UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Public Utility District No. 1 of Okanogan County	)	Project No. 12569-001
	)	
Application for Major New License	)	Enloe Hydroelectric Project
	)	
________________________________	)	

COMMENTS, RECOMMENDATIONS, TERMS AND CONDITIONS, AND PRESCRIPTIONS--Notice of Application Ready for Environmental Analysis for the Enloe Dam Hydroelectric Project, FERC No. 12569-001, Okanogan County, Washington (ER 09/1276)

Introduction

At the direction and on behalf of its member tribes, the Columbia River Inter-Tribal Fish Commission (CRITFC),[1] has reviewed the December 28, 2009, Notice of Application Ready for Environmental Analysis for the proposed Enloe Dam Hydroelectric Project (Project), Project No. 12569-001, located on the Similkameen River in Okanogan County, Washington. The Project would be owned and operated by Public Utility District No. 1 of Okanogan County (applicant). Pursuant to 4.34 (b) of the regulations of the Federal Energy Regulatory Commission (FERC) and the applicable provisions of the Federal Power Act, CRITFC submits the following comments and proposed recommendations including terms and conditions for this proposed Project.

The issue of fish passage as a license requirement for this project has been and remains controversial, but the best scientific evidence at hand indicates the habitat above the dam would be valuable to anadromous fish production. The watershed above Enloe Dam is extensive and could provide significant production potential for summer steelhead, spring Chinook and summer Chinook. IEC Beak (1985) conducted an extensive habitat and spawning potential assessment and estimated that the area above the dam could support

[1] CRITFC was formed in 1977 per formal resolution of the governing bodies of the four Columbia River treaty tribes: the Yakama Nation, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon and the Nez Perce Tribe. The Commission is comprised of elected and appointed tribal officials who are members of their respective fish and wildlife committees. The Commission has technical and legal resources that provide assistance to the tribes in protecting and enhancing their federally-reserved, treaty trust resources.

55,000 adult Chinook and 98,000 adult steelhead. A Chinook spawning production potential assessment (optimum spawning size) by CRITFC was conducted using a hierarchical model analysis (Liermann et. al. in prep) and the data compiled by Parken et al. (2004). The median estimate for combined spring Chinook and summer Chinook from this assessment is 56,167 adults. The salmon and steelhead and Pacific lamprey production with fish passage at Enloe Dam would provide for considerable treaty fishing opportunities for CRITFC's member tribes as well as for others in the Pacific Northwest. With respect to the overarching public interest that FERC must consider in this license proceeding, this issue must be fully examined.

It is important to attempt to resolve the issue of historical anadromy above Enloe Dam using the best available scientific methods.. While the record states that several parties to this proceeding have requested the applicant to conduct historical anadromy investigations through the use of accepted scientific methodologies, to the best of our knowledge the applicant did not conduct the studies.[2]

Because of the gap in information to address whether anadromous fish were historically present above Enloe Dam, CRITFC and the Bureau of Indian Affairs (BIA) initiated a paleolimnological study of historical anadromy above Enloe Dam (Ford 2010a; Attachment 1). The results of initial analyses have led the principal investigator to conclude that there is sufficient evidence to "….warrant extreme caution in accepting the alternate conclusion of no pre-dam anadromous salmon" above Enloe Dam. Additional analyses to resolve uncertainties are currently ongoing and will be completed in several months.

We recommend FERC require that the applicant work with CRITFC and other interested parties in this proceeding to finish the ongoing paleolimnological and other appropriate scientific studies so that the results of these respective studies can be fully vetted in the license proceeding's environmental review.

We request the right to amend these comments, recommendations, and prescriptions - if warranted - based on the results of information and conclusions developed during the submittal of additional information before and during a future Commission environmental analysis.

Our following comments will address 1) procedural history of the Project, 2) interests and rights of CRITFC and its member tribes, 3) comments and recommendations and, 4) conclusion.

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[2] For example, in a January 8, 2008 letter to D. Botteger, Okanogan PUD from Dr. V. Butler, Portland State University several scientific approaches to resolve the issue of historical anadromy above Enloe Dam were proposed based upon archeological and geochemistry methods. In February 4, 2008 comments on the draft license application, CRITFC recommended that the applicant conduct the studies recommended by Dr. Butler as well as paleolimnological studies.

Procedural History

The Similkameen River, in which the Project resides, is located within the drainage of the Columbia River Basin, extending from its confluence with the Okanogan River to tributaries in British Columbia. There is evidence that the upper Similkameen once supported anadromous fish. For example, a study, published in 1970, concluded that Palmer Lake and its inlet stream, Sinlahekin Creek, which is located upstream from the present site of Enloe Dam, provided spawning areas for sockeye salmon.[3] There were also steelhead spawning areas in the upper Similkameen River.[4] According to a report prepared for the Bonneville Power Administration by IEC Beak Consultants, there was at one time a fish wheel or weir which was used to capture anadromous fish in the Similkameen River near Princeton, British Columbia (IEC Beak 1985). There were also salmon and kokanee in the Okanogan River, at least as far as Okangan Falls in British Columbia. [5]

Originally constructed around 1917, Enloe Dam is a 54 foot high, gravity concrete structure located on the Similkameen River, Washington on 144 acres of Bureau of Land Management (BLM) property. The dam impounds a 400 acre reservoir that is largely filled with sediment. The Similkameen is the major tributary to the Okanogan River. The license applicant is engaged in its third effort in three decades to license the dam. The dam has not generated hydropower since the 1960s, and remains mothballed.

The Project was first licensed in 1956 by FERC. Article 26 of that license required the applicant to construct, maintain and operate devices for the protection of fish and wildlife resources. The applicant requested reconsideration and deletion of Article 26. The affected entities discussed this issue for many years without resolving the dispute. The applicant finally halted power generation at Enloe Dam since the facility proved uneconomical and its operating license was rescinded in July of 1974.

In 1976, Congress authorized the Secretary of Interior and the U.S. Bureau of Reclamation to provide fish passage and enhancement of the Similkameen River (1976 Congressional Appropriation Act) and $40 million was appropriated, in part, for the installation of fish ladders or removal of the dam (*Id*).

In 1977, the Bureau of Reclamation determined that the preferred method to achieve the fish passage goals of the 1976 Act was removal of the dam. However, before the goals of the Act could be implemented and removal achieved, the applicant filed another license application to operate the Enloe Project in 1981.

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[3] L. Fulton, *Spawning Areas and Abundance of Steelhead Trout and Coho, Sockeye and Chum Salmon in the Columbia River Basin- Past and Present* (U.S. Dept. of Commerce 1970), p. 25.
[4] *Id.,* p. 11
[5] *See* J. Armstrong, *Enwhisteetkwa: Walk in Water* (Okangan Tribal Council 1982) *passim.*

In 1983, FERC issued a license, which was subsequently appealed by the Yakama Nation. The appeal was based upon a Northwest Power and Planning Council funded extensive habitat inventory of the Similkameen River under its Columbia Basin Fish and Wildlife Program that determined the 320 miles of good habitat above the dam would produce 98,000 adult steelhead and 55,000 adult Chinook salmon (IEC Beak 1985). The study found that dam removal was the least costly means to sustain natural production of anadromous fish above the dam. The study also determined that introduction of anadromous fish runs into the upper Similkameen River was biologically and economically feasible. On March 6, 1986, FERC rescinded the license and ordered consultation between the applicant and the appealing parties regarding unresolved fishery issues. In its Order, FERC stated that:

> It is clear to us that *anadromous fishery issues must be resolved before a decision can be made* on whether or not it would be in the public interest to issue a license for a project at the Enloe Dam site.

In 1991, despite the unresolved fish passage issue, the applicant filed another application to license the Enloe Project. In 1996, the Commission again licensed the Project over the objections of CRITFC, the Yakama Nation and many other parties and in 1997 stayed the license at the applicant's request. In 2000, FERC denied the license application due to the likelihood that the applicant would have to construct fish passage as provided under the Department of Commerce Section 18 mandatory prescription. That prescription took into account the need for a "collaborative planning approach…including the need to recovery endangered steelhead and chinook salmon [by] specifying that the timing of fishway construction should be coordinated with the planning efforts of regional fishery managers" (Stelle 2000). In short, the issuance of a license without requiring fish passage would preclude the ability for "regional fishery managers and other parties on both sides of the border to evaluate and address impacts that any future project configuration may have on salmonids listed under the Endangered Species Act" (Stelle 2000).

On September 14, 2005, FERC granted the applicant a preliminary permit for the Project. Pursuant to that preliminary permit, the applicant prepared the FLA as an application for license for an existing dam major modified water power project under 18C.F.R. §4.41. The applicant again initiated pre-filing consultation on July 20, 2005 for a project at the existing Enloe Dam on the Similkameen River, near the town of Oroville, in Okanogan County, Washington under the Traditional Licensing Process (18 C.F.R. part 4). On January 9, 2006, CRITFC filed formal and specific comments with respect to fish resource, hydrologic and socioeconomic studies to the applicant on the Supplement to the Initial Consultation Document for this Project (ICD). On February 4, 2008, CRITFC filed extensive comments on the proposed Project draft license application. On December 19, 2008 CRITFC formally intervened in this proceeding. On February 17, 2009, CRITFC filed extensive comments on the supplement to the initial consultation document. We incorporate all of these documents into this filing by reference. Most of the CRITFC recommendations and requests for studies and investigations were not addressed without adequate explanation in the DLA and FLA. The applicant filed its Final License Application (FLA) for the Project on August 22, 2008.

To date, despite no resolution to the fish passage issue, the applicant has not developed a fish passage alternative at Enloe Dam. .

Interests and Rights of CRITFC and its Member Tribes

Enrolled members of CRITFC's treaty tribes fish the Columbia River and its tributaries pursuant to their reserved rights.[6] They do so for subsistence, religious and ceremonial purposes, and as an economic necessity.[7] The social and economic well-being of tribal members of the Columbia River treaty tribes is substantially affected by the condition of salmon runs in the Columbia River Basin that are destined to pass the tribes' usual and accustomed fishing places. The Yakama Nation considers salmon and Pacific lamprey to be among its highest cultural and religious resources.[8]

Consistent with FERC's Tribal Consultation Policy,[9] FERC 1) has committed to work with the tribes on a government-to-government basis governing the FPA, 2) assure tribal issues and interests are considered in making decisions and 3) will consider comprehensive plans prepared by tribes or intertribal organizations. Accordingly, FERC should seriously consider CRITFC's recommendations before acting upon the license application. FERC, as an entity of the United States, has a trust responsibility to foster

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[6] CRITFC's four member tribes have treaties with fishing rights reserved by the United States. For example, the Yakama Nation entered into a treaty with the United States (12 Stat.951) which reserved rights including:

> The exclusive right of taking fish in all the streams, where running through or bordering said reservation….*as also the right of taking fish at all accustomed places*, in common with citizens of the territory, and of erecting temporary buildings for curing them.

The reservation of the right to fish was particularly important to the Yakamas. So important, in fact, that the Treaty would not have been signed without this clause (*Sohappy v. Smith* 302 F. Supp. 899, 906 (D. Sr. 1969).

[7] *See Tribal Circumstances and Impacts from the Lower Snake Projects, 1999 by Meyer Resources* *http://www.critfc.org/legal/circum_summ.pdf*. This document was submitted in the record on February 17, 2009. The loss of salmon and steelhead production by construction and operation of dams in the Columbia River basin, including the Enloe Project, have taken much of the river's historic wealth away from tribes. CRITFC's member tribes have levels of poverty three to thirteen times higher than non-tribal people in the Columbia River basin. Thus, opportunities to increase salmon and steelhead production are of considerable economic importance to CRITFC's member tribes.

[8] *See* H. Schuster, *Yakima Indian Traditionalism:a Study in Continuity and Change* (1975) *passim.*

[9] Order No. 635 Policy Statement on Consultation with Indian Tribes in Commission Proceedings (PL03-4-000), III FERC Stats. & Regs, Regulations Preambles 104 FERC Section 61,108 (July 23, 2003).

and protect Tribal treaty rights and resources (*Seminole Nation v. United States,* 316 U.S.286 (1942).

Comments and Recommendations

Regional Plans

The following regional plans should be should be considered by FERC in upcoming environmental review.

Columbia River Basin Fish and Wildlife Program (revised 2000)

In 1980, Congress passed the Pacific Northwest Electric Power Planning and Conservation Act, which authorized the states of Idaho, Montana, Oregon and Washington to create the Northwest Power Planning Council, which was eventually renamed as the Northwest Power and Conservation Council (Council). The Act directs the Council to organize a program to protect, mitigate and enhance fish and wildlife of the Columbia River Basin that have been affected by the construction and operation of hydroelectric dams in the Pacific Northwest (particularly those in the Columbia and Snake River drainages) while also assuring the Pacific Northwest adequate, efficient, economical and reliable power. The Council's Columbia River Basin Fish and Wildlife Program is the largest regional effort in the nation to recover, rebuild, and mitigate impacts on fish and wildlife. In 2000, the Council revised its program and established a new vision that focuses on the "Four H's" of impacts on fish and wildlife – hydropower, habitat, hatcheries, and harvest.

Okanogan Subbasin Plan

The *Okanogan Subbasin Plan* (OSP) (NPCC 2004)[10] is designed to provide the Northwest Power and Conservation Council with a method for allocating fish and wildlife mitigation and conservation resources within the Okanogan Basin. To involve the community, an outreach program is ongoing.

The OSP discusses how hydroelectric facilities and their operations within the basin, water control/management (quality and quantity), urban and infrastructure development, and introduced species strain to keep a salmon ecosystem in balance with the demands of a growing population. The OSP further explains that dealing with these constraints and sustaining a healthy local economy will require both institutional and technical approaches, and links between communities of science, interest, and place in the

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[10] Found at http://www.nwcouncil.org/Fw/subbasinplanning/okanogan/plan/e-Appendix%20K%20Okanogan%20Limiting%20Factors%20Report/Appendix%20_LFA%20Okanogan.pdf

implementation of the subbasin plan. The complexity of the jurisdictional arrangements, and the differences in management objectives within the basin and across the United States and Canadian border, necessitates an extensive and comprehensive process. The success of the OSP hinges upon it being sensitive to the needs of federal, state/provincial and local governments, public utility districts and federal hydropower authorities, tribal entities, stewardship bodies, landowners, and other stakeholders.

The OSP addresses the limiting factors for fish and wildlife ecosystems in the subbasin.

> It is the professional opinion of the TAG that habitat conditions in the upper portions of the Okanogan watershed are sufficiently intact to support and improve self-sustaining populations of salmonids given the following: 1) no further reduction in habitat quality and quantity elsewhere in the watershed; 2) removal of artificial fish passage barriers and installation of approved screening devices on water diversions; 3) rehabilitation of stream functions in the lower reaches of certain tributaries and portions of the mainstem; 4) instream flows sufficient so as not to impede adult fish passage and salmonid rearing during dry years; 5) and sufficient numbers of returning wild anadromous salmon and steelhead from the Columbia River.

With respect to fish passage and historical anadromy above Enloe Dam the OSP states the following:

> The Similkameen River, the largest tributary to the Okanogan, also likely supported spring chinook. There were probably several life history strategies that historically existed in the Similkameen Watershed, prior to construction of Enloe Dam in 1920, although there is no clear evidence that chinook salmon passed the natural falls on the lower Similkameen River.
>
> The Similkameen River is impassable at Enloe Dam, an abandoned power generation facility 8.8 miles above the mouth. It blocks access to more than 95% of the anadromous fish habitat in the Similkameen River. Recently there has been interest in relicensing the Enloe Dam, and fish passage alternatives are being investigated.

Spirit of the Salmon

The CRITFC treaty tribes developed a fishery recovery plan called *Wy-Kan-Ush-Mi Wa-Kish-Wit* or *Spirit of the Salmon* (Nez Perce et al. 1995; Attachment 2). The geographic scope of the plan extends to the Columbia River Basin and Pacific Ocean regions where these fish migrate and wherever activities occur that directly affect them.
The plan's objectives are to halt the decline of salmon, lamprey and sturgeon populations above Bonneville Dam within seven years. Additional objectives include:

- Rebuild salmon populations to annual run sizes of four million above Bonneville Dam within 25 years in a manner that supports tribal ceremonial, subsistence and commercial harvests.

- Increase lamprey and sturgeon to naturally sustaining levels within 25 years in a manner that supports tribal harvests.

To achieve these objectives, the plan emphasizes strategies and principles that rely on natural production and healthy river systems. Simply stated, the plan's purpose is to put fish back in the rivers and protect the watersheds where fish live. The plan has specific subbasin sections, including the Okanogan/Similkameen, which provides:

> Passage should be provided at Enloe Dam (dam removal is the best option) to the lakes located above Lake Osoyoos, Salmon Creek and the natural falls on Omak Creek. Due to the large sediment load, barriers have developed in the mainstem. The riparian area should be restored and bio-engineered erosion control measures implemented. Such approaches will reduce width-to-depth ratio and make limited water more useable as fish habitat.

Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin[11]

The Pacific lamprey (*Entosphenus tridentatus)* or "eel" is an ancient, anadromous, native species, valuable to the ecosystems of the Pacific Northwest and to the Native American Tribes that use this fishery for food, medicine, and ceremony (Close et al. 2002; CRITFC 2008). As with salmon and steelhead, lamprey are a treaty trust resource equally as important as salmon and steelhead. Pacific lamprey have declined precipitously in abundance over the last few decades (Figure 1; Table 2) and the need to acquire information to inform management and conservation initiatives is imperative if this valuable resource is to be maintained and the cultural legacy of Native Americans preserved.

Lamprey have existed for an estimated 450 million years. They have been a foundation species that have brought marine nutrients to the relatively nutrient poor tributaries of the Columbia Basin and have a critical role in the ecosystem as a prey of choice for many animals in the food chain. Close et al. (2005) identified four major factors that likely have caused the decline of Pacific lamprey in the Columbia Basin. These include: 1) juvenile and adult passage problems at dams, 2) poor spawning and rearing habitat, 3) pollution and chemical eradication and 4) reduction of ocean prey.

As has been found in introduced populations of Atlantic sea lamprey in the Great Lakes (Haro and Kynard 1997) and in Europe (Laine et al. 1998), passage impediments throughout the basin considerably impact upstream production. Considering dam count data, adult and juvenile distribution and adult tagging studies, the CRITFC's member tribes believe that inadequate passage is the most urgent problem facing lamprey in the Columbia River Basin (CRITFC 2008).

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[11] Found at http://www.critfc.org/text/lamprey/restor_plan.pdf

In its report on critical uncertainties for lamprey, the Columbia Basin Lamprey Technical Working Group (CBLTWG 2005) prioritized passage improvements as a top ranked critical uncertainty in the overall effort to restore lamprey. Only about 50% of adult lamprey successfully pass each mainstem dam (Moser et al. 2002b). While little is known about juvenile lamprey passage, studies have shown that significant losses of juveniles occur due to impingement on turbine intake screens and juvenile salmon raceway screens at dam transportation facilities for juvenile salmon (CRITFC 2008: Corps 2009). Entrainment and loss of juvenile lamprey also occurs in irrigation and water withdrawal facilities with and without screens since screens are not designed for protecting and excluding larval lamprey and macropthalmia (CRITFC 2008; Jackson pers comm. 2009).

The *Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin* (CRITFC 2008) addresses six specific objectives and actions necessary to implement the Plan and achieve the Plan's vision and goal, which is to halt the decline of lamprey within 10 years and rebuild lamprey to provide for self-sustaining, harvestable populations throughout their historic range. These six objectives include: 1) Assess and improve mainstem and tributary lamprey passage efficiency and survival, 2) Assess lamprey mainstem spatial and temporal distribution and habitat preferences to prioritize actions to improve lamprey habitat, 3) Monitor, evaluate collect and disseminate information on lamprey population status, life histories and trends, 4) Establish and coordinate public education and other outreach programs, 5) Evaluate contaminant accumulation and other water quality impacts on lamprey, and, 6) In collaboration with other regional entities fund, plan develop and implement a pilot lamprey safety net artificial production program.

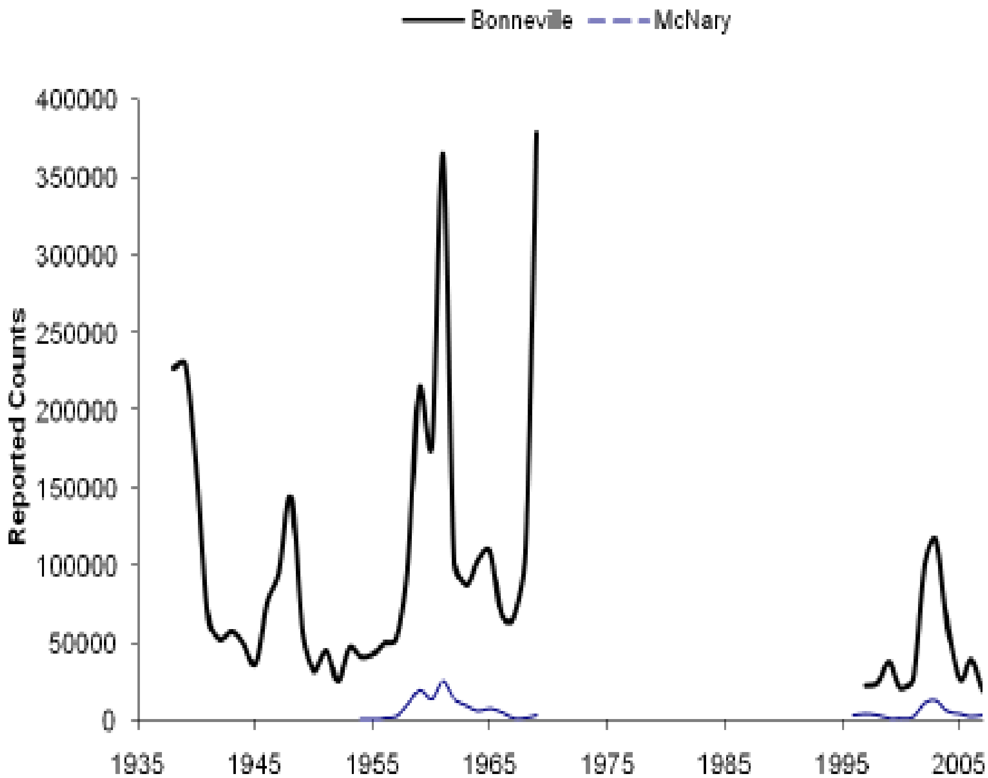


Figure 1. Annual counts of Adult Pacific lamprey at Bonneville (upper line) and McNary (lower line) dams over time. No data were collected 1970-1995.

Year	Bonn	TDA	McN	Priest	Wells *	IH	LWG
2000	19,001	8050	1,281	1,468	NA	315	28
2001	27,947	9061	2,539	1,468	261	203	27
2002	100,476	23,417	6,116	1,624	338	1,127	128
2003	117,027	28,995	13,325	4,007	1,408	1,702	282
2004	61,780	14,873	5,888	4,339	291	805	117
2005	26, 625	8361	4,158	2,647	212	461	40
2006	39,925	6894	2,139	2,598	21	255	35
2007	37,170 *	6077	3,389	3,273	32	288	81 *
2008	45,104 *	4599	1530	5,083 *	7	266	61*
2009	19,429 *	2318	676	2714*	9	57	12*

Table 2. Recent adult lamprey counts at Corps and Mid-Columbia PUD dams 24 hour counts were only available at Bonneville, Priest Rapids, Wells and Lower Granite (FPC and Corps 2009).

Historical Anadromy

FERC should require the applicant to work with CRITFC's member tribes, the BIA and other parties to resolve the issue of historical anadromy by employing the best available scientific methods including paleolimnological, genetic and archeological studies. FERC should refrain from engaging in formal environmental review until the scientific enquiry of historical anadromy has been completed.

Justification:

A foundational issue for many decades of licensing attempts, FERC has refused in the past to issue a license for this proposed Project based upon the continuing uncertainty regarding historical anadromy. While there are reports that document observations of fish passage and those that do not, the best available science should be applied to resolve this issue (Ford 2010; Butler (2008), and Narum et al. (2006)).

At hand is an initial report by Ford (2010a) which notes that paleolimnological methods use δ_{15} N as a proxy for historical anadromy. Studies using these methods have been used throughout the Pacific Northwest to define the extent of historical use of habitats by anadromous fish (Koyoma et al. 2005; Finney et al. 2000; Hatfield and Bos 2007; Ford 2006).

As noted in the DOI February 26, 2010 filing in this proceeding:

> The key finding in the Ford (2010) report with respect to the issue of historical anadromy in the Palmer Lake system (Ford pers. com February 10, 2010) is that δ_{15} N in the Blue Lake core BL08-02 is relatively high (4.5-6%) prior to the construction of dams on both the Similkameen River (1920) and on Blue Lake itself (1923), and then declines such that post-dam signals are low (< 3%). For comparison, δ_{15} N signal from non-anadromous systems in the Yakima, Okanogan and Wenatchee watersheds range from 0-3% (Ford 2007).

While Ford (2010a) states her findings are preliminary, the preliminary nature of the data is related to other analyses on the cores that are scheduled to occur in the near future. Other reviewers of Ford (2010a) retained by the BIA concur that additional analyses on the cores need to be accomplished. Ford (2010a) summarizes these:

> Further investigation should be made using independent lines of paleolimnological evidence to see if there are patterns that are consistent with the waxing and waning salmon runs (and carcass deposition) suggested in the Blue Lake δ_{15}N record.
>
> Recommended future studies include (1) additional studies on cores currently on hand (AMS $_{14}$C dating and (quantities and preservation permitting) analysis of biological proxies), (2) retrieval and analysis of one or more longer cores from

> Palmer Lake in order to investigate whether the earlier history seen at Blue Lake echoes findings from the significantly larger Palmer Lake, and (3) core retrieval and analysis from additional linked upstream lakes in the Palmer Lake watershed.

And Ford (2010b Attachment 3) elaborates on additional analyses and the nature of her "preliminary" conclusion:

> Ford (2010) was submitted to Columbia River Intertribal Fish Commission on 6 January 2010. In the text, I described this as a preliminary report, but I did not explain why I considered it preliminary. There were three primary reasons why I used that qualifier:
>
> 1. There were a few samples not yet analyzed. Specifically, the basal seven samples of the PL08-02 core had not been analyzed for loss-on-ignition.
> 2. QA results were not included
> 3. Only a few of the possible target analytes had as yet been studied, due to the funding constraints. This means that interpretations of the meaning of the data are based on a very few of the many possible paleolimnological variables.
>
> As of today
>
> 1. The remaining seven samples have been analyzed although they have not been formally reported to CRITFC . Results indicate that the bottom of Blue Lake core BL08-02 is calcareous.
> 2. Accuracy and precision have been reviewed for %C, %N, $\delta^{15}N$, $\delta^{13}C$, and precision has been reviewed for both high and low temperature loss-ignition. Results are entirely acceptable.
> 3. Arrangements for analysis of additional target variables (including diatoms, possibly zooplankton, 14C, and possibly whole sediment and/or algal pigments) are scheduled to begin next week.

In addition, genetic analyses on trout and kokanee above Enloe Dam should be conducted by the applicant and compared with upper Columbia Steelhead and Okanogan sockeye. Specifically, DNA microsatellite methods should be employed to reveal genetic structure (analysis of microsatellite loci; Narum et al. 2006). The WDFW February 26, 2010 filing at pages 23-24 in this proceeding, observes that gene flow from resident rainbow trout to steelhead has been reported in other Pacific Northwest rivers with barriers and that trout upstream of Enloe probably would retain a genetic similarity to Similkameen steelhead if passage over Enloe Falls was possible.

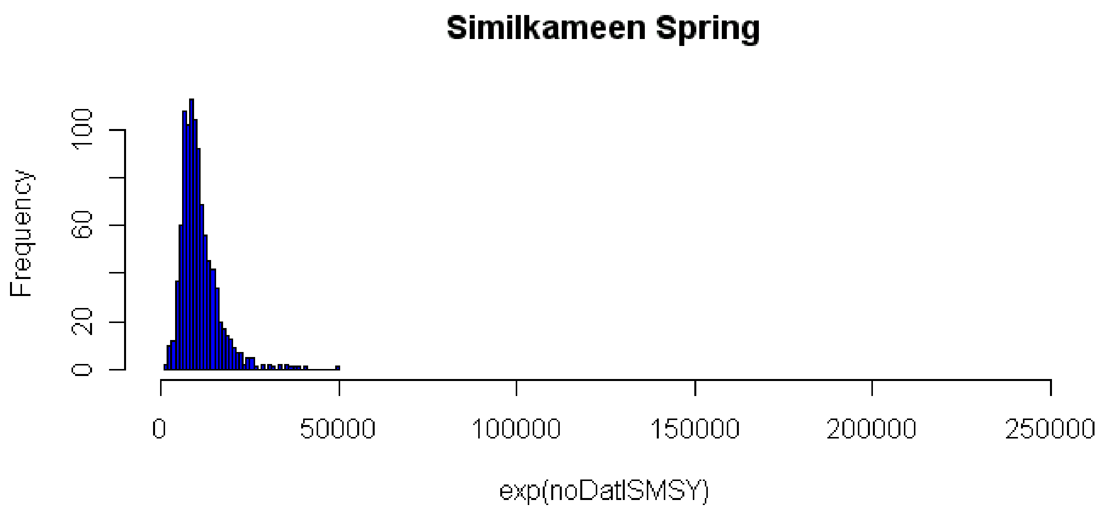
<u>Fish Passage (this section was provided in CRITFC DLA Comments)</u>

The Applicant and FERC should include production potential estimates for salmon and steelhead as part of a fish passage alternative in this license proceeding.

Justification:

The watershed above Enloe Dam is extensive and will provide significant production potential for summer steelhead and spring Chinook, which are ESA listed, and summer Chinook, which is in a depressed status. IEC Beak (1985) conducted an extensive habitat and spawning potential assessment and estimated that the area above the dam could support 55,000 adult Chinook and 98,000 steelhead. A Chinook spawning production potential assessment (optimum spawning size) by CRITFC was conducted using a hierarchical model analysis (Liermann et. al. in prep) and the data compiled by Parken (et al. 2004).

The results for Spring and Summer Chinook are shown below:



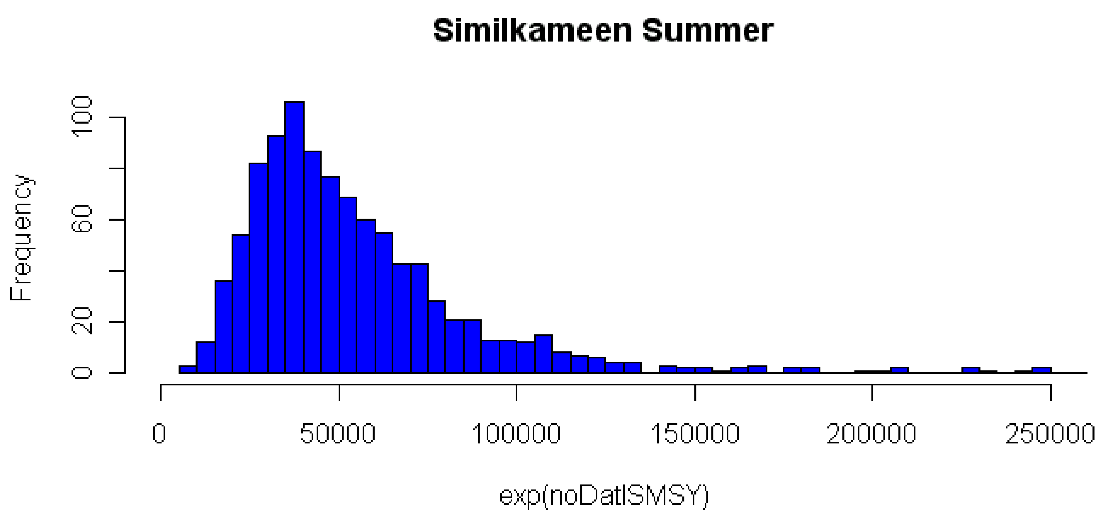


Figure 2: Spring and Summer Chinook Optimal Spawning Stock Escapement Goals based on Similkameen Watershed Area

Table 1: Quartiles of distribution for Spring and Summer Chinook escapement goals

Stock	5%	25%	50%	75%	95%
Similkameen Spring Chinook	4764	7215	9608	12660	19992
Similkameen Summer Chinook	19941	33488	46559	67135	113779

The 50% quartile spawner estimate for both spring and summer Chinook, 56,167 spawners, is very close to the IEC Beak estimate of 55,000 total Chinook spawners. Thus, the two analytical methods produced fairly similar results, producing multiple lines of evidence that fish passage over Enloe Dam could provide significant salmon production. The DLA fails to consider this potential or any sort of fish passage alternative.

CRITFC engaged in a conference call with the applicant in the summer of 2007. At that time, and in all of these filings and junctures, CRITFC has consistently maintained that there is a need to provide fish passage studies as an integral part of the licensing process. The applicant has responded to this position in the DLA by stating that there is "regional consensus" not to provide fish passage, therefore the applicant has not included fish passage studies in the DLA. On the contrary, there are major stakeholders, including CRITFC member tribes, who support further studies of the efficacy of fish passage at Enloe Dam.[12] Enloe Dam continues to block hundreds of miles of critical habitat for steelhead, summer chinook, coho, sockeye and likely Pacific lamprey, both in the U.S. and British Columbia.

Pacific Lamprey

In consultation with CRITFC and other interested parties in this proceeding, the applicant should investigate and if appropriate provide for upstream and downstream passage of Pacific Lamprey through the Enloe Project.

Justification:

The FLA states there is limited information regarding the distribution of Pacific lamprey in the Okanogan and Similkameen river basins. Periodic observations of Pacific lamprey

[12] Elsewhere in the DLA the Colville Tribes are stated to be a treaty tribe. This is not correct, as the CCT are a federally recognized tribe that did not enter into a formal treaty with the United States.

redds have been documented in the lower Similkameen River. Although CRITFC requested the applicant consider lamprey passage in the license, it has not occurred. The historical distribution of Pacific lamprey coincided with the distribution of Pacific salmon (Close *et al* 1995); thus this species may have occurred in the Okanogan Basin. This historic distribution would likely have extended into the Similkameen River at least as far up as Similkameen Falls.

WDFW has documented unidentified ammocoetes in holding ponds in the hatchery pond on the lower reaches of the Similkameen River, located within close proximity to the confluence of the Okanogan River (Okanogan PUD 2008). Lamprey are commonly found in rivers with heavy sediment loads, such as the Similkameen (CRITFC 2008). In 2006, the Colville Confederated Tribe Fish and Wildlife Division collected both adults and ammocetes (juvenile lamprey) from screw traps in the Okanogan River downstream of the confluence with Salmon Creek (Okanogan PUD 2008). Potential lamprey redds (not confirmed) were also observed in the middle reach of the Okanogan River in 2008 (Okanogan PUD 2008).

Historical accounts document the presence of lamprey on Enloe Falls:

Excerpt from Benedict Gubser Diary – Hard copy available from the Okanogan County Historical Society

> JULY 1889
>
> We 3
> Went to the north side of the Similkameen River and camped at Shanker Bend. Bought some cartridges for George's rifle and ginger snaps at Wannacut. Crossed the Similkameen near its mouth and went up it until I came to Billy O'Neal's and John Judge's camp where I stopped, camping with them.
>
> Th 4
> Judge and I spent most of the day at the Falls, fishing. They are about a mile below Shanker Bend. Saw salmon and a good many large eels trying to get up over the falls, which are 25 ft high. Billy worked on one of his prospects.

The recorded presence of lamprey, or "large eels" suggests an established population in the Similkameen River, particularly in early July which is consistent with adult migrating timing in the upper portions of the Columbia Basin. Lamprey are able to navigate over waterfalls and other barriers better than salmon due to their ability to cling to surfaces with their oral discs and even move up completely vertical surfaces for considerable distances. Tagging studies of juvenile sea lamprey in the Great Lakes suggest that they do not rely on natal stream homing when returning as adults but choose spawning streams for other reasons (Begsted and Seelye 1995). Tetter (1980) found that the mere presence of sea lamprey larvae in water was enough to attract immature spawning-run male sea lamprey and consider this pheromone communication. This suggested that resident sea lamprey larvae provide an olfactory cue that guides returning adults to suitable spawning areas. When sea lamprey larvae were chemically removed from Great Lakes rivers, subsequent returning adults declined in these rivers by 99% (Moor and Schleen 1980). These researchers also found that if larvae populations survived chemical treatment, adults continued to be attracted to the streams where the larvae were present. Pheromone studies conducted on Pacific lamprey suggest a similar response (Close et al. 2009). It is possible that construction of Enloe Dam may have prevented adult lamprey from ascending to the upper portions of the Similkameen River. Over time, juvenile lamprey would disappear from these reaches, and adults would not be attracted to these areas because of the lack of juvenile pheromones.

Shankers Bend Project

The applicant and FERC should conduct a cumulative affects analysis to determine the synergistic environmental affects of the proposed Enloe Hydroelectric and Shankers Bend Hydroelectric projects.

Justification:

The NGO February 26, 2010 filing at pages 15-16 in this proceeding describes the importance of a comprehensive watershed analysis for the Similkameen River, and we concur with these comments. The Shankers Bend Project would have power and environmental impacts on the proposed Enloe Project and must be considered in the context of Enloe environmental review.

Project Flows

The applicant should complete a flow regime that comports to fishery agency and tribal ramping rates and providing flows below the dam at all times. FERC should not conduct an environmental review of this Project until the applicant better defines Project flow operations

Justification:

In our DLA comments, CRITFC noted that, “The bypass reach, which is critical habitat, is lost to biotic production under the DLA. Again, it is unknown whether or not salmon or steelhead could ascend the falls to potentially utilize this reach. The applicant fails to consider any mitigation for this loss of river habitat.” In the FLA and the July 21, 2009 response to the FERC AIR, the applicant failed to address this issue.

Conclusion

CRITFC appreciates the opportunity to provide these comments on the REA solicitation for this proposed Project. CRITFC recommends that this Project is not yet ready for environmental review by FERC. There are numerous unresolved issues, including historical anadromy, salmon, steelhead and Pacific lamprey passage, Project flow regimes and the need for a cumulative effects watershed analysis incorporating the synergistic impacts of the proposed Shankers' Bend Project with the proposed Enloe Project, While the extant scientific weight of evidence leans toward the presence of historical anadromy, more work needs to be undertaken.

The fact is that there continues to be no regional consensus regarding fish passage at Enloe Dam. Comprehensive plans developed for the Similkameen River either recognize and support making additional habitat available above Enloe or are based on premature assumptions not supported by the best available science described in these comments and recommendations regarding passage at Enloe Dam.

While we believe that these issues should be resolved before FERC initiates environmental review, a dam removal and site restoration alternative should also be included in the environmental review.

We look forward to further engaging with the applicant, FERC and other parties in this licensing proceeding. Because there are important tribal issues in this particular license proceeding, we suggest that FERC may want to enlist its tribal liaison in the licensing proceeding as an ombudsman to clarify tribal issues. The opportunity to amend, modify, or add to these preliminary recommendations and prescriptions is reserved by CRITFC in the event resource conditions change, project plans are altered, or new information is developed. Should you have questions regarding these comments, please contact Robert Heinith at (503) 238-0667.

Sincerely,

/s/

Babtist P. Lumley
Executive Director

Attachments 1-6

?References

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UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Public Utility District No. 1 of Okanogan County	)	Project No. 12569-001
	)	
Application for Major New License	)	Enloe Hydroelectric Project
	)	
	)	

CERTIFICATE OF SERVICE

I hereby certify that I have this day served the foregoing document upon each person designated on the official service list compiled by the Secretary in this proceeding.

Dated this 1st day of March 2010.

Baptist Paul Lumley
Executive Director
Columbia River Inter-Tribal Fish Commission

Further reflections concerning "Paleolimnological Investigations in the Palmer Lake watershed, Okanogan County, WA: Phase #1 report"

Jesse Ford, Ph.D
Dept. Fisheries and Wildlife
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Corvallis, OR 97331-3803

10 February 2010

Last week I was asked to respond to summaries and reviews of the above-referenced Ford (2010) report. This white paper responds to that request.

Ford (2010) was submitted to Columbia River Intertribal Fish Commission on 6 January 2010. In the text, I described this as a preliminary report, but I did not explain why I considered it preliminary. There were three primary reasons why I used that qualifier:

1. There were a few samples not yet analyzed. Specifically, the basal seven samples of the PL08-02 core had not been analyzed for loss-on-ignition.
2. QA results were not included
3. Only a few of the possible target analytes had as yet been studied, due to the funding constraints. This means that interpretations of the meaning of the data are based on a very few of the many possibles paleolimnological variables.

As of today

1. The remaining seven samples have been analyzed although they have not been formally reported to CRITFC . Results indicate that the bottom of Blue Lake core BL08-02 is calcareous.
2. Accuracy and precision have been reviewed for %C, %N, $\delta^{15}N$, $\delta^{13}C$, and precision has been reviewed for both high and low temperature loss-ignition. Results are entirely acceptable.
3. Arrangements for analysis of additional target variables (including diatoms, possibly zooplankton, 14C, and possibly whole sediment and/or algal pigments) are scheduled to begin next week.

The key finding in the Ford 2010 report with respect to the issue of historical anadromy in the Palmer Lake system is that $\delta^{15}N$ in the Blue Lake core BL08-02 is relatively high(4.5-6 ‰) prior to the construction of dams on both the Similkameen River(1920) and on Blue Lake itself (1923), and then declines such that post-dam signals are low. This core has a relatively slow sedimentation rate, so temporal resolution is not particularly good. The $\delta^{15}N$ signal appears to have begun to decline prior to dam closure although there are no dates associated with the onset of the decline. The $\delta^{15}N$ signal does not recover following dam closure, with the exception of one brief excursion to ~3 ‰.

Stratigraphic analysis of stable isotopes (specifically, δ^{15}), is often used as a paleolimnological method to determine the contribution of anadromous salmonids to freshwater and linked upland environments. The rationale is that salmon spend most of their adult life at sea, and life in the marine environment results in an increase in the heavier stable isotope of nitrogen (^{15}N), relative to the lighter, more abundant, isotope (^{14}N).

The questions relative to the Ford 2010 report in the context of a discussion about dams relate to how much weight should be put on the use of the $\delta^{15}N$ as a proxy for the presence of anadromous salmonids in the Palmer Lake watershed. Specifically,

1. Does this finding constitute compelling evidence for the pre-dam occurrence of anadromous salmonids?
2. Are these findings robust?
3. Are there alternative hypotheses that could explain these findings?

I address each of these points in turn.

<u>Does this finding constitute compelling evidence for the pre-dam occurrence of anadromous salmonids</u>? In my professional judgement it is at best unwise to use only one proxy to establish an historical narrative. The story may well be true, but until there are additional lines of evidence that add supporting weight to the kernel of a narrative based on a single proxy, the narrative remains an interesting and tantalizing sketch. It is not, in my view, "compelling".

<u>Are these findings robust?</u> I am comfortable that the data themselves should be able to withstand any level of scrutiny. It is good practice, although not always entirely necessary, to analyze at least a second core from the same lake in order to confirm that there are no peculiarities about the initial core. However, there is nothing about the results from BL08-02 that raises reservations in my mind as to whether the results should be able to be replicated in another core. In any event, analyses on just such a second core (BL08-05) are scheduled to begin the week of 15 February 2010.

<u>Are there alternative hypotheses that could explain these findings</u>? Other hypotheses to explain stratigraphic changes in $\delta^{15}N$ involve

(1) other sources of either heavy (^{15}N) or light (^{14}N) nitrogen, and/or
(2) internal limnological and/or diagenetic processes that would change the $\delta^{15}N$ ratio following the delivery of N-containing matrix to the lake

<u>Sources</u> Salmon aside, there are several ways that N can enter a lake. These include primarily atmospheric deposition, in-lake N-fixation, soil erosion, inputs of upland leaf litter, pollutant inputs (e.g., sewage, fertilizer), and hydrological inputs via surface and subsurface flow. Atmospheric deposition, N-fixation, and fertilizers generally favor ^{14}N (i.e., lower $\delta^{15}N$), while sewage has a relatively high $\delta^{15}N$. The nature of the $\delta^{15}N$ contribution from soils and surface/subsurface flow depends on watershed-specific details (about which we have no information).

Thus, to produce a $\delta^{15}N$ stratigraphy that (prior to damming) goes from relatively high values in older sediments to relatively low values in younger sediments strictly on the basis of changing source functions other than salmon, one would have to imagine one or more of the following scenarios:

1. there was a permanent change in the composition and/or quantity of soil erosion and/or leaf litter prior to damming resulting in a decrease in heavy (^{15}N) or an increase in light (^{14}N) contributions.
2. there was a permanent change in the composition and/or quantity of contributions from surface flow prior to damming resulting in a decrease in heavy (^{15}N) or an increase in light (^{14}N) contributions

3. there was a permanent change in the composition and/or quantity of contributions from subsurface flow prior to damming resulting in a decrease in heavy (^{15}N) or an increase in light (^{14}N) contributions
4. prior to damming, there was a permanent increase in inputs from one or a combination of the following: atmospheric N deposition, in-lake N-fixation, or inputs of synthetic N-fertilizers
5. there was a permanent decrease in sewage prior to damming

The watershed immediately surrounding Blue Lake has been at most sparsely populated, although there has been mining in the immediate vicinity. It is difficult to imagine how and why a unidirectional change in one or more of these sources should have been, first, initiated prior to damming and then, second, have persisted over an interval on the order of a century or more. I can think of no factor/s related to climate, watershed, or anthropogenic activity that would suit the needs of any of these alternative hypotheses.

<u>Processes:</u> The nitrogen cycle consists of several kinds of biologically-mediated processes that fractionate N according to molecular weight. Biologically mediated processes preferentially use lighter isotopes. (One might also say that processes using lighter isotopes proceed faster.) Thus, for example, the process of N-fixation preferentially uses $^{14}N_2$ over $^{15}N_2$, thus preferentially producing “light” rather than “heavy”-N endproducts. Conversely, denitrification, which is the process by which nitrates are converted back into N_2 gas, favors the production of $^{14}N_{2,}$ which in turn leaves residues enriched in $^{15}N_2$.

Thus, to produce a $\delta^{15}N$ stratigraphy that (prior to damming) goes from relatively high values in older sediments to relatively low values in younger sediments strictly on the basis of limnological and/or diagenetic processes (that is, assuming no change in source functions), one would have to imagine permanent changes in in-lake and/or diagenetic processes in the direction of increased N-fixation and/or decreased denitrification. It is at best quite unclear what might cause such a permanent change in the Blue Lake system prior to damming.

<u>Why weren’t parallel changes seen in Palmer Lake itself?</u> First, the Palmer Lake core was quite short, and the sedimentation rate was sufficiently rapid that the damming horizon only occurred near the base of the core. Higher values of $\delta^{15}N$ might well be found in underlying sediments. However, the salmon biomass necessary to create a high sedimentary $\delta^{15}N$ in a large lake is of course much greater than that required to create a similarly large signal in a smaller lake. This is why I prefer to focus on smaller lakes if/as it seems likely there may also have been both suitable habitat and connectivity.

<u>How much weight could or should be put on the findings in Ford 2010?</u> This of course is a judgement call. In my professional judgement, there is definitely enough evidence to warrant extreme caution in accepting the alternative hypothesis of <u>no</u> pre-dam anadromous salmon. Early results suggest that the evidence seems to be pointing in the opposite direction.

<u>How important are these findings if in fact the putative “salmon signal” really does decline prior to damming?</u> Much is made of the faithfulness of salmon to natal streams. However, straying does clearly occur. If this were not so, none of the waterways north of the glacial border would ever have had salmon. In contemporary times, if there is suitable spawning/rearing habitat for salmon, then there is something to be said for maintaining passage to that habitat whether or not salmon were abundant there when potential passage was first blocked. Natural processes and anthropogenic activities have severely constrained salmon spawning/rearing habitat quality and availability over the past 150 years. If one’s interest is salmon, it is prudent to protect that which can in fact be protected.

Paleolimnological Investigations in the Palmer Lake watershed, Okanogan County, WA Phase #1 report

Jesse Ford
Oregon State University

for
Columbia River Intertribal Fish Commission

5 January 2010

Executive Summary

This paleolimnological study of the Palmer Lake watershed was undertaken to investigate whether the Palmer Lake watershed may have supported anadromous salmonids prior to the 1920 completion of Enloe Dam on its outlet, the Similkameen River. Two field expeditions were made to the Palmer Lake system in fall of 2008 to

- initiate paleolimnological studies at Palmer Lake
- determine whether there were promising smaller lakes upstream of Palmer Lake that combined likely salmonid habitat and reasonable logistic access, and if so,
- initiate complementary paleolimnological studies at one or more of those lakes.

Six surface sediment cores were taken from Palmer Lake of which two were suitable for analysis. Five surface sediment cores were retrieved from the smaller upstream Blue Lake Reservoir, which continued to drain to Palmer Lake via Sinlahekin Creek after the 1923 impoundment of the historic Blue Lake. Two of these cores were suitable for analysis.

This report presents findings from initial analyses on one surface sediment core from each lake. Cores were dated using the ^{210}Pb method. Several standard analyses were performed on contiguous 1-cm samples of bulk sediment: 1) loss-on-ignition studies to determine organic and inorganic (carbonate) composition of the sediment matrix, 2) analyses of the relative abundance (%) of carbon (C) and nitrogen (N) to determine the general source of the sediment matrix (aquatic or terrestrial, based on C/N ratios), and 3) analyses of the stable isotopes δ^{13}C and δ^{15}N to shed light on within-lake processes and sources of nitrogen, with particular emphasis on likely potential contributions of marine-derived (heavy) nitrogen from anadromous salmonids.

The short (28 cm) surface core from Palmer is unremarkable, although there is a general trend toward marginally higher δ^{13}C and lower δ^{15}N signatures in sediments younger than 1923. Overall, however, stratigraphic changes within the core are at best subtle, even

across the 1923 horizon (21-22 cm) that marks closure of the Enloe Dam on the downstream Similkameen River. It is important to note, however, that this core only barely penetrates the damming horizon. A longer core would help reveal whether there is evidence of potential occurrence of anadromous salmonids earlier in watershed history.

The record from the linked upstream Blue Lake is more revealing. In its upper sections, Blue Lake has a much slower sedimentation rate than Palmer Lake; at Blue Lake, the date of 1924 occurs at 8-9 cm. Thus, the entire 46 cm core may be several hundred years old, well beyond the range of ^{210}Pb dating. There is a good deal of stratigraphic detail in the Blue Lake core. In particular, post-dam δ^{15}N signatures are decidedly lower than values on much of the older underlying sediments.

Further paleolimnological studies are recommended in order to probe these initial findings. These include:

- analysis of additional cores on hand from both Blue and Palmer Lakes
- acquisition of AMS ^{14}C dates on macrofossils (if any) from Blue Lake core BL04-02
- further analysis of Blue Lake core BL04-02 focusing on biological remains
- retrieval and analysis of one or more longer cores from Palmer Lake itself
- retrieval and analysis of cores from other linked upstream lakes in the Palmer Lake watershed

This combination of analyses would (1) determine whether initial results can be replicated, (2) establish a timeline for observed stratigraphic changes in BL04-02, and (3) test predictions of expected changes in biological communities that should be associated with changing nutrient status and grazing pressure associated under conditions of changing salmonid dynamics. If these lines of evidence combine to provide additional support for the hypothesis of historical use of the Palmer Lake watershed by anadromous salmonids, additional cores would be useful to develop a landscape-scale understanding of salmon use of this watershed.

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Introduction

There is currently no empirical evidence regarding whether the Palmer Lake watershed supported anadromous salmonids prior to the 1920 completion of Enloe Dam on its outlet, the Similkameen River. Understanding this issue is of particular interest to the Columbia River Intertribal Fish Commission because the Okanogan County Public Utility District (PUD) is in the final phases of a relicensing application for a Federal Energy Regulatory Commission (FERC) to restore the Enloe Hydroelectric Project (EHP) on the Similkameen River. This is the third attempt to relicense the project since the powerhouse was decommissioned in 1959. The dam was originally relicensed in 1983, but the license was rescinded in 1986 due to concerns about fish passage. FERC issued another license in 1992, which was rescinded in 2000 after the National Marine Fisheries Service required the installation of fish ladders, which the PUD considered too expensive to be cost-effective.

The proposed EHP would entail developing a small hydropower plant just below the existing dam, about 3.5 miles northwest of Oroville. The current concrete dam is 54 feet high and 315 feet long. At the same time, there is a proposal to install a second, significantly larger, water retention and hydroelectric dam upstream of Enloe Dam at Shanker's Bend (~river mile 7.3) (www.okanoganpud.org/shankers/shankersmain.htm). The Shanker's Bend Project is studying various alternatives including dam heights ranging from 90 to 260 feet. At the maximum height the dam would be about 1,200 feet long and impound an 18,000 acre reservoir with a storage capacity of ~1.7 million acre-feet (www.okanoganpud.org/shankers/shankersmain.htm).

At issue is whether the 20 foot Similkameen Falls (Figure 1) in fact posed an historical barrier to upriver salmonid passage prior to the construction of the original Enloe Dam (Figure 2). In order to investigate this question, the Columbia River Intertribal Fish Commission commissioned a study in fall 2008 to use paleolimnological approaches to investigate whether anadromous salmonids may have used the Palmer Lake watershed prior to construction of the Enloe Dam. This Phase #1 report summarizes initial findings from that study.

Site Description

Palmer Lake is a natural kidney-shaped lake about 3.5 miles long located four miles north of Loomis, WA in a region that straddles the Northern Rocky Mountain and Okanogan Highland ecoregions. It is situation in the arid Okanogan Valley; records compiled over the period 1939-1969 indicate annual precipitation less than 20 inches of which less than seven inches falls during the April-September growing season (Walters 1974).

The lake itself is located at an elevation of 1145 feet, with an area of about 2063 acres and a maximum depth of 91 feet (Wolcott 1964). It has one outlet to the north, Palmer Creek, which flows downstream to the Okanogan via the Similkameen River. Under flood conditions, the flow of Palmer Creek can reverse and cause Palmer Lake to temporarily store water from the Similkameen River (Walters 1974).

Field reconnaissance in September 2008 identified Blue Lake Reservoir as the most promising linked lake upstream of Palmer Lake for complementary paleolimnological studies of Palmer Lake itself. Blue Lake Reservoir (henceforth: Blue Lake) drains to Palmer Lake via Sinlahekin Creek. It is small, deep enough to stratify, has good road access, and can reasonably be expected to have provided likely salmonid habitat prior to damming. The dam on the outlet of Blue Lake was erected in 1923 (three years after the Enloe Dam on the Similkameen) as part of an irrigation diversion project to support agricultural operations at the north end of the lake (Wolcott 1964; Dale Swedberg, Sinlahekin Wildlife Refuge, pers. comm. October 2008 and December 2009). This dam created an artificial reservoir that inundated three original lakes (Blue Lake (108 acres), Long Lake (46 acres) and Round Lake (12.5 acres)) to create a single lake with three basins. Blue Lake is located at an elevation of 1686 feet, with a current surface area of about 186 acres. Maximum depth is given as 69 feet in Wolcott (1964), and as 114 feet in Walker (1974).

Methods

Field work

Two field expeditions were made to the Palmer Lake system in fall of 2008 (11-15 Sept and 6-12 October). During the September 2008 trip, two short (< 30 cm) surface sediment cores were retrieved from Palmer Lake using a hand-operated Kajak-Brinkhurst gravity corer tripped by messenger. Cores were taken at one primary coring location with the coring raft repositioned between drives. The margin of Palmer Lake was cruised using the outboard-driven Chopaka Lodge dory, in part to observe the nature of inlets and the complex Similkameen outlet. Field reconnaissance was undertaken to identify one or more small target lakes upstream of Palmer Lake for further paleolimnological studies. Blue Lake was selected for this purpose (see Site Description).

In October 2008, four additional surface sediment cores were obtained from Palmer Lake using a lightweight 6.5 cm diameter gravity corer with various combinations of 10 lb weights and a 10 lb hammer. The apparatus was deployed from a wooden coring raft mounted on two inflatable Zodiac boats powered by a 4 hp outboard motor, and sediment cores were retrieved using an electric winch. Cores were taken at two primary coring locations, with the coring raft repositioned between drives. Weather conditions complicated core recovery, and only one short (28 cm) core was retained for analysis. All Palmer Lake cores from both expeditions were acquired from the northern basin due to wind and weather conditions.

Five cores were retrieved from Blue Lake during the October 2008 expedition, of which two were retained. Cores were taken at two primary coring locations, with the coring raft repositioned between drives at the four shallower water locations.

All cores were sectioned in the field at 1 cm intervals within 48 hours, packaged into Whirlpak™ bags, and stored at 4˚C in a dedicated cold room at Oregon State University.

Coordinates for coring locations at Palmer and Blue Lakes were acquired using a handheld Garmin GPS unit. Coordinates are given in Table 1 together with date of core acquisition, water depth at the coring location, and length of the sediment column retrieved.

Figure 3 displays coring locations against bathymetric data from GIS files archived on the State of Washington Department of Ecology (WDOE) website (http://www.ecy.wa.gov/services/gis/data/data.htm). There are slight discrepancies between water depths found in the field for and water depths estimated from GIS contour intervals in the WDOE files. The actual water depth in which Palmer Lake cores PL08-03 and PL08-04 were taken is slightly shallower than appears in Figure 3 (~66.4 vs 70-80 feet), and the actual water depth in which Blue Lake cores BL08-01 through BL08-04 were taken is slightly deeper than appears in Figure 3 (~62.7 vs. 50-55 feet). In general, however, correspondence is quite good.

Basic water chemistry data was obtained from Palmer and Blue Lakes using a YSI-85 multimeter with the probe deployed at 1 meter, and a standard Secchi disk. Deep-water samples were retrieved from both Palmer Lake (~20 m) and Blue Lake (18.25 m) using a horizontal Van Dorn sampler. Analysis of these deeper water samples was performed either from the coring raft (Blue Lake) or (due to weather conditions) later the same evening (Palmer Lake).

Laboratory analyses

Funds for limited laboratory analysis became available in spring 2009. The initial focus was on Palmer Lake core PL08-04. After results from this core were analyzed, it seemed prudent to analyze sediments from Blue Lake as well. Core BL08-02 was chosen rather than BL08-05 even though it was taken in shallower water (Figure 3) because it was a longer core (48 vs. 30 cm). To date, one core from each lake has been dated by ^{210}Pb and initially analyzed for organic matter, carbonates, carbon, nitrogen, and the stable isotopes δ^{15}N and δ^{13}C.

^{210}Pb dating. Cores were analyzed for ^{210}Pb by Flett Research Ltd using alpha spectroscopy on ^{210}Po (the granddaughter of ^{210}Pb). Methods followed Eakins and Morrison (1978).

For the Palmer Lake core, it was initially unclear whether or not background values of ^{210}Pb had been reached at the base of the core. Accordingly this core was rerun, with selected intervals also analyzed for ^{226}Ra (8 -9 cm 16-17 cm, and 27–28 cm). Activities of ^{210}Pb and ^{226}Ra in the 27-28 cm increment (only) are similar, indicating that background levels of ^{210}Pb had been achieved in this region of the core (Figure 4). Net unsupported ^{210}Pb was calculated by subtracting the nearest neighbor ^{226}R measurement from each total ^{210}Pb value.

The Blue Lake core (BL08-02) gave simpler results that did not require ^{226}Ra analyses. The shape of the curve shows an orderly downcore exponential decrease, and background levels were achieved well within the set of samples submitted for dating (Figure 5).

Age estimates calculated by Flett Research Ltd. used two approaches. The regression model assumes a constant rate of input of both ^{210}Pb and sediment. These assumptions are approximately satisfied for the Palmer Lake core in the interval 3-18 cm and the Blue Lake core in the interval 0-3; the model was therefore applied in this interval to estimate sediment accumulation rates (SAR). This SAR estimate is used to verify the constant rate of supply (CRS) model (Oldfield and Appleby, 1984, Appleby and Oldfield 1978). Over the intervals analyzed (the only ranges in which comparison is possible) the CRS and regression models predict very similar sedimentation rates, which suggest that the CRS model is functioning correctly. In general, the CRS model is preferred for age models, because it can provide valid predictions over the entire length of the modeled core, even though the sediment accumulation rate is changing with time. The CRS model assumes constant input of ^{210}Pb and a core that is long enough to include all the measurable atmospheric sources of ^{210}Pb. For the Palmer Lake core, if one assumes that the ^{210}Pb activity in the 27-28 cm increment is the background level (an assumption supported by ^{226}Ra results), the CRS model can be applied. For the Blue Lake core, there are no issues that might interfere with the CRS model. Consequently, the CRS model is used for age estimates on both cores in this report.

Loss on ignition. Contiguous samples of both cores were analyzed for water content, dry density, and low (550±5°C) and high (950±5°C) temperature loss-on-ignition (proxies for organic matter and inorganic (carbonate) carbon, respectively) (Dean 1974). Subsamples were weighed, dried for a minimum of 24 hours using a programmable Fisher Isotemp oven at 100±1ºC, reweighed, and ashed for a minimum of 1.5 hours at 550±5ºC in a muffle furnace with a digital temperature display and thermostatic temperature control. After cooling and weighing, samples were re-ashed for a minimum of 1.5 hour at 950±5°C to determine percent inorganic carbon as carbonates (Dean 1974). Note that analyses on BL08-02 are not yet complete; the bottom seven cm have not yet been analyzed.

Carbon (C), nitrogen (N), and $\delta^{15}N$ and $\delta^{13}C$ stable isotopes. Samples were analyzed for stable isotopes by the Stable Isotope Research Unit (SIRU), Dept. Crop and Soil Science, Oregon State University. Water was removed from the wet samples by gentle oven-heating at 45-50ºC. About 1 cc of the dry material was ground to a fine powder consistency using a Bio101 FastPrep FP120 ceramic-bead beater. Approximately 25 mg of ground material was weighed to three decimal places into tared 8x5 mm silver capsules and the sample weights obtained using a Cahn C-31 microbalance.

In order to determine percent organic carbon as well as the $\delta^{13}C$ signature of organic carbon, inorganic carbonates must be removed. The procedure followed here is an acid (HCl) fumigation rather than aqueous treatment by HCl, as some studies find that aqueous HCl treatment can lead to underestimates of % organic carbon and occasionally inaccurate $\delta^{13}C$ signatures on organic carbon (Komada et al. 2008). Fumigation decreases loss of water soluble carbon (Harris et al. 2001).

Fifty µL of a 1% (v/v) solution of HCl was added to each capsule and open capsules incubated for eight hours in a closed desiccator with a beaker containing 50 mL of concentrated HCl. Fumigated samples were redried at 45-50ºC, and the silver capsules sealed and packaged into secondary 12x5 mm tin capsules.

Samples were analyzed in June 2009 (Palmer Lake) and December 2009 (Blue Lake) for C, N, $\delta^{15}N$ and $\delta^{13}C$ on a PDZ Europa 20-20 isotope ratio mass spectrometer (IRMS) (SerCon, Crewe, GB) interfaced with a PDZ Europa RoboPrep elemental analyzer (EA/IRMS). Stable isotope ratios are reported in delta notation as parts per thousand (per mille) deviation from the international standards V-PDB (carbon) and Air (nitrogen). Typical precision for the SIRU IRMS is <0.3 per mille for $\delta^{15}N$ and <0.2 per mille for $\delta^{13}C$. Total C (mg) and N (µg) were measured after HCl fumigation to remove carbonates; %C (presumed to be organic C) and %N values are reported based on the original (prefumigated) sample mass.

The SIRU laboratory standard is NIST SRM1547 peach leaves (2.94% N, ^{15}N AIR 1.98; 45.54% C, ^{13}C VPDB -25.99). To correct for possible drift in the EA/IRMS combination with time, drift correction standards of the equal mass were run every 10 samples. As a check for linearity, 10 variable weight standards were run in each analysis. Additional standards were run as dummy samples for every 10 samples. In addition, SIRU periodically analyzes NIST SRM1547 peach leaves against a standard certified for C, N, ^{13}C, and ^{15}N (Elemental Microanalysis B2157 wheat flour, batch no. 2823) that has been calibrated against IAEA-CH-6 for carbon and IAEA-N-1 for nitrogen. The most recent analyses were in February 2009 and showed excellent accuracy and precision (Table 3).

Results

Water chemistry

Water chemistry data taken in the field are given in Table 2. Dissolved oxygen values in the deep water sample (~20 m) from Palmer Lake indicate that the lake was still stratified on October 9, 2008. Specific conductance values from the deep water sample (18.25 m) from Blue Lake also suggest stratification, although dissolved oxygen was not measured (data were acquired on the stored water sample several hours after collection).

Radiometric dating

The Palmer Lake core shows an irregular but approximately exponential decrease in ^{210}Pb activity in the region 3-28 cm with a maximum activity of 5.61 DPM/g in the 3-4 cm increment (Figure 4). In theory, highest ^{210}Pb activities should be found in the most surficial sediments; a more or less homogeneous signal in the top few centimeters suggests some mixing in this region. Age estimates using the CRS model are summarized in Table 4, and age-depth relationships are displayed in Figure 6.

The Blue Lake core shows an approximately exponential decrease in ^{210}Pb activity as a function of depth with maximum activity (16.37 DPM/g) in the 0-1 cm increment. The exponential part of the curve extends to the 13-14 cm increment, where the lowest activity (1.20 DPM/g) is found. The shape of the ^{210}Pb activity profile indicates that background activity levels were attained in the 12-13 cm increment (Figure 5). Downcore of this, activities are slightly irregular, most likely due to slight irregularities in supporting ^{226}Ra. Age estimates using the CRS model are summarized in Table 4, and age-depth relationships are displayed in Figure 7.

Radiometric dating results on both PL08-04 and BL08-02 are acceptable; both cores can be confidently dated back to the 1920s. Dates older than this exceed four ^{210}Pb half-lives and so must be considered only coarse approximations.

Table 4 demonstrates that sedimentation rates are much slower at the Blue Lake coring location than at the Palmer Lake coring location; dates in the early 1920s are achieved in the 21-22 cm increment at Palmer Lake but in the 8-9 cm increment at Blue Lake. The slow sedimentation rate at Blue Lake is somewhat surprising, but may be related in part to the shoreward position from which the Blue Lake core was obtained (Figure 3). This site (BL08-02) may serve as a sediment source to deeper water locations during spring and/or fall turnover. If this is so, faster sedimentation rates with better temporal resolution would be expected in core BL08-05, were it to be analyzed. If sedimentation rates were relatively constant throughout these two cores, the Palmer Lake core would date back to the late 1800s and the Blue Lake core to the early 1600s.

Loss-on-ignition

Both high and low temperature loss-on-ignition results for Palmer Lake PL08-04 are unremarkable (Figure 8). Organic matter is in the range 10-12%, and inorganic carbon in the range of 2-4%. There is no evidence of significant carbonate deposition or of lenses particularly rich in either organic or inorganic matter. The samples above the closing of Enloe Dam in 1920 are not distinguishable from pre-dam samples.

Results from Blue Lake BL08-02 have slightly higher organic matter content in the early 1970s (12-14%) relative to underlying sediments (4-34 cm: 8-10%). Increments below this region are markedly higher in organic matter (35-38 cm: 13-20%); the bottommost 7 cm (39-46 cm) have not yet been analyzed. As at Palmer Lake, inorganic carbon is in the range of 2-4% through the 28-29 cm increment; below this, however, carbonate deposition appears to be occurring. Around the period of dam construction the Blue Lake sequence is generally similar to that found in the Palmer Lake core, as there is little stratigraphy in this region of either core.

Carbon and nitrogen

The %C, %N, and C/N ratios from the Palmer Lake core are generally unremarkable. As with the LOI data, the samples above the closing of Enloe Dam in 1920 are not distinguishable in any way from the pre-dam samples. The low C/N ratios reflect primarily algal rather than terrestrial sources of organic matter.

The %C, %N, and C/N ratios from the Blue Lake core are also generally unremarkable, with samples above dam closure not distinguishable from pre-dam samples. The C/N ratios are higher than those from Palmer Lake, indicating more terrestrial influence, which is not surprising considering the smaller size of the Blue Lake basin. The meaning of the excursion at 33 cm needs to be further investigated. It may be an analytical error, or it may represent a lens of terrestrial input.

Stable isotopes

The Palmer Lake core has a narrow range of values for both $\delta^{15}N$ (3-4 ‰) and $\delta^{13}C$ (-30.0 to -31.5 ‰). Values of $\delta^{15}N$ decline very slightly since 1923, from a pre-1923 mean of about 3.7‰ to a low of 2.92 ‰ in 1982, before increasing slightly since about 1998 to about 3.3 ‰.Values of $\delta^{13}C$ increase slightly after 1970 from a mean of about -31.1 ‰ to a mean of about -30.5 ‰.

The situation at Blue Lake is similar to that at Palmer Lake in the time immediately around dam construction, with relatively narrow ranges of both $\delta^{15}N$ (1.5-4.0 ‰) and $\delta^{13}C$ (-27 to -29 ‰). In the Blue Lake core, both analytes generally decline slightly from the pre-dam through the post-dam portions of the record. Deeper sections of this core, however, provide a different picture, with a much broader range of both $\delta^{15}N$ (1-10 ‰) and $\delta^{13}C$ (-28 to -22 ‰). Sediments in the region 11-37 cm are relatively rich in $\delta^{15}N$ (mean = 5.04 ‰), although the $\delta^{13}C$ signal is stable. Below this level, $\delta^{15}N$ declines and $\delta^{13}C$ increases.

Studies in progress

Studies still in progress include completion of basal loss-on-ignition analyses, quality assurance of carbon, nitrogen, and stable isotope data, and intercomparison of results from the fumigation methodology used by SIRU vs aqueous extraction used in previous studies at Wapato Lake (Chelan Co, WA) by University of Alaska-Fairbanks

Discussion

The Palmer Lake PL08-04 core captures the period following the closing of Enloe Dam, but probably does not to go back further than the mid to late1800s. The history contained in the PL08-04 is unremarkable, and does not vary in the immediate proximity of the horizon in which the Enloe Dam came on line. Acquisition of longer cores from Palmer Lake with older sediments might shed a different perspective on this history. Effort might usefully be directed to the southern part of the basin, particularly near the inlet from Sinlahekin Creek where spawning salmon may have lingered in their run up into the inlet creek and on up into Blue Lake.

Results from the Blue Lake BL08-02 core are more interesting. As at Palmer Lake, the history in the immediate proximity of the horizon in which the Enloe (and Blue Lake) dams came on line is unremarkable. However, the record at Blue Lake is substantially longer, and may represent a sediment archive of three to four centuries of information.

Given that Blue Lake is a small lake in rugged terrain, it is not surprising that C/N ratios suggest a higher proportion of terrestrially-derived sedimentary carbon than at Palmer Lake. Deeper sediments reflect carbonate deposition, although this is not a centrally located core and carbonate stratigraphy can be complex in small basins (Wetzel 1970). A long period of relatively enriched $\delta^{15}N$ in the range of 4-6‰ ended sometime in the 1800s, prior to construction of the Enloe (and Blue Lake) dam(s). The enrichment period is consistent with the possibility of presence of anadromous salmonids. Explanations of sedimentary $\delta^{15}N$ enrichment related to pollution and/or eutrophication are unlikely both because the period of $\delta^{15}N$ enrichment precedes settlement by EuroAmericans, and because total nitrogen values are quite low (<1%).

Although the $\delta^{15}N$ findings are tantalizing with respect to the possibility of anadromous salmonids in the Palmer Lake watershed, it is unwise to rest paleoenvironmental reconstructions on single proxies, particularly geochemical proxies that are endproducts of a diversity of inputs mediated by a diversity of in-lake processes. Further investigation should be made using independent lines of paleolimnological evidence to see if there are patterns that are consistent with the waxing and waning salmon runs (and carcass deposition) suggested in the Blue Lake $\delta^{15}N$ record.

Recommended future studies include (1) additional studies on cores currently on hand (AMS ^{14}C dating and (quantities and preservation permitting) analysis of biological proxies), (2) retrieval and analysis of one or more longer cores from Palmer Lake in order to investigate whether the earlier history seen at Blue Lake echoes findings from the significantly larger Palmer Lake, and (3) core retrieval and analysis from additional linked upstream lakes in the Palmer Lake watershed. Specific recommendations include:

- analysis of second cores on hand from both Blue and Palmer Lakes for proxies discussed in this report, in order to see whether these initial results can be replicated
- acquisition of AMS ^{14}C dates on macrofossils (if any) from Blue Lake core BL04-02, in order to establish the temporal dimensions of observed stratigraphic changes, particularly the changes in $\delta^{15}N$
- further analysis of Blue Lake core BL04-02 focusing on biological remains, particularly diatom and zooplankton remains, possibly augmented by whole sediment and (preservation permitting) pigment analysis. Diatom communities would be expected to respond to changing water chemistry if large changes in inputs of spawned-out salmon carcasses occurred. Similarly, zooplankton communities would be expected to respond if large changes in juvenile feeding occurred prior to outmigration (e.g., by sockeye salmon (*Oncorhyncus nerka*)). Finally, both whole sediment and pigment analysis can give a general insights into the composition of soft algae that do not preserve well but would be expected to change in response to changing nutrient status and grazing pressure associated with changing in salmonid dynamics. Whole sediment analysis can also provide insight into soft zooplankton that do not preserve well in lake sediments
- retrieval and analysis of one or more longer cores from Palmer Lake itself, in order to determine whether there are downcore stratigraphic patterns that complement those found at Blue Lake, and what the paleolimnological record can reveal about historical limnology in these two linked water bodies. Due to the size and weather conditions at Palmer Lake, a winter expedition might provide the most successful approach
- retrieval and analysis of cores from other linked upstream lakes in the Palmer Lake watershed to improve our understanding of the spatial dimensions of possible pre-dam historical anadromy in the Palmer Lake watershed. Such sites might include, for example, Chopaka Lake (although this has very poor road access, and thus would probably best be attempted in summer), as well as

the oxbow lakes north of Palmer Lake (northwest of Champney's Slough), at least one of which appears to be accessible by road

Conclusion

Although the short surface core from Palmer Lake (PL08-04) is unremarkable, it may be too short to fully address the issue of whether there was historical use of Palmer Lake by anadromous salmonids. By contrast, the record from the linked upstream Blue Lake (core BL08-02) is longer and provides tantalizing results suggesting historic use of Blue Lake by anadromous salmonids. Although there is little stratigraphic change in immediate temporal proximity to dam construction, post-dam $\delta^{15}N$ signatures are substantially lower than values for the bulk of the Blue Lake record, most of which is undated but enriched in $\delta^{15}N$. Sediment enrichment in $\delta^{15}N$ is often taken as a proxy for anadromous salmonids. The Blue Lake stratigraphy suggests that, if one accepts this preliminary interpretation, one must also note that declines began before (perhaps well before) dam construction.

A series of further studies is recommended on sediment cores from the Palmer Lake watershed currently on hand, to the extent that remaining sediment volume and preservation allow. These studies would be usefully augmented by analysis of additional sediment cores from the south end of Palmer Lake, as well as from other small linked upstream water bodies in the Palmer Lake watershed.

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Table 1. Log of sediment cores, Palmer and Blue Lakes

Date	Core	Site	Position	Core length	Water depth	Coring Comments
9/13/08	PL08-01	Palmer Lake	N48.91123 W119.63267	24 cm	18.6 m	Lost some basal sediment before capping
9/13/08	PL080-02	Palmer Lake	N48.91125 W119.63254	30 cm	ND*	
10/10/08	PL08-03	Palmer Lake	N48.90952 W119.62686	28 cm	20.4	Bottom is water; bubbles rose and mixed the sediment. Core discarded
10/10/08	**PL08-04**	Palmer Lake	N48.90956 W119.62701	28 cm	ND*	Corer appeared to begin to penetrate a dense underlying layer. Lost some basal sediment during capping of bottom while broadside to whitecaps.
10/11/08	PL08-05	Palmer Lake	N48.91058 W119.63024	NM	19.5 m	Core hard to hammer. Bottom is water; bubbles rose and mixed the sediment. Core discarded
10/11/08	PL08-06	Palmer Lake	N48.91060 W119.63029	23 cm	19.5 m	Some mixing; retained for possible archive although should not be analyzed.
10/7/08	BL08-01	Blue Lake	N48.68557 W119.68973	47 cm	19.1 m	Discarded
10/7/08	**BL08-02**	Blue Lake	N48.68557 W119.68946	48 cm	19.1 m	Penetrated tan layer at about ~35 cm. Extruded depth 46 cm
10/7/08	BL08-03	Blue Lake	N48.68554 W119.68972	NM	19.1 m	Water at bottom of core. Discarded
10/7/08	BL08-04	Blue Lake	N48.68571 W119.68987	40 cm	19.1 m	Lost core
10/8/08	BL08-05	Blue Lake	N48.68601 W119.69115	30 cm	20.8 m	

ND* = No data due to depth finder malfunction, but core taken close to previous core
NM = Not measured
BOLD = core discussed in this report

Table 2. Water chemistry data, Palmer and Blue Lakes
Data acquired on October 7, 2008 (Blue Lake) and October 9, 2008 (Palmer Lake).

	Palmer Lake	**Palmer Lake**	**Blue Lake**	**Blue Lake**
Water depth	~ 1 m	~ 20 m	~ 1 m	18.25 m
Temperature (˚C)	14.0	ND	14.2	11.9[1]
Dissolved O_2 (mg/l)	9.2	0.52	8.4	ND[1]
O_2 saturation (%)	89	4.1	81	ND[1]
Salinity (ppt)	0.1	0.1	0.1	ND
Specific conductance (μS cm^{-1})	203	257.3	223	293
Secchi depth (m)	5.5	NA	5.5 (10/7/08) 4.6 (10/8/08)	NA

[1]Van Dorn water sample analyzed later that day; water temperature does not reflect ambient conditions; O_2 would not reflect ambient conditions

ND = Not determined

NA = Not applicable

Table 3. OSU SIRU accuracy and precision results on C, N, δ^{15}N and δ^{13}C

NIST 1547 laboratory standards run against certified wheat flour

1547 Peach Leaves; 2.94 %N, A%15N 0.3670 (delta AIR 1.98)

2/8/2009

1547	*% N*	*total N (µg)*	*Delta AIR*
Mean	2.98705	105.381	1.9404425
Standard Error	0.00319	0.998760504	0.010775991
Median	2.9815	107.71315	1.952825
Mode	2.997	108.0288	#N/A
Standard Deviation	0.014266	4.466592762	0.048191697
Sample Variance	0.000204	19.9504509	0.00232244
Kurtosis	-0.18436	-1.551085893	2.13554195
Skewness	0.429909	-0.577214969	-1.460417048
Range	0.058	11.6335	0.18884
Minimum	2.96	98.0673	1.81544
Maximum	3.018	109.7008	2.00428
Sum	59.741	2107.62	38.80885
Count	20	20	20
Confidence Level(95.0%)	0.006677	2.090429756	0.022554408

Peach Leaves; 45.54 %C, delta 13C VPDB -25.99

2/7/2009

1547	*% C*	*total C (µg)*	*delta 13C V-PDB*
Mean	45.709	590.27675	-26.11475
Standard Error	0.050892	2.530420473	0.02060255
Median	45.73	589.81	-26.14405
Mode	45.8	#N/A	#N/A
Standard Deviation	0.227594	11.31638438	0.092137406
Sample Variance	0.051799	128.0605554	0.008489302
Kurtosis	0.419218	-0.772443323	0.550872738
Skewness	0.258155	-0.389583985	0.983587466
Range	0.99	37.598	0.3426
Minimum	45.25	568.752	-26.2227
Maximum	46.24	606.35	-25.8801
Sum	914.18	11805.535	-522.295
Count	20	20	20
Confidence Level(95.0%)	0.106517	5.296230905	0.043121633

Table 3. (continued)

Certified wheat flour run against NIST 1547 laboratory standards

B2157 wheat flour; 1.47 +/- 0.07 % N, d15N V-AIR 2.85 +/-0.17.

2/8/2009

B2157 wheat	*% N*	*total N (µg)*	*Delta AIR*
Mean	1.472	103.481	2.866956667
Standard Error	0.003	0.263371885	0.022444104
Median	1.475	103.353	2.8827
Mode	1.475	#N/A	#N/A
Standard Deviation	0.005196	0.456173487	0.038874329
Sample Variance	2.7E-05	0.20809425	0.001511213
Kurtosis	#DIV/0!	#DIV/0!	#DIV/0!
Skewness	-1.73205	1.163262417	-1.523519174
Range	0.009	0.885	0.07281
Minimum	1.466	103.1025	2.82268
Maximum	1.475	103.9875	2.89549
Sum	4.416	310.443	8.60087
Count	3	3	3
Confidence Level(95.0%)	0.012908	1.133197761	0.096569186

B2157 wheat flour; 39.53 +/- 0.26 % C, d13C V-PDB -27.21 +/-0.13.

2/7/2009

B2157 controls	*% C*	*total C (µg)*	*delta 13C V-PDB*
Mean	39.56667	567.1106667	-27.10396667
Standard Error	0.055478	4.674619747	0.059962942
Median	39.55	563.314	-27.1024
Mode	#N/A	#N/A	#N/A
Standard Deviation	0.09609	8.096678908	0.103858863
Sample Variance	0.009233	65.55620933	0.010786663
Kurtosis	#DIV/0!	#DIV/0!	#DIV/0!
Skewness	0.757035	1.646144529	-0.067865136
Range	0.19	14.798	0.2077
Minimum	39.48	561.61	-27.2086
Maximum	39.67	576.408	-27.0009
Sum	118.7	1701.332	-81.3119
Count	3	3	3
Confidence Level(95.0%)	0.238701	20.11326541	0.257999717

Table 4. Age models: Palmer Lake (PL08-04) and Blue Lake (BL08-02)
Square brackets indicate age/date estimates that should be taken with extreme caution.
Depths below bracketed age/date values are undated.

TOP of increment (cm)	BOTTOM of increment (cm)	PALMER LAKE Age (yrs) (CRS Model Estimate)	PALMER LAKE Date	BLUE LAKE Age (yrs) (CRS Model Estimate)	BLUE LAKE Date
0	1	1	2007	4.9	2003
1	2	2.5	2005	10.9	1997
2	3	5	2003	16.6	1991
3	4	7.5	2000	27.5	1981
4	5	10.1	1998	36.7	1971
5	6	12.5	1996	44.9	1963
6	7	15.9	1992	51.9	1956
7	8	19.9	1988	61.6	1946
8	9	22.6	1985	84.4	1924
9	10	26	1982	111	1897
10	11	30	1978	[156.5]	[1852]
11	12	33.8	1974		
12	13	38	1970		
13	14	41.9	1966		
14	15	45	1963		
15	16	49.8	1958		
16	17	54.9	1953		
17	18	58.5	1949		
18	19	65.7	1942		
19	20	71.9	1936		
20	21	76.9	1931		
21	22	84.9	1923		
22	23	98.4	1910		
23	24	116.1	1892		
24	25	[168]	[1840]		
25	26				
26	27				
27	28				
28	28.5	**Bottom PL08-04**			
29					
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					
41					
42					
43					
44					
45				**Bottom BL08-02**	

Figure 1. Natural falls on the Similkameen River prior to Enloe Dam
Undated photo from local archives, courtesy of Dale Swedberg, Sinlahekin Wildlife Refuge

Figure 2. Enloe Dam on the Similkameen River
Undated photo from local archives, courtesy of Dale Swedberg, Sinlahekin Wildlife Refuge

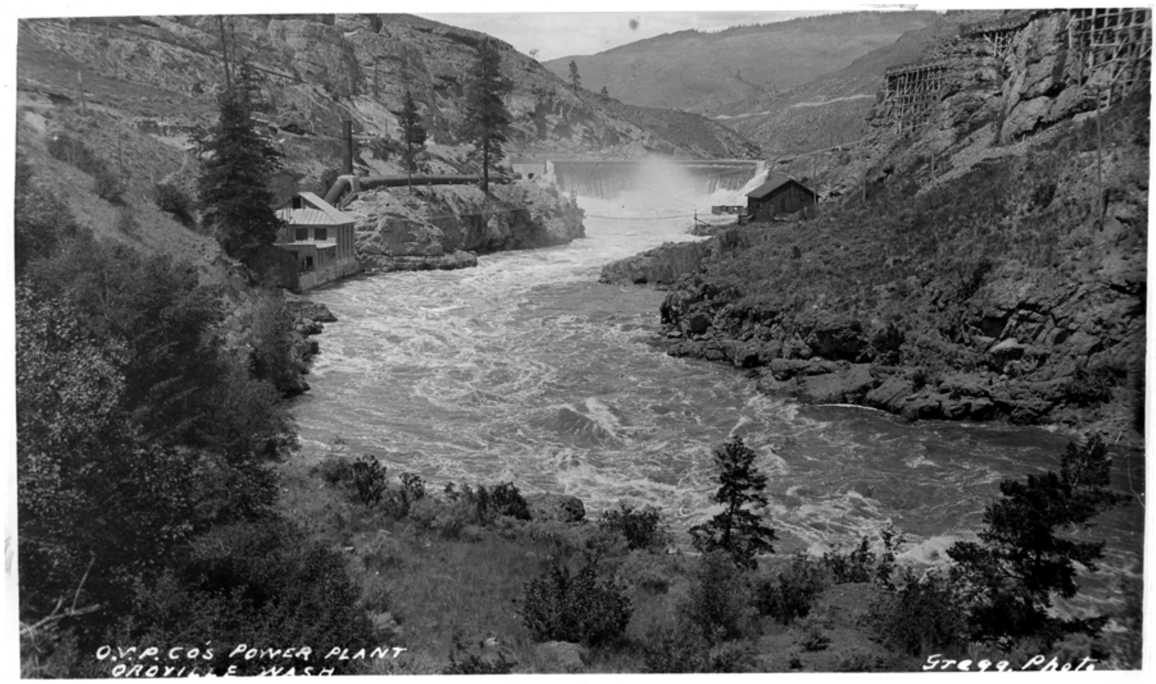


Figure 3. Location, bathymetry, and coring sites, Palmer and Blue Lakes (Okanogan County, WA). Coring locations are displayed against GIS bathymetry obtained from the Washington Dept. of Ecology website. Note that contour intervals in the WDOE files are 10 feet for Palmer Lake, but 5 feet for Blue Lake. See text (Methods) for a discussion of the discrepancy between observed and estimated (GIS) water.

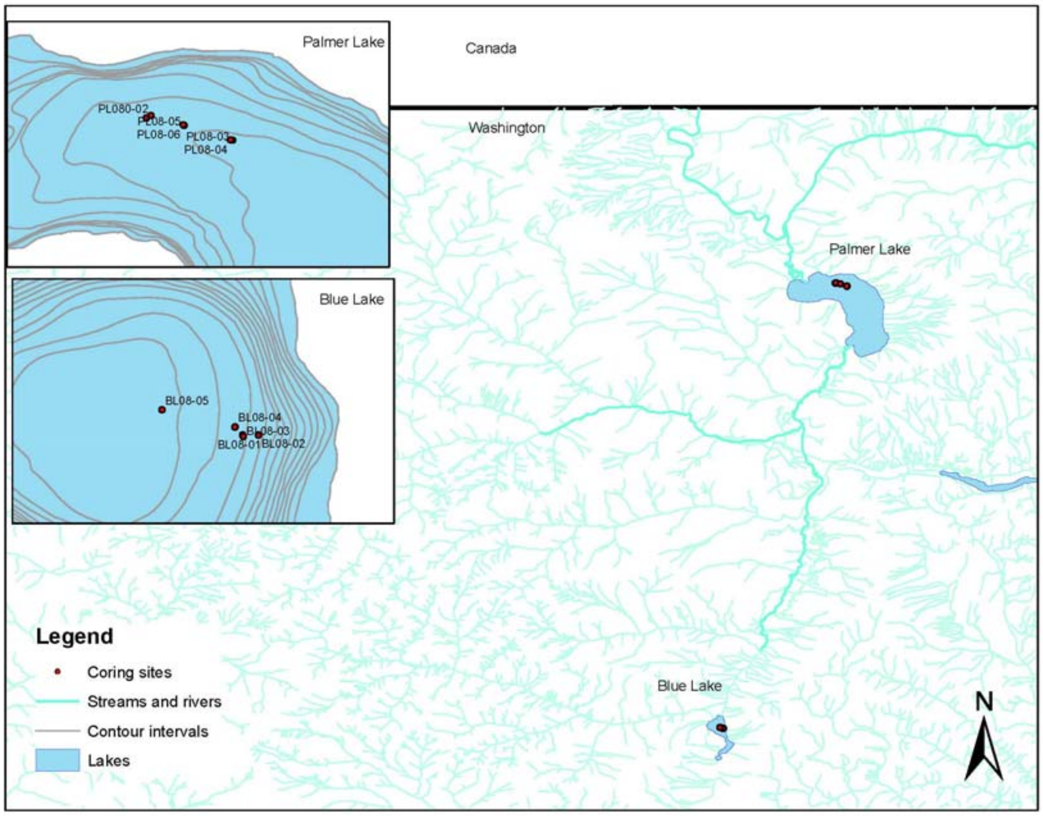


Figure 4. Palmer Lake PL08-04: Total ^{210}Pb and ^{226}Ra activity
Note the congruence between ^{210}Pb and ^{226}Ra in the 27-28 cm sample, indicating that background has been reached.

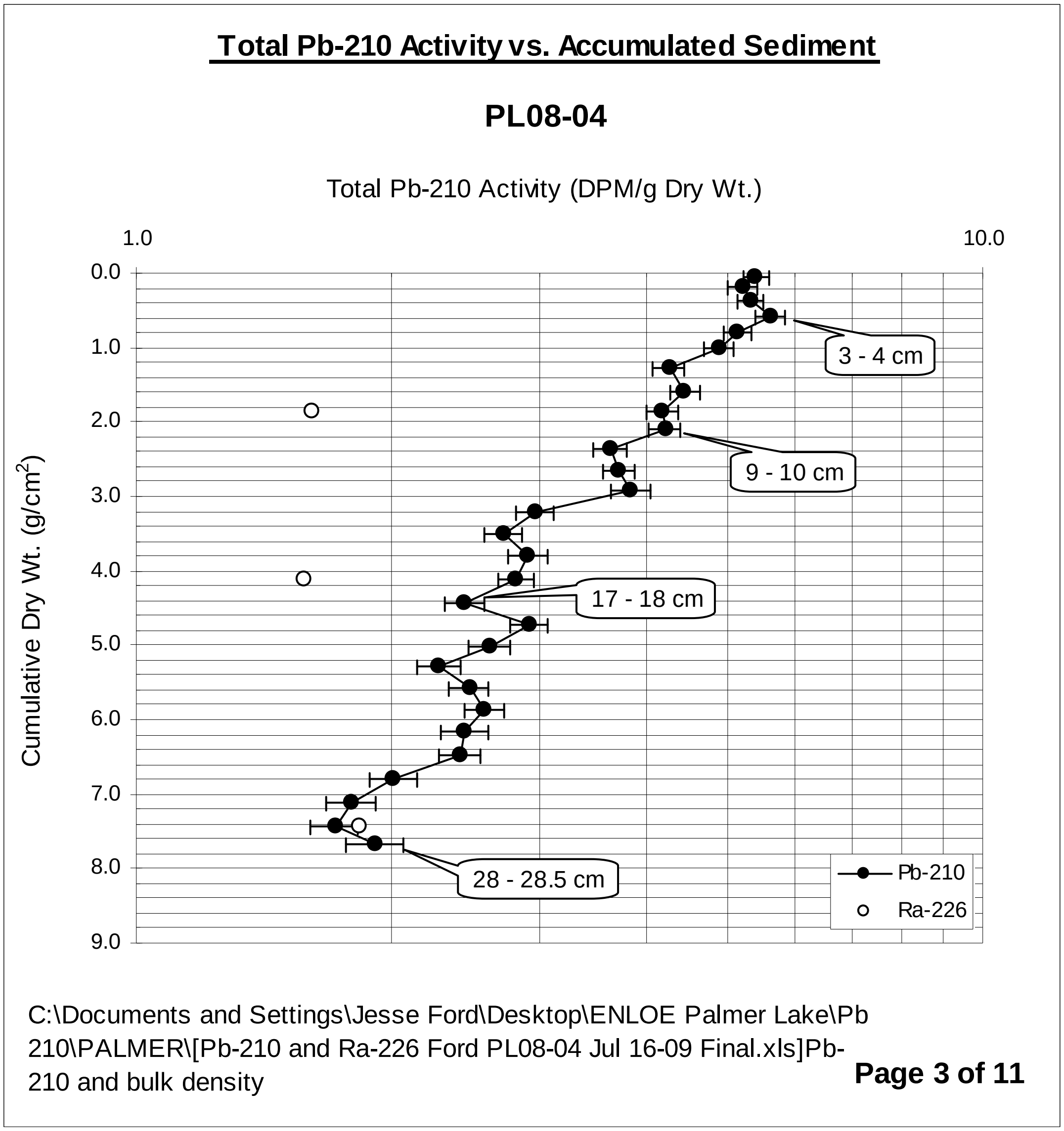


Figure 5. Blue Lake core BL08-02: Total ^{210}Pb activity

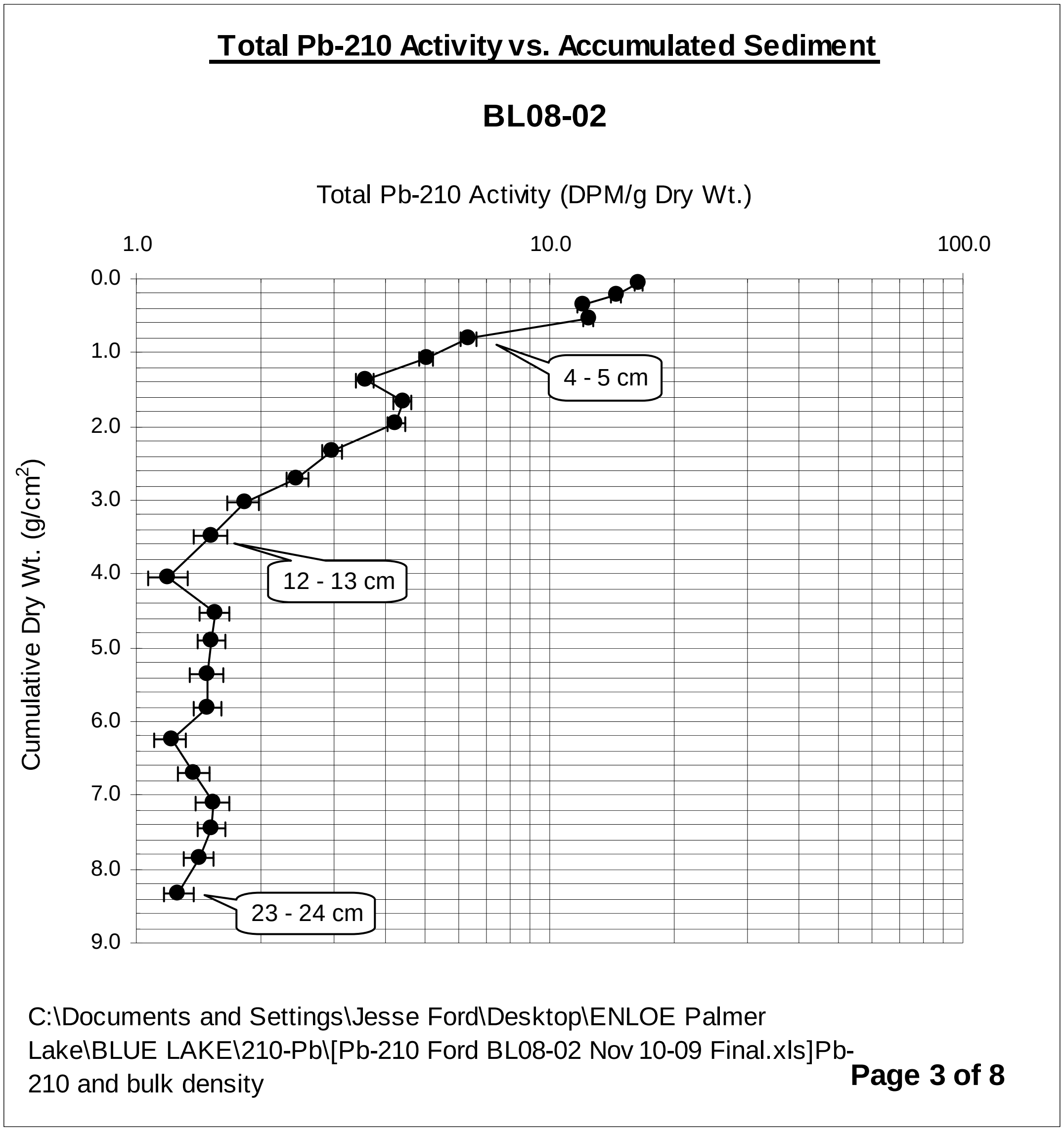


Figure 6. Palmer Lake core PL08-04: age vs. depth
Both regression and constant rate of supply models are shown. Age estimates older than 80 years (four ^{210}Pb half-lives) are coarser approximations than younger ages.

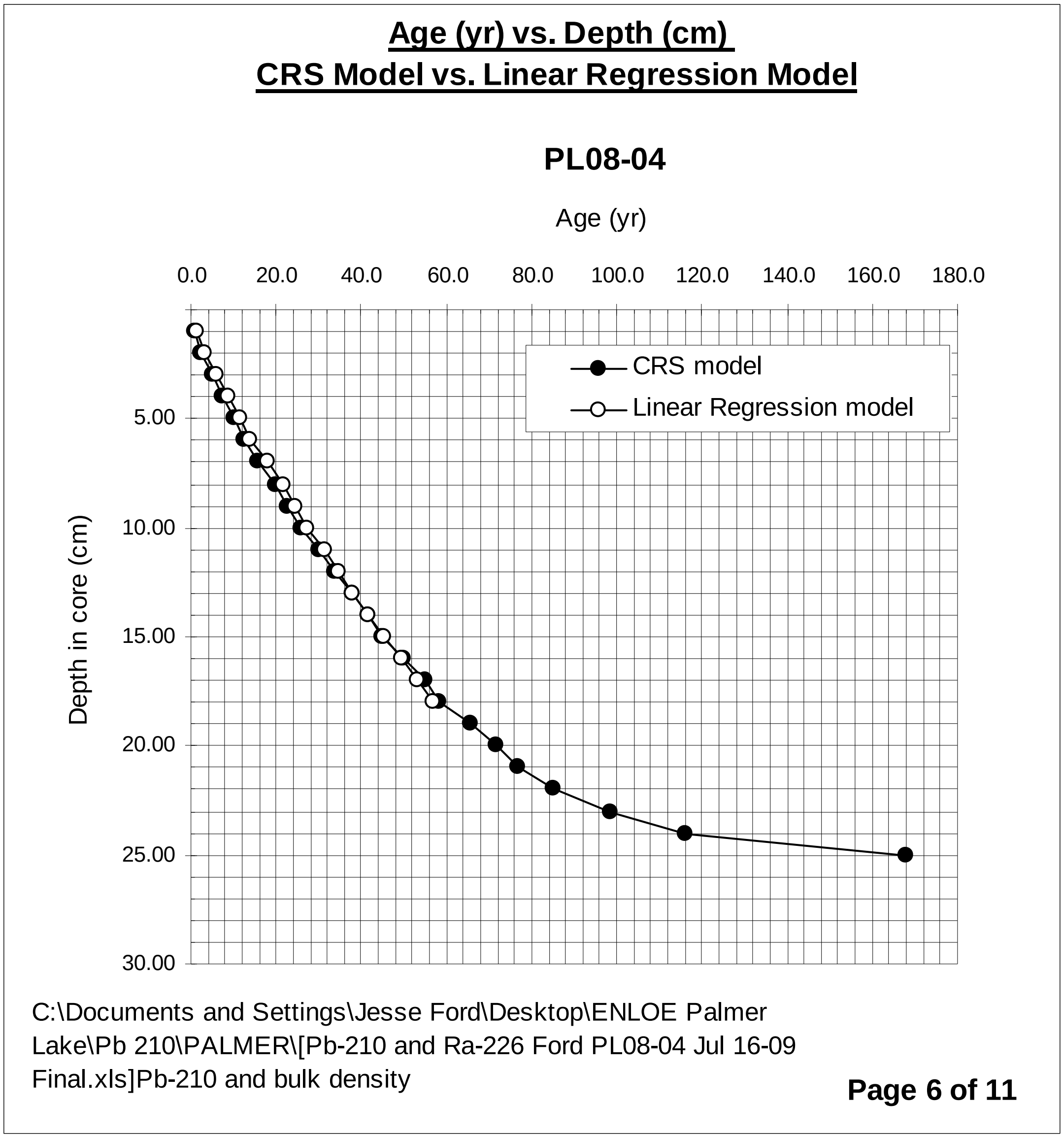


Figure 7. Blue Lake core BL08-02: age vs. depth
Both regression and constant rate of supply models are shown. Age estimates older than 80 years (four ^{210}Pb half-lives) are coarser approximations than younger ages.

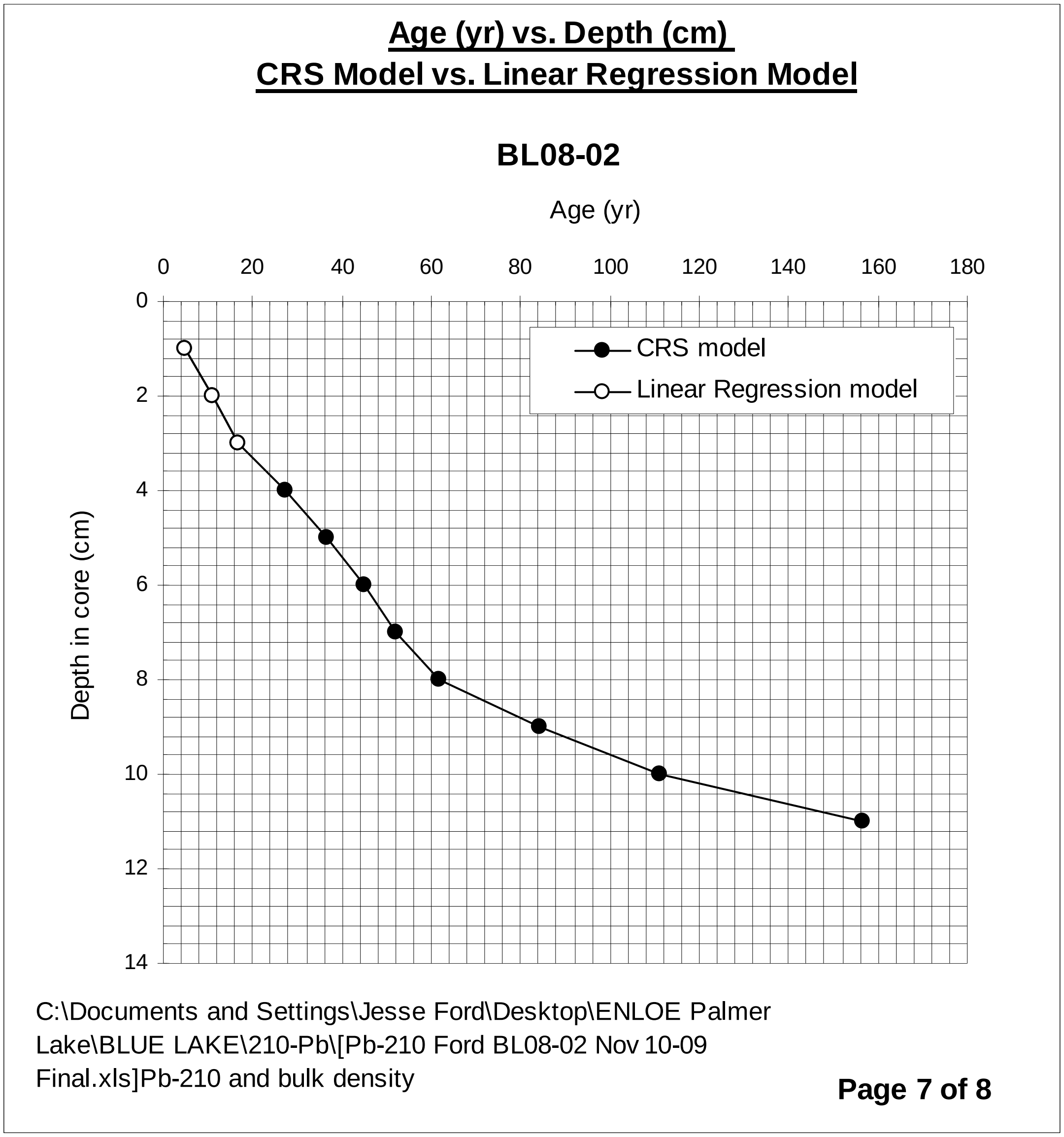


Figure 8. Palmer Lake (PL08-04) loss-on-ignition

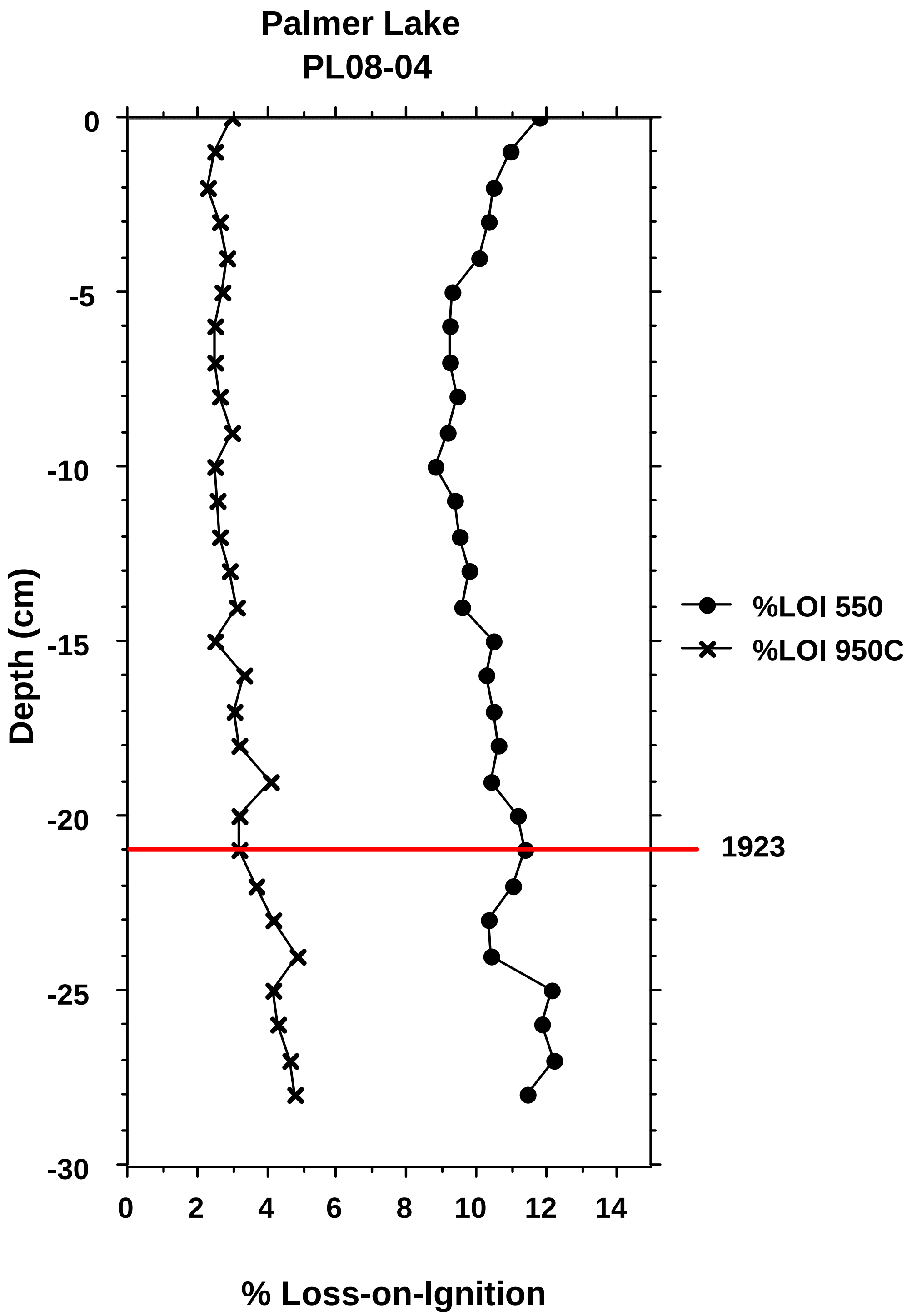


Figure 9. Blue Lake (BL08-02) loss-on-ignition
Note that seven samples from the base of the core (39-46 cm) are not yet analyzed

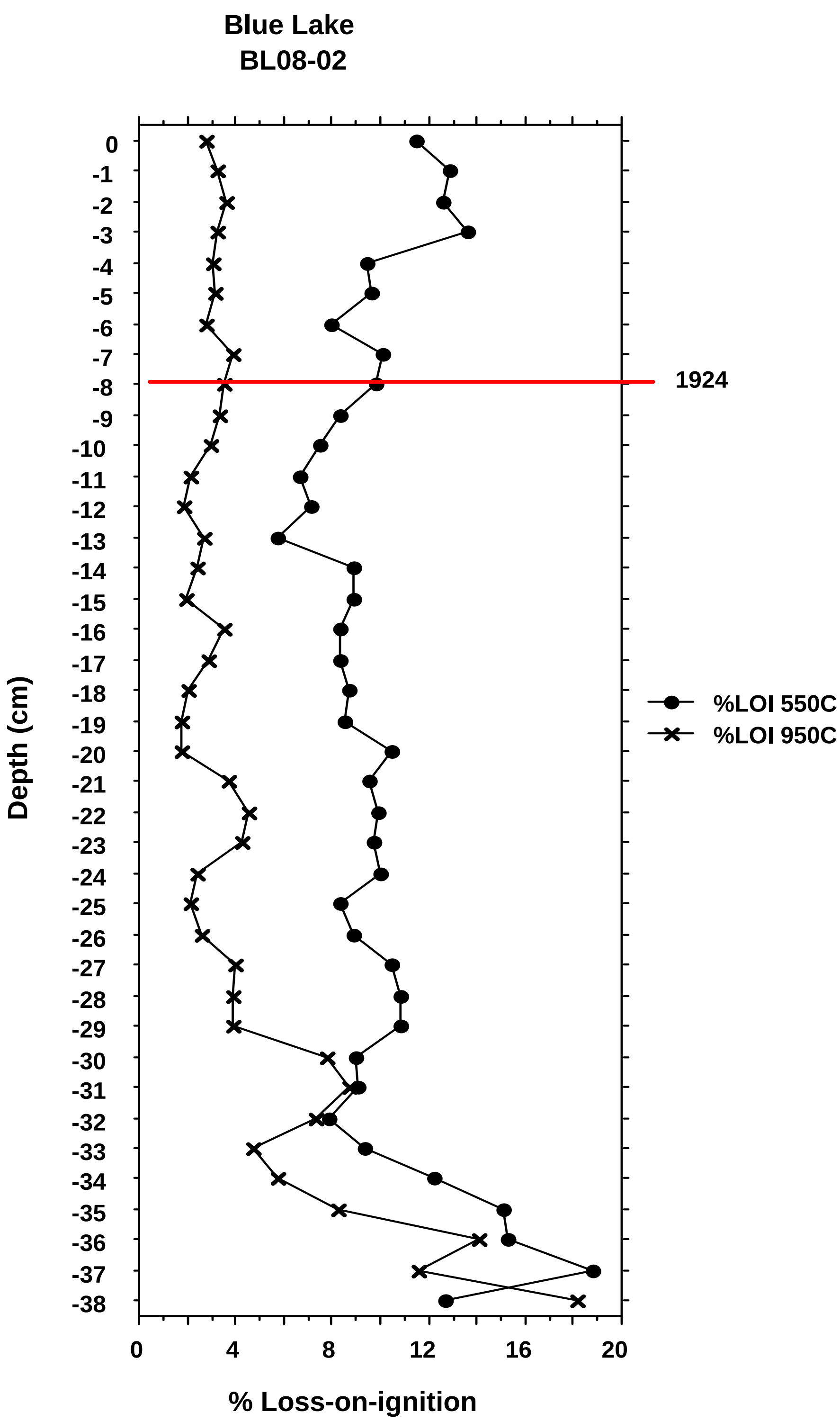


Figure 10. Palmer Lake core PL08-04: % carbon, % nitrogen, and C/N ratio

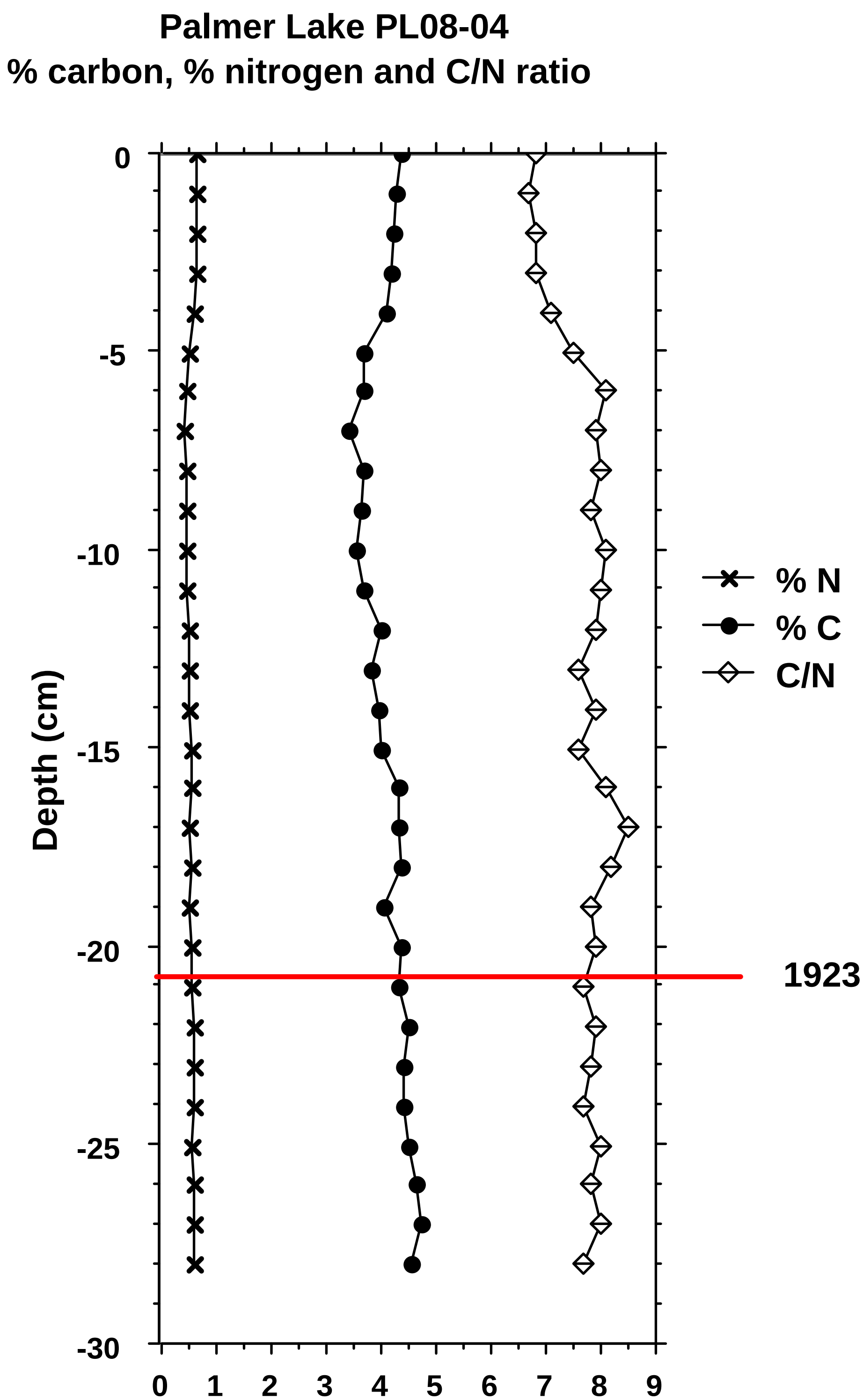


Figure 11. Blue Lake core BL08-02: % carbon, % nitrogen, and C/N ratio

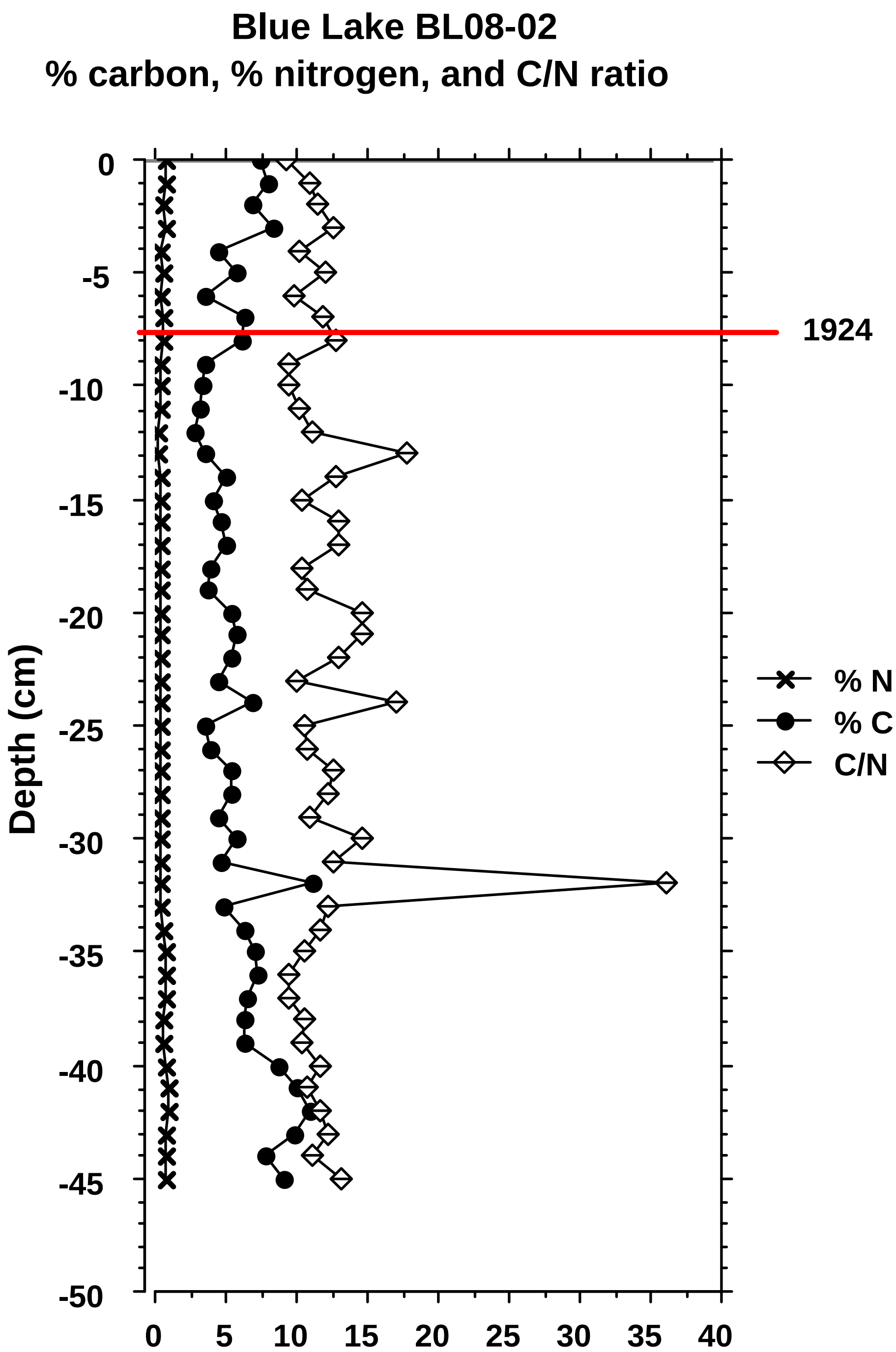


Figure 12. Palmer Lake core PL08-04: $\delta^{13}C$ and $\delta^{15}N$
(units are ‰)

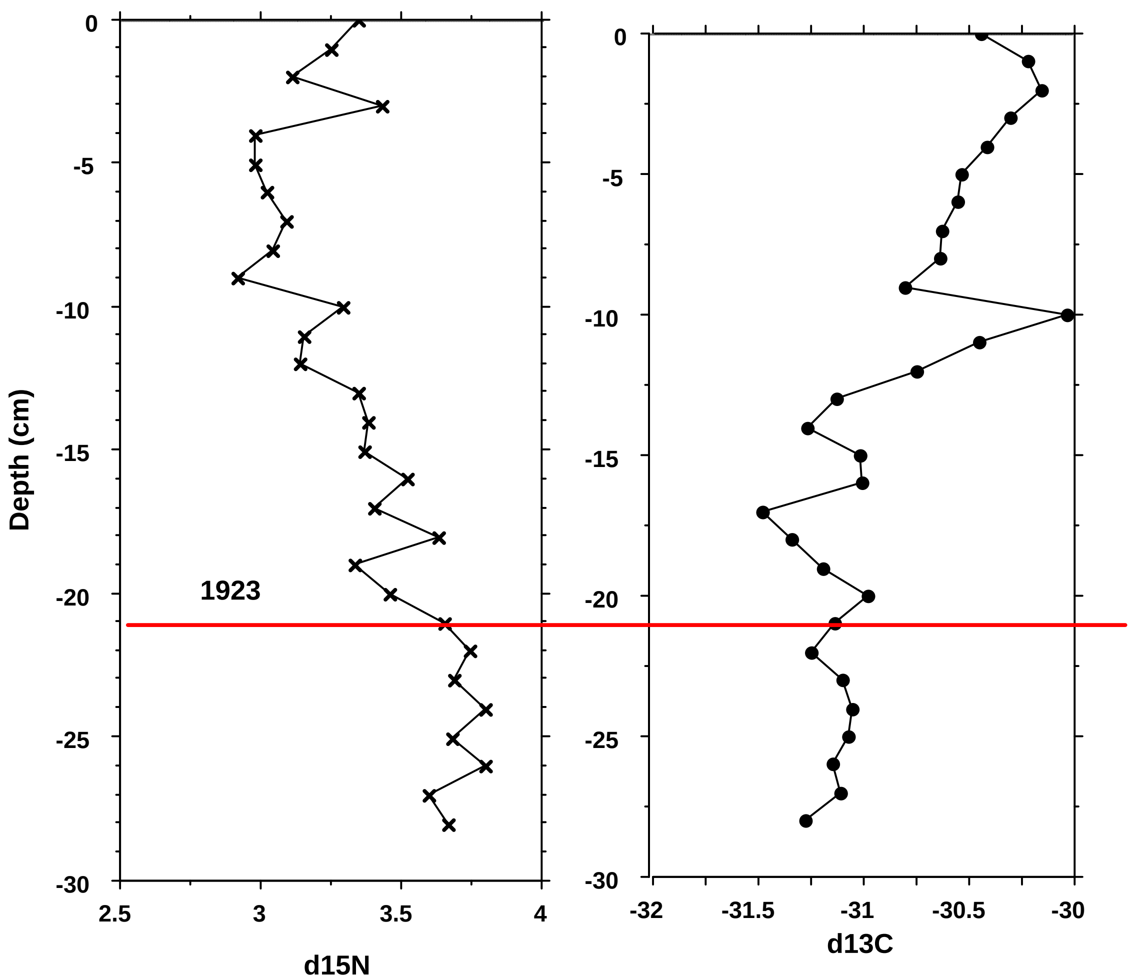
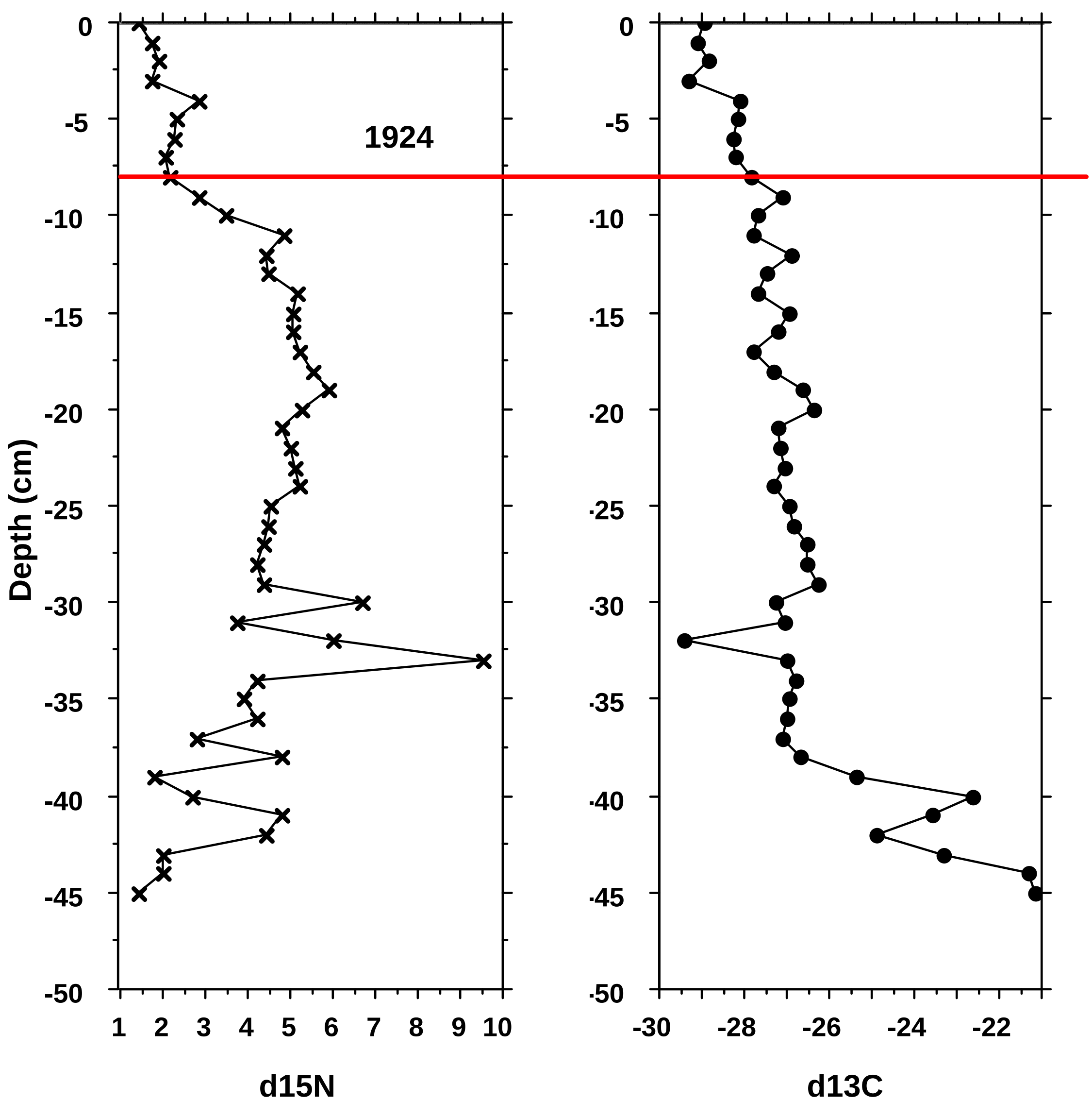


Figure 13. Blue Lake core BL08-02: $\delta^{13}C$ and $\delta^{15}N$ (units are ‰)



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