Native fishing in the Great Lakes
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CHAPTER 4: TAPHONOMY

Introduction
Before discussing the possibilities of fish bone interpretation, it is essential to reflect on the limitations imposed by taphonomy – extending from bias introduced by butchering practices, to bias introduced by soil preservation conditions, to bias introduced by field recovery techniques. Some of the issues discussed below are relevant to fish bone analysis in general, some to zooarchaeological analysis in general. This chapter, however, concentrates on taphonomic factors that are specific to the fish taxa recovered, to the culture area, and to the excavation context.

Butchering and processing
Many Iroquoian assemblages exhibit little evidence for butchering or burning on fish remains. It is likely, however, that fish underwent varying degrees of processing at the catch site, at the village, or inside the houses.

Sagard (1939:186, 316-318) describes how the Huron gutted lake sturgeon and Salmonidae to dry them in the sun, or if the weather was unfavourable, to smoke them on hurdles or poles. The oily flesh of lake sturgeon and Salmonidae could be preserved by smoking. Natural freezing has also been suggested as an option (Cleland 1982: 779; Rostlund 1952:137), although Molnar (1997:30) argues that temperatures were too inconsistent to practice this method effectively in the Georgian Bay area. Sometimes the Huron boiled lake whitefish in kettles, skimming off the oil with a spoon and putting it into hollowed-out gourd containers (Sagard 1939:186). It appears preservation through salting was unknown.

Off-site processing
Catch site processing is an important source of taphonomic bias. One way of establishing whether fish were decapitated or otherwise butchered at the catch site is to look at the ratio of cranial bone to vertebrae at the village. Fish vertebrae have been used to evaluate the importance of lake trout, lake herring and lake whitefish, and to examine butchering patterns by several local researchers (Cooper 1996; Molnar 1997; Thomas 1996a).

If the village inhabitants were decapitating and filleting fish at the catch site, and bringing only the cleaned fish back to the village, the posterior pre-caudal and all caudal vertebrae may be expected to be over-represented at the village. Unfortunately, relatively few vertebrae were recovered from the three sites. An attempt was made to identify the majority of vertebrae to family, and those of Salmonidae to genus. The proportion of vertebrae that could be identified below class is much higher at Barrie (80 percent) than at either Dunsmore (46 percent) or Carson (48 percent).

The number of vertebrae represented in the taxa identified range from 28 to 69 (Table 6) (Oates et al. 1993; Scott and Crossman 1973). Most of the individual fish to whom these vertebrae belonged are accounted for by cranial bones in the identified component of the sample. There are some contexts with only a few vertebrae. Most features contained under 10 identified vertebrae per family. There are no features with more vertebrae identified to family than could be accommodated in a single fish.

Can the cranial to vertebral ratios enlighten us about off-site processing, perhaps at a fishing camp? Establishing “expected” cranial to vertebral ratios is fraught with difficulty. The number of cranial bones varies between taxa, and the number that are routinely identified will also vary between taxa and among researchers. For cranial bones, the “expected” number of bones relates to what is considered analytically useful, which taxa are present, and how much time and expertise is available. The “expected” number of cranial bones will usually include the eight diagnostic elements discussed above, and a variable number of other elements per species.

Taphonomy plays a major part, as many bones will be destroyed or fall through the dry screen mesh. Vertebrae will be lost if their diameter and length are less than the screen mesh aperture. Caudal vertebrae and vertebral centra can be lost because they lack the projections that may prevent them from falling through the screen (e.g. Prevec 1985). For vertebrae, therefore, the “expected” number of elements is in large part dependent on recovery. If all vertebrae are recovered and are in good condition, it should be possible to identify many of them at least to the family level. The most difficult distinction in these assemblages is between Centrarchidae and Percidae, something noted previously by Cossette (1995:403).

A total of perhaps 40-60 “expected” number of cranial bones appears to be a reasonable estimate for Esocidae, Catostomidae, Ictaluridae, Centrarchidae and Percidae. If fish were brought to the site whole, the ratio of cranial bones to vertebrae for these taxa can be expected to range from 2.1:1 to .9:1. However, this ratio is likely much lower for Salmonidae (Salmonidae taphonomy is discussed in more detail below). Given that lake trout possess up to 69 quite robust vertebrae and have especially fragile cranial bones, the “expected” ratio may be only .4:1. Lake herring and lake whitefish have somewhat fewer (50-64) and less robust vertebrae than lake trout, so the ratio there would be intermediate.

Overall, cranial bones outnumber vertebrae: Barrie 3:1, Dunsmore 14:1, and Carson 16:1 (Table 11, 12, 13). There are, therefore, substantially fewer vertebrae than would be expected based on the range of realistic natural ratios. All else being equal, Carson should have relatively more vertebrae because of improved recovery of small vertebral centra and caudal vertebrae in the 3.2 mm mesh. A comparison with Carson is problematic because vertebra
size distribution as it may relate to recovery was not investigated. The cranial to vertebral ratios may indicate that more off-site processing was practised at Barrie than at Dunsmore, although none of the sites have strong evidence for off-site processing.

At Barrie, vertebrae represent 23 percent of all fish bones in the houses, 37 percent in the middens. At Dunsmore the proportions are 12 percent vs. 10 percent; at Carson six percent vs. 20 percent (although the sample size from the midden is very small). If fish scales had been recovered at Barrie, the relative contribution of fish vertebrae would be proportionately less. Nevertheless, it is obvious that Barrie contains substantially more vertebrae than the two later sites. This does not appear to be related to the increased heavy fraction sample at this site, as 19 percent overall came from flotation, and 38 percent from the 6.4 mm dry screen. At Barrie and Carson, vertebrae are more numerous in middens than in houses, perhaps indicating that at least some vertebrae were removed before cooking and preferentially deposited in external refuse deposits.

The high proportion of vertebrae that could be identified to family at Barrie requires explanation. It may relate to the overall larger size of the fish at this site, since vertebrae of very young or small fish may be harder to identify. It may also relate to the degree of fragmentation, since incomplete vertebrae are also harder to identify. This in turn may relate to fish size: the larger the fish, the more likely it is to be filleted, rather than pounded up in its entirety (see section on food preparation, below). Alternatively, processing and cooking methods at the Barrie site may have favoured preservation of vertebrae.

Skinning

Fish scales are less numerous in the zooarchaeological collections than vertebrae, despite the fact that each fish possesses many more of the former than the latter. This is probably owing to the relative fragility of scales, and perhaps also to off-site fish processing and skinning. Fish scale recovery varied considerably between the three sites. Only one fish scale was recovered from the Barrie site (Midden D heavy fraction). This may be in part due to the slightly inferior preservation at this site, indicated by extensive iron staining observed on some bones. The Dunsmore sample contained 105 scales (70 from screens, representing seven percent of fish by recovery, 35 from flotation, representing five percent). The Carson sample contained 376 scales (342 from screens, representing 10 percent, 34 from heavy fraction, representing four percent). Additional scales may be present in the light fractions; those of the Carson site have not yet been sorted.

The Barrie assemblage was subjected to the most intensive flotation, whereas the Carson site underwent only limited flotation. This discussion shows that more extensive flotation does not necessarily result in the recovery of more fish scales; burial conditions and the degree of fossilisation are also important.

All the fish scales are Perciformes. While this correlates to some extent with the proportions of identified cranial bones, certain taxa, like Esocidae and Catostomidae, are conspicuously absent. In modern samples of comparable-sized fish to those represented by the cranial material, these cycloid scales appear somewhat less robust than the ctenoid scales of the Perciformes. Indeed, the very large Catostomidae scales recovered from a midden at the Steward site (Junker-Andersen 1984) were all fragmentary, although the condition of large Catostomidae scales at the Hector Trudel site (Cossette 1995) was much better. Salmonidae scales are fragile and also very small relative to body size, so that they are more likely to break and/or slip through the screen.

The main taphonomic difference between Carson and the other two sites is screen mesh aperture. While fish scale recovery may not be enhanced by fine mesh dry screening, the recovery of many small perch bones from the Carson 3.2 mm mesh and flotation samples and, more recently, the recovery of very small perch bones and small cycloid scales from the flotation heavy fractions from the Grafton site by Thomas and Needs-Howarth (Thomas 1997a), may well be a compelling argument for the use of small aperture wet-screening or more extensive flotation on sites with sandy soil. It is possible that the smaller dry screen mesh size employed at Carson has allowed for the recovery of greater numbers of fish scales.

There are some differences between houses and middens. At Dunsmore, fish scales represent four percent of the total bone recovery from the houses, and seven percent of the middens. At Carson fish scales represent nine percent of the total from the houses, and 16 percent of the middens. This may suggest that refuse from primary processing in the form of descaling was deposited more frequently in external refuse deposits. Taphonomic effects may have been more severe in the houses because of burning, trampling and delayed burial.

The fact that the rest of the Carson fish assemblage is so similar to the Dunsmore assemblage indicates that perhaps there are real differences in the frequency of fish processing at these sites. Fish scales of several species tend not to survive being buried after they have been cooked (Nicholson 1996a). Cooking method and feature deposition history combined probably play a major role. It is quite possible, for example, that the Carson material simply included more refuse from fish that were skinned prior to cooking and less from fish that were cooked or roasted with the scales still attached.

Additional support for this hypothesis is found in the fact that the proportion of brown bullhead, a species that does not possess scales, is higher at Carson than at Dunsmore, so that there would be relatively fewer scales associated with the Carson fish catch, based on taxonomic distribution. It is hypothesized here that the Dunsmore people were more likely to descale their fish at the catch location or boil or
roast their fish in the skin, which would result in fewer fish scales being deposited or preserved at the site. On-site dog scavenging cannot be ruled out, but this would affect fish heads, vertebrae and other animal remains as well as fish skins with scales.

Filleting
Another way to look at fish butchering is to examine the relative representation of the cleithrum, a bone that may well have been broken during decapitation. Brown/yellow bullhead and yellow perch cleithra are frequently broken. It is almost always the dorsal part of the element that survives to be identified (Table 14). It is interesting to note that five of the complete yellow perch cleithra from Dunsmore are from H8 F206 (MNI 4), and that all of these are much smaller than the site average. Perhaps these smaller individuals were cooked whole. For brown/yellow bullhead broken cleithra almost always include all or part of the articulation for the pectoral spine, while for yellow perch they include mainly the dorsal “wing.” This is likely related to element morphology and robusticity.

While the anterior/ventral cleithrum in brown/yellow bullhead is much more robust than the corresponding part in yellow perch, anterior/ventral portions are conspicuously absent in both taxa. The range of dimensions of the anterior/ventral portion in each species is fairly similar, and their sizes would in many cases have enabled recovery in 6.4 and 3.2 mm mesh. Recovery bias is probably not the only explanation.

A further examination of relative element representation of these two taxa in relation to element robusticity, however, reveals that these two taxa experienced quite different taphonomic histories. Percidae have relatively fragile vertebrae that look somewhat similar to Centrarchidae, causing some, perhaps, to have been lumped inadvertently with Centrarchidae. In contrast, Ictaluridae vertebrae are more easily recognisable and quite robust. The high number of Ictaluridae cleithra (and other cranial bones) in relation to vertebrae is, therefore, hard to explain. A similar dearth of Ictaluridae vertebrae was noted at the Keffer site (Stewart 1991b). Breakage of brown/yellow bullhead cleithra may be a side-effect of extraction of the pectoral spine, either to avoid injury or to enable curation of the spines as tools. Given the extreme robusticity of brown/yellow bullhead cranial bones in relation to other fish, it is possible that the heads were avoided by the dogs, thus leading to the observed relative over-representation in relation to post-cranial elements. Pike heads, containing very little meat and sharp teeth, may have been similarly unattractive for consumption by humans (Noe-Nygaard 1983:130; Noe-Nygaard 1987:28) and dogs. In conclusion, the ratio of cranial bone to vertebrae can only be used as direct evidence for butchering if both identification and taphonomic biases are considered, including dog scavenging.

Food preparation
Iroquoian food preparation techniques in general may not have been conducive to bone preservation. Fish might be preserved by drying or smoking, depending on the season (Thwaites 1896-1901:10:101, 34:215). The Huron sometimes packed the smoked fish in “casks” to have at feasts or use in soup, especially in winter (Sagard 1939:186). Writing about the New York Iroquois in the mid-nineteenth century, Morgan (1962:64-65) says that “whatever was gained by any member of the household on hunting or fishing expeditions, or was raised by cultivation, was made common stock. Within the house they lived from common stores.” Most of the fish at these three sites were small (compared, for example, to some marine fish), and may well have been eaten during a single meal by one or more families in the same longhouse.

Huron foods consisted mainly of corn-based stews, cooked in large ceramic pots, or corn bread (Heidenreich 1972:57). Ordinary meals frequently consisted of corn soup, flavoured by berries, fish or meat (Sagard 1939:106-107, 230). A glimpse of the cooking process was seen at the Peace Bridge site at the north end of Lake Erie near Niagara Falls where Thomas (1998) analysed the contents of a ceramic cooking vessel dating to about A. D. 675. It contained remains of walleye (Stizostedion vitreum) and other fish, as well as the scapula of a whitetailed deer. While the exact relationship between the Princess Point people who were responsible for this pot and the second millennium occupants of the area between Lake Simcoe and Nottawasaga Bay is unknown, some cultural continuity in cooking practices may be assumed.

Some food preparation techniques may have resulted in considerable loss of fish bones. Smaller fish were likely cooked whole and may have been eaten in their entirety (e.g. Brinkhuizen 1989: 267). This may explain the dearth of small Cyprinidae, and other taxa that are common in the area today (Latta 1998:10). In discussing Mesolithic midden refuse from Denmark, Enghoff (1991:116) offers the scenario that “bones and scales have simply been skimmed off potfuls of fish soup.”

Cooking or stewing may have adversely affected the preservation of fish remains, because heating causes morphological change in bone (Richter 1986); boiled fish bone loses much of its mechanical strength (Jones 1990). Considerable loss and breakage of fish bones occurs during roasting, although “block-shaped” bones (such as vertebrae) and dense, hard bones survive better than others (Spennemann and Colley 1989).

In any event, if animal bones survived the stewing process to be buried and recovered, there would not necessarily be many butchery marks. Iroquoian researchers have made much of Sagard’s (1939:316-318) description of the Huron taboo on burning fish bones, which also holds for Algonkian groups such as the Ojibway (Stephen Crawford, personal communication 1999): “They take special care not to throw any fishbone into the fire [because the bones represent]...spirits of the fish themselves..., which would
warn the other fish not to allow themselves to be caught....” As was noted above, however, burnt and calcined fish bones do show up in zooarchaeological assemblages. These are often bones of the pectoral girdle, which may have been exposed during cooking. A number of the lake sturgeon dermal plates from the Barrie site were burnt, though not calcined, perhaps because they were exposed during roasting.

Consumption
Fish at Iroquoian sites were most likely consumed by both humans and dogs. Dogs were kept by Iroquoian people as pets and as a food source (Sagard 1939:111, 117, 123, 226, 227). They may have been fed kitchen refuse, and since they were probably allowed to roam free at least some of the time, they had easy access to refuse in middens and pits. Dogs, therefore, are likely to have been an important taphonomic agency. Carnivore gnawing was observed on three of the identified bones from Barrie, 10 from Dunsmore, and four from Carson, i.e. roughly in proportion to the total NISP. No carnivore damage was observed on fish bones. This does not, however, mean dogs did not eat food refuse. They probably were fed or scavenged from middens scraps of kitchen refuse, of which nothing identifiable would remain.

There is a considerable amount of literature on the effects of human consumption and dog scavenging on the destruction or (in the case of dogs) displacement of animal bones. The degree to which bones become modified by the eating and digestion process is related to a number of factors, including the species, age, condition of the tissue, structural density, shape, completeness of skeleton and bones, pretreatment of bones, and the disposal method (Butler and Schroeder 1998; Jones 1986; Kent 1981; Lyon 1970; Payne and Munson 1985; Stallibrass 1990; Walters 1984). Smaller fish especially may have been eaten whole or reduced to unidentifiable fragments through cooking or chewing (Royo 1987). In one feeding experiment (Jones 1986), less than 10 percent of ingested bones of fish 24 to 35 cm total length (hereafter TL) survived passage through the digestive system of a human being and a dog, while 25 percent survived in another study using fish of 6.5 - 8.5 cm standard length (SL) (Butler and Schroeder 1998).

Discard
Details on in-house refuse deposition are obscured by plough damage to the house floors; the excavated refuse deposits represent only the truncated remains of the original features. In general, sedentary populations discard items outside their use locations (Gifford 1980; Murray 1980). Middens mostly contain a random mix of byproducts of activities conducted over unspecified periods of time, from one or several adjacent structures. It is also possible that refuse was deposited down-slope, outside the house and midden areas. However, the abundant food refuse in interior pits, hearths and reused semi-subterranean sweatlodges suggests that the inhabitants of these three sites did not discard all their refuse outside their houses. Excavations at one undisturbed Iroquoian site indicated that refuse inside houses accumulates near the outer walls (Finlayson 1985). This patterning is, of course, obscured at a plough-disturbed site.

Since processing activities relating to large catches of animals may be expected to be conducted preferentially in outside work areas, middens may be expected to contain more refuse resulting from mass-capture events (1996b; Thomas 1996d). House feature deposits, on the other hand, are more likely to contain refuse from activities carried out inside the house.

Feature fill may include redeposited material from unrelated activities, and food debris representing, for example, preserved fish. It is also conceivable that food refuse in secondary contexts has become mixed with food excreted in faecal matter of humans and dogs. A feature may, therefore, contain superimposed evidence of more than one procurement and refuse deposition event. One of the problems on Iroquoian sites is distinguishing between primary and secondary refuse contexts. Much of the bone in middens and reused sweatlodges is probably secondary refuse.

There is always a certain amount of bone in ash pits, which may contain hearth sweepings. A comparison of thermally altered bones between feature types at Barrie and Dunsmore demonstrates that ash pits do not contain more burned and calcined bones than other feature types (Needs-Howarth and Thomas 1994a). It was argued that this may indicate that ash pits do not consist of unmodified hearth sweepings, which could be expected to include bones thermally altered from overheating or being dropped in the fire. Pits, on the other hand, contain over twice as much thermally altered bone as other feature types. It seems likely that pit fill consisted in part of normal hearth sweepings (Needs-Howarth and Thomas 1994a).

Burial
Bone preservation at all three sites is facilitated by the sandy, non-acidic soils and the fact that natural and cultural taphonomic processes have been allowed little time to destroy the zooarchaeological evidence. The collections have undergone only about 500 to 700 years of post-depositional disturbance and metal plough agriculture has been a significant factor in site disturbance for less than 200 years. All categories of bone at these sites are capable of being preserved without carbonisation.

Preservation of the bones was generally good; diagnostic features were preserved on many of the bones and they exhibited only minimal excavation damage. There are some unquantified differences in preservation between the Barrie sample and the two later ones. The Barrie bone appears to have been subjected to iron staining. Some of the surface texture of mammal longbones appears somewhat more porous than comparable bones at the other sites. There was also more soil and/or root etching. The differences in
preservation became quite apparent when viewing sectioned pectoral spines of brown bullhead from each of the sites. The sections from Barrie are noticeably more stained and display a loss of some of the bone interior. These phenomena were also observed on the lake sturgeon spine sections, although here comparable material from the two later sites was not available. The paucity and poor condition of fish scales from Barrie may also relate to differential preservation. Preservation at the Dunsmore site was generally very good, particularly in Midden A, Midden B and most of the major features. Preservation at Carson was also generally very good. Intact, well-preserved fish scales were recovered from both Dunsmore and Carson.

Storage of the Carson flotation samples may have affected bone preservation of the heavy fraction samples. Samples from Barrie and Dunsmore were processed on-site, using the two-bucket method. In contrast, the Carson flotation samples were stored for six years in an unheated garden shed before being processed. The plant remains in the flotation samples suffered considerable deterioration during storage (Della Saunders, personal communication 1996). Some fish bones had assumed a rubbery consistency, suggesting some deterioration of the zooarchaeological remains as well. Deterioration was apparently not uniform among samples, since some flotation heavy fractions contained substantial numbers of intact fish scales.

Nicholson's (1996b) actualistic studies indicate that “bone loss between taxa frequently does not follow easily defined rules, for example based on bone size or bone density, and [...] soil environment such as pH and drainage.” While the latter do play a role in bone preservation, a major factor, at least in the initial stages, may be the range and types of soil microorganisms available (Nicholson 1996a). Autolysis by the fat contained in the bone may have caused additional taphonomic loss (Mézes and Bartosiewicz 1994).

Bone loss also relates to processing and cooking method, and may differ between species (Nicholson 1996a). Buried fish bones decompose more rapidly when the flesh has been removed and when they have been boiled (Nicholson 1996a; Nicholson 1996b). As Nicholson (1992) established, fish bone survival is mediated not by bone density, rather by bone shape and size. In general, one would expect the thin, flat cranial bones to be destroyed more quickly than the cylindrical vertebrae, simply because they have less mechanical strength and relatively more surface area (Morales Muñiz 1984; Rojo 1987; Spennemann and Colley 1989).

Taphonomy of Salmonidae bones requires some further consideration. Salmonidae may be subject to two biases not affecting other taxa. The first is a depositional bias relating to off-site processing. This is explored below. The second is a taphonomic bias against representation of Salmonidae cranial bones, indicated by recent actualistic experiments (Butler and Chatters 1994; Lubinski 1996). Because they are relatively less dense than vertebrae, chinook salmon (Oncorhynchus tshawytscha) cranial bones do not preserve as well as their vertebrae (Butler and Chatters 1994). Lake whitefish cranial bones are more fragile and less likely to survive being cooked or roasted than their vertebrae (Lubinski 1996).

Recovery
Introduction
Some aspects of zooarchaeological recovery were previously discussed in Chapter 2. This information needs to be expanded upon in order to understand certain aspects of taphonomic bias. The zooarchaeological samples from Barrie and Dunsmore were recovered with the aid of 6.4 mm dry screen, from Carson with 3.2 mm dry screen (this refers to the mesh grid; actual mesh apertures are somewhat smaller). All three assemblages derive a proportion of their bone fragments from flotation. The aperture of the smallest heavy fraction nested sieve is 2 mm for Barrie and Dunsmore, 2.4 mm for Carson. Flotation samples are a sub-sample of the feature fill in any given refuse context, the remainder of which is screened (Table 3, 4, 5). The intensity of flotation varies and soil volumes are available only for the floated components. Since screened volumes are not available (except in a general way, by multiplying feature dimensions), it is not possible to calculate the number of fragments per soil volume. The lack of comprehensive volume density information leaves a big gap in our understanding of taphonomy. Screen mesh size is undoubtedly a significant bias in the recovery of faunal remains, especially smaller taxa such as fish.

Because of the differences in mesh sizes and intensity of flotation and the lack of screened volume data it is difficult to judge to what extent each assemblage is subject to recovery bias. There are further complicating factors, which are discussed below. In general, however, the combinations of different recovery methods generate certain expectations. One would expect both the kind and number of remains recovered and their fragment sizes to correlate to some extent with mesh aperture. In the absence of soil volume data, our only guide to recovery biases are fragment sizes, and the proportions of NISP, number of unidentified specimens (i.e. usually those bones not identified below the taxonomic level of class, hereafter NUSP) and BW as they relate to the different recovery methods. The cultural and temporal similarities between Dunsmore and Carson may be expected to have resulted in somewhat similar original bone assemblages. If major differences were found, these might be attributed to recovery. Determining whether variability in the zooarchaeological samples can be attributed to differential recovery is essential to inter-site comparisons.

Cautionary tales from the literature
In general, the relationship between sieve sizes and frequency of material recovered is curvilinear; flotation is considered by some to be the most cost-intensive means of intensive data recovery (e.g., Ball and Bobrowsky 1987). A comparison between 6.4 mm and 3.2 mm dry screening showed that the larger aperture biases against species...
diversity (Gordon 1993). A much-cited experiment by David Thomas (1969) showed that large quantities of small mammal bones were lost in 6.4 and even 3.2 mm dry screen mesh. Only 1.6 mm dry screen mesh resulted in full recovery of mammal bones, while fish were not recovered at all from the larger mesh sizes. An experiment by Casteel (1972) indicated that all freshwater fish vertebrae (species and size not specified) were lost in the approximately 5.6 mm mesh. A comparison of recovery methods for Hawaiian material (Gordon 1993; 1994) concluded that sediment screened at 3.2 mm produced about 250 times as much fish bone per volume as sediment screened at 6.4 mm. Another comparison, using Hohokam material, indicated the 3.4 mm mesh produced between 1.6 and 5 times more bone fragments, and that 90 percent of fish remains may be lost through the 6.4 mm mesh (James 1997). Recovery tests at the Middle Woodland Hector Trudel site (Cossette 1995) showed that fish bones were particularly under-represented in the 6.4 mm field recovered sample and that smallest fish were only collected in the 2 mm and 1 mm fine screens and flotation samples. A recent publication (Cannon 1999) indicates that, at least for mammals, mathematically correcting for differential recovery is extremely problematic.

**Effects of dry screening**

All else being equal, a smaller mesh aperture should result in more fish, and even more unidentified fish than a larger aperture. The 3.2 mm dry screening mesh used at Carson is expected to result in increased recovery of (small) fish remains compared to the 6.4 mm mesh used at Barrie and Dunsmore. In addition, the finer dry screen mesh size is expected to result in a much greater number of unidentified fish at Carson than the other two sites.

Carson lags behind Dunsmore in proportion of screened fish NISP (Table 15). The effects of the smaller mesh size are, however, noticeable in the huge number of unidentified fish fragments from the screen. At Barrie and Dunsmore, 63 percent and 57 percent of the fish from the screen, respectively, could not be identified. At Carson 85 percent could not be identified (with the exception of fish vertebrae, which, while frequently identified to family, are included in the NUSP). Considering only the fragment counts, it appears, therefore, that the smaller mesh size has not really increased the recovery of identifiable fish bones; it has, however, substantially increased the number of unidentifiable fish bones.

Note that the number of lake herring or lake whitefish vertebrae is low compared to lake trout vertebrae at Dunsmore and Carson. This may be because the former are less robust and generally much smaller; as noted above, lake herring caudal vertebrae in particular would fall right through the 6.4 mm mesh.

**Effects of flotation**

The Barrie sample was subjected to substantially more flotation than the other two samples (Table 16). More contexts were sampled at Carson than at Dunsmore, but the effects of the increased flotation are not that noticeable. This may relate to the absolute volume of the samples, which was 2 litres or less at Carson, and usually more than 2 litres at Dunsmore. There appears to be a relationship between intensity of flotation and average number of bone finds per context; at Barrie, the number of finds per context is greater than at Dunsmore and Carson.

How does ubiquity of flotation and mesh aperture of the geological sieve used to recover the heavy fraction relate to fish recovery? Although the ratio of screened to floated volumes is not available, it is known that the flotation samples are only a fraction of the screened volumes. The flotation samples, however, contribute a disproportionately large number of bones. At Barrie flotation accounts for 41 percent of the overall number of bone fragments recovered; at Dunsmore 31 percent; at Carson 36 percent. This conforms to expectations.

One would also expect to see a correlation between the proportion of fragments derived from the flotation heavy fraction and the proportion of fish. Initially, this appears not to be the case, with Barrie having the lowest proportion of identified fish (53 percent vs. Dunsmore 75 percent, and Carson 67 percent). The proportion of unidentified fish is surprisingly similar between the sites (Barrie 74 percent, Dunsmore 78 percent, Carson 82 percent of NUSP). However, the proportion of fish finds within the flotation sample shows that flotation does result in increased fish remains, at least at Barrie, where fish represent 85 percent of the heavy fraction and fish represent only 57 percent of the screened material. For Dunsmore the figures are 81 percent and 75 percent, for Carson and 75 percent and 80 percent.

These differences between recovery methods are not as marked as at other sites. At the Keffer site (AkGw-14), located just north of Lake Ontario, the number of bone fragments derived from 6.4 mm screening and flotation were roughly similar. In the former sample fish represented only 30 percent, while in the latter they represented 70 percent (Stewart 1991b). Animals bones from the 1983 excavations at the Wiacek site (BcGw-26), analysed by Christine Dodd (Lennox et al. 1986), derived mostly from flotation. Fish represent 69 percent of the screened sample, and 84 percent of the floated sample. For this site soil volumes are available; screened material represents 92 percent by volume, but only three percent by number of fragments. At the St. Lawrence Iroquoian Steward site (BfFt-2) (Junker-Andersen 1984), flotation also markedly increased bone recovery; 36 percent of all analysed elements were recovered from four percent of the soil volume.

**Comparison of screened and floated samples**

Consistent with expectations, Barrie shows a substantial improvement in fish recovery through flotation. Almost half of the fish bones in the assemblage derive from the heavy
fraction. Also as expected, the proportion of unidentified fish in the whole floated sample is greater than in the screened sample. Fish are 87 percent of floated NUSP, only 13 percent of floated NISP. The Dunsmore sample has more equal proportions of fish from the screens (Table 15). In terms of ratios of identified to unidentified fish, Dunsmore, however, is similar to Barrie. Fish are 91 percent of floated NUSP, only nine percent of floated NISP. At Carson, these numbers are almost identical: 92 percent and eight percent. Again, it is necessary to look at ratios of fish in the whole sample to identify an anomaly. Identified fish at Carson contribute 94 percent to the heavy fraction of all five classes combined, compared to a 65 percent contribution to the screened component. This is very odd considering that the difference in mesh aperture for screened and floated material at Carson is less than 1 mm: 3.2 mm vs. 2.4 mm. If screen size is the only determinant of recovery, there should be little difference between the screened and floated components. The question arises: “Why are there not more fish in the Carson screened sample?”

The answer may lie in how effectively bones were retrieved from among other finds and dirt in the screens. The Barrie and Dunsmore sites were excavated by experienced field crews, but Carson was excavated in part by inexperienced field school students. Following recovery tests at the Hector Trudel site (Cossette 1995), it was suggested that field crews may miss smaller, incomplete or less recognisable bones that would be recognized under laboratory conditions by trained zooarchaeologists. Although this study also found significant biases relating to mesh aperture, it was concluded that screen operator bias or screening conditions were in many respects more important than mesh size. It is hypothesized here that field recovery from the dry screens at the Carson site is biased against the recovery of fish bones in general, and of small and fragmented fish bones in particular.

Support for this hypothesis is found in fragmentation rates (Table 17). The number of broken fish bones within the flotation samples is fairly consistent between the three sites, indicating that the collections may have started out being similarly fragmented. Indeed, the proportions of complete and broken bones are similar between the screened and the floated components, with one exception. It is interesting to note that there are fewer identified fish bones with major damage in the screened component at Carson than at the other two sites, whereas the number of complete fish bones is more similar. This may indicate that field crews did not retrieve broken fish bones that could have been identified. If this is so, the real proportion of unidentified fish bones could be expected to be much higher than what was retained for analysis. The relatively high proportion of complete mammal bones compared to Barrie and Dunsmore supports the hypothesis that field recovery may have been biased towards complete bones. The lower fragmentation rates at Carson do, however, suggest that the unexpectedly low fish NISP is not the result of overly aggressive screening or forcing sediment through the mesh.

Fragment weights

Fragment weights can be used as a proxy for fragment size, and thus aid in understanding taphonomy (Landon 1992). As noted above, many identified fish bones weighed less than the precision limit of the balance. It is not possible, therefore, to elucidate taphonomic issues relating to BW from the identified fish bones. The combined unidentified fish bones, including vertebrae, were weighed per context; here average fragment weights can provide some insight into taphonomy. It should be pointed out that the Carson assemblage does include more small features with small sample sizes, so that the precision limits of the electronic balance may result in the recording of .1g weights for (groups of) small unidentified fragments that in fact weigh less than .1g.

As expected, fragment weights correlate to some extent with intensity of recovery. Screened material tends to weigh more than heavy fraction material. This difference is particularly obvious at the Carson site, where the midden material was recovered entirely through screening. Floated mammal remains at Barrie form an exception because of the inclusion of a large section of bear (Ursus americanus) humerus, weighing 32.1 g.

The absolute fragment weight of all classes is substantially larger at Barrie than at either Dunsmore or Carson. Surprisingly, this is the site with the most intensive flotation. While differences in mammal BW may relate to taxa included (i.e. more large mammals at Barrie), this is far less of a problem for fish. The large number of sturgeon bones from the middens at Barrie probably do account for much of the difference in average identified fish BW between Barrie and the two later sites. However, since it is unlikely that any sturgeon bones are included in the unidentified material, the difference there must be attributed to other factors. It appears from proportional element size observations that the occupants of the Barrie site caught slightly larger fish (see below), but the difference is not huge. Therefore, the cause must be sought in increased pre-depositional fragmentation and/or post-depositional trampling, especially at Dunsmore.

Fish element size

To further identify taphonomic bias, fish cranial bone size can be used to assess fragment sizes, as a proxy of fish size. Some zooarchaeologists record fish size as small, medium, or large in relation to a reference specimen of known size (e.g. Cooper 1996). Other techniques involve comparing archaeological material to several reference skeletons of known length and grouping them into size classes (e.g.
The proportional element sizes were recorded at 10 percent intervals, except for some intuitive fractions, such as 1/3 or 3/4. The back-calculated proportional element sizes based on osteometrics were recorded at one percent intervals. The osteometrics facilitated a verification of the proportional element size. The difference between the proportional element size and the back-calculated proportional element size based on osteometrics on an individual bone was small (usually less than 10 percent). Where there were discrepancies, the back-calculated proportional element size was adopted in favour of the proportional element size.

The proportional element size refers only to relative bone size, not to fish size. Intra-individual asymmetry, as well as inter and intra-individual differences in the relationship between element measurements and TL (Brinkhuizen 1989:66-67), make it difficult to decide the range of percentage points that could signify a “real” individual.

Figure 9 shows the proportional element size distribution of all sized and/or caliper-measured fish bones by site. Because this graph relies on size in relation to a reference specimen of known size, the size distribution is to some extent dependent on species composition. For example, the archaeological northern pike (Esox lucius) bones tended to be smaller than the reference specimen, whereas the yellow perch and brown bullhead were fairly similar in size to the reference specimen. This means that the graph for the site with the most pike is going to be shifted towards the left. This graph also masks some of the variation resulting from differences in taxonomic distribution between recovery methods. This combined size information at the site level can, however, be used in a very general way to explore differences in fish proportional element size between recovery methods. As one would expect, the sub-sample derived from flotation includes bones from smaller individuals. Comparison of fish relative element size within each site indicates that there is a discrepancy in average fish bone size between the screened and floated material at all three sites. At Barrie the difference is negligible, at Dunsmore it is 18 percent, and at Carson 20 percent.

To verify this pattern Figure 10 shows the proportional element sizes of the most abundant taxon at each site, yellow perch. At Barrie there is a discrepancy of five percent between screened and floated material, while at Dunsmore it is 17 percent and at Carson it is 19 percent. The small difference at Barrie may relate to the fact that the overall size of yellow perch is larger at this site, so that the small end of the spectrum would be less adversely affected by loss through screening.

The differences in proportional element size between recovery methods at Dunsmore probably relate to the 4.4 mm difference in mesh aperture between the two recovery methods. The differences between the two recovery methods at Carson are hard to explain. If screen mesh size was the major determinant of bone (fragment) size the two sub-assemblages should show little difference in average
size. This parallels the unexpected differences in percentages of identified fish in the heavy fraction compared to the screened component noted above.

**Absolute fragment size**

As will be discussed below, age and growth analysis of fish scales and pectoral spines recovered by dry screening demonstrated that the average age of two fish taxa is less at Carson than at Dunsmore. The average size of various cranial elements is also less. This is exactly what one would expect if screen size is biasing towards smaller fragments and/or fish size at Carson. Although the data will be discussed later, in Chapter 6 and 7, it is necessary at this point to briefly discuss whether these differences might be attributable to differential recovery bias.

The dimensions of the brown bullhead pectoral spines, even when only the medial/proximal 25% survives, are large enough to have be retrieved in both the 6.4 mm dry screen mesh used at Dunsmore and the 3.2 mm mesh used at Carson. An important clue to recovery bias between Dunsmore and Carson comes from the size of fish scales. To test whether the decreased age of fish scales at Carson was a function of recovery, the anterior-posterior length of the scales from Dunsmore and Carson was measured. This dimension is easier to measure than the greatest height. While the relationship between height and length varies with placement on the body, the height is usually the greater of the two. In other words, the length is a conservative measure of fish scale size. The size distribution in Figure 11 indicates that there are some smaller scales in the Carson sample. However, only the very smallest Carson scales would have fallen through the 6.4 mm mesh size used at Dunsmore. This would suggest that differences in age-at-death between the two sites are not entirely attributable to recovery bias.

Osteometrics of cranial bones of major fish taxa also show consistent differences. In order to examine differential recovery as an explanation for differing fish element sizes, Figure 12 shows dial-caliper measurements of two abundant elements, the dentary and operculum, of brown bullhead and yellow perch (Figure 12). The average size at Carson is slightly smaller, and it is possible that some smaller brown bullhead dentary fragments may have been preferentially recovered in the smaller mesh size used at Carson. However, bearing in mind the generally triangular shape of the operculum and the magnitude of the caliper measurements, it appears that the opercula at Carson would also have been caught in the larger mesh size in use at Barrie and Dunsmore.

**Sorting out recovery biases**

The combination of NISP, BW, and measurements of fish cranial bones and scales has provided some insights into taphonomy. Barrie and Dunsmore differ quite substantially. Given that recovery is so similar (except for flotation volumes), the explanation is likely to relate at least in part to culture or environment. Findings at Carson did not conform to expectations. Differences between the Barrie or Dunsmore samples, and the Carson sample may be more difficult to interpret.