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FISHING FOR DOG FOOD: ETHNOGRAPHIC AND ETHNOHISTORIC INSIGHTS ON THE FRESHWATER RESERVOIR IN NORTHEASTERN NORTH AMERICA

William A Lovis

Department of Anthropology and MSU Museum, Michigan State University, East Lansing, Michigan, USA. Corresponding author. Email: william.lovis@ssc.msu.edu.

John P Hart

Research and Collections Division, New York State Museum, USA. Email: jph_nysm@nysed.gov.

ABSTRACT. A review of current research reveals multiple lines of evidence suggesting that no single freshwater reservoir offset (FRO) correction can be applied to accelerator mass spectrometer (AMS) ages obtained on carbonized food residue from cooking vessels. Systematically evaluating the regional presence, magnitude, and effects of a freshwater reservoir effect (FRE) is a demonstrably difficult analytic problem given the variation of ancient carbon reservoirs in both space and time within water bodies, and which should be performed in advance of AMS assays. In coastal and estuarine contexts, *a priori* partitioning FRE from known marine reservoir effects (MRE) is also necessary to eliminate potential mixed effects. Likewise, any FRE varies based on the proportional mix of resources producing the residues and the ancient carbon uptake of those products. Processing techniques are a significant component of assessing potential FRE, and each pot/cooking vessel is therefore an independent context requiring analytic evaluation. In northeastern North America, there is little ethnohistoric/ethnographic evidence for fish boiling/stewing in ceramic cooking vessels; rather, fish were more often dried, smoked, or cooked for immediate consumption on open fires. Assays of fatty acids extracted from prehistoric vessel fabrics even on known fishing sites reveals no evidence for fish in the food mix. These observations suggest that the likelihoods of FRE in carbonized food residue in northeastern North America is therefore low, and that assays potentially suffering from FRO are minimal. In turn, this suggests that AMS ages from carbonized food residues are reliable unless analytically demonstrated otherwise for specific cases, and should take primacy over ages on other associated materials that have historically been employed for critical threshold chronological events.

INTRODUCTION

This study's goal is to explore several facets of the relationship between resource choice and processing and ^{14}C ages on carbonized food residues (i.e. "food crusts") adhering to the interiors of nonperishable cooking vessels by employing ethnographic, archaeological, and geologic case studies from interior northeastern North America (NNA; Figure 1). By way of *entrée*, it is important to briefly contextualize our research within the framework of this volume. Our work has focused on various facets of carbonized food residue formation, and on the systematic evaluation of the freshwater reservoir effect (FRE) as it might be manifested in such residues (Hart and Lovis 2007a,b, 2014; Hart et al. 2007, 2009, 2013; Lovis et al. 2011; Hart 2014; Upton et al. 2014).

Our research is premised on the following: (1) an FRE is potentially present wherever appropriate bedrock and aquatic conditions occur, where such conditions are associated with food resources; (2) these potential effects can be evaluated; and (3) there is the potential for a freshwater reservoir offset (FRO; i.e. older than true age assays) depending on the resource carbon contributions to the dated residue. Further, given that ^{14}C ages are estimates with distributions, which allow for varying probabilities that the estimate accurately reflects the age of the datable substance, any ^{14}C assay may not capture the true age of the material or event in question regardless of whether an FRO is present. Among the outcomes of our research program are protocols for evaluation of both the potential for an FRE, the order of magnitude of an FRO, and various means to evaluate the relative likelihood that datable material might result in an inaccurate ages (Hart et al. 2013; Hart 2014; Hart and Lovis 2014).

This article exclusively investigates the FRE among past societies inhabiting interior regions of NNA with freshwater lacustrine and riverine/riparian water sources and resources. We take a strong ethnographic behavioral component in our discussion of the potential for a freshwater reservoir at

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a regional scale. As we caution, however, the outcomes of our research, which are rooted in ethnography, ethnology, and ethnohistory, require judicious application of direct ethnographic analogy (Peregrine 1996).

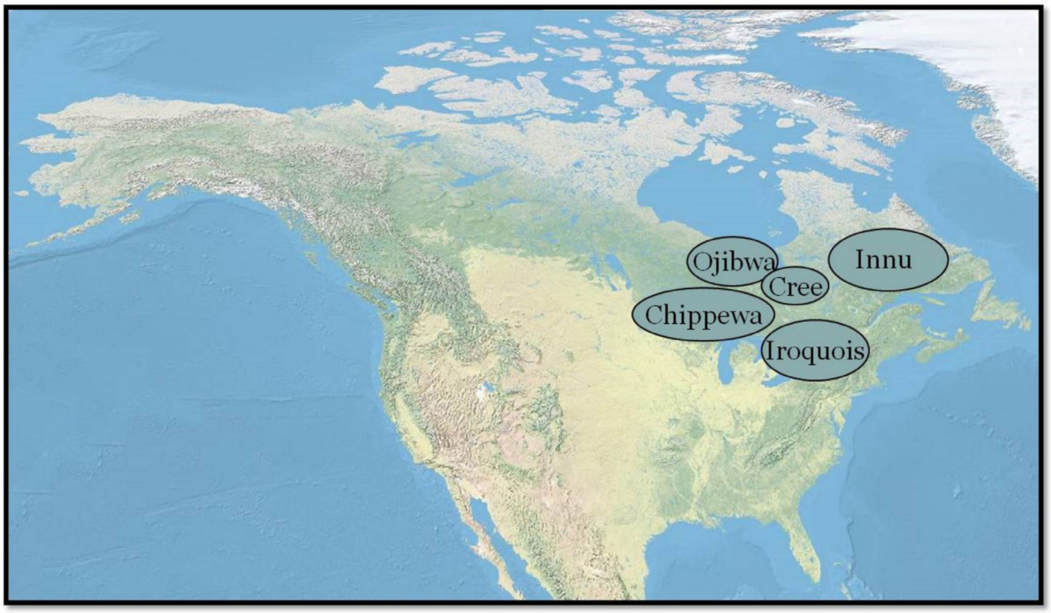

Figure 1 Locations of northeastern North American ethnographic groups discussed in text

DO FRESHWATER FISH ALWAYS LIVE IN WATER WITH ABUNDANT ANCIENT CARBON?

While the FRE is a fact (Philippsen 2013), it is not uniform across either time (Geyh et al. 1998) or space (Olsen et al. 2009; Philippsen and Heinemeier 2013), including water column depth, in any given location (Ascough et al. 2011; Zigah et al. 2012). This is certainly true in NNA. As such, it is necessary to explore local- and regional-level FRE potential at particular points in time (Phillipsen et al. 2010) in advance of invoking FRO as an explanation for the rejection of AMS ages, particularly on carbonized food residues, or on conventional ^{14}C ages on materials such as charcoal that might have been impregnated with fats from freshwater resources. In this regard, while there may be higher or lower regional potentials for an FRE (Philippsen 2008; Keaveney 2010), we maintain that each carbonized food residue sample from a cooking vessel context should be considered as an independent analytic problem, and subjected to appropriate evaluative protocols (Hart et al. 2013).

The potential for an FRO is a function of the carbonate and bicarbonate ion densities in water bodies from which food resource(s) derive, the amount of dead carbon fixed into the tissues of resources as a result of metabolic processes, and the proportion of carbon these resources contribute to cooking residue formation. Total alkalinity of a water body ($CaCO_3$ mg/L) has been demonstrated to correlate positively with FRO variation in fish and water from England and Ireland (Keaveney and Reimer 2012). Further, total alkalinity and dead carbon % (DCP) in fish suggests that total alkalinity values of >90 mg/L are needed to result in DCP of >5 in fish (Hart et al. 2012:544–5). In the absence of knowledge of the proportions of fatty or lean fish contributing carbon to residue formation (see Hart et al. 2013:542, Tables 3 and 4; Hart 2014), the measured total alkalinity of water bodies appears to be a viable proxy for assessing the potential of an FRE at a regional scale assuming that such values are stable over time. The latter assumption, however, is not always the case (Mullins et al. 2011; Hart et al. 2013:545). Recent evidence suggests that modern measurements may not well reflect past alkalinity states given current agricultural or urban land use, and that consequently modern values may not necessarily be suitable proxies for past conditions (Butman et al. 2015).

There are high-resolution local level as well as compiled subregional data available with which to evaluate general FRE potential across North America (Briggs and Ficke 1977:30, Figure 8; Fisheries and Environment Canada 1978:Plate 28A). These total alkalinity data display significant spatial information that bear on the current problem. While not precisely accurate proxies for past conditions, these maps do allow for broad regional assessments of FRE potential. In current context, the most significant point is that the vast majority of NNA had measurable total alkalinity levels <60 mg/L in the mid-1970s (Figures 2 and 3). Such levels make it unlikely that sufficient ancient carbon was available in the freshwater reservoir to result in an FRO on AMS ages on carbonized food residues containing freshwater fish carbon. This does not absolve us from considering this potential, but the likelihood of such potential is low, and seemingly has been borne out in studies by Taché and others (Taché and Hart 2013; Taché and Craig 2015), for the initial inception of pottery in temperate northeastern North America.

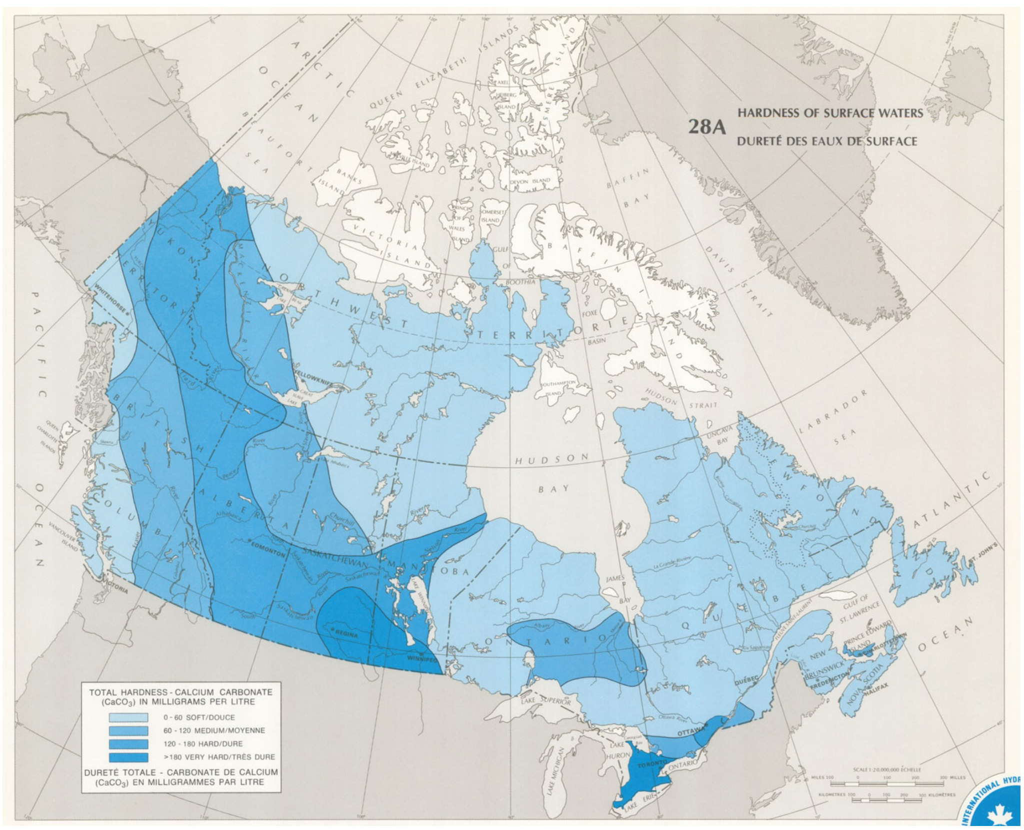

Figure 2 Mg/L $CaCO_3$ Canadian distribution: Note low concentration in eastern Canada (Fisheries and Environment Canada 1978:Plate 28A).

This observation, however, does not hold for parts of the Great Lakes region or areas to the south or west of the Great Lakes where total alkalinity values greatly exceeded 90 mg/L in the 1970s (Figure 3). In these areas, it is possible that the incorporation of freshwater fish into a food mix in some proportion resulted in potentially detectable FROs in carbonized residues. The FRE and FRO have been invoked as explanations for earlier than expected ages on certain pottery traditions in the western Lake Superior basin, and generated sufficient concern that the proposition provoked an evaluative study (Hohman-Caine and Syms 2012). While the authors state that the drainages in their study area are unlikely to have significant ancient carbon reservoirs, both the analytic protocols employed and the outcomes reveal that this remains an open question.

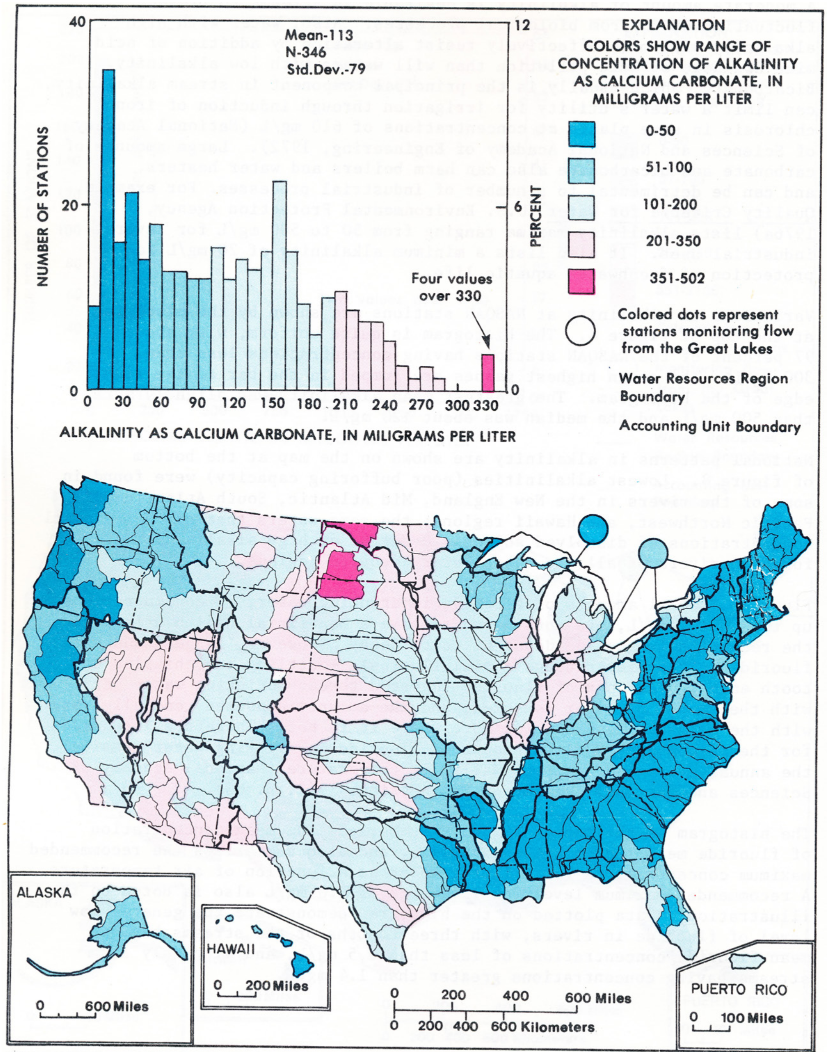

Figure 3 Mg/LCaCO$_3$ USA distribution: Note low concentrations across NE US, increases to west in Great Lakes region (Briggs and Ficke 1977:30, Figure 6).

There are data to suggest that either there is a statistically undetectable FRO even in subregions with current >90 mg/L CaCO$_3$ levels, or that the dead carbon content of boiled food mixes resulting in carbonized residues was sufficiently low that such effects are not recognizable (Hart and Lovis 2007b; Hart et al. 2013). Comparisons of ^{14}C dates on residues and terrestrial resources (primarily wood charcoal) have been undertaken from areas with current CaCO$_3$ levels as high as 290 mg/L. The results suggest that in only very few cases is there a statistically significant difference that might indicate the presence of an FRO, although archaeological context issues may be the critical factors in the noted offsets (Hart and Lovis 2007b, 2014).

On its face, the current weight of evidence suggests that (1) based on regional total alkalinity, the potential for an FRO is limited across much of NNA but increases in parts of the western Great Lakes and western Midwest, i.e. FRE is regionally and subregionally variable; (2) an FRO is statistically undetectable when AMS residue assays have been compared with charcoal dates from the same context (assuming that charcoal ages do not themselves suffer from an FRO—see below); and (3) that in instances where lipid analysis has resulted in the detection of fish as one of the resources producing AMS-dated residues that the age of ceramic inception has become more recent rather than older. Those who wish to totally eschew the potential for an FRO might view these observations optimistically. However, we view these results as creating a context for systematic regional and subregional evaluation before dismissing out of hand the potential for FRO.

As shown by Keaveney and Reimer (2012) and Fernandes et al. (2013), among others, dissolved organic carbon (DOC) and particulate organic carbon (POC) are also potential causes of FRO, depending on the sequestration of old carbon in soils. The presence of old carbon in freshwater bodies from organic detritus in soils is dependent on soil erosion and variable flows of streams, which in turn depend on seasonal and annual precipitation rates. Butman et al. (2015) suggest that currently 3–9% of DOC in rivers is aged, and the result of human disturbance of landscapes through agriculture and urban development globally. Whether this is solely the result of weathering in soil organic matter or also from fossil-fuel-based organic carbon is undetermined (Butman et al. 2015:114). However, the extent of land disturbance is a factor in the potential contribution of DOC/POC in any drainage system prehistorically, as is DIC (Lajewski et al. 2003).

FISH IN THE DIET? ARE FISH ALWAYS COOKED IN CERAMIC VESSELS?

To categorically assert that lacustrine or riverine food resources, particularly fish, never contributed to carbonized food residues on container walls would be a high-level assumptive error and could not be credibly sustained (e.g. Taché and Craig 2015). That said, statements can be made on the relative potential for such contributions by employing a mix of archaeological and ethnographic data. Lipid analysis is commonly used for the evaluation of prehistoric pottery. Despite this, there are few systematic analyses of the lipid content of ceramic fabrics and carbonized food residues from various areas of eastern North America. The majority of assays from the interior of NNA and the Great Lakes suggest a low potential for fish contributing significant amounts of carbon to food residue formation even at locations commonly interpreted as fishing sites (e.g. Reber and Hart 2008; Kooiman 2012; Malainey and Figol 2012a,b). By contrast, some recent lipid analyses of charred cooking residues and pottery fabric demonstrate that the earliest widespread pottery in certain interior, coastal, and estuarine regions have biomarkers for fish (Taché and Craig 2015). Interestingly, a regional analysis of ^{14}C dates associated with this pottery, including residues with biomarkers for fish, showed that AMS dates on residues result in a more constrained age range for the early pottery ware than do ^{14}C dates on associated charcoal—suggesting a later adoption and shortened use span for the ware (Taché and Hart 2013). However, archaeological data are not the only line of evidence that can be brought to bear on this issue. In NNA, there are extensive, albeit often late, ethnohistoric and ethnographic records that can inform us on cooking practices for fish and other aquatic animals.

Excluding the Arctic zone, the interior-adapted societies of NNA extended from the Boreal Forests in the north, to the Plains and Prairies of the Midwest, south to the Ohio River Valley, and eastward to the Appalachian Mountains and their subsidiary ranges. This region includes major fisheries, such as the Great Lakes. Culturally and adaptively societies in this broad region can be subdivided into what are best characterized as complex middle range systems associated with multiple semi-autonomous societies collectively framed under the rubric of Iroquoian, practicing intensive maize-based agriculture supplemented by hunting, fishing, and wild plant collection (southern Ontario, central New York, southern Quebec). The eastern Boreal Forests were the domain of low population density hunter-fisher-gatherers largely organized as seasonally mobile multifamily groups. These Algonquian-speaking groups include the Innu (aka Naskapi/Montagnais) of the Labrador Peninsula, and the Cree to the south of Hudson's Bay. Westward to Lake of the Woods, western Lake Superior, and south to the middle reaches of Lakes Michigan and Huron were a variety of related groups with similar tribal designations including Ojibwa, Ojibway (Ojibwe), Chippewa, and Chippeway (*not* Chippewyan), as well as Saulteaux. The more southern of these groups practiced mixed economies including hunting, plant food gathering, and either fishing and/or agriculture of variable intensity, while others were more reliant on harvesting wild rice (*Zizania* spp.), an aquatic plant, and large game hunting. All of these groups incorporated aquatic resources, including fish, plants, and mollusks into their diets, almost exclusively from interior lakes and streams. There are extensive ethnohistoric and ethnographic records available for most, often spanning several centuries in time.

The full range of containers employed for processing, cooking, and/or consumption in pre-contact NNA are not preserved in the archaeological record, introducing a potentially substantial taphonomic bias into our perspectives on cooking practices. There is an abundant literature on the use of vessels constructed of organic materials, primarily but not exclusively of birch bark, for boiling, evaporation, frying, storage, and other activities, and it can be argued that in some cases such containers were more useful than either ceramics or metals for certain purposes; they are lighter, more portable, and less prone to damage: "Occasionally cups or small bowls made of birch bark were used for broth or beverages . . ." and "It is also said that cooking was done without metal kettles by making dishes of freshly cut birch bark with the inside of the bark as the outside of the dish. So great is the moisture that the cooking was accomplished before the bark dried sufficiently to take fire" (Densmore 1929:41). However, Densmore also records local histories of the production and use of ceramic containers and hot stone boiling. Even several centuries after the introduction of metal cooking containers, there is evidence for continued, if low-level use of ceramics for cooking (e.g. Cabot 1912).

Boiling fish and fish oil rendering, the processes most likely to contribute carbon to food residue formation, are the least commonly mentioned in ethnographic and ethnohistoric discussions of food preparation. Fish were not typically boiled when fresh or preserved through partial or complete air-drying, smoking, and freezing (resulting in drying) for later use. Preserved fish was most typically consumed as a flaked, pounded, or paste preparation, or broiled. Such practices are documented for a range of pottery-using groups with mixed economies including the Cree (Rogers 1973), Round Lake Ojibwa (Rogers 1962), and a variety of Chippewa (sic) groups in Ontario, Canada, and Minnesota and Wisconsin (Densmore 1929; Hilger 1951; Steinbring 1981:247) and would not result in a contribution of carbon to food residues on cooking vessels.

That said, boiling, which may or may not result in residue formation depending on the consistency of the cooking medium and the acuity of the cook, was used for some fish preparation: "The heads of fresh fish, especially sucker, were boiled . . ."; "fresh fish were boiled and the broth used" (Densmore 1929:42 in general western Chippewa discussion). The last of Densmore's notes parallels the discussion of fish oil below.

FISHING FOR DOG FOOD? QUANTITIES AND DISPOSITIONS

Rogers (1973) presents ethnographic quantifications of the contributions of fish to diets of interior hunter-fisher-gatherers that shed light both on the contributions of fishing to the overall resource pool, and the preferences and dispositions for preparation and consumption of different types of fish.

Lessons from the Mistassini Cree

Among the Mistassini Cree, fish constituted 27% of the faunal contribution to the diet, well below the 64% contributed by "big game" (Rogers 1973:78). During a single annual round, the average number of fish caught by a single Mistassini hunting group was autumn ~100, winter ~ <80, and spring ~55, for a total of ~235 (estimated from Rogers 1973:65, Graph 5). This amounts to 3000 pounds of fish, with "an estimated 2000 pounds" fed to dogs or used as bait for traps (Rogers 1973:65). Thus, 2/3 of the fish procured by poundage *was not consumed by humans*.

Experiments on residue formation reveal that the amount of carbon contributed is related to the percentage of fatty acids, carbohydrates, and protein, each with different proportions of carbon content. For example, fatty acids have ~80% carbon content (Needham 1965), while protein is ~53% and carbohydrate ~42% (O'Brien et al. 2000). Fish harbor different volumes of fat by species, carbon, including ancient carbon, is linked to fat content, and fat content varies seasonally. Fish with higher fat content will contribute more carbon to residue formation than will fish with less fat content.

However, we recognize that it is often the case that more than one resource may contribute to the formation of residues, and that the mix may include terrestrial as well as freshwater resources. Lipids, proteins, and carbohydrates respond differentially to pyrolization. Experimental resource carbonization experiments have begun to elucidate resulting changes in C:N isotope ratios and refine taxonomic identifications, such as the ability to distinguish nuts from generic C_3 plants (Yoshida et al. 2013:1328), although this work has yet to be able to provide clear insights into the proportional contribution of individual species to carbonized residue formation.

Mathematical modeling and matching to the outcomes of experimental residues have demonstrated that regardless of the raw proportions of resources in a mix, it is the carbon fractions of fat, carbohydrate, and protein of each resource that determines residue formation (Hart et al. 2007). While it was subsequently demonstrated that cooking time affected carbon mobilization (Hart et al. 2009), the carbon fraction remains the primary determinant. Finally, it is the fraction of ancient carbon contribution by freshwater resources relative to contemporary carbon of freshwater and terrestrial resources that is critical in producing an FRO (Hart 2014). While we focus here on the potential contributions of freshwater fish, it is in fact the relative contribution of carbon, both ancient and contemporary, by all components of a mix that must be considered in assessing FRO potential.

As a result, knowledge of individual fish species is of interest in understanding the potential transfer of ancient carbon to carbonized food residues. While it is claimed the Mistassini Cree ate "all major species" of fish (walleye[d] pike, whitefish, lake trout, etc.), Rogers (1973:68) notes "except suckers which were reserved for dog food and trap bait and ling which were thought to be poor food, except for the liver which was considered a delicacy." Unfortunately, there is nothing to indicate in what quantity nor in what fashion the livers were processed. According to Cabot (1912:154), ling is a freshwater cod. Thus, in regional considerations of potential residue formation sucker, and with the exception of the potential for liver processing, ling (both "fatty" fish) should be eliminated.

Lessons from the Round Lake Ojibwa

Consistent with the observations for the Mistassini, fish contributed approximately 25% to the diet of the Round Lake Ojibwa (Rogers 1962:C55, Figure 19), constituting 25,000 to 50,000 pounds total consumption including for dogs and bait, with the higher estimate more likely (Rogers 1962:C17–

C18). It was observed that "species other than whitefish are infrequently used for food. . ." (Rogers 1962:C47), once again pointing to a selective factor in understanding which fish species should be modeled for ancient carbon contribution to residue formation. Likewise, relative to our understanding of the composition of different food mixes that might contribute to a "one-off" food preparation event, among the Round Lake Ojibwa Rogers observed that almost all foods were cooked separately or individually; there are only two "composite" dishes consisting of *tripe de roche*, hare livers and fish heads with or without fish roe (Rogers 1962:C56). However, there is no evidence for dedicated cooking containers for individual food items, so that any given cooking container might have traces of multiple preparation events and therefore multiple resources. More generally, Rogers (1962:C53) made the sweeping statement that all food is prepared by either boiling or spit roasting. Spit roasting large fish raises the significant taphonomic question of the potential for fish oil to saturate wood charcoal, and subsequently being employed to ^{14}C date occupation events. Can dates on wood charcoal under such circumstances potentially suffer from FROs? As of yet, the discussion has been largely confined to AMS dates on carbonized pottery food residues, with an assumption that FRO does not occur in wood charcoal, and that age assays from the latter should be more accurate. This may require re-evaluation in the context of systematic experiments that focus on saturation potential, and the effects of sample treatments prior to assay. Standard pretreatment of wood charcoal for ^{14}C assay does not include extraction of lipids (e.g. Brock et al. 2010:104, 107).

Lessons from the Innu/Naskapi (Leacock 1954; Leacock and Rothschild 1994)

The following excerpts from Speck (1935) provide an informative perspective on dietary choice among the Innu/Naskapi that has implications for the manner in which we view the potential for mixes of freshwater and marine reservoirs in cooking containers:

> For instance, the varieties of fish inhabiting the salt water are not eaten by the Indians of the interior about Lake St. John—such as salmon and cod, and the eel. This applies also, and even with more force, to the seal and porpoise. They dislike the greasy flavor and say the meat of these creatures is too strong (Speck 1935:77).

When discussing food taboos in the Lake St. John vicinity, he continued: "the clam, eel, seal, porpoise and whale are also in the forbidden class" (Speck 1935:78). These observations suggest that at least on the interior of Labrador, that the Innu did not mix marine and freshwater foods, and in fact formalized this behavior as a series of food consumption taboos. This of course has evident implications for assessment of potential reservoir effects.

Isolated fresh fish boiling is mentioned in several travelers' journals among the Innu (e.g. Cabot 1912:75, 115 [in saltwater], 272), with "big trout" and whitefish specifically mentioned, as well as an allusion to frying (p. 229), and specific mention of broiling or roasting (Cabot 1912:xii, 273; Figure 4).

Fresh Fish, Feasts, and Fish Oil

Among the Mistassini Cree, some fish-related feasts involved specific forms of cooking: "Another feast, of lake trout, was given when a hunter had caught one or more especially large fish. For this feast the fish were boiled" (Rogers 1973:15).

Of potential importance to the issue of aquatic resources potentially introducing ancient carbon into residues on cooking vessels is the following excerpt from Roger's exposition on the Round Lake Ojibwa:

> Fish heads and intestines provide oil. The excess fat is removed from the intestines by pulling them between the thumb and forefinger. After this is done the heads and intestines are boiled in water. As the oil rises to the surface it is skimmed off with a wooden spoon. The oil that is removed is again boiled to drive off any remaining water (Rogers 1962:C49).

Figure 4 Innu roasting whole fish on spits over fire in lodge. Note the empty metal kettles in the foreground (Cabot 1912:facing 279).

Lessons from Iroquoians

Iroquoian groups lived in major fishery areas and exploited the resource extensively. Ethnographic and ethnohistoric records provide evidence for how fish were traditionally cooked. For example, Waugh (1916:136) indicated that "[f]ish were everywhere a favorite food." He listed several manners of cooking fish including boiling, frying, roasting, and drying (Waugh 1916:137). Pertinent to the present topic, he offered the following recipes for boiled fish:

- "*Boiled.* A very simple method was to boil fish until tender, adding salt to suit taste."
- "*Fish Soup*…Fish of any kind is boiled in a pot with quantities of water. It is then removed and course corn siftings stirred in to make a soup of a suitable consistency."
- "*Fish and Potato Soup*. When potatoes are boiled, spread fish out on top, cover with liquid and cook. When done, remove fish and add salt and pepper."

In general, Waugh (1916:79) noted that: "A very large proportion of Iroquois foods were evidently of a liquid nature." This is substantiated by the numerous references to soups and broths prepared from ripe and green corn, beans, squashes, meats, and other resources. Maize was the primary basis of most of the recipes Waugh relates, the vast majority of which involved boiling of various forms of maize including green and ripe kernels as well as meal (Figure 5). Of these, few mention fish as an ingredient, and of those that do, fish is a supplementary ingredient, except as mentioned above when used in fish soup or boiled alone. For example, Waugh (1916:97) quoted Sagard (1865) in a description of parched green corn soup that the Huron add "a little fish, fresh or dry, if they have it on hand." In short, Waugh's presentation of Iroquoian recipes involving boiling resources in water, rarely mentioned fish. Parker's (1910) account of the Iroquois of New York was much the same, with fewer mentions of fish. Kinietz's (1940) review of Huron subsistence indicated a similar pattern. Large fish were cooked over the fire, except when some were boiled to extract oil. Otherwise, except on special occasions, "there was one dish, which of course was corn, into which the available fresh or dried meat or fish was put" (Kinietz 1940:30). As with other Iroquoian nations, fish broth and fish as an added ingredient to boiled maize-based dishes were used by the Huron. Among the Iroquoians, then, there is little evidence that boiled fish was a primary source of food.

Figure 5 Seneca woman boiling corn, showing use of paddle, crane, and wooden pot hook (Harrington 1908:Figure 128).

DISCUSSION AND CONCLUSION

Ethnographic behavioral evidence from the boreal and temperate forest zones of NNA illuminate a variety of subtleties central to understanding the potential for FRE to create a detectable FRO in carbonized food residues or, potentially, wood charcoal. These include the following:

- In general, when fish is employed as a food resource there is a preference and selection for larger fatty fish over smaller lean ones. Fatty acids contain ~80% carbon including ancient carbon. When fatty fish contribute carbon, including ancient carbon to residue formation, therefore, there is an enhanced potential for an FRO.

- When fish is boiled it is generally freshly caught resources, for certain ceremonial purposes, and for rendering of fish oils. Roasting of fish over fires is the more common and preferred form of fish cooking. Roasting may introduce additional taphonomic issues of concern, and undermines certain commonly invoked operating assumptions.

- There is a suggestion, among the Innu in particular, that food taboos, also expressed as taste preferences, may limit the potential for the mixing of marine and freshwater resources, and therefore limit the potential for a marine offset to occur in tandem with an FRE/FRO. This is cause for optimism among those working in coastal and estuarine contexts, although the current case cannot be globally extended and the potential for mixing of effects remains.

- The presence of abundant fish remains in an archaeological site does not necessarily imply that an abundance of fish was incorporated into the food mixes in cooking containers. Large amounts of fish processing for storage, or consumption as food by dogs (archaeologically post-Upper Paleolithic in Europe) may better account for an abundance of fish remains. Fish processed for storage is not always subsequently boiled or roasted for consumption.

- In most ethnographically recorded recipes involving water-based cooking in pottery, fish is not a primary ingredient. Rather, it comprised relatively small amounts of the resources cooked in multiple-resource meals.

- Ceramic (or metal) food containers were not the only ones employed for the cooking of foods; bark containers were regularly employed for such purposes. The archaeological record may suffer from taphonomic issues that skew our observations of cooking practices, and the availability of datable materials.

- There is no ethnographic evidence to suggest that different types of containers were employed for the preparation of different resources, i.e. there is no specialization of vessel type or use. Thus, carbonized food residues on vessel interiors have high potential to be cumulative or palimpsest formations. Measures of aquatic resource presence may be differentially affected by such multiple resource uses.

- The widespread use of skewer roasting over an open fire as a means of cooking whole fish introduces the potential for wood charcoal dates to also be potentially subject to a FRO, although we recognize that this observation runs counter to most claims that AMS carbonized residue dates are older than ages obtained on wood charcoal. This may require inquiry into the taphonomy of datable material subjected to high-temperature direct heating versus indirect heating of diluted solutions. Regardless, this observation again calls into question the invocation of consistency between conventional or AMS ^{14}C ages obtained from wood charcoal, and those obtained from carbonized food residues, as well as the assumption that chronologies built largely but not exclusively on charcoal-derived ages are more accurate than those built on AMS ages on carbonized food residues.

This exploration of key ethnographic information on the inclusion of freshwater fish in interior NNA Native American diets, the manner in which such aquatic products are selected, processed, and cooked independently or in combination, distributed among humans and animals, and the potential these observations have for evaluating the potential for an FRO, provide significantly refined behavioral contexts within which to consider the FRE in regional archaeological research.

As is the case with most ethnographic data, however, our results should neither be used independently nor as direct analogs for past human behaviors, but rather they should be applied judiciously and with proper evaluation (Martelle Hayter 1994). For example, the enhanced role of dogs for transportation during the observation periods may require certain adjustments, as is true of the increased role of trapping and the need for trap bait in post-contact economies. As such, we do not endorse a one-to-one analogy. Rather, these data should be cast against and used in tandem with macro-regional proxies for FRE potential such as total alkalinity (Briggs and Ficke 1977; Fisheries and Environment Canada 1978; Philippsen 2008), and considering the potentials for DOC/POC infusions at the watershed or drainage level (Lajewski et al. 2003; Keaveney and Reimer 2012; Fernandes et al. 2013; Butman et al. 2015).

Archaeological analysts have the ability to systematically evaluate the potential for ages derived from datable materials of variable taphonomy and provenance to experience an FRO (Mullins et al. 2011; Hart et al. 2012:544–5; Hohman-Caine and Syms 2012; Keaveney and Reimer 2012; Taché and Craig 2015). In a research context that views each vessel as an independent analytic problem, approached through systematic and replicable protocols, multiple lines of evidence can be generated and applied. The application of biomarkers, C/N ratios, direct measurements of offsets between modern and archaeologically derived ages, taphonomic clarification, and other approaches when used independently (e.g. Kubiak-Martins et al. 2015) or in concert can alleviate uncertainties real or fictive that currently surround FRO discourse and inference. We look forward to a strong cadre of practitioners addressing these issues objectively and systematically.

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