JOURNAL OF NORTHWEST ANTHROPOLOGY

VOLUME 42 FALL 2008 NUMBER 2

TOWARDS THE IDENTIFICATION OF LAMPREYS (*LAMPETRA* SPP.) IN ARCHAEOLOGICAL CONTEXTS

Ross E. Smith and **Virginia L. Butler**

ABSTRACT

Lampreys were and continue to be an important resource for Native Americans in the Pacific Northwest. Lampreys possess several skeletal structures that are regularly identified in marine mammal and bird stomach contents and fecal samples, suggesting that lamprey elements may preserve in archaeological contexts. However, their remains have not been identified in archaeological faunal samples in the Pacific Northwest. This may be due to the lack of an adequate "search image" for lamprey remains among faunal analysts and limited use of fine screen sampling. Descriptions and photographs of lamprey remains that are most likely to survive in archaeological contexts are presented to increase awareness of lamprey anatomy. Horn-like teeth located around the lamprey oral disc are the largest and most distinctive elements that may be encountered in archaeological samples. Use of standard 1/8 in. (3.2 mm) and 1/16 in. (1.6 mm) mesh will retain elements from mature adult Pacific Lampreys.

Introduction

Lampreys (*Lampetra* spp.) were and continue to be an important resource for many Native Americans in the Pacific Northwest. While it is likely that this fish was utilized prior to the contact period, lamprey remains have not been identified in Pacific Northwest archaeological settings. We suggest they are an underappreciated component of prehistoric subsistence systems in the region. While lampreys lack a bony skeleton, they possess mineralized dental plates and statoliths (specialized structures similar to otoliths in teleost fishes). Such structures are robust enough to have been recovered in the fecal material and stomach contents of marine mammals and birds, suggesting they might preserve in archaeological contexts.

Establishing the presence and distribution of lampreys from archaeological contexts is important for several reasons. Understanding their role in past human subsistence is of obvious value. With recent declines in lamprey populations, fishery scientists and resource managers have emphasized the need for detailed historical records regarding the distribution and abundance of lamprey populations prior to industrial fishing, introduction of alien species and

modification of Pacific Northwest river environments to inform future management decisions (Kostow 2002; Moser and Close 2003). Archaeological sites provide a repository for such data (Butler and Delacorte 2004; Gobalet 2004; Lyman and Cannon 2004).

Over 30 years ago, Casteel (1972) suggested that lamprey remains may be present in western North American archaeological contexts. Why have their remains *not* been documented since his publication? We suggest four possible reasons: lack of knowledge of lamprey anatomy and morphology of lamprey elements, inadequate field and lab recovery methods, low presser-vation potential, and finally limited human use. This paper addresses the first two factors. Our goal is to familiarize archaeologists with the lamprey physical remains that may be encountered in the course of archaeological investigations. We also describe the appropriate sampling and identification strategies to document the occurrence of lampreys in archaeological faunal assemblages.

Natural History

Lampreys (family Petromyzontidae) are members of the superclass Agnatha ("jawless fishes"). They possess an elongated eel-like body form and lack jaws, internal ossification, scales, and paired fins (Fig. 1) (Wydoski and Whitney 2003). Many Native Americans in the Pacific Northwest refer to lampreys as "eels." True eels are part of a different evolutionary line within the "jawed vertebrates," superclass Gnathostomata, Order Anguilliformes. The lamprey life cycle involves two stages: a larval stage (during which they are referred to as ammocoetes) followed by an adult stage. Ammocoetes burrow into river sediments and filter feed for up to six years. At the end of the ammocoete stage, larvae transform into the adult form, which involves development of eyes and an oral disc with pointed, horn-like teeth. At the end of their meta-morphosis, adult lampreys assume a parasitic or nonparasitic mode of life. Parasitic forms are usually migratory, spending the majority of their adult life in marine environments where they feed on fish or other organisms, and then return to rivers to spawn. Most lampreys die soon after spawning, although cases of multiple spawning migrations have been observed (Michael 1980, 1984; Kostow 2002; Wydoski and Whitney 2003). Nonparasitic lampreys typically spend more time in their larval stage and significantly less time in their adult stage. It is common for nonparasitic lampreys to spawn and die within a month of their metamorphosis.

Three lamprey species from the family Petromyzontidae are generally recognized in the Pacific Northwest. Two of these taxa, the Pacific Lamprey (*Lampetra*, subgenus *Entosphenus tridentata*) and the Western River Lamprey (*Lampetra ayresi*) are anadromous, while the River Lamprey (*Lampetra richardsoni*) spends its entire life in freshwater river systems. In addition to these three species, several enigmatic lamprey taxa have also been described in Washington, Oregon, and northern California (Kostow 2002). The Pacific Lamprey, which may grow up to 750 mm in length, is the largest and most commonly recognized lamprey species found in the Pacific Northwest. River and Western Brook Lampreys are typically much smaller (averaging 280 mm and less than 180 mm in length respectively) (Hart 1973; Wydoski and Whitney 2003).

Ethnohistoric Lamprey Utilization

Lampreys were a seasonally abundant resource that was widely used by the indigenous peoples of the Pacific Northwest. A review of the published accounts of Native American subsistence practices from the Northwest Coast and Plateau culture areas (Suttles 1990; Walker

1998 editor) reveals that lamprey are listed as food items for 13 out of 43 named Native American tribal groups (Table 1). Detailed descriptions of the cultural importance and traditional ecological knowledge of lampreys have been collected and published for American Indian groups such as the Umatilla (Close et al. 2002; Close et al. 2004). At least two types of lamprey are recognized and distinguished by native peoples on the Plateau (Close et al. 2004). Among Sahaptin speaking peoples along the Yakima River, two different names are used to refer to lampreys from the stretches of the river above and below Rock Creek (Hunn et al. 1990).

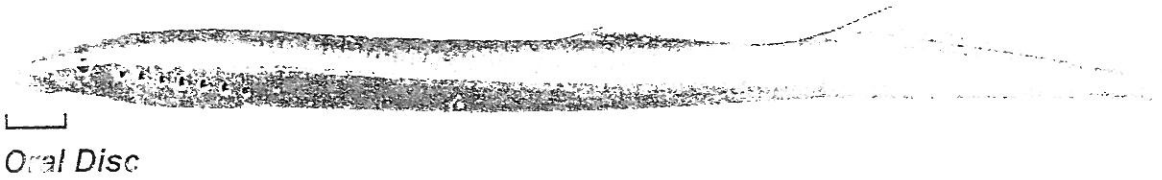

Fig. 1. Photograph of a Pacific Lamprey (*Lampetra tridentata*). Reproduced courtesy of Wydoski and Whitney (2003).

Lampreys were primarily harvested during the summer months in the course of their annual upstream migration towards the spawning grounds. Since lampreys are not fast swimmers, they tend to congregate at waterfalls where steep grades and fast flows slow their progress upstream. At these locations, lampreys use their oral discs to attach themselves to the surface of rocks to rest in the water, and in the steepest portions they may use their oral discs to secure themselves to the rocks as they slowly crawl up over the falls. Native peoples harvested lampreys on both the mainstem of large river drainages at locations such as Celilo Falls and Kettle Falls on the Columbia River (Morris 1975; Close et al. 2004), and from tributary drainages such as at Willamette Falls on the Willamette River (Kostow 2002).

If the area were accessible, lampreys were picked off the surface of rocks around a falls by hand or with a hook (Close et al. 2004). Dipnets with small mesh were also used below the falls (Close et al. 2004) and lamprey harvest sometimes occurred at night. While lampreys were sometimes taken at the same locations as salmon, it is clear from ethnohistoric accounts that lampreys were sought specifically, and were not simply incidental catch in the course of the salmon fishery (Close et al. 2004). According to these accounts, lampreys were eaten fresh but also frequently processed and stored for later consumption. For example, in early July 1835, John Townsend, botanist with the Wyeth Expedition, noted thousands of lampreys smoke-curing in Native American houses near the Cascades, a major rapid now submerged behind Bonneville Dam, Columbia River (Thwaites 1966:346–347 as cited in Martin 2006). Besides food, lampreys were used for medicinal purposes; lamprey oil was put on distressed areas of the body, used to cure ear aches, and condition hair (Bonneville Power Administration 2005). In addition, the Nez Perce utilized lampreys as bait for sturgeon (Walker 1998).

By comparing abundance estimates from early historic observations with recent counts of lampreys passing through fish ladders at dams, it is clear that Pacific Northwest lamprey populations have experienced severe declines over the last 70 years (Kostow 2002; Moser and Close 2003). Cases of unintentional extirpation of anadromous lamprey populations trapped upstream of dams following dam construction have been recorded (Beamish and Northcote 1989; Wydoski and Whitney 2003). Lamprey populations perceived to be a threat to salmon and trout fisheries in some river systems were intentionally reduced through poisoning (Close et al. 1995).

TABLE 1. PLATEAU AND NORTHWEST COAST NATIVE AMERICAN LAMPREY USE BASED ON THE HANDBOOK OF NORTH AMERICAN INDIANS (SUTTLES 1990; WALKER 1998 editor)

Area	Group	Lamprey Utilized
Plateau	Lillooet	+
	Thompson	-
	Shuswap	-
	Nicola	-
	Kootenai	-
	Okanagan, Lakes, and Colville	+
	Middle Columbia River Salishans	+
	Spokane	+
	Kalispel	-
	Flathead and Pend d'Oreille	-
	Coeur d'Alene	-
	Yakima	+
	Palouse	-
	Wasco, Wishram, and Cascades	+
	West Columbia River Sahaptins	+
	Cayuse, Umatilla, and Walla Walla	-*
	Nez Perce	+
	Molala	-
	Klamath and Modoc	-
Northwest Coast	Eyak	-
	Tlingit	-
	Haida	-
	Tsimshian	-
	Haisla	-
	Haihais, Bella Bella, and Oowekeeno	-
	Bella Coola	-
	Kwakiutl	-
	Nootkans	-
	Makah	-
	Quileute	-
	Chemakum	-
	Northern Coast Salish	-
	Central Coast Salish	-
	Southern Coast Salish	-
	Southwestern Coast Salish	+
	Kwalhioqua and Clatskanie	-
	Chinookans of the Lower Columbia	-
	Kalapuyans	+
	Tillamook	+
	Alseans	-
	Siuslawans and Coosans	+
	Athapaskans of Southwestern Oregon	+
	Takelma	-

* Subsequent research by Close et al. (2002) and Close et al. (2004) have documented extensive use of lampreys by the Umatilla.

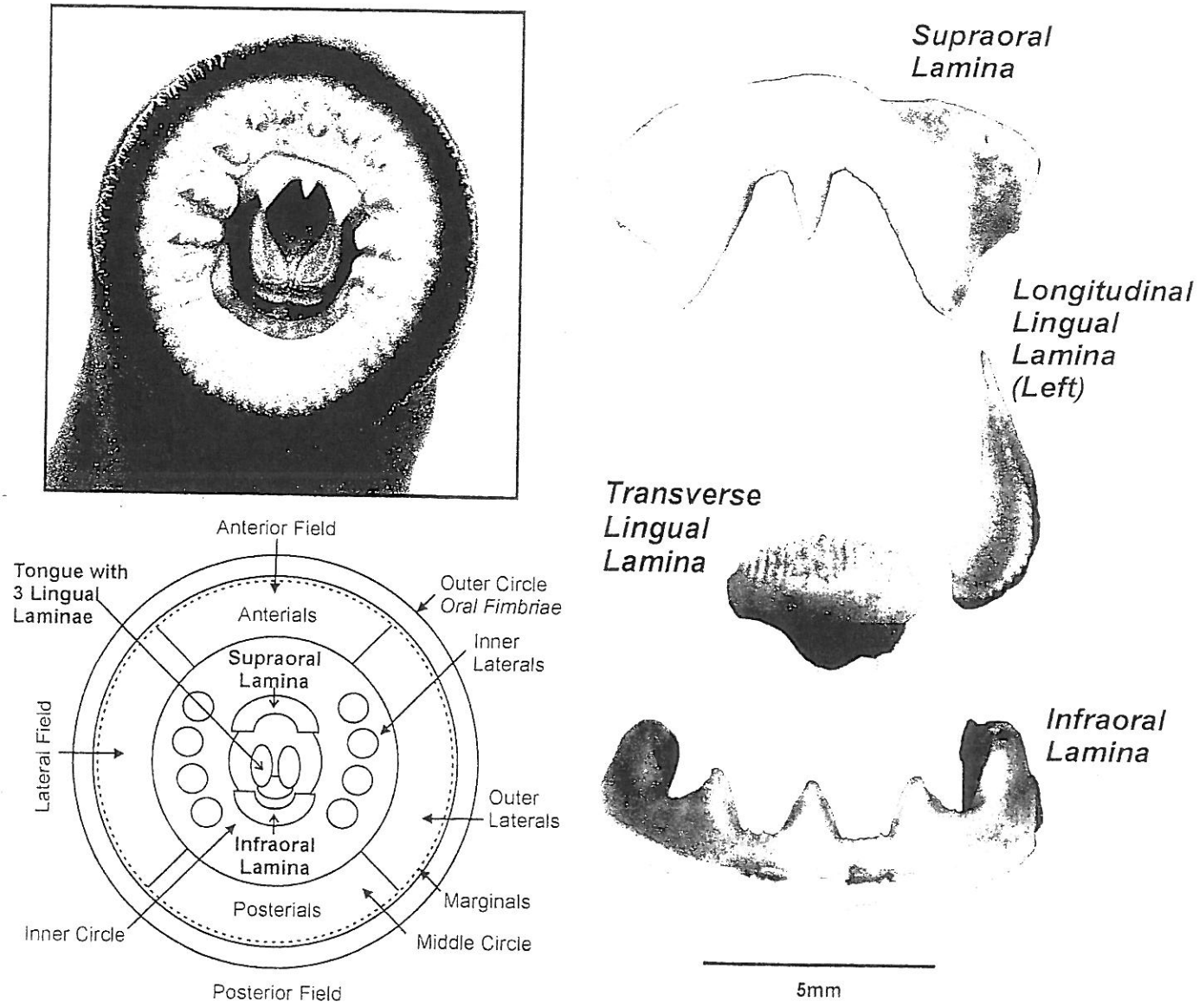

Fig. 2. Top left, photograph of Pacific Lamprey (*Lampetra tridentata*) oral disc and the idealized oral disc and dentition of a lamprey (Petromyzontidae); bottom left, illustration modified from Casteel (1972:78); right, anterior view of Pacific Lamprey oral disc dentition (PSU Reference Specimen No. 07-2-1). Reproduced courtesy of Wydoski and Whitney (2003). Additional photographs at <http://web.pdx.edu/~virginia/photocollection.htm>.

The loss and degradation of spawning and rearing habitat, mortality during downstream migration at hydroelectric dams, and increased predation pressure by non-native species have also contributed to declines in lamprey populations (Moser and Close 2003). Native American communities in the Pacific Northwest were among the first to recognize the decrease in lamprey abundance and have urged management agencies to study existing lamprey populations and restore diminished populations (Kostow 2002; Close et al. 2004).

Taxonomic Identification from Skeletal Structures

Lampreys have two types of hard skeletal structures that could be preserved in archaeological deposits. The surface of a lamprey's oral disc is covered with pointed teeth or dental plates (Fig. 2) and paired statoliths (specialized internal structures similar to otoliths in teleost fishes) are found in the labyrinth chambers of the cranium (Jebbink and Beamish 1995).

Lamprey teeth are not true teeth as known for other vertebrates, but rather hollow pointed structures with one or more cusps made of keratin—a form of protein comprising hair, claws, hooves, and horn—that appear to develop from epithelial cells (Warren 1902). Taxonomic identifications are made using the shape and number of the cusps found on the principal teeth, specifically the supraoral and infraoral laminae located along the anterior and posterior margins of the mouth, and the lingual teeth located on the surface of the tongue (Vladykov and Follett 1958). The lingual teeth are composed of a pair of longitudinal lingual laminae and a single transverse lingual lamina (Fig. 2). Since the Pacific Lamprey is the largest and most commonly occurring lamprey species found in the Pacific Northwest, the following discussion will focus on the dental characteristics that are most useful in identifying this species.

The Pacific Lamprey supraoral lamina bears two larger pointed cusps lateral to a third smaller cusp at the center of the element and the infraoral lamina is semicircular in shape with five sharp cusps (Fig. 2; Table 2). In contrast, the River Lamprey exhibits two cusps on the supraoral lamina and six or more cusps on the infraoral lamina. Regarding the lingual laminae, Pacific Lamprey collected in Oregon possessed between 17 and 21 cusps on the transverse lingual lamina and from 18 to 28 cusps on the paired longitudinal lingual laminae (Kan 1975:40). Both the Pacific and River Lampreys possess an enlarged median cusp on the transverse lingual lamina. However, the River Lamprey exhibits fewer cusps on both transverse and longitudinal lingual lamina (Kan 1975:41; Vladykov and Follett 1958:57). The presence or absence of posterior teeth and the number of paired lateral teeth are also useful for distinguishing intact specimens of Pacific Lampreys from River and Western Brook Lampreys (Table 2).

TABLE 2. DISTINGUISHING LAMPREY ORAL DISC ATTRIBUTES

Name	Supraoral Lamina	Infraoral Lamina	Lateral Teeth	Posterior Teeth
Pacific Lamprey (***Lampetra tridentata***) Maximum Length: 30 in. (~760 mm)	3 Cusps	5 Cusps	4 Pairs	Present
River Lamprey (***Lampetra ayresi***) Average Length: 11–12 in. (~280–300 mm)	2 Cusps	6+ Cusps	3 Pairs	None
Western Brook Lamprey (***Lampetra richardsoni***) Average Length: Less than 7 in. (<180 mm)	Very Small Weakly-Developed Rounded Teeth			

Sources: Hart (1973), Wydoski and Whitney (2003).

While the criteria presented above are commonly employed to identify mature adult Pacific Lamprey, species determinations may be complicated by changes in lamprey dentition associated with maturation and reproduction. It has been estimated that lampreys may shed and replace their teeth from 20 to 40 times between transforming into adults and spawning (Hardisty and Potter 1971). Captive studies of Pacific Lampreys demonstrated that young adult Pacific Lampreys may exhibit only two cusps on their supraoral lamina and that the third cusp develops between four and six weeks after transformation (Wydoski and Whitney 2003). Morphological and physical changes are also associated with the spawning migration (Hardisty and Potter 1971). In some lampreys, the approach of spawning may be accompanied by the shedding and replacement of sharp-cusped teeth with blunter teeth, or the degeneration and fusion of disc teeth into a single mass (Kan 1975).

The second type of hard skeletal structures found in lampreys are the statoliths. Statoliths are composed primarily of noncrystalline calcium phosphate and small amounts of calcium carbonate. These structures assist in the orientation and balance of the lamprey and grow by acquiring additional rings at regular intervals in the course of a lamprey's life. While statoliths are not commonly used to make specific taxonomic identifications, statoliths have been used to make age determinations (Beamish and Medland 1988; Jebbink and Beamish 1995).

Assessing Preservation Potential

Lamprey fossils are present in Upper Carboniferous fossil locales in North America (Forey 1995) and have recently been discovered in Early Cretaceous fossil locales in China (Chang et al. 2006). Although these fossils clearly exhibit cartilage that supports the oral disc and the branchial basket (Bardack and Zangerl 1971; Forey 1995; Chang et al. 2006), dental plates are not visible in the fossils. Lamprey dental plates have been recovered and identified from the stomach contents and feces of extant marine mammals and cast pellets of birds along the Northwest Coast (Roffe and Mate 1984; Ford et al. 1998; Lance et al. 2001; Browne et al. 2002; Couch and Lance 2004), the coast of New Zealand (Imber 1976), and the South Georgia Islands of the southern oceans (Xavier et al. 2003). The presence of identifiable lamprey dental plates from these contexts, and the recovery of other rigid proteinaceous materials (such as the chitin exoskeletons of insects and marine arthropods) in archaeological contexts, suggests that lamprey dental plates should also be preserved under certain conditions. While there are anecdotal accounts of "dried eel" being recovered from a cache pit located in McGregor Cave near Joso, Washington, on the Palouse River, in 1953 (Mallory 1966; Kirk and Daugherty 2007), this material has not been systematically analyzed and lampreys have not been subsequently identified among the faunal remains recovered from archaeological sites in the Pacific Northwest.

Recovery Recommendations

The small size of lamprey dental plates and statoliths suggest that relatively fine mesh sizes are needed to recover these elements from archaeological contexts. Although numerous statoliths form in the labyrinth chambers of the lamprey's cranium, lamprey statoliths are extremely small, the largest reaching a maximum length of between 100 and 250 μm (Jebbink and Beamish 1995). Therefore, it is unlikely that lamprey statoliths would be recovered from archaeological samples using even extremely fine mesh (for example 1/128 in.). Descriptions of

the screening of albatross stomach contents suggests that identifiable lamprey dental plates may be recovered using ~1/8 in. (3.2 mm) or smaller mesh (Xavier et al. 2003). However, differences in the size of dental plates found in different lamprey taxa would influence recovery, particularly of fragmentary remains.

To provide a crude estimate of the minimum mesh size needed to recover Pacific Lamprey dental plates, we attempted to pass complete dental plates from two modern Pacific Lamprey reference specimens (PSU07-2-1, 520 mm total length; PSU07-2-2, 665 mm total length) through archaeological screens with 1/4 in. (6.4 mm), 1/8 in. (3.2 mm), and 1/16 in. (1.6 mm) mesh openings. We included the supraoral, infraoral, and three lingual laminae (Fig. 2) in this test because they are the largest, most easily recognized elements used to make species level identifications. While dental plates were not retained in the 1/4 in. mesh, the 1/8 in mesh retained the supraoral and infraoral laminae. The lingual laminae were only caught by the 1/16 in. mesh. Degree of fragmentation and other factors would obviously affect the likelihood of recovering lamprey dental plates in screens of varying mesh sizes. Recent laboratory analysis of bulk samples from a lower Columbia archaeological site that were processed through 1 to 2 mm mesh shows the value of including such samples in research (Butler 2005). Extremely small fish (for example three-spine stickleback (*Gasterosteus aculeatus*) and eulachon (*Thaleichthys pacificus*)) were primarily found in bulk sample processing; their frequency (as measured by Number of Identified Specimens) greatly surpassed counts of fish such as sturgeon (*Acipenser* sp.) and salmon (*Oncorhynchus* sp.). We recommend that future research designs related to faunal recovery include some bulk samples and laboratory processing to establish the presence and abundance of fish such as lamprey from archaeological contexts.

Summary

In spite of abundant evidence of Native American lamprey utilization in ethnohistoric and contemporary accounts, and anecdotal accounts of "dried eels" from McGregor Cave, lamprey remains have not been identified in archaeological contexts in the Pacific Northwest. As noted, four factors could account for this absence, including low preservation potential, the limited use of fine screen recovery methods in the field and lab, lack of knowledge on the part of the analysts who process archaeological samples, and a lack of use by native peoples. The last possibility seems unlikely due to their significance in oral traditions and widespread use by Native Americans in the Pacific Northwest during the post-contact period (Close et al. 1995). It is more likely that regional archaeologists and even faunal specialists have not had an adequate search image to identify lamprey remains.

This work addressed the "lack of knowledge" problem by presenting detailed descriptions and photographs of diagnostic structures most likely to survive in archaeological contexts. It is hoped that increasing awareness of the importance of lampreys in the Pacific Northwest, improving knowledge of lamprey anatomy, greater use of fine mesh recovery methods, and future research projects focused specifically on documenting native use of lampreys in the Pacific Northwest (Neuman in press), will result in the inclusion of lampreys among the fish taxa recovered and identified in the course of archaeological research.

ACKNOWLEDGEMENTS

We thank Luis Ruedas for his generous assistance and the use of a microscope digital camera, Dave Hatch for help in securing the modern lampreys we studied, and the University of Washington Press for permission to republish images of the Pacific Lamprey body and oral disc. We also appreciate the thoughtful and most helpful comments on the manuscript from Dennis Dauble, Julie Longenecker, and Pat Lubinski.

REFERENCES CITED

Bardack, David, and Rainer Zangerl
1971 Lampreys in the Fossil Record. In *The Biology of Lampreys*, Martin W. Hardisty and Ian C. Potter, editors, pp. 67–84. Academic Press, New York.

Beamish, F. William H., and T. E. Medland
1988 Age Determination for Lampreys. *Transactions of the American Fisheries Society*, 117(1):63–71.

Beamish, Richard J., and Thomas G. Northcote
1989 Extinction of a Population of Anadromous Parasitic Lamprey, *Lampetra tridentata*, Upstream of an Impassable Dam. *Canadian Journal of Fisheries and Aquatic Sciences*, 46(3):420–425.

Bonneville Power Administration
2005 Pacific Lamprey, http://www.efw.bpa.gov/Integrated_Fish_and_Wildlife_ Program/-PacificLamprey-FINAL.pdf. Department of Energy, Bonneville Power Administration, Columbia Basin Fish and Wildlife Authority, Portland, OR.

Browne, Patience, Jeffry L. Laake, and Robert L. DeLong
2002 Improving Pinniped Diet Analyses through Identification of Multiple Skeletal Structures in Fecal Samples. *Fisheries Bulletin*, 100(3):423–433.

Butler, Virginia L.
2005 Appendix H: Fish Remains from the St. Johns Site (35MU44/46). In *Archaeological Excavations at the St. Johns Site (35MU44/46), Portland Oregon*, Richard M. Pettigrew, pp. H1–H30. Cascadia Archaeology, Seattle.

Butler, Virginia L., and Michael G. Delacorte
2004 Doing Zooarchaeology as if it Mattered: Use of Faunal Data to Address Current Issues in Fish Conservation Biology in Owens Valley, California. In. *Zoarchaeology and Conservation Biology*, R. Lee Lyman and Kenneth P. Cannon, editors, pp. 25–44. University of Utah Press, Salt Lake City.

Casteel, Richard W.
1972 *The Use of Fish Remains in Archaeology with Special Reference to the Native Freshwater and Anadromous Fishes of California.* Doctoral dissertation, University of California, Davis. University Microfilms International, Ann Arbor.

Chang, Mee-mann, Jiangyong Zhang, and Desui Miao
2006 A Lamprey from the Cretaceous Jehol Biota of China. *Nature,* 441(7096):972–974.

Close, David A., Martin S. Fitzpatrick, and Hiram W. Li
2002 The Ecological and Cultural Importance of a Species at Risk of Extinction, Pacific Lamprey. *Fisheries,* 27(7):19–25.

Close, David A., Martin S. Fitzpatrick, Hiram W. Li, Blaine Parker, Douglas Hatch, and Gary James
1995 Status Report of the Pacific Lamprey (*Lampetra tridentata*) in the Columbia River Basin. *U.S. Department of Energy, Bonneville Power Administration, Environment, Fish and Wildlife Report.* Portland, OR.

Close, David A., Aaron D. Jackson, Brian P. Conner, and Hiram W. Li
2004 Traditional Ecological Knowledge of Pacific Lamprey (*Entosphenus tridentatus*) in Northeastern Oregon and Southeastern Washington from Indigenous Peoples of the Confederated Tribes of the Umatilla Indian Reservation. *Journal of Northwest Anthropology*, 38(2):141–162.

Couch, Stacey L. L., and Monique M. Lance
2004 Diet Composition and Breeding Success of Brandt's Cormorants in the Columbia River Estuary. *Northwest Naturalist,* 85:62–66.

Ford, John K. B., Graeme M. Ellis, Lance G. Barrett-Lennard, A. B. Morton, Rod S. Palm, and Kenneth C. Balcomb III
1998 Dietary Specialization in Two Sympatric Populations of Killer Whales (*Orcinus orca*) in Coastal British Columbia and Adjacent Waters. *Canadian Journal of Zoology,* 76(8):1456–1471.

Forey, Peter L.
1995 Aganthans Recent and Fossil, and the Origin of Jawed Vertebrates. *Reviews in Fish Biology and Fisheries,* 5(3):267–303.

Gobalet, Kenneth W.
2004 Using Archaeological Remains to Document Regional Fish Presence in Prehistory; A Central California Case Study. *Transactions of the Western Section of the Wildlife Society,* 40:107–113.

Hardisty, Martin W., and Ian C. Potter
1971 The General Biology of Adult Lampreys. In *The Biology of Lampreys,* Vol. 1, Martin W. Hardisty and Ian C. Potter, editors, pp. 127–206. Academic Press, New York.

Hart, John L.
1973 Pacific Fishes of Canada. *Fisheries Research Board of Canada, Bulletin* 180. Ottawa.

Hunn, Eugene S., and James Selam and Family
1990 *Nch'i-Wana "The Big River": Mid-Columbia Indians and Their Land.* University of Washington Press, Seattle.

Imber, Michael J.
1976 Comparison of Prey of the Black *Procellaria* Petrels of New Zealand. *New Zealand Journal of Marine and Freshwater Research,* 10(1):119–130.

Jebbink, Jo-Anne, and F. William H. Beamish
1995 Prospectus on the Use of Statoliths for Age Determination in Lampreys. In *Recent Developments in Fish Otolith Research*, David H. Secor, John M. Dean, and Steven E. Campana, editors, pp. 331–339. The Belle W. Baruch Library in Marine Science Number 19, University of South Carolina Press, Columbia.

Kan, Ting Tien
1975 *Systematics, Variation, Distribution, and Biology of Lampreys of the Genus Lampetra in Oregon.* Doctoral dissertation, Oregon State University, Corvallis. University Microfilms International, Ann Arbor.

Kirk, Ruth, and Richard D. Daugherty
2007 *Archaeology in Washington.* University of Washington Press, Seattle.

Kostow, Kathryn
2002 Oregon Lampreys: Natural History, Status, and Analysis of Management Issues. *Oregon Department of Fish and Wildlife Information Reports,* 2002-01. Portland.

Lance, Monique M., Anthony J. Orr, Susan D. Riemer, Michael J. Weise, and Jeffrey L. Laake
2001 Pinniped Food Habits and Prey Identification Techniques Protocol. *National Marine Fisheries Service, Alaska Fisheries Science Center, AFSC Processed Report,* 2001-04. Seattle.

Lyman, R. Lee, and Kenneth P. Cannon, editors
2004 *Zooarchaeology and Conservation Biology.* University of Utah Press, Salt Lake City.

Mallory, Oscar L.
1966 A Comparative Cultural Analysis of Textiles from McGregor Cave. Master's thesis, Washington State University, Pullman.

Martin, Michael A.
2006 Ethnohistoric Fisheries of the Lower Columbia River: Cascades to the Columbia River Mouth 1792–1855. Master's Thesis, Portland State University, Portland, OR.

Michael, John H.
1980 Repeat Spawning of Pacific Lamprey. *California Fish and Game Notes,* 66(3):186–187.

1984 Additional Notes on the Repeat Spawning by Pacific Lamprey. *California Fish and Game Notes*, 70(3):186–188.

Morris, Stan
1975 The Lamprey at Kettle Falls. *The Beaver*, Autumn:18–19.

Moser, Mary L., and David A. Close
2003 Assessing Pacific Lamprey Status in the Columbia River Basin. *Northwest Science*, 77(2):116–125.

Neuman, Alex
in press Aboriginal Use of Lamprey (*Lampetra tridentata*) on the Columbia Plateau. Master's thesis, Eastern Washington University, Cheney.

Roffe, Thomas J., and Bruce R. Mate
1984 Abundance and Feeding Habits of Pinnipeds in the Rogue River, Oregon. *Journal of Wildlife Management*, 48(4):1262–1274.

Suttles, Wayne, editor
1990 *Handbook of North American Indians, Vol. 7, Northwest Coast*. Smithsonian Institution, Washington, DC.

Vladykov, Vadim D., and Wilbur I. Follett
1958 Redescription of *Lampetra ayresii* (Gunther) of Western North America, a Species of Lamprey (Petromyzontidae) Distinct of *Lampetra fluviatilis* (Linnaeus) of Europe. *Journal of the Fisheries Research Board of Canada*, 15(1):47–77.

Walker, Deward E., Jr.
1998 Nez Perce. In *Handbook of North American Indians, Vol. 12, Plateau*, Deward E. Walker Jr., editor, pp. 420–438. Smithsonian Institution, Washington, DC.

Walker, Deward E., Jr., editor
1998 *Handbook of North American Indians, Vol. 12, Plateau*. Smithsonian Institution, Washington, DC.

Warren, Ernest
1902 On the Teeth of Petromyzon and Myxine. *Quarterly Journal of Microscopical Science,* 45(180):631–636.

Wydoski, R. S., and R. R. Whitney
2003 *Inland Fishes of Washington*, 2nd edition. University of Washington Press, Seattle.

Xavier, Jose C., John P. Croxall, and Keith Reid
2003 Interannual Variation in the Diets of Two Albatross Species Breeding at South Georgia: Implications for Breeding Performance. *Ibis*, 145(4):593–610.

Ross E. Smith
9207 12th Ave NE
Seattle, WA 98115
rsmith@pdx.edu

Virginia L. Butler
Portland State University
Portland OR 97207
butlerv@pdx.edu