of magnitude higher than the lake sediments obtained from other lakes. The presence of volcanic rocks in the area, and ore deposits nearby may indicate a very different source area for these sediments. Alternatively, these might represent ‘older’ lake sediments that underlie the glacial lake sediments found in most cores. Continued work on the clay mineralogy will allow us to determine if these minerals have formed *in situ* under different diagenetic conditions (age, pressure, ground water) or if they reflect a different sediment source. Continued work next summer and a search for organic fragments and

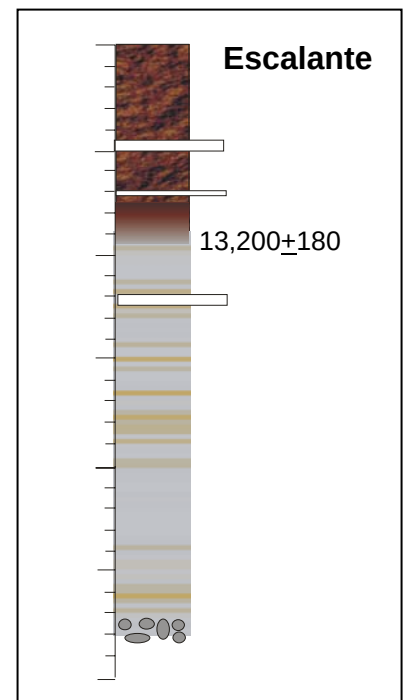


Figure 7. Sediment core from Escalante Lake

volcanic ashes within the sediments will allow us to better determine the age and origin of these deposits. The dates from the Escalante core indicate that these sediments are older than ~13,000 yBP. Stiff sediments, encountered twice (but not penetrated or collected) in Lily Pond suggest that the upper sediments may be underlain by these iron-rich, very fine clays. Attempts may be made this winter to core deeper in Lily Pond in order to determine possible stratigraphic relationships with these unusual sediments.

Comparative mineralogical analyses using X ray diffraction (XRD) will provide clay mineral content of the iron-rich clays versus the “regular lake clays” collected from up lake. These data show that the iron-clay sediments from Escalante are lower in expandable clays and considerably higher in kaolinite and chlorite than the lake sediments from “up lake”. Horseshoe bend sediments have extremely high expandable clays and lower illite values than Escalante and the upper lakes. We have just begun interpretation of this data. However, we expect it to provide valuable information on source areas, degree of weathering or alteration, and possibly age of the sediments. Additional samples are being analyzed and interpretation will follow when more data is collected.

Table 2. Bulk Mineralogical analysis of sediment samples.

No.		E	I	K	C	CMs	H	Q2	Kf	Pf
A	Olga 59.5	0.1	3.9	0.1	0.5	4.6	14	15	15	51
B	Olga 76	0.1	4.0	0.2	0.3	4.5	15	14	14	52
C	Lily 18.5	0.2	7.9	0.0	1.0	9.0	18	7.3	14	52
D	Lily 290	0.1	9.0	0.2	0.8	10	16	9.4	14	51
E	Escalante.142	0.5	5.6	1.1	3.7	11	15	14	13	48
F	Escalante.174	0.3	2.7	0.5	1.9	5.4	11	23	12	49
G	Tlikakila.275	0.5	4.2	0.2	0.7	5.5	16	10	13	55
H	Taz red	0.6	4.8	0.6	3.4	9.3	11	16	16	47
I	Taz grey	0.1	0.5	0.1	0.3	1.0	10	19	15	55
J	Horseshoe	0.2	0.1	0.0	0.1	0.4	18	16	15	50
K	Horseshoe	1.2	1.2	0.2	0.6	3.2	16	32	19	29

Key:

E, I, K, C, CMs, H, Q, Kf, and Pf = respectively, expandables, illite, kaolinite, chlorite, total % clay minerals, hornblende, quartz, K-feldspar, and plagioclase feldspar.

Table 3. Clay mineral percentages on a 100% basis.

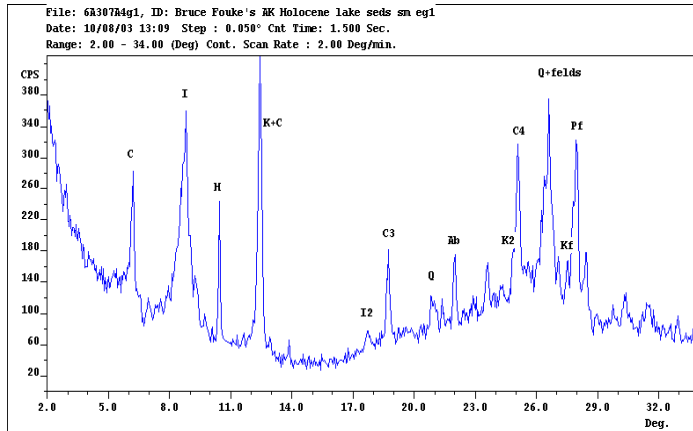
Key:

E-expandable clays
I – illite
K – kaolinite
C - chlorite

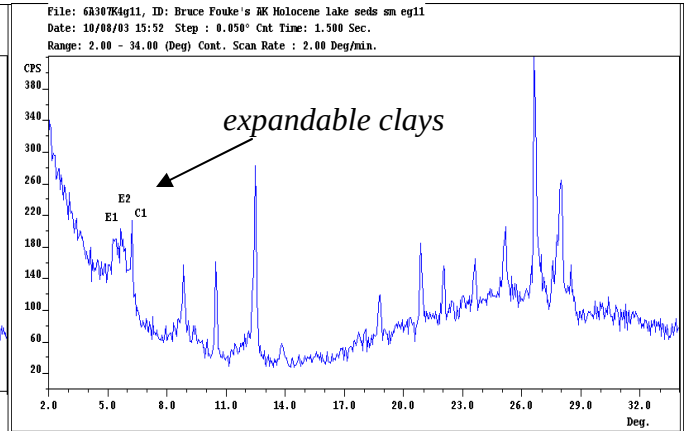
No.		E	I	K	C
A	1 Olga 59.5	2.4	85	3.0	9.8
B	2 Olga 76	1.2	88	3.5	7.5
C	3 Lily 18.5	1.8	88	0.0	11
D	4 Lily 290	1.3	89	2.2	7.5
E	5 Escalante.142	5.0	51	10	34
F	6 Escalante.174	5.1	50	9.2	35
G	7 Tlikakila.275	8.9	75	3.1	13
H	8 Taz red	6.3	51	6.0	36
I	9 Taz grey	8.2	52	13	26
J	10 Horseshoe	48	30	3.9	19
K	11 Horseshoe	38	38	6.1	18

The following diagrams show “peaks” of X ray spectra, at angles specific to certain minerals and their crystal planes. The first pair of traces show relative amounts of clay and some minerals in <4µm and bulk powder samples. The second pair compares just the bulk powder samples.

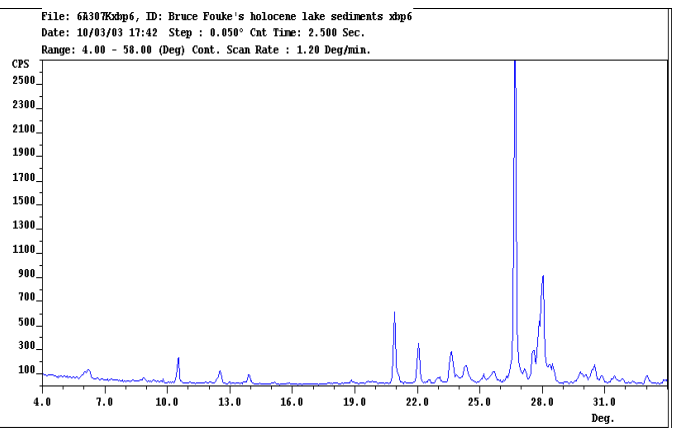
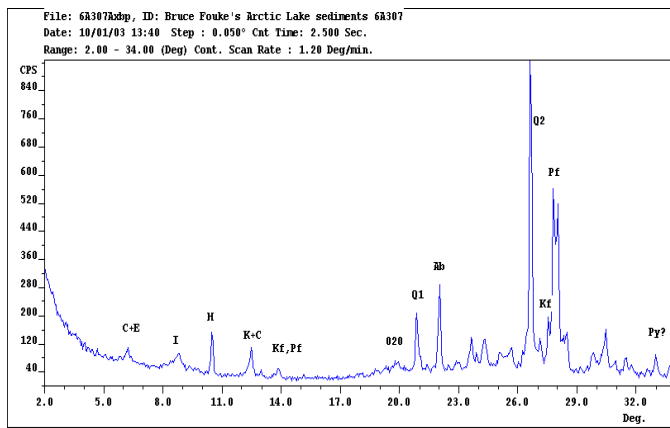
OLGA POND



HORSESHOE BEND



Key: C, I, H, K, Q, Ab, Kf, and Pf = respectively, chlorite, illite, hornblende, kaolinite, quartz, albite, K-feldspar, and plagioclase.



Key: C+E, I, H, K, C, Kf, Pf, 020, Q1, Ab, Q2, Kf, Pf, and Py? = peaks for chlorite + expandables, illite, hornblende, kaolinite + chlorite, K-feldspar, plagioclase, the “b” axis of clay minerals, 2nd-most intense quartz peak, albite, the most intense quartz peak, the most intense peaks for Kf and Pf, and questionable pyrite, which I think is a feldspar peak.

Figure 8. X-Ray diffraction peaks for samples from Olga Pond and Horseshoe Bend.

As mentioned above, work is continuing on the mineralogical and clay mineral analysis of these sediments. Collection and analysis of potential source clays (e.g. Tazimina Lake) will aid in the interpretation of the data.

Magnetic Susceptibility

Exploratory magnetic susceptibility measurements were conducted on several cores. Magnetic susceptibility is a relative measure of the amount of magnetic minerals present in the sediment. These data have been used in many studies as a proxy for grain size, to differentiate source areas, to locate volcanic ash layers, and to assess post-depositional alteration or soil formation. Our preliminary data on four cores show a dramatic difference in magnetic mineral composition in lake clays found in Escalante Pond and in the sections along the Newhalen River and Tazimina River (see Figure 7 and discussion above). The MS signal for these sediments is more than an order of magnitude (Figure 9) higher than sediments found in all other lakes. These sediments

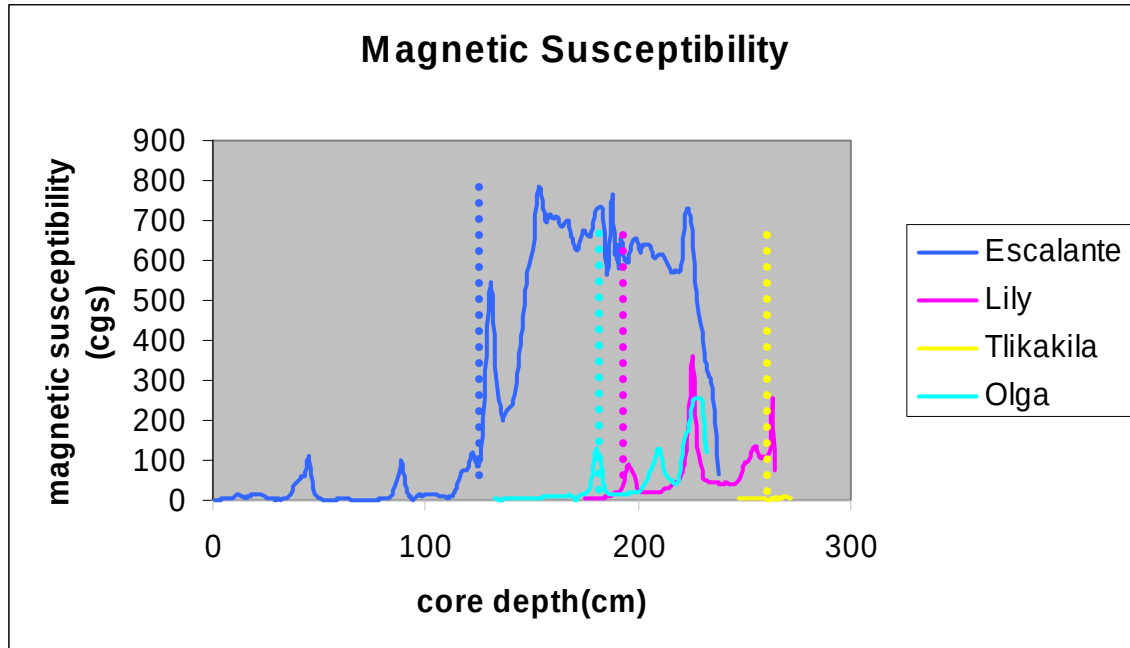


Figure 9. Magnetic susceptibility curve for four lakes in Lake Clark basin.

exhibit greater bulk density, iron staining, stronger rhythmite patterns, and possible signs of groundwater influence. Current hypotheses for this data include: 1) a different and iron-rich source area for the Escalante, Newhalen and Tazimina sediments, 2) post-depositional alteration by iron rich groundwater, 3) a different, possible older lake depositional event. The exclusive occurrence of these sediments in ‘down lake’ deposits suggests a different hydrologic regime of some type. These sediments also contain higher weathered clay minerals (discussed above).

We are continuing to collect additional data (mineralogy, XRD clay mineralogy, Fe content, density, pore water chemistry) that will allow us to determine whether these sediments are different in origin, in age, or possibly both. Other small peaks in the MS readings indicate volcanic ash layers.

Microbial DNA Analyses

We conducted a pilot study with Dr. Bruce Fouke of the University of Illinois to see if bacterial communities preserved in lake sediments might provide valuable indicators of environmental change. This study was conducted on the Olga Pond core shown below (Figure 10). We collected samples from the bottom of the glacial lake clays, the top of the clays, the organics ‘isolated pond’ sediments and from the volcanic tephra. The sediments range both in age and in composition. If microbial communities are indeed ancient and related to the depositional environment, then we would expect to see different species composition.

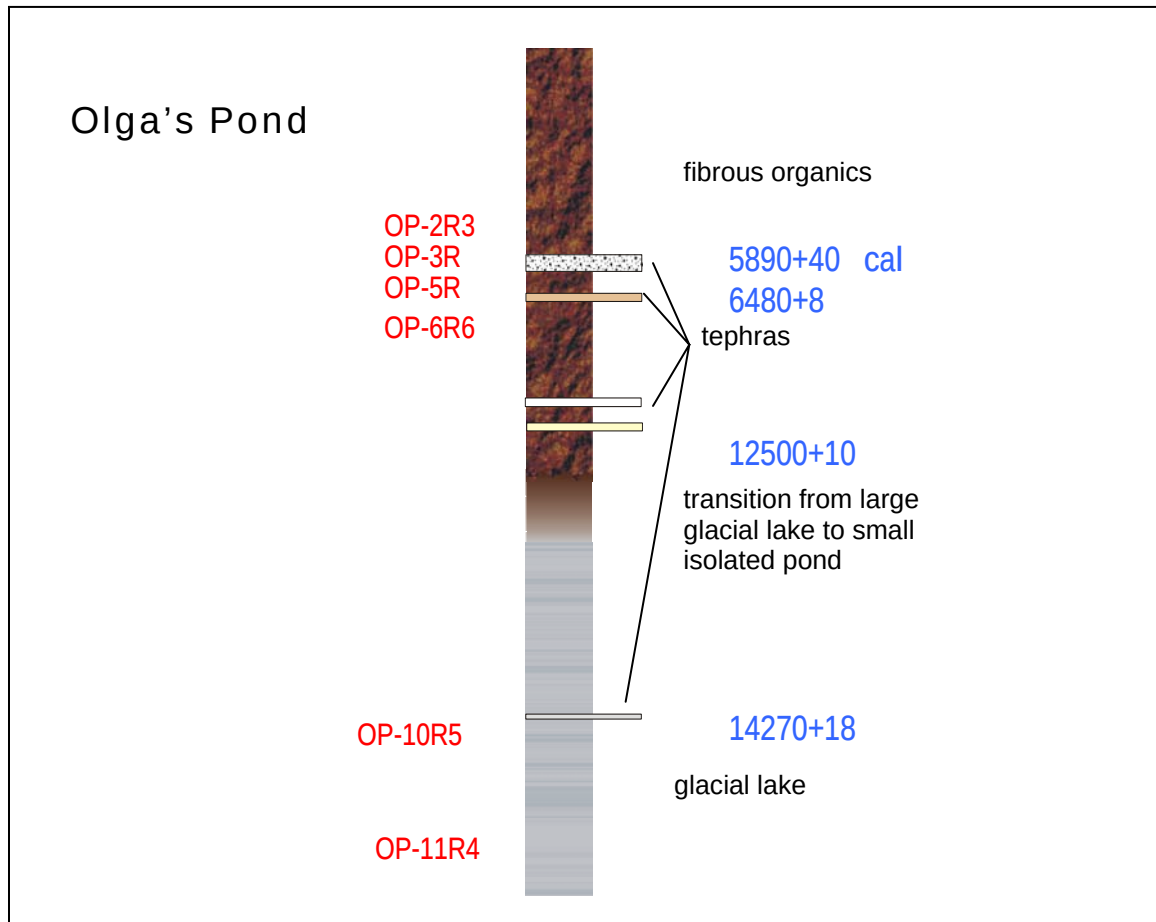
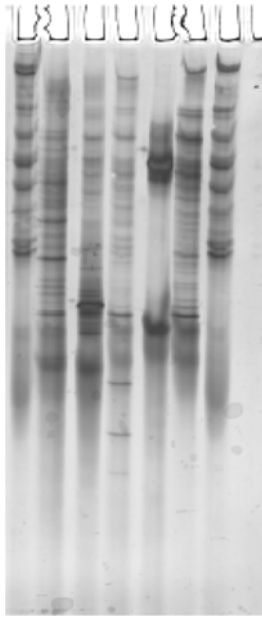


Figure 10. Olga Pond core with radiocarbon dates, sediment type, and location of samples for DNA analyses.

Preliminary results of gel electrophoresis studies show that each sample is > 90% different than the other samples in genetic codes of microbes. These data suggest that the community structure is, indeed different, and does reflect different environmental conditions (see abstract included below)



Key

1. Standard
2. Organic-rich brown muds
3. Tephra
4. Inorganic blue clays
5. Positive control
6. Negative control
7. Standard

1 2 3 4 5 6 7

*Figure 11. Preliminary denatured gel electrophoresis reveals separation of DNA extracted from lake sediments. Each column is a different sample or standard.***

Additional genetic work is underway to determine major groups and community structure of the microbes in the lake sediments. We are also trying to determine if the material is indeed ancient. Additional analyses including more detailed genetic work should allow us to make this distinction. If successful, this technique may revolutionize the way we study and interpret environmental changes in the past. Microbes will be much more sensitive indicators than pollen, diatoms, and other proxies in use today.

*** Microbial analyses are part of a pilot study into the potential of using genetic microbial information in the reconstruction of paleo environments and lake productivity. This work is funded via the University of Illinois and the lab of Bruce Fouke.*

Publications , Products, Deliverables to date:

Paper No. 224-10

LAKE LEVEL CHANGE IN LARGE LAKE SYSTEMS: IMPLICATIONS FOR INTERPRETING RECORDS OF SALMON HISTORY IN THE LAKE CLARK/ILIAMNA REGION, ALASKA

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Dave Hopkins inspired generations of students and researchers to study the paleo- ecology, geography, and climate of Beringia. His interdisciplinary approach and broad scope of interest led him, and many others, to pursue collaborative research efforts that typically broke down both disciplinary and political boundaries. Today many projects continue to unravel the history of Beringia, many of which maintain the spirit of interdisciplinary and international cooperation fostered by the lifelong efforts and example of Dave Hopkins.

Current research in Lake Clark National Park and other Southwest Alaskan parks combines landscape history, paleoecology, salmon history, and geoarcheology in an effort to understand the formation of the present ecosystem and its vulnerability to climatic or other change. Studies of landscape changes such as timing of deglaciation, lake level history, and change in drainage patterns compliment ongoing studies on the archeology and salmon ecology of these lake systems. Records of changing salmon abundance over millennia have been obtained from marine derived ^{15}N isotopes in lake sediments (Finney 2002). While regional climate trends, and changes in ocean productivity likely influence salmon return to nursery lakes, it is also important to determine other factors such as geologic and hydrologic barriers. Lake level histories around Lake Clark and other large southwest Alaska lakes can be determined using sediment cores obtained from kettle ponds located within the paleoshorelines of the larger lakes. These small lakes act as 'isolation basins' recording the change from large, glacial fed lake to small isolated pond as the lake level drops below its threshold. Studies to date show that Lake Clark gradually dropped at least 25 meters between deglaciation and the mid Holocene. A similar history is expected from Lake Iliamna, Naknek Lake, and others on the northern Alaska Peninsula. Extensive radiocarbon dating combined with excellent tephra stratigraphy will allow us to determine the timing, rate, and synchronicity of lake level changes within connected lake systems as well as over the large area encompassed by Southwest Alaska parks. These detailed histories will allow us to determine the potential cause of lake level change (e.g. isostasy, climate, tectonics).

Paper No. 29-12

BACTERIAL COMMUNITIES IN PLEISTOCENE AND HOLOCENE LAKE SEDIMENTS, LAKE CLARK, ALASKA

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We have conducted an exploratory study to determine if bacterial communities inhabiting grain surface biofilms and pore waters in lake sediments are unique to specific lacustrine sedimentary depositional facies. If so, bacterial community analyses may eventually provide a sensitive gauge of environmental change in modern and possibly Quaternary sediments that will directly augment

other sedimentary, geochemical, and biological proxies for environmental change in arctic lakes. We collected a 3.9 meter sediment core from a kettle pond adjacent to Dice Bay on the north shore of Lake Clark, Alaska. The core contains two major units: ~70 cm of blue-grey clay at the bottom overlain by ~3m of brown organic lake sediments. This transition to organic deposition occurred when a formerly larger, topographically higher, and glacially fed Lake Clark dropped below the threshold of the basin containing the kettle pond. The upper organic unit contains two tephra layers that are distinct from each other in grain size and composition and serve as recognized markers in other lake cores in the area. The older lake clays likely date from deglaciation (~12,000 BP) and the isolation of the pond probably occurred in the early to middle Holocene. Polymerase chain reaction (PCR) amplification of bacterial 16S rRNA genes with universally conserved rDNA primers and terminal-restriction fragment length polymorphism (T-RFLP) analyses were used to determine the phylogenetic diversity of the bacterial communities within each of the depositional facies, including the tephra. Results indicate that each sedimentary horizon contains a unique and diverse microbial community that is more than 90% different from bacterial communities detected in the other sedimentary facies comprising the core. This stratigraphic distribution indicates that bacterial communities observed in each down-core lacustrine sedimentary facies are not associated with modern lake sedimentary environments, and therefore may represent either modern or ancient bacterial communities that inhabit(ed) these sedimentary units.



2003 Seattle Annual Meeting
November 2–5, 2003
Seattle, Washington

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WORK IN PROGRESS

Heiser and Fouke have submitted a proposal to the National Science Foundation Biocomplexity in the Environment Program that expands on this current project. We, with David Natcher of UAA, are proposing to look at the linkages between natural geologic, biologic, climatic, and human drivers to ecosystem change and response to change. The study encompasses the Lake Clark – Iliamna system and focuses on salmon as both an indicator and driver of other system components. The proposal is for four years, requests ~1.8 million dollars, and provides support for one 4 year undergraduate fellowship for a student from Nondalton, as well as comprehensive public outreach and education. This project, if funded, should contribute to NPS efforts to monitor, understand, and mitigate changes in the Lake Clark ecosystems. A copy of the proposal is available upon request.

Student Theses

Currently there are three masters students beginning work on this project. One student, Brian Cohn is funded dominantly through the project. The others (and Brian some semesters) are supported at the university through teaching assistantships. Field work and analytical for all students is funded through the project. The students will be presenting their thesis proposals at the upcoming Cultural and Natural Resources meeting at NPS

March 9-12. In total four papers will be presented, an overview by P.I. Heiser followed by the three students each presenting their proposed thesis research.

Paleoenvironmental Reconstruction and Landscape History of Southwest Area Network Parks: An Overview

Patricia Heiser, Department of Geology, University of Alaska Anchorage

In order to fully understand the dynamics of any ecosystem, it is important to have some knowledge of how that ecosystem developed through time, how it has changed in the past, and how it may change in the future. Landscape history studies such as the timing of deglaciation, location and timing of hydrologic connections or barriers, and the history of lake level change will provide a framework for understanding salmon population dynamics in terms of colonization, isolation, and bottleneck effects, as well as for the ongoing efforts to locate and date early human settlements in the area. Paleoenvironmental reconstruction using pollen and other indicators from lake sediment cores will provide a history of ecological succession and vegetation change since the last ice age. Volcanic history, also obtained from lake sediment cores, will allow us to construct a regional tephra stratigraphy useful for dating inorganic lake sediments, landforms, and archeological sites. The potential effects of ash fall into different lake systems can also be investigated through the study of such events in the sedimentary record.

Results to date include:

- Glaciers retreated from Lake Clark valley by ~15,000 yBP.
- A preliminary lake level history indicates that lake level lowering occurred early (probably prior to ~11,000 yBP) and took several thousand years.
- At least 6 tephras have been identified and dated, ranging in age from ~7,500 to 1,900 yBP.
- Exploratory research into using microbial DNA as sensitive indicators of environmental change in lake sediments shows initial success with the identification of 5 distinct microbial communities extracted from 5 different sediment facies.

Work is continuing on all aspects of this study and will expand into Katmai lakes in the summer of 2004.

Alder vs. Salmon as Sources of Nitrogen In Lake Systems: Potential Effects on Lake Productivity and Sediment Records Salmon History

Brian Cohn and Patricia Heiser, Department of Geology, University of Alaska Anchorage

Recent studies have used stable nitrogen isotopes (^{15}N) to reconstruct historical changes in salmon abundance. Nitrogen content of lake sediments has also been used as an indicator of lake productivity. While the potential influence of marine derived nutrients (dominantly N) from anadromous salmon, and the terrestrial input of nitrogen from vegetation have been investigated in numerous studies, no attempt has yet been made to distinguish between the two sources or between the potential influences of these two different sources on lake productivity. A study of sediment record of Snipe Lake (in LCNPP) showed a response in lake productivity to an “alder rise” that occurred in the early Holocene (Hu et al. 2001). A similar “alder rise” is occurring today in Lake Clark and other regions of the state. This study will examine the different sources of nitrogen in lake systems by investigating the sedimentary record of N and other nutrients by comparing lakes dominated by alder vegetation, by salmon spawning, and a control lake that has neither alder nor salmon as a source of nitrogen or other nutrients. This study will also allow comparisons between the climate driven ‘alder rise’ of the early Holocene and the one that appears to be occurring today.

Timing and Mechanism of Lake Level Change in Lake Clark

Ann Maglio and Patricia Heiser, Department of Geology, University of Alaska Anchorage

Lake Clark has experienced significant changes in lake level since deglaciation. The potential mechanisms behind lake level change include: 1) isostatic rebound following deglaciation, 2) down cutting of an outlet or dam (such as a moraine), or 3) tectonic activity. Because Lake Clark is subject to all of these potential drivers, a detailed spatial and temporal chronology of lake level history is required. This study will include the detailed elevation survey (surface profile construction) at numerous sites around Lake Clark including beach ridge sequences, delta surfaces, and abandoned stream outlets. These features will be dated using isolation pond sediments that record the transition from 'large glacial lake' sedimentation to "small isolated pond" sedimentation. Other methods of dating will include tephra chronology and radiocarbon dating of any material found in beach or delta sediments. Reconstruction and dating at numerous sites will allow us to determine there has been tilting, episodic versus gradual change, and differences in rate of change between sites. These data will provide tests of the hypotheses regarding mechanism of lake level change in Lake Clark, as well as a need framework for the timing of formation of outlet fans, deltas and shorelines. These later dates will aid in the reconstruction of salmon habitat and early human settlement patterns and resource use.

The Record and Potential Effect of Volcanic Ash Fall in Southwest Alaska Lakes

Matthew Bowes and Patricia Heiser, Department of Geology, University Alaska Anchorage

Lake Clark and other Lake in the Southwest Alaska Network (SWAN) have received numerous significant volcanic ash falls which are preserved and recorded in lake sediments. A study of these ashes (or tephra) will provide valuable information regarding the age of volcanic eruptions, geographic variability in thickness and mineral composition, and potential clues to source volcanoes. This study will also investigate the potential effects of ashfall into lakes of different size hydrologic regime. The major objective of the study is to establish a regional tephra stratigraphy using ashes embedded in organic lake sediments that can be easily and accurately dated. Morphologic characteristics such as grain size, mineralogy, and glass shard morphology will be determined for each major ash layer. Detailed geochemical and microprobe analyses will be conducted on selected samples. The potential effects of ash fall on lake ecosystems will be explored by analysis of lake sediments below and above tephra layers. In at least two lakes of different size and hydrologic regime (flow-through version ground water fed) the sediments above and below selected ashes will be analyzed for changes in diatoms, testate amoeba, pollen, and pore water/sediment geochemistry. The results of this study will provide 1) a regional tephra stratigraphy for use in dating inorganic lake sediments, landforms, and archeological features, 2) valuable data for ongoing studies of volcanic history and event history of Aleutian volcanoes, and 3) data on the potential effects of ashfall of different types into different lake systems.

PLANS FOR COMING YEAR

Laboratory work will continue on the cores that were collected in the Summer 2003 season. This includes all analyses discussed above. Additional coring will be attempted in the winter in Lake Clark National Park (Kontrashibuna Lake, several more small ponds, possibly an upper lake for pollen records). Summer of 2004 will focus on coring lakes in Katmai National Park for deglacial history, lake level history, and volcanic history. Additional field work will also be conducted in Lake Clark mapping, measuring and creating profiles for the raised beach ridges, terraces, and stream outlets.