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The Holocene History of Fish and Fisheries of the Upper Klamath Basin, Oregon

ALEXANDER E. STEVENSON
Historical Research Associates, Inc.
1904 Third Ave., Ste. 240, Seattle, WA 98101

VIRGINIA L. BUTLER
Portland State University, Department of Anthropology
P.O. Box 751, Portland, OR 97207

Historical and ethnographic records and ongoing cultural traditions highlight the importance of fishing to native peoples of the Upper Klamath Basin. Previous researchers have discussed the importance of fish to past people in the basin, but a systematic review of taxa and their abundance through time had not been closely considered until our study. We analyzed over 15,000 fish remains from six sites located above Upper Klamath Lake and obtained 11 new radiocarbon dates, which—in conjunction with previous records—suggest the fishery extends to ~5,300 cal B.P. Three fish families are represented in most time periods—suckers (Catostomidae), minnows (Cyprinidae), and salmon/trout (Salmonidae)—but suckers dominate. Their prominence, particularly large-bodied forms, is consistent with foraging models that rank this fish highly. Distinctive patterns in body-part representation are argued to reflect butchery linked to storage, rather than post-depositional destruction. The Holocene fish records suggest long-term stability in fishing practices.

T HE UPPER KLAMATH BASIN REGION HAS MUCH in common with basins within the hydrographic Great Basin as a high desert, sagebrush steppe, with snow-fed rivers and springs that provide extensive lake, marsh, and stream habitat for desert fishes such as minnows (Cyprinidae) and suckers (Catostomidae) (La Rivers 1962; Moyle 2002; Sigler and Sigler 1987). Yet the Klamath Basin is connected to the Pacific Ocean via the Klamath River that flows 260 miles (420 km.) from Upper Klamath Lake to the Pacific Ocean (Fig. 1), adding migratory salmon and trout (*Oncorhynchus* spp.) to the possible mix of fish taken by indigenous fishers.

Nineteenth century explorer accounts and ethnographic records emphasize the importance of fish to the subsistence and overall lifeways of the area's indigenous peoples, the Klamath and Modoc (Deur 2003; Gatschet 1890; Lane & Lane Associates 1981; Spier 1930). Decades of archaeological work in the Upper Klamath Basin (Cheatham 1991; Cheatham et al. 1995; Cressman 1956; Sampson et al. 1985) and adjacent basins of the Northern Great Basin (Greenspan 1985, 1990; Jenkins 1994, 2004) have shown the importance of fish to past

people. However, at least for the Upper Klamath Basin, systematic review of the types of fish and their varying abundance over time and space had not been closely considered until our project.

The ultimate goal of our study was to develop a Holocene history of fishes that would assist ongoing conservation efforts in the Klamath Basin, which has been seriously degraded over the last 100 years by large-scale irrigation and hydroelectric projects (National Research Council [NRC] 2004). Plans are underway to remove four dams on the Klamath River to allow migratory salmonid passage to spawning areas. Historical records are ambiguous about which salmonid species once spawned in the upper basin. We were contracted by National Marine Fisheries to conduct a systematic study of the previously excavated fish-bone assemblages from above Upper Klamath Lake in an effort to obtain an independent empirical record of ancient fish biogeography in the region. We located and analyzed all of the available fish remains from six archaeological sites and obtained 11 new radiocarbon dates to place deposits in better chronological context than was previously
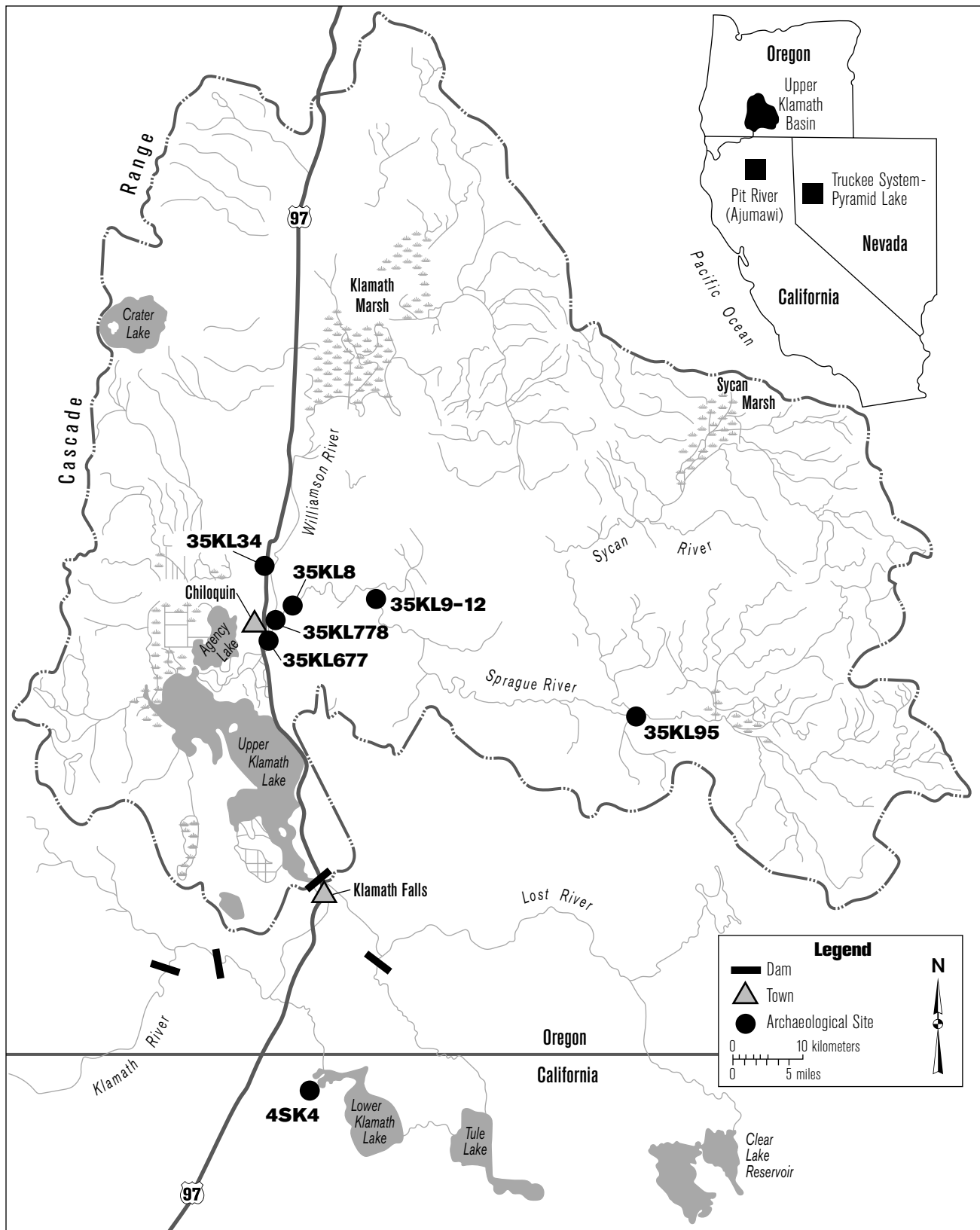
Figure 1. Map showing locations of Upper Klamath Basin archaeological sites included in study and nearby projects (Modified from Brownell and Rinallo 1995, with permission from USGS).

possible. Our research sought to document which species were present, and identify any patterned changes through time that might be linked to environmental changes or independent cultural processes. Our study found that suckers absolutely dominate all site assemblages, with lower frequencies of minnows and salmonids. We also found patterns in body-part representation that may be linked to intentional butchering practices and preparations for storage, which has implications for larger questions related to hunter-gatherer land use. The heavy emphasis on suckers in the ancient past should not be surprising, given their size, abundance, and other cultural values as seen from historical and ongoing traditional practices of indigenous peoples of the region (Deur 2003; Evans 1990; Spier 1930).

UPPER KLAMATH ARCHAEOLOGICAL RECORDS

To determine which archaeological sites above Upper Klamath Lake had fish remains, we examined records at the Oregon State Historic Preservation Office (Salem, Ore.). Six sites were identified: Medicine Rock Cave (35KL8), Kawumkan Springs Midden (35KL9–12), Collier State Park (35KL34), Beatty Curve (35KL95), Williamson River Bridge (35KL677), and Bezuksewas Village (35KL778) (Fig. 1; Table 1). These sites are located within approximately 100 m. of the Sprague or Williamson Rivers, major tributaries to Upper Klamath Lake (Fig. 1). Since this analysis, at least one other small fish assemblage from above Upper Klamath Lake (35KL2773; O'Grady 2011) has come to our attention; it is not included here. The sites include two excavated by Luther Cressman in the 1940s (Cressman 1956); one by David Cole in the 1960s (Cheatham 1990); and three sites excavated since 1990 as part of highway mitigation (Cheatham 1991; Cheatham et al. 1995; Connolly et al. 2015). The presence of a pithouse or other structural features at three of the sites suggests multi-season residential occupation; lack of such features and more limited tool and faunal diversity at the other three sites suggests use as specialized fishing camps (Table 1).

Field sampling and curation have affected fishbone recovery and taxonomic representation to varying degrees. The Cressman and Cole projects used 1/4 in. (6.4 mm.) mesh, whereas the more recent projects

Table 1

ARCHAEOLOGICAL SITES INCLUDED IN STUDY[a]

Site Name/(Number)	Inferred Site Function	Excavated Volume (m.³)	Screen Size	Citation
Medicine Rock Cave (35KL8)	Fishing Camp	unknown	1/4 in.	Cressman 1956
Kawumkan Springs Midden (35KL9-12)	Residential Base	unknown	1/4 in.	Cressman 1956
Collier State Park (35KL34)	Residential Base	unknown	1/4 in.	Cheatham 1990[b]
Beatty Curve (35KL95)	Variable	74	1/8 in.	Connolly et al. 2015; Butler et al. 2015
Williamson River Bridge (35KL677)	Fishing Camp	43.7	1/8 in.	Cheatham 1991
Bezuksewas Village (35KL778)	Residential Base	124.7	1/8 in.	Cheatham et al. 1995

[a]Fish remains also documented for Nightfire Island (4SK4) (Sampson et al. 1985), located on Lower Klamath Lake, Oregon/California border. Remains from a single "microcolumn" were reported, dominated by minnows (*Siphateles bicolor*/ *Gila coerulea*). Since our project focuses on fish records from above Upper Klamath Lake, this site not considered further.

[b]Based on field notes from D. Cole's 1960 excavation

used 1/8 in. (3.2 mm.) mesh in field recovery. Much previous study has shown that 1/4 in. tends to bias the representation of small fish bones (e.g., Gordon 1993; Partlow 2006); in some contexts, even 1/8 in. mesh is inadequate for characterizing fish representation (Butler and Schroeder 1998; Tushingham et al. 2013). Mesh size bias probably is not as serious a problem in our Klamath project sites—with their prominence of large-bodied suckers—as it is in some settings where small minnows were the primary resource documented (e.g., desert areas of the western Great Basin; Butler 1996). Nevertheless, we will consider the effects of screen size in comparing fishbone records across collections.

More problematic is that an unknown but likely sizeable number of the fish remains from Cressman's sites—Medicine Rock Cave and Kawumkan Springs Midden—were not saved after excavation. The Cressman collections were not at the state repository (Oregon Museum of Natural and Cultural History—OMNCH) when we made our initial inquiries. We tracked the fish remains to the University of Michigan Museum of Zoology (Stevenson 2011). After receiving and studying the remains, we noticed major discrepancies between the number of bones originally described and the number available for study. For example, Cressman (1956: Table 9) reports 1,493 fish remains from Kawumkan Springs

Midden, while we only documented 148. Cressman suggested that Medicine Rock Cave was a fishing camp, an interpretation that he based on the high frequency of fish bones, but we only documented 27 specimens from this site. Without any way to control for the apparent attrition, we will treat the Cressman faunal records at the nominal level: the presence of taxa at different time periods will be noted, but the relative proportion will not be considered.

To put the fish records in the most precise temporal framework possible, we obtained 11 additional radiocarbon dates to join the 33 previously obtained (Table 2). Bones from terrestrial mammals (medium-size mammal, not rodent) were selected for dating because they met necessary sample mass requirements and, additionally, are more likely to be directly associated with past human activity than charcoal or wood. Two samples from Kawumkan Springs Midden Level I did not provide enough collagen for dating after pretreatment. Samples were not selected from 35KL8 or 35KL34 because suitable materials were not available. Radiocarbon samples were prepared by B. Culleton and D. Kennett, then at the University of Oregon Archaeometry Laboratory. All results have been corrected for isotopic fractionation according to the conventions of Stuiver and Polach (1977), with d^{13}C values measured on prepared graphite using the AMS spectrometer. CO_2 samples were analyzed at the Keck Carbon Cycle Mass Spectrometer at the University of California, Irvine. Radiocarbon dates from previous studies and those we obtained were calibrated into calendar years before present (cal B.P.) using OxCal v4.2 (Bronk Ramsey 2014).

FISH BONE ANALYTIC METHODOLOGY

The fish bone collections were borrowed from the OMNCH and analyzed at Portland State University, Department of Anthropology. For each fish specimen, we recorded a standard set of information: provenience, mesh size, taxon, skeletal element, presence/absence of a unique landmark, whether the specimen was burned, and other surface modifications such as digestive etching or possible butchering marks. Representative skeletons from all historically documented freshwater species (e.g., minnows and suckers), and anadromous species (salmonids) from Oregon and northern California were available for comparison.

Specimens were identified to the finest Linnaean taxonomic level possible, occasionally to species, but most commonly to the family level, using modern skeletons in Butler's lab and those borrowed from Oregon State University. Except for the first and second vertebra on the column, which can be distinguished as Cyprinidae (minnow) or Catostomidae (sucker), vertebrae from these taxonomic groups cannot be easily distinguished, so the joint category, cyprinid/catostomid, was used. Other remains assigned to this category were too eroded to assign to family. The two species of minnow identified, blue chub (*Gila coerulea*) and tui chub (*Siphatales bicolor*) were distinguished based on the pharyngeal: blue chub typically has a tooth row formula of 2,5–5,2, while tui chub usually has only one row of four or five teeth (Bailey and Uyeno 1964; see Carl et al. 1977 for nomenclature). Extensive efforts to differentiate the four sucker species endemic to the Upper Klamath Basin, *Deltistes luxatus* (Lost River sucker), *Chasmistes brevirostris* (shortnose sucker), *Catostomus snyderi* (Klamath largescale sucker), and *Catostomus rimiculus* (Klamath shortscale sucker) (NRC 2004), were not successful. We focused on several cranial elements (dentary, maxilla, quadrate, articular, hyomandibula) previously shown to be useful in distinguishing sucker species (see Butler 2004), but were not able to isolate distinctive morphological features. These species are known to hybridize (Tranah 2001, cited in NRC 2004). Based on a study of the morphology and taxonomy of the four Klamath suckers, Markle et al. (2005) found much similarity across a range of attributes. Differences in bony anatomy may simply not be very great. We distinguished Lost River sucker remains from the rest, based on their extremely large size. Lost River sucker can reach lengths of ~75 cm., while the other three can reach almost 50 cm. in size (Table 3). We compared archaeological specimens against reference skeletons of known body size and assigned specimens to cf. *Deltistes* when they were clearly from fish longer than 50 cm.

Table 3 summarizes background information on size, preferred habitats, and migration patterns for the main minnows and suckers known for the upper basin. Suckers mainly graze on zooplankton, algae, and detritus on the bottom of lakes and streams. Lost River and shortnose suckers are adapted for lake living, spending most of the year in Upper Klamath Lake, moving into rivers such

Table 2

RADIOCARBON AGES INCLUDED IN STUDY, CALIBRATED AGE RANGE AT TWO STANDARD DEVIATIONS[a]

Site Sample Number	Sample Description and Context	Radiocarbon Age (B.P.)	δ13C	δ13C	2-sigma Calibrated Age (B.P.)	Citation
Kawumkan Springs Midden 35KL9-12						
C-844	Wood from house pit	435 ± 165	–	–	690 – modern[b]	Libby (1954)
UCIAMS-84463	Level II, (40-80 cm) terrestrial mammal bone	1,265 ± 20	–19.3	7.6	1,270 – 1,170	Butler et al. (2010)
UCIAMS-84462	Level II, (40-80 cm) terrestrial mammal bone	2,860 ± 20	–16.9	9.9	3,060 – 2,890	Butler et al. (2010)
UCIAMS-84464	Level III (80-120 cm) terrestrial mammal bone	4,510 ± 20	–14.1	6.9	5,300 – 5,050	Butler et al. (2010)
Collier State Park 35KL34						
GaK-1659	Charred house timber	240 ± 50	–	–	470 – modern[b]	Cheatham (1990)
GaK-1660	Charred bark on house timber	310 ± 40	–	–	480 – 290	Cheatham (1990)
Williamson River Bridge 35KL677						
Beta-26255	D/D/6/2 feature 2 charcoal	70 ± 80	–	–	290 – 0	Cheatham (1991)
UCIAMS-84454	E/D/8 terrestrial mammal bone	205 ± 20	–20.7	3.9	300 – modern[b]	Butler et al. (2010)
UCIAMS-84459	O/A/4 terrestrial mammal bone	940 ± 20	–20.0	6.8	920 – 790	Butler et al. (2010)
UCIAMS-84458	M/A/7 terrestrial mammal bone	985 ± 20	–20.7	6.1	960 – 790	Butler et al. (2010)
Beta-27451	L/B&D/5/2 charcoal	1,080 ± 110	–	–	1,270 – 780	Cheatham (1991)
Beta-29044	M/C/6/2 charcoal	1,150 ± 200	–	–	1,480 – 680	Cheatham (1991)
UCIAMS-84455	J/A/2 terrestrial mammal bone	1,205 ± 20	–20.1	8.2	1,190 – 1,060	Butler et al. (2010)
Beta-27449	B/C&D/10/2 charcoal	1,410 ± 150	–	–	1,690 – 980	Cheatham (1991)
Beta-29043	M/C/5/2 feature 1 charcoal	1,600 ± 70	–	–	1,700 – 1,340	Cheatham (1991)
Beta-29041	M/C/4/2 feature 1 charcoal	1,700 ± 80	–	–	1,820 – 1,410	Cheatham (1991)
UCIAMS-84457	M/C/5 terrestrial mammal bone	1,755 ± 20	–20.1	7.5	1,720 – 1,600	Butler et al. (2010)
Beta-27452	O/A/6/2 charcoal	1,810 ± 100	–	–	1,990 – 1,520	Cheatham (1991)
UCIAMS-84456	J/D/9 terrestrial mammal bone	2,250 ± 20	–21.5	7.6	2,340 – 2,150	Butler et al. (2010)
Bezuksewas Village 35KL778						
UCIAMS-84461	4W-5B-5 terrestrial mammal bone	175 ± 20	–19.7	5.9	290 – modern[b]	Butler et al. (2010)
UCIAMS-84460	4W-6B-6 terrestrial mammal bone	185 ± 20	–20.7	7.0	290 – modern[b]	Butler et al. (2010)
Beta-40178	5E-3C-3 Feat10 charcoal	200 ± 60	–	–	430 – modern[b]	Cheatham et al. (1995)
Beta-32843	Test Pit B-5 charcoal	240 ± 80	–	–	480 – modern[b]	Cheatham et al. (1995)
Beta-40176	4W-6A-7 charcoal	260 ± 60	–	–	490 – modern[b]	Cheatham et al. (1995)
Beta-39288	4W-5B-4 feature 4 charcoal	280 ± 50	–	–	490 – modern[b]	Cheatham et al. (1995)
Beta-40177	5E-1B-8 charcoal	330 ± 90	–	–	540 – modern[b]	Cheatham et al. (1995)
Beta-40175	4W-4D-3 Feat 1 charcoal	420 ± 60	–	–	540 – 310	Cheatham et al. (1995)
Beta-40174	2E-1A-8 Feat 12 charcoal	500 ± 60	–	–	660 – 330	Cheatham et al. (1995)
Beta-40179	5W-1C-10 charcoal	830 ± 70	–	–	920 – 660	Cheatham et al. (1995)
Beta-39289	5W-3A-5 feature 13 charcoal	1,170 ± 50	–	–	1,240 – 960	Cheatham et al. (1995)
Beta-40180	8W-6A-12 charcoal	1,220 ± 90	–	–	1,300 – 960	Cheatham et al. (1995)
Beta-32920	8W-1A-10 living floor charcoal	1,960 ± 80	–	–	2,120 – 1,720	Cheatham et al. (1995)
Beatty Curve 35KL95						
GAK-7705	'77-Feat1 charcoal	Modern			Modern	Connolly et al. (2015)
GAK-7706	'77-Feat2 charcoal	50 ± 90			290 – modern[b]	Connolly et al. (2015)
Beta-265859	FeatE6 charcoal	100 ± 40	–	–	280 – modern[b]	Connolly et al. (2015)
Beta-265855	FeatE2 charcoal	180 ± 40	–	–	310 – modern[b]	Connolly et al. (2015)
Beta-254045	WFB-7-W5 charcoal	860 ± 50	–	–	910 – 680	Connolly et al. (2015)
GAK-7703	'77-Feat1 charcoal	1,110 ± 110	–	–	1,280 – 790	Connolly et al. (2015)
Beta-265857	WFB-W5sh mussel shell	1,620 ± 50	–	–	1,690 – 1,390	Connolly et al. (2015)
GAK-7704	'77-Feat2 charcoal	1,530 ± 110	–	–	1,700 – 1,280	Connolly et al. (2015)
Beta-254043	WAC-11 charcoal	1,980 ± 40	–	–	2,040 – 1,820	Connolly et al. (2015)
Beta-254044	WAB-5-W1 charcoal	2,070 ± 40	–	–	2,150 – 1,930	Connolly et al. (2015)
Beta-265856	WAB-W1sh mussel shell	2,590 ± 40	–	–	2,790 – 2,500	Connolly et al. (2015)
Beta-254046	WL-13/14-MF charcoal	2,320 ± 40	–	–	2,460 – 2,160	Connolly et al. (2015)
Beta-265858	WLC-13sh mussel shell	2,910 ± 40	–	–	3,180 – 2,920	Connolly et al. (2015)

[a]Two standard deviations has the greatest probability of being correct.

[b]Indicates dates that may extend out of calibration range.

Table 3

**BACKGROUND INFORMATION ON MAIN FRESHWATER FISH TAXA FROM UPPER KLAMATH BASIN
(BASED ON MOYLE [2002] AND SIGLER AND SIGLER [1987])**

Taxon	Size	Preferred Habitat	Spawning Time	Spawning Location
Siphateles bicolor (tui chub)	10–20 cm. SL (springs) 30–40 cm. SL (large lakes)	Quiet water, aquatic plants	Late-April to early-July	Shallow water (<1.5 m.), many aquatic plants
Gila coerulea (blue chub)	Less than 35 cm. SL	Quiet water	May and June	Shallow gravelly/rocky areas
Rhinicthys osculus (speckled dace)	< 8 cm. SL	Small streams, but varies greatly	June and July	Gravelly areas in lakes and streams
Catostomus snyderi (Klamath largescale sucker)	20–30 cm. FL (up to 46 cm. FL)	Rivers and lakes	March to early-May	Rivers and lakes
Catostomus rimiculus (Klamath shortscale sucker)	Up to 45 cm. SL	Deep river pools	mid-March to late-April	Small streams
Deltistes luxatus (Lost River sucker)	35–50 cm. FL (up to 74 cm. FL)	Lakes; shallow water (<1.5 m.)	early-February to early-April	Tributary streams
Chasmistes brevirostris (shortnose sucker)	30–40 cm. FL (up to 50 cm. FL)	Large shallow lakes	late-February to early-May	Tributary streams; occasionally springs in lakes

Note: SL = standard length; FL = fork length

as the Williamson and Sprague rivers to spawn between February and April (Moyle 2002). The other two suckers also migrate upriver in spring as part of their spawning activity (Moyle 2002). While suckers would have been most abundant when they were aggregating as part of their spawning migrations, they would have been available much of the year.

In order to identify butchery patterns, we divided the body into head and trunk segments, assigning skeletal elements to these two units (Table 4). For this part of the study, we included only specimens that had a unique non-repetitive landmark to reduce the effects of fragmentation on frequencies. For example, with vertebrae, the opening for the notochord needed to be present to be counted. For hyomandibula, the opercular process needed to be present. In short, we based our summaries of body-part representation on the minimum number of elements (MNE) (Grayson 1984).

Two genera of salmonids known historically for the region could be present in the archaeological samples: *Oncorhynchus* and *Salvelinus* (from bull trout, *S. confluentus*). *Oncorhynchus* includes the familiar sea-run salmon species such as Chinook (*O. tshawytscha*) or coho (*O. kisutch*) salmon, as well as anadromous and resident trout (rainbow, redband [*O. mykiss*]). All of the remains identified as Salmonidae are likely from *Oncorhynchus* spp., based on their relatively large size.

Table 4

SKELETAL ELEMENTS USED IN BODY PART ANALYSIS

Head	Trunk
Articular, Basioccipital, Ceratohyal, Dentary, Endopterygoid, Epihyal, Epiotic, Exoccipital, Frontal, Hyomandibula, Hypohyal, Interopercle, Maxilla, Mesopterygoid, Opercle, Palatine, Parietal, Pharyngeal, Preopercle, Premaxilla, Prefrontal, Prootic, Parasphenoid, Pterotic, Quadrate, Supraoccipital, Subopercle, Supraethmoid, Sphenotic, Urohyal, Vomer	Basipterygium, Cleithrum, Coracoid, Postcleithrum, Suprcleithrum, Scapula, Vertebrae (atlas, abdominal, caudal, ultimate), Weberian Apparatus and dorsal expanded process

Because salmonid remains are notoriously difficult to identify to species on the basis of morphology, as well as the necessity of ascertaining which species were present to assist fish conservation, we collaborated with DNA specialists D. Yang and C. Speller at Simon Fraser University, who analyzed 57 archaeological salmonid remains to determine the species present (Butler et al. 2010). We attempted to use geochemistry (Sr/Ca ratios, carbon isotopes) to determine whether the salmonids represented were sea-run or fully freshwater residents (Butler et al. 2010), but the efforts were not successful (Butler et al. 2015.).

As noted previously, our samples came from three sites excavated using 1/4 in. mesh and three with 1/8 in.

mesh. From one site, Beatty Curve (35KL95), we also examined fish remains from five 1-liter flotation samples; the remains studied included the light fraction and half of the heavy fraction that was screened through 1/16 in. mesh. This effort generated only a small number of identified specimens. Butler et al. (2015) concluded that 1/8 in. mesh used during field recovery did not bias fish representation.

All records were entered into SPSS (Statistical Package for the Social Sciences) for further analysis. To compare and contrast faunal records within and between archaeological sites, we primarily used the counting measure number of identified specimens (NISP) (Grayson 1984).

RESULTS

Temporal Distribution

The 44 calibrated radiocarbon dates from project sites show several trends in occupation (Fig. 2). The oldest records are from Cressman's Kawumkan Springs Midden, which suggests site use ~5,300 cal B.P., then at 3,000 cal B.P., slightly before 1,000 cal B.P., and finally over the last 600 cal years. Importantly, the radiocarbon dates from Kawumkan Springs agree with the obsidian hydration dates for the site obtained in the 1970s (Aikens and Minor 1978). The earliest dated occupation at the Beatty Curve site dates to ~2,500 cal B.P.; a series of younger dates suggest ongoing occupation up to the historic era (Connolly et al. 2015). Bezuksewas Village and Williamson River Bridge
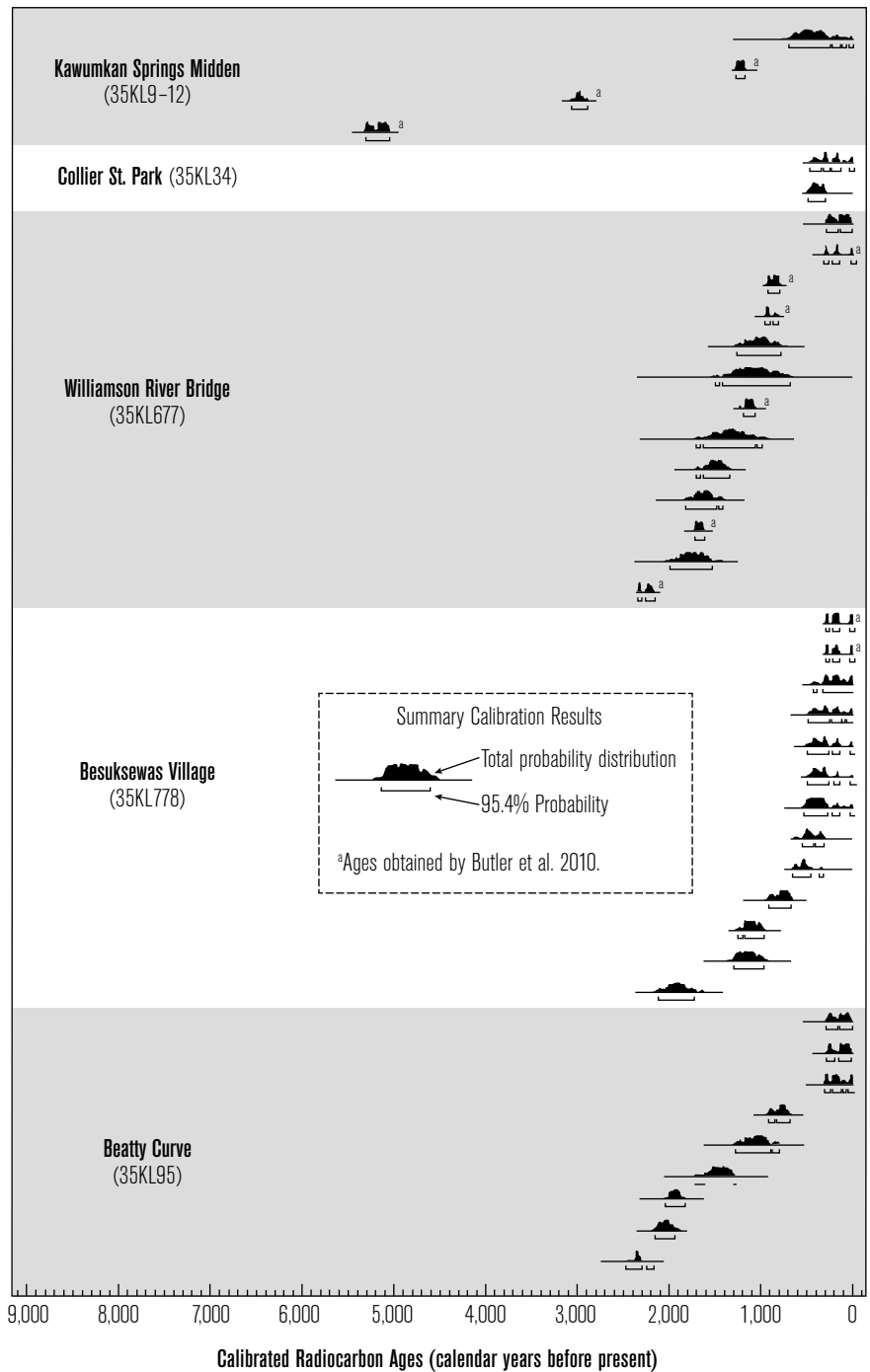

Figure 2. Probability plot of calibrated radiocarbon ages of Upper Klamath Basin archaeological sites included in study excluding shell dates. All ages calibrated using OxCal 4.2.3 (Bronk Ramsey 2014; see Table 2).

show similar trends in use, with beginning occupations at or slightly before 2,000 cal B.P., then with ongoing occupation up to the historic era. The Collier State Park site radiocarbon dates suggest occupation in the

last 500 cal years. Medicine Rock Cave did not provide radiocarbon dates, but the presence of tephra attributed to the eruption of Mount Mazama (Cressman 1956) suggests an occupation as early as 7,500 cal B.P.

Many of these site locations are linked to ethnographically-known Klamath winter villages or fish camps (Connolly et al. 2015; Deur 2003; Spier 1930), suggesting long-term connections between indigenous people and fishery resources. Some locations were of ritual significance. For example, Medicine Rock Cave was said to be the home of the Klamath creator, *Kemŭ'kŭmps*, which was also the location of a spring "First Sucker Ceremony" (Spier 1930)—similar to the first salmon ceremony of many Pacific Northwest tribes (Gunther 1915).

Despite the substantial radiocarbon record, it is difficult to place the fish records in precise time periods because of extensive stratigraphic disturbance, limited provenience information, or both. The oldest and youngest dates in a given excavation block, arbitrary level, or stratigraphic unit of an archaeological site were used to define the temporal periods, which are usually quite broad (Table 5; see Appendix). For most

sites, the clearest temporal break was between the precontact and historic era, with the latter defined as containing Euro-American related items (e.g., glass, nails, ceramics). Following previous archaeological practice (Cheatham et al. 1995), the year A.D. 1860 (90 B.P.) was used as the beginning of the historic era, as this marks the establishment of Fort Klamath and time of sustained Euro-American presence in the Upper Klamath Basin. Provenience information for Medicine Rock Cave fish remains was not available; thus the remains are linked to the full duration of possible cultural occupation, based on possible Mazama ash and projectile points with stylistic links to this long period.

Fish Taxonomic Representation

A total of 7,202 of the approximately 15,000 fish bones and teeth we examined could be identified to family, joint family, or species level (Table 5). Two species of salmonid (*O. mykiss*, redband or steelhead trout, and *O. tshawytscha*, Chinook) were identified from the DNA study. The presence of Chinook salmon in multiple sites and time periods (including the 5,300 to 5,100-year-old context at Kawumkan Springs Midden) suggests

Table 5

NUMBER OF IDENTIFIED SPECIMENS (% NISP) OF FISH TAXA BY SITE AND TIME UNIT

Site/Time Period	Salmonid	*O. mykiss*	*O. tshaw.*	*Siphat. bicolor*	*Gila coerulea*	Cyprinid	cf. *Deltistes luxatus*	Catostomid	Cyprinid/ Catostomid	Total NISP
Medicine Rock Cave[a] 35KL8										
~7,500–Historic B.P.	1	0	0	0	0	0	1	17	7	26
Kawumkan Springs Midden[a] 35KL9–12										
3,100–1,200 B.P.	3	3	0	4	0	1	3	15	76	105
5,300–5,100 B.P.	0	1	1	6	0	0	0	6	26	40
Unknown (Lev. I & IV)	5	3	1	11	1	0	3	13	58	95
Collier State Park 35KL34										
500–300 B.P.	4 (1.3)	0	0	0	0	0	4 (1.3)	263 (85.4)	37 (12.0)	308
Beatty Curve 35KL95										
Historic (A.D. 1860+)	68 (10.2)	11 (1.7)	3 (0.4)	0	1 (0.2)	32 (4.8)	10 (1.5)	357 (53.6)	184 (27.6)	666
2,500–90 B.P.	22 (3.7)	5 (0.8)	0	23 (3.9)	4 (0.7)	97 (16.4)	3 (0.5)	262 (44.3)	175 (29.6)	591
Williamson River Bridge 35KL677										
2,400–Historic B.P.	9 (0.3)	5 (0.2)	2 (0.1)	3 (0.1)	7 (0.2)	54 (1.9)	63 (2.2)	2,025 (71.9)	650 (23.1)	2,818
1,800–800 B.P.	7 (0.6)	7 (0.6)		1 (0.1)	3 (0.3)	20 (1.8)	24 (2.1)	740 (65.3)	331 (29.2)	1,133
Bezuksewas Village 35KL778										
Historic (A.D. 1860+)	12 (1.6)	4 (0.5)	0	6 (0.8)	5 (0.7)	69 (9.5)	12 (1.6)	248 (34.1)	374 (51.2)	730
700–90 B.P.	5 (1.0)	2 (0.4)	2 (0.4)	4 (0.8)	8 (1.6)	23 (4.5)	4 (0.8)	179 (35.3)	277 (55.0)	504
2,100–700 B.P.	2 (0.5)	0	0	3 (1.6)	3 (1.6)	11 (6.0)	0	68 (36.8)	99 (53.2)	186

[a]Unknown number of faunal remains originally reported not re-located; % NISP not considered.

that anadromous species of salmon migrated into the Upper Klamath Basin prior to early twentieth-century dam construction. The presence of skeletal elements representing all parts of the body suggests whole fish were captured nearby, versus only stored fish traded in from elsewhere. The remains from *O. mykiss* could be from the anadromous form or the resident redband trout.

Using osteological comparison, we identified two species of minnow (*Siphateles bicolor*, Klamath tui chub; *Gila coerulea*, blue chub) and one species of sucker (cf. *Deltistes luxatus*, Lost River sucker), although as noted above, morphological similarities between sucker species kept us from distinguishing other sucker species.

At the nominal level, the same three fish families are represented in most of the time periods defined for each site (Table 5). Exceptions are two contexts that lack cyprinid (Medicine Rock Cave and Collier State Park), which may be explained by the 1/4 in. mesh used.

In general, the same fish species are ubiquitous across sites and dated contexts, suggesting the same mix of taxa were part of the fishery for the past 5,300 years.

We focus attention on quantitative patterns for the three sites excavated since 1990, for which we have the most control over recovery and curation. We have grouped the taxonomic information at the family or joint-family level to compensate for small sample sizes and to isolate patterns for the seven time periods documented for the three sites.

The overwhelming trend is the dominance of sucker, followed by minnow (Fig. 3). Sucker is the most abundant family in all periods within sites (Fig. 3). Minnow is the second most common family in six of the time periods. The only context that breaks this trend is the Beatty Curve historical occupation, where salmonid is second after sucker. Otherwise, salmonids are the third most common fish across contexts.
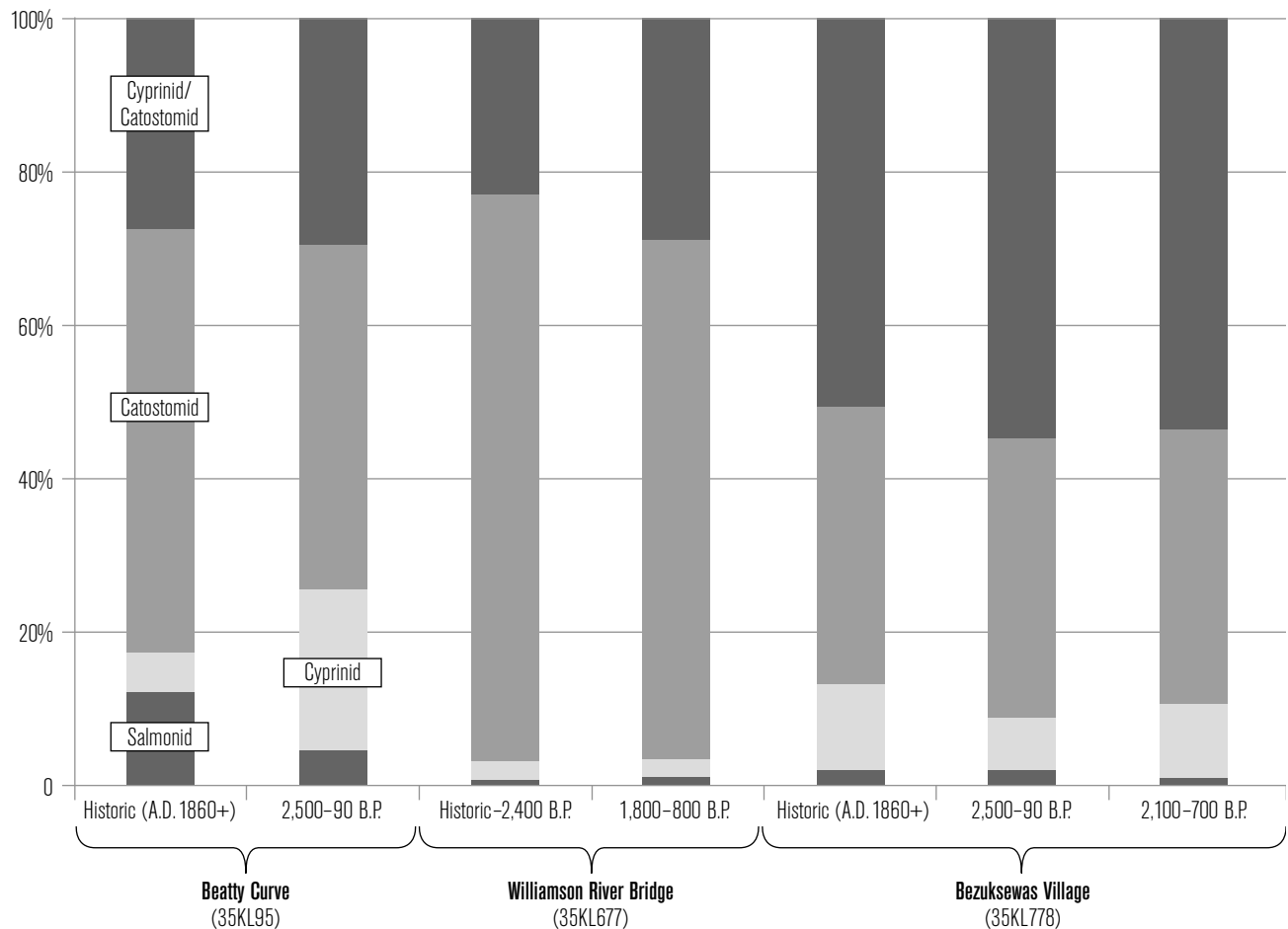

Figure 3. Proportional representation of fish group by site and time period.

Beyond this strong trend, we can examine within-site fish representation to track more subtle patterns and contrasts across the site records. First, the Williamson River Bridge and Bezuksewas Village site records show little change in fish representation through time, yet show distinct fish representation at each site. The two components at Williamson River Bridge have similarly low cyprinid frequency, whereas the three components at Bezuksewas show a consistently higher frequency of cyprinids. The two sites also consistently differ in the frequency of cyprinid/catostomid remains (more in Bezuksewas, fewer in Williamson River Bridge), which suggests different representation of vertebrae that can only be identified to this joint-family level. Beatty Curve shows the most contrast before and after European contact of the three sites. In the precontact period, cyprinid has the highest representation of any time period; the historical occupation shows the highest representation of salmonids of any period.

The *between-site* differences in fish representation could relate to subtle differences in the local habitats supporting fishes or slightly different seasons of occupation, among other factors. We are struck more with the *consistency* in fish representation over time at Williamson River Bridge (suggested to be a specialized fishing camp) and Bezuksewas (a multi-season residential base), which points to a continuity in site function or season of use before and after European contact, a time period associated with extraordinary social-demographic changes. The more dramatic change in fisheries at Beatty Curve associated with the historical occupation (decline in cyprinid; increase in salmonid) are probably linked to changes in site function, although the specific reasons for the shifts are unclear. The historical component is represented by the remains of an above-ground house that was occupied by Klamath tribal members during the late nineteenth and early twentieth century (Connolly et al. 2015). In precontact times, the site area may have been a residential base for single or extended families.

Why Sucker?

The dominance of sucker in all sites and time periods and the relative scarcity of salmonids was surprising. Does the lopsided representation reflect differences in preservation potential, sampling, differences in seasonal availability, or actual fish abundance? Our future work

will review various hypotheses to account for relative salmon bone scarcity. Here, we turn the question around, and by appealing to optimal foraging models, assert that the prominence of sucker in regional sites reflects the taxon's high ranking relative to other resources.

Lindstrom's (1992, 1996) detailed diet-breadth modeling of profitability (costs/benefits) for fishery resources of the Truckee River system of northwest Nevada/northeast California provides a basis for comparison with the Upper Klamath Basin. Historically, both basins were characterized by lake systems linked to large, snow-fed rivers that supported extremely large and more moderate-sized suckers, large-bodied salmonids, and moderate-sized to small suckers and minnows. Lindstrom estimated profitability of fish prey, considering body size, abundance, and the technology used to procure and process fish, and considered whether fish were consumed fresh or dried for delayed consumption. The "large fish" of the Truckee Basin—cutthroat trout (*O. clarki*) and the sucker, cui-ui (*Chasmistes cujus*)—are comparable in size to Klamath Basin fishes such as redband/steelhead trout, and three of the sucker species: Lost River, Klamath largescale, and shortscale sucker. Lindstrom placed both Tahoe sucker (*Catostomus tahoensis*) and tui chub in the medium and small fish category, as size varies depending on fish age and habitat. Likewise, several of the Klamath sucker and minnow species could be considered "medium" and "small" fishes for the same reasons.

Lindstrom's modeling suggests several things. First, fish (small and large)—whether freshly consumed or stored—are ranked higher than terrestrial mammals. Small fish consumed fresh had higher return rates than large or medium fish. When fish were dried, large fish outranked medium and small fish, as well as terrestrial game. Finally, fish caught using mass capture had a much higher profitability than individual fish capture (spear/harpoon, hook and line). Ethnographic records for the Upper Klamath describe a large number of fish capturing methods, but as Spier noted (1930:149), "Fish are taken mostly with nets (*wĭtco'lhus*). As among professional fishermen everywhere, line fishing is hardly sufficiently profitable to be trifled with…. There are several kinds of dip net as well as a gill net." Spier also noted that stone traps or fish dams were

> quite common in the rivers wherever a shelf of rock in the stream bed favors their construction…. These are

short dams (*sa'mkauŭs*) or wings of rocks extending out from one bank. Their purpose is to create an eddy of still water in which the fish can be netted when they take refuge from the swift current. [One example] in the low falls of middle Williamson River…takes advantage of a bend in the river bank to enclose a pool thirty-five feet across [1930:149].

In short, focusing on large-to-small fish in Great Basin environments such as the Upper Klamath Basin with rivers and lakes would be a profitable subsistence strategy, especially when joined with mass capture. Lindstrom's work does not shed any light on why suckers would be preferred over salmon, given her lumping of large suckers and salmonids into the "large" fish grouping. Along the nearby upper Pit River of northern California, the Ajumawi people targeted sucker (in this case Sacramento sucker, *C. occidentalis*), especially in the winter season when stored foods might have been depleted (Evans 1990). Consultants stated a preference for suckers over salmon, since salmon were considered less flavorful. Evans (1990) describes a complex, communal night-fishing strategy that involved the construction of stone traps; a small group of men would corral sucker in shallows where they could be easily speared.

The prominence of sucker in Upper Klamath Basin archaeological sites agrees in many ways with the ethnographic record; suckers figure prominently in Klamath history, cosmology, and traditional diet (Deur 2003; Sobel and Bettles 2000; Spier 1930). As noted previously, the Klamath celebrated a "First Sucker Ceremony" to mark the spring spawning migration of sucker, a fact which highlights the fish's importance to indigenous people. According to Jordan and Evermann (1902:57; as cited in Lane & Lane Associates 1981), Lost River sucker was "the most important food-fish of the Klamath Lakes region…running up the rivers in March and April in incredible numbers.… It is of vast importance to the Klamath Indians, who, during the spring run, catch it in immense numbers and cure it for winter use." The archaeological record supports the view that native people of the upper basin relied heavily on suckers (Lost River sucker and likely other species) for several thousand years.

Evidence for Sucker Storage

Establishing whether hunter-gatherers processed foods for immediate or delayed consumption is an important research question, as it offers insights into a myriad of factors such as hunter-gatherer organization, demography, land use, and mobility patterns (e.g., Binford 2001; Kelly 2001). Ethnographic and historical sources indicate that indigenous people in the Klamath Basin stored fish extensively (Spier 1930). Indeed, Lane & Lane Associates (1981:84) note that the severe winters would have made occupation in the area extremely challenging without storage (see also Sobel and Bettles 2000, for a lengthy review of the ways Klamath people coped with subsistence stress). Documenting the deeper history of fish storage in the Klamath Basin could help us understand how people adapted to this highly seasonal landscape of periodic food scarcity.

The main way fish storage has been studied in Great Basin archaeological contexts has involved mummified remains found in caves and rockshelters, particularly in the Lahontan Basin of western Nevada (Follet 1977; Hattori 1982; Tuohy 1990). Working in the Fort Rock Basin, Jenkins (2004) argued that the abundance of fish remains in a large pit feature reflected a stockpiling of fish for future use. To document fish storage based on faunal remains alone, a model is needed that would specify how fish bones resulting from storage processing and deposition would differ from those resulting from immediate consumption (see, for example, work carried out in the Pacific Northwest [Butler and Chatters 1994] and Alaska [Hoffman et al. 2000]). Here, we summarize previous discussions of fish processing in the western Great Basin that provide a basis for generating such a model. Most attention is on sucker, since the taxon dominates Klamath area sites.

Food storage in general has two main goals: (1) to reduce weight, thereby lowering transport costs; and (2) to reduce the likelihood of spoilage, so that the resource can be used long after capture or collection. Ethnographic records for the Great Basin emphasize that small fish such as tui chub were typically dried whole with minimal processing (Fowler 1992); tui chub remains from Humboldt and Winnemucca Caves of northwest Nevada appear to have been dried whole (Heizer and Krieger 1956; Orr 1974; Raymond and Sobel 1990).

While medium to large fish were sometimes dried whole with minimal additional processing (Fowler 1986), many descriptions suggest larger fish required butchering, which was done in order to expose internal

tissue to air for drying or to separate different units of the carcass for differential treatment. One of Willard Z. Park's consultants noted, "In the spring kuyui [= cui-ui, a large sucker species] were dried on a rack. After they were dried they were stacked one on top of the other with successive fish having its head placed in the opposite direction" (Fowler 1992:40). While not explicit, the description suggests that sometimes heads were kept with the rest of the body in the drying process. On the other hand, Fowler and Bath (1981:185) noted that "cui-ui were filleted with unhafted obsidian knives… [and]…were then dried on pole platforms." One of Margaret Wheat's consultants demonstrated the process of butchering cui-ui to make fillets:

> …she first removed the large, ugly heads. She cut the cui-ui down the back on both sides of the vertebrae, enabling her to remove the entrails and the backbone at the same time. Then she trimmed off the fins and, finally, washed the fish thoroughly before setting it out to dry. To dry the cui-ui, Harry Winnemucca cut slashes across the fish to keep them from curling, tied their tails together and hung them up with the flesh side out [1967:63–64].

Follett (1977) suggested that prehistoric people living in the Pyramid Lake area sometimes decapitated and skinned cui-ui to reduce their weight and allow them to be transported to remote locations. For the Pit River, Evans (1990:54) noted that "Suckers were scaled, gutted, and a portion of the tail removed. The head was cleaned and washed.… Removing large bones could be done at this time or later, just prior to drying."

Descriptions of fish processing by the Klamath people are comparable to those noted elsewhere. Spier noted that the "fish is slit down the back, entrails and backbone removed, the head cut off and the flanks opened…" but also stated that sometimes "the head is left on and the poles [for drying] are passed through a hole near the tail" (1930:155).

These records suggest the possibility of using frequencies of body parts (head bones vs. trunk bones, for example) to identify fish butchering and storage. If limited processing and immediate consumption were the primary activities that created the assemblages, we would expect the proportion of head and trunk parts to be consistent with a standard skeleton, which is close to 50:50 (Fig. 4). If fish were prepared for storage, we might expect an uneven frequency of body parts; the prominence of
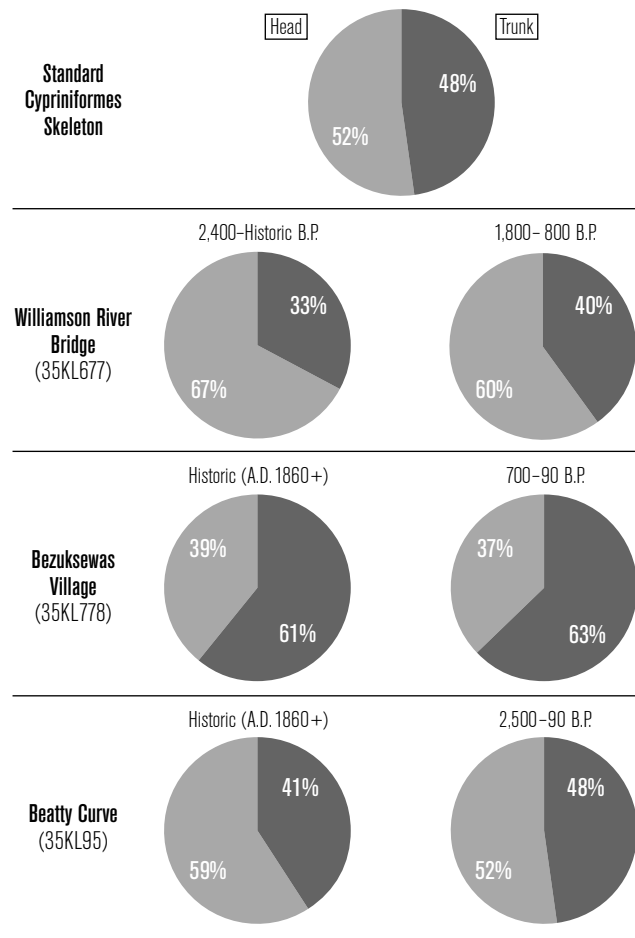

Figure 4. Comparison of cyprinid/catostomid body part representation at three project sites against a standard skeleton (note: oldest assemblage from Bezuksewas Village not included because of small sample size).

head vs. trunk parts would depend on the location of the site in the settlement and subsistence system, taking a monitoring perspective (*sensu* Thomas and Mayer 1983) into account. We would expect the greatest amount of preparation and butchery to take place at fishing camps adjacent to fish capture locations and at the beginning of the activity chain for storage and/or transport systems. One possibility is for head parts to be relatively more common if they are being removed to prepare the trunk for transport. Sites such as residential bases that were the final destination of a storage and/or transportation system should yield relatively more trunk parts.

Two sites in our study provide an excellent opportunity to test this simple model, given that they have been linked to distinct functions and places in the

settlement system. Using multiple lines of evidence, the original investigators suggested that Williamson River Bridge functioned as a fishing camp throughout its documented history and that Bezuksewas Village functioned as a residential base. Based on these interpretations and applying our model, we would expect the assemblage from Williamson River Bridge to contain relatively more head parts and for the Bezuksewas Village assemblage to contain relatively more trunk parts. As the functional setting of Beatty Curve is uncertain, we have no specific expectations about body-part representation.

We made several analytic decisions in developing tests of our expectations. Even though our focus was on suckers, given their dominance in project sites, we included all skeletal elements (such as vertebrae) attributed to cyprinid/catostomid. This decision should not greatly affect results. Most of these remains are likely from suckers, given the family's numerical dominance in project sites.

To test for the significance of the patterns in body-part representation, we used the one-sample chi square goodness-of-fit test, comparing proportional representation in archaeological assemblages to a standard skeleton (Zar 2013). We excluded the oldest component from Bezuksewas Village from our analysis of body-part representation because of its small sample size (Table 6).

Representations of head vs. trunk specimens at Williamson River Bridge and Bezuksewas Village meet the expectations for assemblages resulting from fish processing for storage. The two Williamson River Bridge assemblages have relatively more head parts than trunk parts when compared to the standard skeleton (Fig. 4), a pattern predicted from its suggested function as a fishing camp. The two assemblages from Bezuksewas Village have a relatively higher proportion of trunk parts vs. head parts, again conforming to the prediction that more of the trunk was transported to this residential base, with heads removed elsewhere. These trends are statistically significant (Table 7). Interpreting the two Beatty Curve assemblages is less clear. The precontact assemblage is almost identical to that expected from a standard skeleton (Figure 5; Table 7), suggesting that the whole body was processed and deposited in place. The historical assemblage has significantly more cranial specimens (and

Table 6

FREQUENCY (MNE) OF CYPRINID/CATOSTOMID SPECIMENS FROM THE HEAD AND TRUNK FROM PROJECT SITES

Site/Time Period	Head MNE	Trunk MNE
Williamson River Bridge 35KL677		
2,400–Historic B.P.	1,646	808
1,800–800 B.P.	587	394
Bezuksewas Village 35KL778		
Historic (A.D. 1860+)	219	340
700–90 B.P.	148	254
Beatty Curve 35KL95		
Historic (A.D. 1860+)	295	202
2,500–90 B.P.	252	231
Standard Skeleton	59	54

Table 7

RESULTS OF CHI SQUARE TESTS COMPARING BODY PART REPRESENTATION IN ARCHAEOLOGICAL SITES TO STANDARD SKELETON

Site/Time Period	df	X^2	Sig.
Williamson River Bridge 35KL677			
2,400–Historic B.P.	1	223.4	$p > .005$
1,800–800 B.P.	1	24.1	$p > .005$
Bezuksewas Village 35KL778			
Historic (A.D. 1860+)	1	36.8	$p > .005$
700–90 B.P.	1	37.1	$p > .005$
Beatty Curve 35KL95			
Historic (A.D. 1860+)	11	10.7	$p > .005$
2,500–90 B.P.		.005	$0.95 > p > 0.9$

fewer trunk specimens) than expected (Figure 5; Table 7). Perhaps this reflects local fish capture and subsequent removal of the heads on-site; the remaining part of the body was transported elsewhere. Although we had no specific expectations about body-part representation, the remains recovered from the precontact assemblage would seem to support Connolly et al.'s (2015) interpretation of the site as a residential base.

Before accepting these results at face value, we need to consider taphonomic factors, such as skeletal element density, that could contribute to the differential representation of body parts at the sites (e.g., Butler and Chatters 1994; Lyman 1984). Element density studies have shown that all things being equal, skeletal elements (or segments of elements) with the highest bone mineral content (g./cm.^{3}) will survive post-depositional
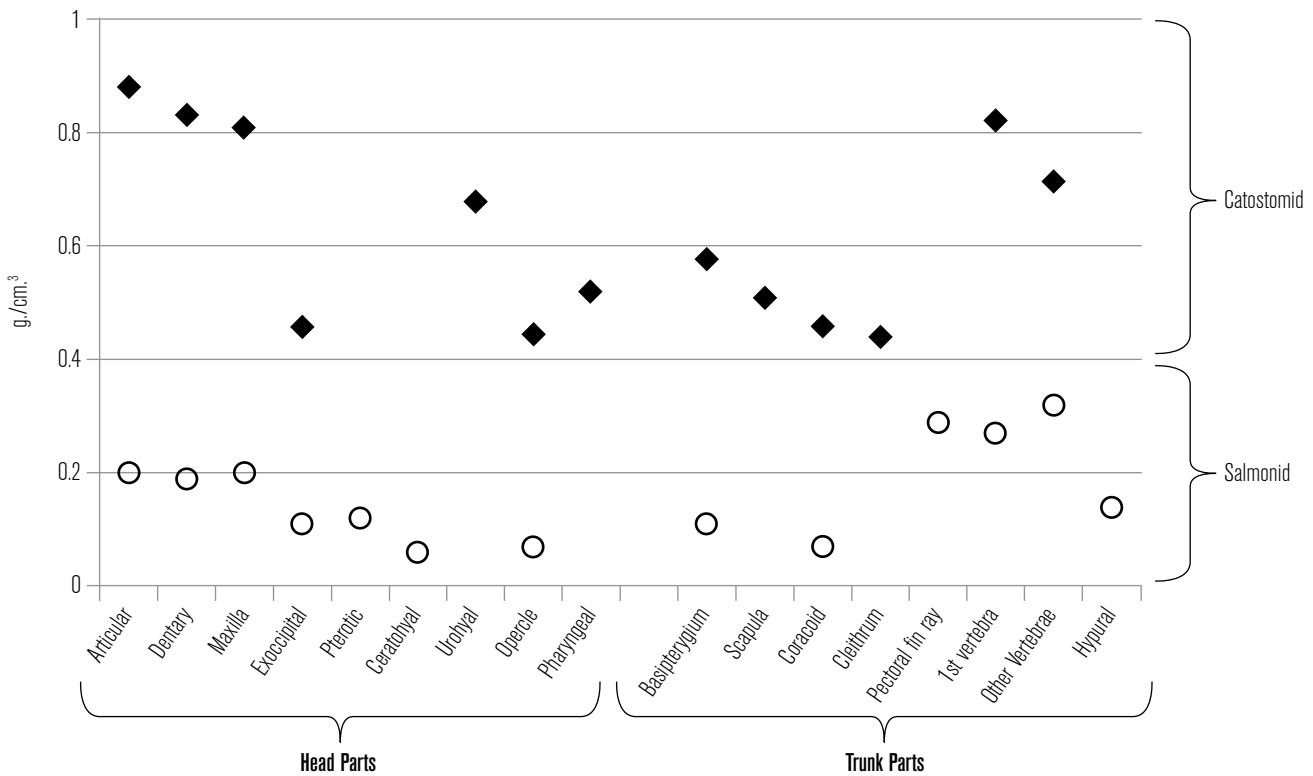
Figure 5. Comparison of bone mineral density (g./cm.³) in catostomid vs. salmonid skeletal elements. Catostomid values based on measures from five individuals (see Butler and Chatters 1994 and Butler 1996 for information on methods).

destruction with higher frequency than those elements with lower mineral density. Researchers have determined skeletal element densities for a range of vertebrate taxa, which provides an independent way to assess the extent to which body-part frequency reflects original human animal butchering and processing behavior; i.e., which parts were originally deposited at a location, or were simply those specimens that survived various destructive processes (Lam and Pearson 2005). For example, Butler and Chatters (1994) showed that salmonid cranial elements tend to have lower bone mineral content than elements of the trunk, and therefore are less likely to preserve post-depositional destruction. However, similar measures for sucker (*Catostomus macrocheilus*), which serves as a reasonable analog for the Klamath suckers, suggest a different pattern (Fig. 5). First, sucker skeletal elements tend to have much higher densities than salmonids, suggesting sucker remains may survive post-depositional destruction better than salmonids. Of particular relevance to sucker butchery questions, however, is the fact that sucker element density values are much more variable than salmonids. Cranial and trunk

elements have relatively high, medium, and low values (Fig. 5). The implication is that density *per se* does not easily account for the disproportionate representation of head vs. trunks parts (a similar pattern exists for Pacific cod [*Gadus macrocephalus*]; see Smith et al. 2011). Thus, the relative scarcity of cranial remains at Bezuksewas Village and their abundance at Williamson River Bridge is not easily linked to a general factor such as preservation. Moreover, if post-depositional destruction contributed to the distinctive body-part representation, we would expect fragmentation to *differ* between sites. One measure of fragmentation is the percentage of the total number of fish specimens that could be identified to family or below. As seen in Table 8, the percentage of identified specimens does vary across contexts, but not in any way that could explain the variable representation of body parts. The two assemblages at Williamson River Bridge show the greatest difference in percentage identified (34% vs. 46%), yet both contexts show a high representation of head parts.

In sum, our review suggests that the distinctive patterns in body-part representation at two of our sites

Table 8

PERCENTAGE IDENTIFIED FISH SPECIMENS AS INDICATION OF FRAGMENTATION, SITES 35KL677 AND 35KL778

Site/Time Period	Percent Identified Specimens
Williamson River Bridge 35KL677	
2,400–Historic B.P.	34.3
1,800–800 B.P.	46.4
Bezuksewas Village 35KL778	
Historic (A.D. 1860+)	34.5
700–90 B.P.	37.2

reflect something real about original human behavior in relationship to fish processing. We make the inferential leap that the trends are linked to fish storage, while we recognize that much more scrutiny of this is needed, both in terms of modeling and empirical reviews of additional site records.

CONCLUSIONS

Our project has many values. While the focus was on fisheries, our background work, including obtaining new radiocarbon ages, clarifies the timing of human occupation of the region. Three new radiocarbon ages from Luther Cressman's project site, Kawumkan Springs Midden (35KL9–12), show that occupation extends back to ~5,300 cal B.P. years, corroborating previous obsidian hydration ages for the site. Eight additional radiocarbon ages for Williamson River Bridge and Bezuksewas Village pushed back the history of occupation at these sites; however, they also illustrate the extent of post-depositional mixing, which increased the length of the time periods we were able to use.

Our project also reaffirms the importance of curated museum collections for addressing evolving research goals and questions. All but one of the project sites were excavated decades ago, mainly as part of mitigation projects for cultural resource management. Indeed, the very construction projects which instigated the archaeological work have greatly diminished the archaeological sites. Thus the curated collections are sometimes the main source of site information.[1] Such collections can be challenging to work with, with problems such as controlling for curation bias; nonetheless, they can provide a relatively low-cost, low impact way of addressing a range of questions (e.g.,

in conservation biology and habitat restoration; see Wolverton and Lyman 2012).

Our study also provides a simple model for documenting fish butchery for storage purposes using body-part representation of suckers and minnows, fish types common to Great Basin archaeological sites. "More work is needed," of course, to further explore the linkage we have made—that the high frequency of cranial elements at fish camps and their low frequency at residential bases reflects the preparation of fish for storage. However, our results were provocative with regard to the assemblages we studied, suggesting the value of pursuing this line of research in the future.

Our project demonstrates that there was an extraordinary degree of stability in fish selection and use in the region over several millennia. At least one species of sucker, two species of minnow, and two species of salmonids were part of the resource mix; while some of the stability seen in the archaeological record may be tied to the coarse temporal units employed, when we were able to isolate finer-scale time units (such as the historical period), the main trends are maintained. As a measure of the enduring character of the indigenous fishery, most of the project sites are ethnographically-known fishing locales (Deur 2003; Spier 1930). This stability is particularly noteworthy in light of changes that likely occurred in settlement-subsistence patterns or in Holocene environments, or both, which were not considered here. In another sense, the overall record for stability in Native American fisheries stands in sharp relief to current conditions. Almost all of the extant fish taxa in the Upper Klamath Basin have experienced major declines over the past 100 years, mainly from habitat degradation associated with agricultural development (NRC 2004). Records such as those presented here provide empirical testimony regarding the long and enduring relationships between people and fish in this region.

APPENDIX

The Holocene History of Fish and Fisheries in the Upper Klamath Basin, Oregon

[Appendix: Explanation for time units used in study. Dates attributed to Cheatham (1991) and Cheatham et al. (1995) below are calibrated 1-sigma dates as reported by

the original author; other dates are reported as calibrated 2-sigma age ranges and rounded to the nearest century.]

Medicine Rock Cave: The fish remains were not associated with excavation level information; thus we had to assign all the remains to a single time unit. While radiocarbon ages were not available, Cressman (1956) noted a tephra at the base of excavation, which he attributed to the eruption of Mount Mazama (with a calibrated age of ~7,500 cal B.P.). Projectile points representing time periods spanning the Holocene and historical remains were noted in the cave deposits. We thus assigned all the remains to this extended time period, 7,500-Historic cal B.P.

Kawumkan Springs Midden: Cressman's (1956) excavation levels (from which faunal remains were documented) were used as a basis for establishing time units at this site. One radiocarbon age, 4,510±20 B.P., was determined from bone recovered from excavation Level III; this represents our 5,300–5,100 cal B.P. time period. Two radiocarbon dates on bone from Level II suggested occupation between approximately 3,100 and 1,200 cal B.P. Libby (1954) obtained a radiocarbon age of 435±165 B.P. on a large piece of wood from a pit house at this site; when calibrated, this date yields an age of 700 cal B.P. to modern. The position of the wooden house post that yielded this date in relation to the fish remains studied here is uncertain. Given this and the large range of uncertainty, we did not include it in our time period assignment. Radiocarbon dates were not obtained for material from Level IV. Because of sampling issues and the lack of certainty regarding the age of Level I deposits, fish remains from Levels I and IV were combined into our unknown time period in Table 5.

Collier State Park: All of the faunal remains were assigned to a single time unit. The absence of historical-era materials and two radiocarbon dates of 240±50 and 310±40 suggest an occupation between 500–300 cal B.P. (Butler et al. 2010; Cheatham 1990).

Beatty Curve: Faunal remains were assigned to two time units—a historical period (A.D. 1860+), represented by all of the remains recovered from the eastern side of Highway 140, and a prehistoric period (2,300–90 cal B.P.), which includes all the remains from the west side of the highway. The time span of the earlier component is based on radiocarbon dates from charcoal, not shell, obtained

by Connolly et al. (2015) and on the scarcity of historic-era artifacts.

Williamson River Bridge: Freshwater shell dates obtained by Cheatham (1991) were not used for time unit assignment. Cheatham (1991) defined three cultural components on the west side of the site (west of State Highway 97). Component 1 was defined as a late precontact to historic-period component based on a single radiocarbon date and the presence of historic artifacts. Five radiocarbon ages and a large number of small Gunther series projectile points were the basis for Cheatham's (1991) age designation for Component 2, A.D. 250–A.D. 900 (1,700–1,050 cal B.P.). Cheatham's age designation for Component 3 of A.D. 1–A.D. 250 (1,950–1,700 cal B.P.) is drawn from a single radiocarbon date and a mixed suite of projectile points. No cultural components were defined on the east side of the site because sediment was mixed; however, Cheatham's (1991) radiocarbon dates suggest occupation between approximately A.D. 70 and A.D. 980 (1,880–970 cal B.P.). Our additional radiocarbon dates suggest that deposits on the west side were very mixed. We identified multiple stratigraphic inconsistencies in radiocarbon dates, including the oldest date at the site, 2,250±20 B.P., above a sample approximately 1,000 years younger. Because of these issues, we collapsed Cheatham's cultural components on the west side of the highway into one: 2,400–Historic B.P. time period. On the east side of the site, we relied on our dates, which slightly increased the time span of the occupation on the eastern side of the site, which accounts for cultural material assigned to the 1,800–800 cal B.P. time period.

Bezuksewas Village: Freshwater mussel shell dates obtained by Cheatham et al. (1995) were not used in our time period assignments. Cheatham identified three distinct cultural components at this site, with two sub-components in the latest period. Component 3, Mid-Holocene to A.D. 250 (~5,000–1,700 cal B.P.) was identified based on the presence of Elko Side Notched projectile points and a single radiocarbon date. Component 2 is marked by a decrease in large projectile points and an increase in Gunther series points, as well as a series of three radiocarbon dates which range from A.D. 790 to A.D. 1225 (1,160–725 cal B.P.). The presence of historic-era artifacts is used to differentiate Components 1a and 1b. Component 1b includes Desert Side Notched

and Gunther series points as well as seven radiocarbon dates between A.D. 1430 and A.D. 1795 (520–125 cal B.P.). Finally, Cheatham et al.'s (1995) Component 1a is defined by the presence and large numbers of historic-era artifacts as well as Desert Side Notched projectile points. Again, because of our additional radiocarbon dates and observed stratigraphic inconsistencies in dates, we collapsed some of Cheatham et al.'s (1995) cultural components into large time periods. We collapsed components 2 and 3 into a single time period, dating between approximately 2,100 and 700 cal B.P. We did not collapse components 1a and 1b into a single time period because of the overwhelming presence of historic-era artifacts in Component 1a; this became our Historic (A.D. 1860+) time period. Component 1b then became our time period 700–90 cal B.P.

NOTES

[1]One important exception to this is the Kawumkan Springs Midden, which appears to have substantial intact deposits. Given radiocarbon dates extending back to the mid-Holocene, this site would be an excellent candidate for future field research on ancient fisheries.

ACKNOWLEDGEMENTS

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