Native fishing in the Great Lakes
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There are differences between the samples based on screen size; these cannot be quantified, however, since neither the potential universe of bones in the ground immediately prior to excavation or the soil volume are known. There are also differences based on method of excavation (floatation, screening) and field retrieval from the dry screens.

As expected, flotation has resulted in better fish recovery. At Dunsmore and Carson it resulted in retrieval of smaller fish remains. This was unexpected at Carson, since the dry screen mesh size and heavy fraction sieve size were almost identical. There are surprisingly few differences between the screened components from Dunsmore and Carson. This is not to say that 3.2 mm dry screening is without merit, simply that a lot more comparative samples are needed to understand these complicated issues. The finer dry screen mesh aperture has had a considerable effect on the sample because of the much lower identification rate – it is not known, however, in what other ways it has affected the sample. The fact that the Dunsmore and Carson samples look alike does not exclude the possibility that the originally deposited samples may have been very different. It is likely, however, that differences in fish element size and fish age between Dunsmore and Carson are not solely a function of recovery bias. Under different circumstances, some of these issues might have been settled using BW. However, since fragment weights for individual fish bones at these sites are mostly at the limit of precision of the electronic balance used, this conclusion could not have been reached without proportional element size observations, osteometrics and age-at-death data.

CHAPTER 5: INTERPRETING FISH REMAINS DATA

Historical data
The practice of late precontact (zoo)archaeology in southern Ontario is enriched because of abundant ethnohistoric descriptions of the Huron. As Ramsden (1996:104) has recently pointed out, the extensive written observations on the Huron provide archaeologists with “precisely what archaeologists in other areas try to create models for: a set of plausible hypotheses about the social, political, economic and ideological processes that produced at least part of the observable archaeological pattern.” In some ways this is a drawback, because it distracts attention from archaeological data (Ramsden 1996), especially topics such as subsistence.

Ethnohistorical descriptions of the Huron, other Iroquoian-speaking peoples, and their neighbours from the early contact period are useful, but they are probably quite biased and limited in scope. The Jesuit Relations (Thwaites 1896-1901) were written by Fathers Jean de Brébeuf, F. J. Le Mercier, Jerome Lalemant, Paul Ragueneau and Francesco Bressani. Their accounts pertain to their work as Jesuit missionaries in southern Ontario from A.D. 1634 to 1650 and emphasize mythology and religion. Correspondingly, their descriptions of animals and the natural world are weak (Heidenreich 1972:9-10). Explorer, trader and coloniser Samuel de Champlain (Biggar 1922-36) spent the winter of 1615 in the area between Lake Simcoe and Nottawasaga Bay. The writings of Récollet Friar Gabriel Sagard (1939), who spent the winter of 1623-24 among the Huron, are more similar to those of an anthropological participant-observer, making his writings in some ways more comprehensive (Tooker 1964:6). A follower of St. Francis, Sagard was more interested in the animal world than either the Jesuits or Champlain (Heidenreich 1972:8-9).

These sources were written about an alien society by European males whose primary interest was in converting the native inhabitants to Christianity or finding trade opportunities. Extrapolating back in time 50 or 100 years the precontact Huron (if they can even be called Huron at that point) is problematic enough using some form of Direct Historical Approach. Extrapolating back 325 years to the date of occupation of the Barrie site must be done with great caution, even though these people may have direct ancestral links to the Huron. While underlying customs and beliefs may have remained fairly stable over time, it appears likely that the subsistence choices would have varied with chronological and geographical changes in the environment.
and subsistence base. The seasonal cycle described for the Huron is closely linked to the men’s roles as fur traders, which took them away from the villages for long periods of time in spring and summer. While precontact Iroquoian people in the area probably traded furs to some extent with neighbouring groups, this was not as important as it was in the French period. Huron women spent most of the spring and summer tending the corn fields (perhaps at special-purpose horticultural cabins), until the harvest in late August or early September.

The use of ethnohistoric analogy brings its own problems. Iroquoian archaeologists recognise that the archaeological record “departs significantly from ethnohistoric descriptions” (Jamieson 1989:309). The kinds of questions now being asked about Iroquoian behaviour involve topics not included in the abundant ethnohistorical data (Trigger 1982). Ethnohistorical sources provide some detail on food processing, yet are uninformative about discard behaviour (Needs-Howarth 1992); they do not provide the kind of information necessary to identify formation processes or the cultural context of foods. Fortunately, however, the ethnohistorical sources do contain some useful details on techniques of capture for fish. These will be discussed below.

**Fisheries science data**

The fish identified at the three sites include representatives of all the major fish families one would expect to find in the area. Small Cyprinidae, such as shiners and minnows, are lacking, but these are rarely recovered at archaeological sites in the area. Fisheries biologists have described in detail the biology, growth and behaviour of some of the taxa commonly found on archaeological sites, such as lake sturgeon, Salmonidae, longnose sucker (*Catostomus catostomus*), white sucker (*Catostomus commersoni*), and Percidae. However, there is a lack of fisheries data for species that are not important to the twentieth century Ontario commercial or sport fishery, such as yellow and brown bullhead. This problem was also noted by Cossette (1995). Local data are essential, since fish biology and behaviour, especially seasonal movements, vary with latitude and environment. Wherever possible, general observations have been replaced by, or complemented by, local data provided by fisheries researchers (Table 7).

**Biogeography**

**Introduction**

Having local data about the fish identified in the collections is helpful to some extent. However, in order to be able to understand to what extent humans were selective in their subsistence choices it is essential to know the biogeographic distributions of all taxa available at that time. Modern environmental data are not refined enough for this purpose, and cannot be extrapolated back in time. It has been recommended archaeologists do their own palaeoecological reconstructions (Lovis and MacDonald 1997). Unfortunately, while this might be feasible for mammals or birds, for fish this is quite problematic.

Palaeobotanical and zooarchaeological research confirms that prior to Euro-Canadian settlement of the area there was substantial forest cover. Iroquoian settlement likely resulted in substantial but patchy forest clearance by different villages for agriculture and construction wood. This may be expected to have caused erosion and associated changes in stream flow. Euro-Canadian settlement likely caused additional changes, including modification of the local wetlands habitats. Contemporary species distributions are influenced by construction of dams and other obstacles in various streams and rivers surrounding Lake Simcoe. Discussions with fisheries biologists and conservation officers suggest that the flow regimes of watercourses and marshes are likely to be so changed, even by the early 1800s, that extrapolating hydrobiology back in time before Euro-Canadian settlement is problematic. Even minor differences in flow, depth, width, or substratum of the water sources in the area could have major implications for fish ecology, especially species composition and spawning behaviour. This argument has been used (Yerkes 1981b) to critique the use of species composition from modern fish catch for the purpose of archaeological analogy (Limp and Reidhead 1979). In other words, historic environmental data are of limited use to this kind of micro-scale investigation.

While there may exist some potentially relevant information on the biogeographical distribution of fish in the form of nineteenth century fishing records, this information can only be used as proof of the existence of a taxon in a particular watershed. It cannot be used as negative evidence for lack of taxa, since absent taxa may not have been sought after by Euro-Canadian fishers. Blind reliance on current biogeographical data can result in circular arguments. The zooarchaeological record provides our only empirical evidence for fish species distribution and diversity in the period immediately before contact. However, using zooarchaeological data to extrapolate precontact biogeography is problematic, because the extent of human selectivity is unknown.

In theory, it should be possible to determine the water body of origin through DNA signatures that are unique to a particular fish population. DNA analysis is currently being applied to modern fish material by fish biologists and environmental scientists. Dr. Thomas Whillans of Trent University and colleagues at the Ontario Ministry of Natural Resources are planning to obtain DNA signatures from lake herring and lake whitefish vertebrae from the Warminster site to determine whether these fish derived from the Georgian Bay/Nottawasaga River drainage or the Lake Simcoe drainage (Thomas Whillans, personal communication 1998).

**Lake Simcoe**

Lake Simcoe is part of the Trent-Severn Waterway system that connects Lake Ontario to Georgian Bay of Lake Huron (Figure 1). Lake Simcoe covers an area of 722 km², with an average depth of 6 m (Johnson 1997). It is a cold water system, while adjacent Lake Couchiching is shallower, and hence warmer. Kempenfelt Bay on the west side of Lake
Simcoe (Figure 2) is steep-sloped, with a maximum depth of 41 m (Evans et al. 1996). In the past, Kempenfelt Bay may have extended further westward into a marsh-like lagoon (Robin Craig, personal communication 1998). Cook’s Bay, at the southern end of the lake is up to 15 m deep (Evans et al. 1996); fish habitat in and around Cook’s Bay may have been altered by the draining of the Holland Marsh in the 1930s.

Recent research has shown that phosphorous loading from soil erosion, agriculture and effluent has resulted in increased phytoplankton production and subsequent depletion of hypolimnetic dissolved oxygen (Johnson and Nichols 1988; Nichols 1997). While the increase in primary production may have helped some of the warm water near-shore taxa (Michael McMurtry, personal communication 1998), depleted levels of hypolimnetic dissolved oxygen in late summer constitute a major stress for the cold water fish species in the lake, including lake trout, lake herring and lake whitefish. The effect on cool water species, such as yellow perch, is less certain because they are more flexible in their habitat requirements (Michael McMurtry, personal communication 1998).

Eutrophication is not the only factor in the current decline of lake whitefish and lake trout. Heavy harvesting and invasion of the lake by rainbow smelt (*Osmerus mordax*, Osmeridae) have also affected these species. Accidental introduction of another non-native species, the common carp (*Cyprinus carpio*, Cyprinidae), in 1896 is thought to have caused destruction of the wild rice beds and other rooted aquatic vegetation in the Holland River and Cook’s Bay, thereby degrading important habitat for muskellunge (MacCrimmon and Skobe 1970). In short, “eutrophication, increased fishing pressure, habitat destruction and invasion of non-native plants and animals have transformed Lake Simcoe and its assemblage of fishes over the past 150 years” (McMurtry et al. 1998). This transformation includes the loss of lake sturgeon, decline of muskellunge, failure of recruitment of lake trout and lake whitefish, and major fluctuations in abundance of lake trout, lake whitefish, lake herring, and yellow perch. The combination of habitat change and fish introductions poses considerable difficulties for reconstructing precontact fish communities from modern fisheries data.

**Rivers**

The Nottawasaga River is a warm water ecosystem. Shifting sand bars at the mouth of the Nottawasaga River (Hunter 1906:30), and silt on old levies in the river, indicate that the lower reaches of the Nottawasaga River were probably almost as muddy in the past as they are today, possibly making the main channel of the river an unsuitable spawning habitat for some species (Robin Craig, personal communication 1998). An influx of groundwater in Minesing Swamp, however, causes the water to be very clear beside the main channel. In spring, the groundwater has sufficient volume to restrict the muddy river water to the main channel (Robin Craig, personal communication 1998). Water levels in the river vary considerably from year to year. With sufficient volume, the main channel is navigable by fish (and humans pursuing them in canoes) from the mouth at Nottawasaga Bay to at least 40 km south of Minesing Swamp, near the branching of the Boyne River (Robin Craig, personal communication 1998).
**Wetlands**
The extensive wetlands in the area between Lake Simcoe and Nottawasaga Bay may have been ecologically diverse compared to the upland forests. Indeed, Minesing Swamp may have been more productive than Lake Simcoe itself (Robin Craig, personal communication 1998). Minesing Swamp was more extensive in the precontact period (Sutton 1996a). The name Minesing is an Ojibway word that translates as “at the island” (John Steckley, personal communication 1998), probably referring to an area of higher ground surrounded by marsh and swamp just north of Willow Creek and just east of the Nottawasaga River (Hunter 1906). As noted above, the west end of Kempenfelt Bay may have accommodated wetlands species.

**Fish habitat**
Fish in lake habitats, such as Lake Simcoe and Nottawasaga Bay, were inaccessible for much of the year, and only abundantly available during their spawning season (Cleland 1982:766). However, given the site locations, most fish species in these three assemblages were obtainable in more than one kind of habitat, including the large lakes, but also rivers, creeks, smaller lakes and marshes. To bring this potentially ambiguous picture into better focus, following Thomas’ work on the nearby and culturally similar Hubbert site (Thomas 1996b), Needs-Howarth and Thomas (1998) turned to a fish habitat preference study conducted by wildlife biologists Jude and Pappas (1992). This study used correspondence analysis of fish abundance statistics from 16 Great Lakes fish census studies from the 1970s, 1980s and early 1990s to rank the habitat preferences of 113 species on an ordinal scale. Three major species complexes were defined on the basis of habitat preference scores: the open water (1-31); transitional, including open water, nearshore, and wetlands (32-66); and coastal wetlands (67-113) taxocenes. In these three zooarchaeological assemblages the extremes of the spectrum are represented by lake herring (rank 7, open water) and grass pickerel (rank 109, coastal wetlands) (Figure 13).

**Fishing techniques**

*Introduction*
It is not known how the site occupants perceived the costs and benefits of the various fishing techniques available to them. In a general way, it can be assumed they used the simplest technology appropriate to the intensity of exploitation, and a location involving a short travel distance (Needs-Howarth and Thomas 1998; Thomas 1996b). While the Great Lakes have a large sustainable production of fish, it is spread out over a huge volume of water, most of it inaccessible to people travelling in small canoes. Both Sagard (1939) and Joutel (Kinietz 1965) indicate that native people did not travel more than a league from shore. The location of Odawa camps on islands in Georgian Bay indicates that the Odawa at least were capable of covering 8 km of open water. However, because creek, river, wetland and lake habitats are found within a five km radius of each site, most fish species represented at the sites would be convenient to exploit, without necessitating long canoe journeys on open water.

Fishing techniques can be divided into active and passive (e.g. Brinkhuizen 1983). The active techniques, such as spearing or angling, result in one fish being caught at a time. Passive techniques are usually less time consuming and involve netting or fish-trapping, allowing many fish to be caught simultaneously. As might be expected, variation in time, location and method of fishing results in different catches.

*Angling*
Angling could have been used to obtain most of the taxa represented. Hand-held lines can be used in the upper Great Lakes on open water and through the ice to catch large predateous species (Cleland 1982:764). Angling at the Barrie, Dunsmore and Carson sites may not have been as important as netting because it is not as efficient in obtaining large numbers of fish. Fishing lines were most likely made from indian hemp (*Apocynum cannabinum*) (Sagard 1939:189), which has poor tensile properties when wet (Salls 1989). Indeed, Sagard (1939:189) mentions that hooks, made of wood with a bone bar, tied with hemp cord, were often found in the stomachs of fish, suggesting that the lines were not sufficiently strong. No fish hooks were recovered at the three sites, although two worked bone splinters from Dunsmore may have functioned as gorges.

*Spearinhg/harpooning*
Spear and harpooning was likely practised on many of the fish species recovered, especially the larger individuals. Cleland suggests the harpoon was in use by Middle Woodland times and may have largely replaced spearing, since its detachable head attached to a line vastly improved chances of capture (Cleland 1982:774). Wooden shafts or leister-type implements discarded at the sites would long since have decomposed. Chert spear heads are frequently recovered at Iroquoian sites and it is possible that some of them were used on fish.

*Netting*
Evidence for the use of netting technology in the Great Lakes dates to at least the Late Archaic/Early Woodland (Petersen et al. 1984). Large quantities of fall-spawning lake herring, lake whitefish and lake trout bones indicate a redesign of the existing net technology, leading to the development of the gill net (Cleland 1982; Cleland 1989). While it has been argued (Martin 1989) that non-horticultural groups in Michigan were using gill-nets during the Middle Woodland, the zooarchaeological data from Ontario appear to concur with Cleland’s Late Woodland timing. The use of nets was a cooperative enterprise, requiring a considerable labour investment for making, setting and tending nets and also for processing and/or preserving the catch (Cleland 1982).

Iroquoian fishing nets were commonly made from Indian hemp (Sagard 1939:240) or nettle (*Urtica holosericea*) (Hennepin 1903:522). It is unlikely that many nets and their
attached netsinkers would be found at the village. They were probably maintained at the fishing locations. No netsinkers were recovered from the sites, and the nets themselves would not be preserved.

When spring-spawning fish travelled from Kempenfelt Bay up the tributary streams in large numbers, they may have been caught in shallow water in seine-nets or fish-traps (Needs-Howarth and Thomas 1998). A broader size range would be expected in each depositional context if the site inhabitants used techniques of mass capture such as seine-netting or fish-trapping. Seine- (or impounding) nets are long, deep, fine-meshed nets that have floats at the top and weights at the bottom so they rest on the substrate. A seine-net is used as a fence to actively corral fish towards the shore. The finer the mesh, the more small-sized fish will be taken. Compared to gill-nets, seine-nets trap a wider range of sizes. Seine-nets continued to be used after the adoption of gill-nets because they were better suited to the capture of shallow water fish (Cleland 1982:778). Fish caught in seine-nets would usually still be alive when the fishermen came to claim them. This means undesirable fish could released alive.

Ice fishing was conducted by means of angling and seine-nets (Sagard 1939:98).

“They make several round holes in the ice and that through which they are drawn the seine is some five feet long and three feet wide. Then they begin to set their net in this opening; they fasten it to a wooden pole six or seven feet long, and place it under the ice, and pass this pole from hole to hole, where one or two men put their hands through and take hold of the pole to which one end of the net is tied, until they come back to the opening five or six feet wide. Then they let the net drop to the bottom by means of certain small stones fastened to the end of it. After it has been to the bottom they draw it up again by main force by its two ends” (Biggar 1922-36(3):166-168).

In this quote, Champlain records how the Huron used nets for ice fishing. Cleland (1982:762) sees this as an example of gill-netting, while others interpret this activity as seine-netting (Heidenreich 1972:72; Molnar 1997:24).

Gill- (or entangling) nets are set to form an underwater curtain for entangling, gilling and wedging fish, with the latter two being the dominant modes of capture. Floaters and sinkers keep the net vertically stretched at a set depth. This technology is suited to offshore fishing in the deeper waters of the Great Lakes (Cleland 1982). The size distribution of fish from a gill-net is often more restricted than a seine-net (Hamley 1975). Modern gill-nets are size selective, with most fish being within 20 percent of the size median (Hamley 1975). Gill-nets made from cotton (and other plant fibres by inference) may be less efficient than modern nylon nets (Berst 1961; McCombie and Fry 1960). Handmade plant fibre nets may have displayed some variation in mesh aperture within a single net and, therefore, probably resulted in a somewhat less restricted size distribution. The effectiveness of the net is related to girth (McCombie and Berst 1969; McCombie and Fry 1960). In general, deep-bodied fish are represented by shorter individuals than the more elongated fish from the same netting event, although swimming speed and gill morphology also play a role. Fish of a given size are taken most efficiently when their girth is approximately 25 percent greater than the perimeter of the mesh (McCombie and Berst 1969).

Unlike impounding nets, gill-nets are lethal to most things that become stuck in them; fish in gill-nets are often dead by the time the net is pulled up. The Algonkian-speaking Ojibway who currently live on the Bruce Peninsula have a taboo against returning dead fish, blood and guts to the water (Molnar 1997, citing a personal communication from Stephen Crawford). Paradoxically, the use of gill-nets may, therefore, result in a more varied species and size distribution at the processing location than the less selective method of seine-netting (Molnar 1997, citing a personal communication from Stephen Crawford). This taboo may have also pertained to the Huron and their ancestors.

The presence of diving birds may suggest the use of gill-nets. In discussing merganser (Mergus merganser) bones found at a Middle Neolithic lake-side site in Switzerland, Studer (1992:81) describes how the merganser “exploits the same areas as the fishermen and enjoys abstracting some of the fish entangled in the nets and, if caught in the net [it drowns].” Large quantities of bones derived from lake-dwelling deep-water fish may be another indication of the use of gill-nets.

Gill-net fishing could be carried out by two or three people from a canoe. Net fishing can be quite a dangerous activity, as was indicated by an interment of two intermingled skeletons of adult men together with numerous net sinkers at a seventeenth century Iroquoian component near the Niagara River at Fort Erie (Granger 1976-77). In this case the current may have proved lethal, whereas on open lake water it would most likely be the high winds and waves.

Sagard (1939:185-186) recounts joining in a fishing expedition with the Huron, apparently involving gill-nets. They went by canoe to an island in the “Fresh-Water Sea” (Georgian Bay of Lake Huron) and “every evening they carried the nets about half a league or a league out into the lake, and...at daybreak they went to draw them in, and always brought back many fine big fish such as Assihendo [lake whitefish], trout, lake sturgeon, and others.”

Having observed gill-netting at the straights of Mackinac in Lake Michigan in 1687, Joutel (Kinietz 1965:29) provides the following description:

“There are fish of various kinds which they catch with nets...and, although they only make them with
ordinary sewing thread, they will nevertheless stop fish weighing over ten pounds. They go as far as a league out into the lake to spread their nets... They have nets as long as 200 fathoms, and about two feet deep. At the lower part of these nets they fasten stones, to make them go to the bottom; and on the upper part they put pieces of cedar wood. Such nets are spread in the water...the fish being caught as they pass... The nets are sometimes spread in a depth of more than thirty fathoms, and when bad weather comes, they are in danger of being lost.”

_Fish-traps and weirs_

Fish-traps made of twigs or wicker can be custom-built to catch fish within a certain size range. They are often efficient for catching smaller, more plentiful fish (Brinkhuizen 1983:25). Other methods for catching fish involve the use of impounding gear or a weir. Residents of the river and wetlands, like northern pike and brown bullhead, may have been caught with fish-traps and weirs (Needs-Howarth and Thomas 1998). There are fish weirs between Lake Couchiching and Lake Simcoe, which were described by Champlain in 1615 (Biggar 1922-36(3) :56-57).

“There is another lake immediately adjoining [Lake Simcoe],...draining into the small one [Lake Couchiching] by a strait [Atherley Narrows], where the great catch of fish takes place by means of a number of weirs which almost close the strait, leaving only small openings where they set their nets in which the fish are caught; and these two lakes empty into the Freshwater Sea [Georgian Bay, by way of the Severn River].”

The weir has been investigated by archaeologists (Cassavoy 1993; Johnston and Cassavoy 1978) and was found to have been in intermittent use from the Late Archaic, around 2500 B. C. (Johnston and Cassavoy 1978). The orientation of the stake pattern indicates that the weir was used to obstruct fish swimming in both directions, towards Lake Couchiching and towards Lake Simcoe. Excavator Kenneth Cassavoy (personal communication 1995) suggests that the construction indicates that users of the weir were primarily fishing for large quantities of smaller fish.

Both weirs and fish-traps require frequent inspections to avoid losing the contents to fish-eating aquatic mammals (G. J. Boekshoten, personal communication 1999). A permanent fish weir would have demanded labour cooperation and coordinated visits (Martin 1989:596). It is quite likely that the weir at Atherley Narrows was operating by people living in the immediate surrounding area, and that the occupants of these Barrie, Dunsmore and Carson sites did not have access. No other archaeological weirs are known locally.

_Zooarchaeological indicators of method and location of capture_

**Introduction**

It is possible to infer the technique of capture, location and time of capture, from the fish bones themselves, by going beyond simple reliance on habitat or spawning behaviour. As Wheeler and Jones suggest, “fishing methods are usually targeted to catch a particular species or range of species of a limited size range. Thus, by considering the species composition and size of fishes represented in archaeological assemblages, it may be possible to suggest which fishing technique was used in the past” (Wheeler and Jones 1989:168).

This research presents a model for identifying the refuse of discrete or related fishing events through evaluation of fish biology, co-occurrence of taxa in refuse deposits, relative fish element sizes and seasonality attributes of fish and other animal remains. The basic premise for this method was presented by Needs-Howarth and Thomas (1998). It is explicitly aimed at elucidating both the nature of the deposits and the season of deposition.

Fishing for food is a sensible option only when you can be reasonably sure to encounter fish. This involves targeting specific locations or specific times. “If a fisherman knows the habits of non-migratory fishes he wishes to catch and the places where they live during the year... and the techniques needed to catch them, he can obtain these fishes throughout the year” (Brinkhuizen 1989:111). This statement, while formulated in a European context, is probably equally valid for North American freshwater taxa. During their spawning times many fish congregate in predictable locations. Sagard says that the Huron knew within one or two days when each fish would start its spawning-run (Sagard 1939:231). Since fish lipid content, and correlated to that, caloric content, is at its peak at spawning, this may have been a time of intensified fish exploitation. The fact that the exploitation of certain taxa is considerably more efficient around their spawning time does not, however, justify the explicit or implicit assumption underlying many zooarchaeological analyses in southern Ontario that fish were almost exclusively caught during spawning time. In other words, optimisation of the resource does not necessarily imply spawning time exploitation. It is also possible that not all fishing activity was aimed at maximum efficiency.

The use of spawning time and location as an explanatory device is most applicable to species that aggregate during spawning (Needs-Howarth and Thomas 1998). With some exceptions (Thomas 1996b) much previous local research (D'Andrea et al. 1984; Lennox et al. 1986; Naylor and Savage 1984; Stewart 1991a:Figure 4; Stewart 1992) has not fully utilized the distinction between those species whose spacing behaviour makes them more available and/or abundant during spawning, and those whose spacing behaviour does not.

For example, during most of the year lake sturgeon and
longnose sucker occupy deep water habitat (Scott and Crossman 1973, 86, 532-4) that is generally inaccessible to exploitation with precontact Iroquoian fishing technology. During their spring spawning-runs these species aggregate in harvestable quantities and move into watercourses, making them accessible to people equipped with simple technology (Cleland 1982). The lake sturgeon represented at the Barrie site were likely only purposefully procured during their spring spawning-run up the Nottawasaga River (Needs-Howarth 1996). The open water taxocene thus includes more taxa that were seasonally restricted in availability than either the large bay and estuarial or coastal marsh taxocene (Figure 13). In contrast, the spawning behaviour of other taxa – such as brown bullhead, Rock bass (Ambloplites rupestris), and Pumpkinseed (Lepomis gibbosus) – does not involve aggregation or movement that significantly increases their availability (Scott and Crossman 1973, 589-603, 703-6, 716-7). Instead, these species are available throughout warmer weather for stream-based and onshore exploitation (Needs-Howarth and Thomas 1998).

Between these two extremes are species like white sucker, yellow perch, and Smallmouth bass (Micropterus dolomieu) (Needs-Howarth and Thomas 1998). These fish congregate in nearshore shoals and in local streams during their spring spawning-runs, but they are also available in various watercourse or nearshore habitats during the rest of the fishing season (MacCrimmon and Skobe 1970, 67, 101, 118-9).

**Fish bone size and technique of capture**

For fish that may have been caught with techniques of mass capture (e.g. seines, weirs), NISP or MN1 alone are inadequate in examining fishing techniques. The size of lake whitefish at Algonkian sites along Lake Huron and Michigan has been used to infer method of capture (Smith 1996). Fish size has been used in conjunction with known size and weight of fish of various sizes intervals in the reference collection to estimate size distribution (Martin and Colburn 1989).

Unless some fish were released alive, a broader size range in each depositional context should result if the site inhabitants used techniques of mass capture (Needs-Howarth and Thomas 1998). Because a seine-net acts like a fence, the finer the mesh, the more small-sized fish will be taken. The disparity in the distribution of very small perch bones between Barrie and Dunsmore (Figure 10), may indicate that, on average, finer net mesh sizes were used at Dunsmore (Needs-Howarth and Thomas 1998). It is obvious that fish proportional element size observations, in addition to being useful in clarifying taphonomic issues (as discussed in Chapter 4), are essential in interpreting fishing techniques.

Proportional element size were used to identify groupings of bones of similar size that may constitute the catch from a net. Fish size can be quantified as TL or total weight (hereafter TW). The weight will vary because of seasonal condition and reproductive state, whereas the length will stay the same or increase. The size estimations and metrics derived from the archaeological samples, therefore, should relate better to total length than to total weight (Brinkhuizen 1989; Owen and Merrick 1994; Shawcross 1968). Since it is not known a-priori whether a given bone results from a gill-net catch, a seine-net catch, or some other method, and since accurate TL estimates are lacking, we are limited to analysing netting events in terms of similarly shaped taxa or single species, rather than net type or mesh size. In addition, to obtain somewhat reliable information, this can only be done for taxa with relatively large NISP values.

Table 20 shows what size range of each species could be expected in different stretched mesh sizes, illustrating clearly the effects of fish shape and body depth. Esocidae, with their torpedo-like shape are less likely to get stuck in a given mesh size than perch, with their deeper body, which in turn are less likely to get stuck than brown bullhead with their wide body and protruding pectoral and dorsal spines.

**Fish bone size and state of maturity**

Most of the species represented at these sites could be caught at different times of the year. For example, yellow perch are more easily obtained during their spawning-run from mid-April to early May, but can also be caught throughout the warmer weather or during ice-fishing on the lake. In addition to informing about recovery bias and technique of capture, fish bone size has yet a third application. Fish cranial bone size can be used as a general guide for maturity and hence time, location and mode of capture. Mature fish may have been part of a spawning-run catch, whereas most immature fish were not. Immature fish could still have been caught at the time of the spawning-run, but, for most taxa this would probably represent a different intensity of fishing effort, in a different location.

Because yellow perch constitute such a large proportion of the fish NISP it was important to find out whether the fish represented at the sites were part of a spawning-run catch, or part of a more generalized fishery throughout the warmer weather. Indeed, the interpretation of the nature of fish catches represented in refuse deposits hinges to a significant extent on these yellow perch. Using relative-size observations as a very general guide to fish size it is possible to estimate at what proportional element size percentage bones were likely large enough to belong to sexually mature individuals.

Modern Lake Simcoe male perch reach sexual maturity by about 150 mm fork length (hereafter FL); females by about 170 mm FL (McMurtry 1991:30-31). Mature female yellow perch caught by anglers in 1983 at Atherley narrows had an average FL of 198 mm (Arndt 1989:12-13). It is, therefore, cautiously suggested that archaeological bones measuring 80 percent or more of the size of the reference specimen element belong to sexually mature individuals (Needs-Howarth and Thomas 1998) (Table 21).
Size at maturity of yellow perch fluctuates in relation to latitude and watershed productivity, which in turn is related to climate, composition of the fish population, absolute numbers of fish, and predation (David Brown, Michael McMurtry, personal communication 1999). The presence of many Percidae scales in the Dunsmore and Carson assemblages appeared to afford the opportunity to get independent data on fish age and associated sexual maturity.

Age and season of death

Introduction

Parts of this section were previously presented (Needs-Howarth and Brown 1998; Needs-Howarth and Casselman 1996). The study of age and growth from calcified structures has a long history in fisheries research, where it is used to obtain important physiological and environmental information. Most research concentrates on describing seasonal growth in order to establish population structure and growth patterns. The technique that is most widely employed involves deciphering age from cyclic growth evidenced in optically different seasonal growth zones in calcified structures, and using this seasonal growth history to infer the passage of time.

The main premises for calcified structure analysis is that fish grow throughout their life and that fish body temperature is inconstant. Body temperature varies in a positive manner, within certain limits, with the temperature of the surrounding water. Fish therefore display a marked seasonal regularity that relates to their cold-bloodedness. Temperature is a major influence on growth, development and spawning (Hokanson 1977). “Fish grow in response to their biotic and abiotic environment and in accordance with some function of size or age already attained” (Weisberg 1993:1229). An individual growth increment is thus the sum of growth related to the characteristics of the calendar year in which it formed, and growth related to the age (size) of the fish when it formed (Casselman 1983). To interpret calcified tissue correctly, these underlying mechanisms of fish growth must be understood and applied.

Interpretations of age and growth rely on the presence, continuity and spacing of circuli and interruptions in scales, and the optical density, opacity and translucity of zones in other structures. The annulus is associated with the distal vertebrae (Marzolf 1955; Ovchynnyk 1962; Ovchynnyk 1965), opercula (Bardach 1955; Ovchynnyk 1965), pectoral spines (Beamish 1973; Cuerrier 1961; Hogman 1968; Lane 1954; Ovchynnyk 1962; Ovchynnyk 1965; Regier 1961), in part, at least, because it is not necessary to kill the fish to obtain them and they are easy to prepare. Other elements discussed in the North American fisheries literature include otoliths (Yosef and Casselman 1995), pectoral spines (Beamish 1973; Cuerrier 1951; Marzolf 1955; Rien and Beamesderfer 1994), vertebrae (Marzolf 1955; Ovchynnyk 1962; Ovchynnyk 1965), and cleithra (Casselman 1974). Recent research on fish biochronology holds much promise, for both biological and archaeological applications. By detrending growth increments for the effects of age-related allometry, it is possible to establish a history of environmental effects (Weisberg 1993). In fish species located close to the northern limit of their range, these environmental effects may be used as indicators of climate change. Long-lived fish that shared a few years of their lives as contemporaries can then be cross-matched in a manner analogous to dendrochronology to obtain a population biochronology. This method has been successfully applied.
to populations of freshwater drum (*Aplodinotus grunniens*, Sciaenidae) (Pereira et al. 1995a; Pereira et al. 1995b).

**CSAGES fish growth interpretation system**

Fish age and growth have been recorded with the use of a microcomputer and digitizer since the early nineteen eighties (Cailliet et al. 1996; Frie 1982; McGowan et al. 1987; Small and Hirschhorn 1987). The Calcified Structure Age and Growth Extraction System (CSAGES) and related software (Casselman and Scott 1994) currently being developed at the Ontario Ministry of Natural Resources Fisheries Research Station, Glenora, makes age and growth interpretation more objective and more accurate (Casselman and Scott 1994). Interpretations are made on the anterior field, measuring from the focus (or centre) of the scale to the outer margin, at 50x or 100x magnification. The position of growth interruptions is recorded using a hand-operated digitizing tablet. The extent, nature and temporal significance of each check or zone is described and classified using confidence ratings that range from 1 to 9. The appearance of the edge of the structure in relation to the seasonal growth cycle is coded in a standard manner (Table 22).

The edge conditions described in Table 22 require some additional clarification. Assigning a date of capture based on the most recent growth history is somewhat more difficult. The absolute and relative chronology of growth cessation, spawning, and growth resumption varies, even within genera. Interpretation of the margin in relation to the fish’s life cycle, therefore, requires determination of the expected time of annulus formation and spawning at different ages for each taxon represented in the sample. Depending on the species and the age, a scale in the “o” condition (annulus incompletely formed, translucent check or zone present on the edge) (Table 22), could have been obtained any time from late autumn to late spring. Depending on the age of the fish, and whether growth resumed before or after spawning, it may be difficult to establish whether a fish was caught around spawning time. The “+” condition is very restricted in time, and therefore rarely encountered. It is the most difficult to interpret, owing to the fact that the annulus becomes visible only when new bone tissue is laid down. The variability in rate of growth within a season, and between seasons, entails that the “+” first new growth, annulus just completing formation) and “++” (growth less than half of previous annual zone) conditions do not necessarily equate to the absolute amount of time elapsed.

CSAGES (Casselman and Scott 1994) increases the replicability of results because it relies on standardized descriptions and qualifiers. It goes beyond simply marking the location of checks and zones. It incorporates standardized procedures for describing specific criteria, and more precise and detailed interpretive systems for data extraction and interpretation. The CSAGES computer program permits conditions on the edge that may affect interpretation, such as erosion or resorption, to be described. It also permits recording of negative observations, which can be just as important as positive observations. The digitized measurements are stored on disk as absolute measurements, but they are also visually recorded on a relative scale, so that the growth cycles of individuals of different ages and sizes may be compared on the screen or in a print-out. The software is used to standardize interpretation procedures and, in younger individuals of well-studied species, to convert the growth conditions on the edge of the structure to a calendar age.

**Potential of age and growth analysis on archaeological fish remains**

The utility of age and growth analysis to archaeologists was first described in detail by Casteel (1974). The principle of uniformity allows us to assume that the parameters that affect modern fish also operated in the past. Provided that adequate local comparative samples are available, calcified structures from archaeological sites offer us the potential of establishing age structure of the catch as well as season of capture. The age of the fish can be used to infer whether the individual was sexually mature or not. This is a major benefit, since age is a more reliable indicator of maturity than size (Brown, personal communication 1998). An important additional benefit of age and growth analysis is only just now being explored (Bergquist 1996). Using biochronology, growth records of long-lived fish may be used to obtain a minimum duration of site occupation. If appropriate climatic data, or a proxy thereof, is available, fish growth sequences may even provide an absolute chronology of site occupation, using the temperature signal as the common variable to anchor the chronology in time.

Age and growth analysis is a useful tool to archaeologists; CSAGES is sophisticated enough to provide considerably more reliable results than have been obtained in previous archaeological studies of calcified structures. In order to get realistic results, however, the limitations of age and growth analysis in general must be considered. Archaeological age and growth studies face additional challenges, since they are based on a different premise than those in fisheries science. Archaeologists lack the basic, a-priori information that is usually available to the fisheries biologist: species, date of capture, and location of capture. In addition, it is not always possible to choose the most useful element; the practical application is limited by what is preserved and recovered (Cossette 1995:543).

Because otoliths grow at a faster rate than the body during slow somatic growth they are excellent structures for recording growth in slow-growing and old fish (Casselman 1990:686). Thus lake trout and northern pike otoliths continue to record seasonal growth after the scales have started to fail, resorb or erode (Casselman 1990). The suitability of otoliths in recording growth of old fish has also been demonstrated in freshwater drum (Pereira et al. 1995b). However, it appears that otoliths were not preserved and/or recovered on sites in the Lake Simcoe area. Indeed,
Freshwater drum is rare on the earlier sites, although it was identified in reasonable quantities at the Auger site (BdGw-3), a Huron village located near the Coldwater River, north of Bass Lake (Latta 1998).

The opercula and cleithra of all species at Barrie, Dunsmore and Carson are too uniformly opaque and/or mineral stained for interpretation, although these elements have been used successfully in biological studies (Casselman 1974; Ovchynnyk 1965) and on archaeological material from the Warminster site, a Huron village located north-west of Dunsmore and Carson (Whillans, personal communication 1998).

Fish scales are among the more fragile zooarchaeological remains, although there is considerable variation among taxa and body sizes. As noted above, cycloid scales are expected to be under-represented in relation to the more durable ctenoid scales. In general, Salmonidae scales are very small and fragile in relation to body size, although some intact lake whitefish scales were successfully used to indicate autumn capture at the Gros Cap site (Martin 1982:83). Given the relatively aggressive method of recovery (dry screening vs. water screening), it is entirely likely that the sample of fish scales from the sites under discussion here is biased towards larger scales from taxa with the most durable scales. Imperfect preservation and edge damage on scales from archaeological sites can result in many rejected samples, causing additional bias.

When working with fish scales, rather than paired cranial elements, archaeologists are further hampered because they do not know the exact location of the scale on the fish body. It is argued (Tesch 1978:96) that “for comparability the scales in any one study series should be taken from the same location on all the fish...” Archaeological scales could be from any part of the body, which limits the potential for comparing scales in a sample. For this reason also, it is not possible to calculate MNI, and thus rule out duplication of individuals. If two scales show different ages or different growth patterns on the margins, they are likely to represent two individuals (for an example, see Penmann and Yerkes 1990), however, the opposite is not necessarily true.

Identification of archaeological scales below family level using drawings and photos (Daniels 1996; Lagler 1947; Oates et al. 1993) or a reference collection may be difficult because size and shape of scales vary with age, TL and placement on the body of the fish. Because cranial and pectoral girdle bones can often be identified to species, the identified taxa from the faunal sample will narrow the choices. It is, however, conceivable that a taxon is represented only by its scales. Such scales must be confidently identified to species in order to maintain control over MNI (see Brinkhuizen 1997 for a discussion). As will be shown in Chapter 6, in some special cases a detailed age and growth analysis has the potential to confirm a species identification.

In addition to any problems specific to archaeological studies, there are many problems surrounding age interpretation that are encountered by both modern and archaeological interpretations. As noted above, because of the cyclicity of growth, it is easiest to establish seasonality from individuals that were taken during periods of rapid growth. The difficulty in pinpointing time of catch in cases where a fish was caught during the period of growth arrest is explicitly acknowledged by many zooarchaeological researchers (Carlson 1988; Morey 1983; Rojo 1987; Van Neer 1993). It has led one researcher (Carlson 1988:69) to conclude, perhaps overly pessimistically, that it is “impossible to distinguish the time of death within that eight month period” of slow growth. While all methods, including CSAGES, are hampered when the calcified structure is experiencing growth arrest, CSAGES provides the analyst with a system to look in more detail at growth at the scale edge. This forces the analyst to examine the calcified structure more critically, and to be explicit about criteria used to evaluate checks and zones. The condition of the margin can be described as different levels within the “++” and “o” condition (Table 22). In addition, the accurate description of the edge condition of other scales in the sample can be used for corroboration.

The nature of fish growth means that scales from older animals will be harder to interpret, although it is still possible to obtain a reliable minimum age. Erosion or resorption of the edge in older fish can also complicate interpretation of season of death. Another problem arises from regenerated scales, which are formed when the original scale is lost, often in the first years of life, or during spawning. Regenerated scales have an amorphous centre, but possess edges characteristic of the species. Because they lack a focus, they can only be used to establish a minimum age, not an absolute age. While regenerated scales are readily recognisable (Casselman et al. 1986), they do not allow for precise age determination. It has been suggested by some (Artz 1980:51; Casteel 1976:71) that all archaeological scales ages four or five and over should be eliminated from analysis. This is, however, unnecessarily cautious for most species, and would bias the samples with respect to longevity (Carlander 1987).

Problems with age and growth interpretation encountered by fisheries biologists are compounded for those working with archaeological material (Cossette 1995:494; Martin 1982:84; Wheeler and Jones 1989:157). Archaeologists are advised (Wheeler 1978:73) to “have their results checked by competent fishery biologists, at the outset of their study” and to “not expect simply to examine one or two scales or otoliths and establish seasonality of capture on this basis” (Wheeler and Jones 1989:156). Indeed, some archaeological researchers discuss how their own inexperience with age and growth interpretation may have led to bias (Hanna 1981; Junker-Andersen 1984), and have their material re-examined by a fisheries biologist (Junker-Andersen 1984).
The method described here has the potential of greatly enhancing the amount and quality of age and growth information extracted from archaeological fish bones and scales. Experience with CSAGES teaches the interpreter to be careful and increasingly observant. Experience in interpreting material from different species of different ages allows the interpreter to achieve much greater precision than is usual for archaeological age and growth studies. This is because the method goes beyond simply recording whether the annulus has formed yet, or has formed recently; it also quantifies and qualifies the status of the margin. Confidence codes allow for an evaluation of the assigned season of capture. CSAGES therefore satisfies the important criteria of efficiency, accuracy and precision identified by Monks and Johnston (1993), although not exactly in the manner they recommend.

Informative skeletal structures at Barrie, Dunsmore and Carson

As has been discussed above, inter-site distributions of fish remains indicate that fish scales do not always survive precontact butchering, cooking, long-term burial and subsequent excavation. All bone material from the Barrie site was noticeably less well preserved. This may explain why only one scale was recovered from this site, despite the fact that it was subject to the most intensive flotation sampling. Improved preservation at Dunsmore and Carson has resulted in much better scale recovery (Table 23).

As noted above, no otoliths have been recovered from Barrie Dunsmore or Carson. If otoliths were preserved, some should have been recovered from the flotation heavy fraction. The residues from Barrie and Dunsmore were sorted by the palaeoethnobotanist (Monckton 1993; Monckton 1996); the residue from Carson was sorted by the author. Since none of the flotation residues contained otoliths, operator bias during sorting is probably not a factor. And since other cranial elements were recovered in abundance for most taxa, off-site disposal of fish heads is not a sufficient explanation for the absence of this particular element. Instead, the lack of otoliths likely results from a combination of large dry screen mesh aperture; the relative and absolute small size of the otoliths of taxa represented (especially Salmonidae); and the unique chemical composition of this element.

Percidae scales

Age and seasonality interpretations based on archaeological fish scales usually give the time of catch as a range of several months (Artz 1980; Benecke and Thue 1995; Pennmann and Yerkes 1990; Scott 1989). In addition, many problematic scales are rejected (Hanna 1981; Scott 1989). In recognition of the problems surrounding fish scale interpretation, and in order to get precise and reliable data, fish scale interpretation for this project has been carried out by David Brown, a specialist who has worked for eight years as research biologist, examining fish growth and fish community dynamics at the Ontario Ministry of Natural Resources, Glenora Fisheries Station, under direction of CSAGES co-author John Casselman. A random sample of 37 larger scales was analysed by David Brown using CSAGES.

Sample preparation was carried out by the author and sample interpretation was carried out by David Brown. Initially, the archaeological scales were gently cleaned in warm water and liquid soap and dry-mounted between microscope slides. Surprisingly, warped scales were easily flattened by taping the two slides together. While dry-mounted archaeological specimens can be interpreted in some cases (Scott 1989), often they are much more opaque than modern scales and therefore more difficult to interpret (Artz 1980; Hanna 1981). The scales were discoloured and appeared to be covered in a thin film of mineral concretions.

Placing them in 60 percent glycerol (often used for modern samples) did little to enhance the image. A sonic cleaner was also used, although there are concerns (Yerkes 1980) that this may cause breakage at the annulus. This too did little to enhance the image. Finally it was decided to impress them. This involves placing the scale sculptured side down on a thin slide of warmed, clear cellulose acetate. The slide and scale are then passed through a roller press. Although this is the technique preferred by fisheries biologists, there was a certain reticence towards impressing the more degraded archaeological material. Tests showed, however, that despite the mineral concretions that covered the scales, the impressed images were very clear. Either the concretions affected just the valleys between the circuli, or they covered the entire scale uniformly. If just enough pressure was used, rolling the slides left a perfect impression, which could then be viewed under a microscope or in a microfiche reader. This indicates that scales do not necessarily have to be rejected because they appear degraded during macroscopic examination. This in itself is an important finding of this study. Discussion of the results is provided in Chapter 6.

Brown bullhead spines

As mentioned in relation to the discussions of bone tools and diagnostic elements, brown bullhead dorsal and pectoral spines have a better than average change of being recovered and identified. Pectoral spines of Ictaluridae have been used successfully to establish age and approximate time of capture (Cossette 1995; Morey 1983). While both the fisheries data discussed above and the zooarchaeological data discussed in Chapter 6 suggest that brown bullhead at Barrie, Dunsmore and Carson were caught throughout the warmer months of the year, the recovery of substantial numbers of pectoral and dorsal spines from the three sites offered the opportunity to test this hypothesis. The entire sample of pectoral and dorsal spines recovered from Barrie, Dunsmore and Carson was analysed using CSAGES. Sample preparation was carried out by the author under supervision of David Brown. Interpretation was carried out on a contract basis by David Brown at the Ontario Ministry of Natural Resources, Glenora.
To avoid the section breakage experienced by other researchers (Cossette 1995), it was decided to embed all spines. Brown bullhead pectoral and dorsal spines with intact proximal ends were hardened in high resolution epoxy resin matrix for two days. Two sections of about 325 micron thickness were cut from each spine with an Isomet low-speed blade wafering saw operating in a tap-water blade bath. The location of the first section was immediately below the v-shaped basal groove, ensuring that the total circumference of the spine was present (cut #2 in Harvey and Fortin 1982). Sectioning at the correct angle and thickness is necessary to avoid obscuring annuli. The best of each of the sets of two thin-sections was then polished on fine lapping film and fixed with epoxy resin to microscope slides. After another day of curing the reverse was polished on 600 and 800-grit Carborundum paper until the zonation was clearly visible.

The translucent zones on spines appeared less variable in appearance than the circuli on scales, and were therefore easier to interpret. The sections were viewed under transmitted light at 50x and 100x magnification, examining the posterio-lateral section of the medial surface of the cut. The radius of measurement was oriented from the centre of the lumen along the maximum radius for growth. For pectoral spines, this runs to the outer edge of the dorsal/posterior area of the spine (i.e. longest length) (Cossette 1995: 545; Marzolf 1955: 244; Sneed 1951:178).

Focussing required some precision so as not to become confused by zones lower down, which are closer together, because the element tapers. Deterioration of tissue around the lumen in spines from older individuals of a closely related taxon, the channel catfish (Ictalurus punctatus), can partly obscure the first annuli (Marzolf 1955:245). This was found to be true for our Bullhead samples. It appears that spine growth is accomplished by seasonal deposit of tissue on the outside. The basal groove continues within the spine as a central lumen; as the spine grows, the lumen enlarges at the expense of the earliest bone deposits (Marzolf 1955:246). The basal groove also lengthens and enlarges, so that the point of sectioning has to be moved distally along the spine for older fish. Discussion of the results is provided in Chapter 6.

Lake sturgeon spines
Thin sections of lake sturgeon spines can be used to establish age and approximate time of capture (Cuerrier 1951; Cuerrier and Roussow 1951; Rossiter et al. 1995; Roussow 1957). Only one previous archaeological application has involved this particular species of sturgeon (Cossette 1995).

In a recent validation study, age estimations based on annulus counts were highly consistent with known ages for fish up to 15 years old. Agreement declined slightly at age 18 and older, but never fell below 80 percent (Rossiter et al. 1995). The oldest fish was 36 at recapture. These data suggest that lake sturgeon pectoral spines continue to record growth to an advanced age. Archaeological material may be considerably harder to interpret; inexperienced interpreters working with older individuals from the Hector Trudel site exhibited considerable intra-reader variation in age estimates (Cossette 1995:556).

Lake sturgeon age at sexual maturity varies between bodies of water, and by latitude (Harkness and Dymond 1961; Roussow 1957). First spawning may take place some years after maturity is reached (Roussow 1957:560). It is probably safe to assume that if the sturgeon represented at the sites were older than 25 years, they were of spawning age (Harkness and Dymond 1961:32). This does not imply the fish were actually on their spawning-run when caught, but it would allow for that possibility.

Five fragments of the first (ossified) fin ray, or pectoral spine, of lake sturgeon were recovered from the Barrie site. An introduction by Dr. David Noakes of University of Guelph led to a collaboration in 1996 between the author and Mr. Greg LeBreton, who at the time was completing his M.Sc. on growth histories of lake sturgeon in Canadian waters. While CSAGES analysis has been successfully applied to this taxon previously, budgetary constraints made it desirable to take up LeBreton’s offer of complimentary analysis, using a method he developed.

The size of the elements indicated that they were quite old, and that it would not be possible to obtain season of death information. Instead, it was hoped to establish a minimum age in order to establish whether the bones derived from sexually mature individuals. The “clumping” of annuli in older fish in the years preceding spawning could be another indicator of reproductive status (Roussow 1957). Caution is required, however, because annulus pairing also happens in immature fish of some populations (Rossiter et al. 1995), and it is entirely absent in other populations (Dumont et al. 1987). In addition to getting clues to reproductive status, it was hoped the spine data could be used to build a biochronology (Bergquist 1996), using LeBreton’s modern lake sturgeon samples as a model.

A successful application of fish biochronology must satisfy three biological criteria (Bergquist 1996). The first criterion is that the calcified structures of the species in question must strongly reflect the temperature signature (or other fluctuating environmental signal) of the surroundings. This is the case with lake sturgeon spines. The second criterion is that the species must be long-lived, in order to increase the likelihood of cross-matching with other individuals and a temperature series. Lake sturgeon is more suitable than most species because it is so extremely long-lived, although age estimates do become less accurate with age. The third criterion is that the species must be living at the limit of its range, so that it is more sensitive to temperature fluctuations. In this respect, lake sturgeon is noticeably less suitable than the species on which fish biochronology was first developed, the freshwater drum.
The range of lake sturgeon extends to Hudson’s Bay; individuals living in the Great Lakes region cannot be considered to be close to the northern limit of their range.

A biochronological study must also satisfy sample size criteria (Bergquist 1996). In a pilot study involving freshwater drum otoliths, several individuals in both the modern and the archaeological samples exhibited low correlation between otolith patterns and temperature series. Larger samples are needed to assure consistent and strong cross-matching and to obtain a statistically valid correlation with temperature, both as a way to validate the cross-matched series, and to anchor it in absolute time. Small sample size alone was likely to preclude cross-matching of our lake sturgeon spines and correlation to a temperature series. Against the odds, it was hoped we would be able to cross-match the five pectoral spine fragments to obtain a minimum duration of site occupation, using LeBreton’s modern samples of known capture date as a model for cross-matching and de-trending (i.e. factoring out age effects) of the archaeological samples. LeBreton was also exploring the possibility of using old growth cedar trees on the Niagara Escarpment (some of which are 800 years old) as a surrogate of temperature, so that he might anchor the “floating” relative growth chronology in time, and thus obtain an absolute date for site occupation. Again, the aim was to use the matching of modern population data series to air temperature as a model for matching the archaeological spines to the cedar tree ring data.

In the end, it was the poor state of preservation of the archaeological material that proved fatal to the project. Initial examination of the sections indicated they suffered from delamination, decalcification and probable iron-staining. The longest consecutive segment was 10 years. This precluded all but a rudimentary estimation of minimum age. The research plans are presented here so that they might be tried by other researchers on better preserved samples.

The Three Fisheries Model

Introduction

Three kinds of fishing strategies were proposed by Thomas (1996b) for the Hubbert site (BbGw-9), located south of Kempenfelt Bay near Lover’s Creek: 1) a spring upstream fishery that concentrated on species which migrated a substantial distance upstream; 2) a long-term watercourse fishery to exploit resident populations of fish living upstream, in the low gradient lower reaches, and in the estuary; and 3) a lacustrine fishery to exploit resident populations of fish throughout Kempenfelt Bay, perhaps with emphasis on fish spawning on shoals. These fisheries complexes were further refined by Needs-Howarth and Thomas (Needs-Howarth and Thomas 1994b; Needs-Howarth and Thomas 1998) by the inclusion of detailed information on taxa co-occurrence within single refuse contexts, by categorising yellow perch bones based on proportional element size, by identifying and quantifying Salmonidae vertebrae; and by emphasizing the temporal components of each fishery (Needs-Howarth and Thomas 1998). Species that regularly occur together in archaeological deposits were thus used to establish the most likely time and location of capture for the species recovered in each archaeological context. Co-occurrence of taxa to interpret fishing events from deposits has been used in Odawa and Ojibway contexts (Molnar 1997; Smith 1996). For the current application, the model has been expanded to incorporate identifications of all vertebrae at the genus or family level, and data on age and season of death. The model presented here combines fish habitat and spawning data, fish behaviour, relative element frequencies per taxon, age and growth data, associations between taxa within features, and seasonality inferences related to those features.

The three fisheries complexes defined for the current work are: 1) Spring Spawning-run Fishery: a spring time watercourse-oriented inland fishery that focuses on intensive exploitation of spring-spawning taxa such as lake sturgeon, suckers, yellow perch and walleye; 2) Generalized Warm Weather Fishery: a generalized bay or inland fishery for opportunistic warm weather exploitation of resident taxa that do not aggregate in harvestable quantities during their spawning-run, such as Esocidae, brown bullhead and Centrarchidae, and of immature and non-spawning yellow perch; and 3) Lake Fishery: a lake-oriented fishery on Kempenfelt Bay and Nottawasaga Bay that included inshore exploitation of autumn-spawning Salmonidae.

Fish may be found together in a deposit because they inhabit the same waters and/or they spawn together and/or they are amenable to the same techniques of capture. An understanding of fishing strategies was facilitated by a consideration at the feature level and site level of detailed species identifications, fish biology, scales, vertebrae, element size, age and season of capture. Some components of this model have been employed by other researchers working with freshwater fish remains in a North American context. Cleland’s discussion on the inland shore fishery in the upper Great Lakes (Cleland 1982) highlighted the uniqueness of the autumn Lake Fishery in terms of habitat, spacing behaviour, method of capture and preservation. Species composition and size has been used in conjunction with seasonality data from scales to identify fishing practices at an Oneota site in Wisconsin (Yerkes 1981a). Cossette’s (1995) interpretation of fishing at the Hector Trudel site incorporated both ethnohistoric and local ecological and fisheries biology data. She explicitly recognized that fish exploitation does not necessarily correlate with spawning season. She used diversity and richness indexes to assess variability among samples, and used fin spines to estimate the ages of four fish species.

The issue of fishing strategies has been investigated recently in two studies by Ontario archaeologists. Using student analyses of fish remains from a midden at the Huron period Auger site, near Bass Lake, Latta (1998) relates fish remains to “opportunistic”, “flexible” and “structured” procurement patterns that are based on method of
exploitation; fish spacing behaviour; spawning; feeding behaviour; habitat; travel distance and organisation of labour. Seasonal variability in fish behaviour and human exploitation play a more limited part in this model. Molnar’s (1997) interpretation of an unstratified, multi-component fish bone assemblage at the early seventeenth century Odawa Hunter’s Point site, a temporary camp located next to a deep bay in Georgian Bay, uses statistics to define refuse deposits. Fishing strategies are described on the basis of the kinds and numbers of elements; the number of species; fishing equipment and location of catch. A restricted range of fishing activities results from the seasonal occupation and the limited range of environments. Fishing strategies at Barrie, Dunsmore and Carson, which were likely more variable in terms of location and time of capture, cannot be explained by this model.

An overview of fishing activities as they relate to the fish taxa identified at the sites is presented below.

**Lake sturgeon**
The biology, behaviour and capture of lake sturgeon were discussed in an earlier paper (Needs-Howarth 1996). Lake sturgeon are bottom-feeders that usually live in large lakes and large rivers (Table 7). It is likely that lake sturgeon were abundant in Lake Simcoe and connecting waters during the time of occupation of Barrie, Dunsmore and Carson. Because of overfishing there was no significant lake sturgeon population left in Lake Simcoe by the beginning of this century (MacCrimmon and Skobe 1970:30). Lake Couchiching and the Holland and Severn rivers also had a commercial lake sturgeon fishery (Harkness and Dymond 1961:99). Fisheries biologists (David Loftus, William Beamish, personal communication 1995) confirm there may have been a resident population in the Nottawasaga River in the past. There certainly is now, and probably was in the past, a resident population in Georgian Bay of Lake Huron, which spawns in the Nottawasaga River (David Loftus, personal communication 1995).

Lake-resident populations of lake sturgeon were not really available to the site occupants for most of the year, because they were dispersed and inhabited deeper water, away from the lakeshore (Scott and Crossman 1973:86). During the spawning season, however, lake sturgeon move into shallow waters or rivers. River-resident populations also become more concentrated and more accessible at spawning. Lake sturgeon spawn in rivers at depths of about .5 m to 5 m, in areas of swift water or rapids, or at the foot of low falls that prevent further migration (Harkness and Dymond 1961:17, 38). In the lower Great Lakes, there were also populations of lake-spawning sturgeon, which spawned in shallow water over rocky ledges close to shore or around rocky islands (Harkness and Dymond 1961:40). The spawning date appears to be associated with water temperature, which has to have reached between 13.9 and 15.5°C (Harkness and Dymond 1961:36, 38). For the lower great lakes, this means sometime in May. Because of differential heating of the water mass, spawning temperatures will be reached earlier in rivers than in lakes (Harkness and Dymond 1961:40).

Although lake sturgeon can travel great distances, they have a strong homing instinct (Lloyd Mohr, William Beamish, personal communication 1995 and Harkness 1923:19; Scott and Crossman 1973:87). Return to the same spawning locations is confirmed by recent tagging experiments (Lloyd Mohr, personal communication 1999). The mean age at first spawning for females in a St. Lawrence River population was 19 years (Guenette et al. 1992). Year classes of males spawn every one, two or three years, females every four to six years ( Dumont et al. 1987; Magnin 1962; Roussow 1957). A group of spawning sturgeon may, therefore, be composed of individuals of different states of maturity, and different ages and sizes (Roussow 1957). In any given year, some year classes would not spawn (Lloyd Mohr, personal communication 1995). It is thought that the periodicity of spawning may vary within a year class; CSAGES studies are currently being implemented to confirm this hypothesis (Lloyd Mohr, personal communication 1999). It should be noted that both immature sturgeon (Cuerrier 1951; Dumont et al. 1987; Harkness and Dymond 1961) and non-spawning mature sturgeon (McKinley et al. 1993) go up rivers in spring at the time mature fish of certain age classes are on their spawning migration. It is likely that members of the same population spawned in more or less the same locations, minimizing the year to year variation in which spawning sites were actually being used (William Beamish, personal communication 1995).

In his overview of precontact fishing in the upper Great Lakes, Cleland argues that lake sturgeon were probably only purposefully procured during their spring spawning-run up larger streams and rivers (Cleland 1982:766). This is substantiated by earlier investigations by the author (Needs-Howarth 1996).

Several fisheries biologists have suggested that lake sturgeon can be caught individually from the shore, especially if they are in shallow water. Spearing may also have been practised from canoes on either Lake Simcoe or Nottawasaga Bay. The French explorer Charlevoix (1923:236) described the following technique for catching sturgeon, relating to one of the Great Lakes (name not specified), during his visit to New France in 1720:

> “Two men place themselves in the two extremities of a canoe; the [one] next [to] the stern steers, the other standing up holding a dart to which is tied a long cord, the other extremity whereof is fastened to one of the cross timbers of the canoe. The moment he sees the sturgeon within reach of him, he lances his dart at him and endeavours, as much as possible, to hit in the place that is without scales. If the fish happens to be wounded, he flies and draws the canoe after him with extreme velocity; but after he has swam the distance of an hundred and fifty paces or thereabouts, he dies, and then, they draw up the line and take him.”
Lake sturgeon can also be captured by means of set lines (Harkness and Dymond 1961:61; Rostlund 1952:11), as implied in the description of sturgeon fishing by Sagard (1939:189), who mentions that hooks were often found in the stomachs of fish. In the same section he mentions that in Georgian Bay there were fish “of such monstrous size that nowhere are they to be found bigger.” This appears to indicate that the lines the Huron used to catch sturgeon were not always strong enough to hold the larger individuals. For this reason, Cleland (1982:778) argues that spears and harpoons probably continued to be the dominant mode of capture.

Sturgeon are apparently easily entangled in gill-nets because their pectoral spines get stuck, even in wide-meshed nets (Von Brandt 1984:170). Father Louis Hennepin (1903:522) mentions that the Iroquois in New York fished for lake whitefish and lake sturgeon with large gill-nets that required two men at either end to draw them into shore. Taking into consideration Sagard's comments about fish breaking the fishing line, it is likely that larger lake sturgeon would sometimes break these nets made from hemp or nettle fibre. Nevertheless, netting probably was a effective manner of catching lake-dwelling populations of lake sturgeon.

The weir at Atherley Narrows was suggested as a possible catch location by several fisheries biologists (William Beamish, Lloyd Mohr, personal communication 1995), but it is not known whether any sturgeon remain were found at the associated multi-component Dougall site (Burns, personal communication 1995). It is likely that the resident Lake Simcoe and Lake Couchiching populations moved between their respective lakes, especially if they were part of the same genetic population (William Beamish, personal communication 1995). It appears likely, therefore, that sturgeon could be caught in the weir, but not necessarily in great numbers at a predictable time of year, unless they happened to pass through the weir on their spawning migration.

In addition to the arguments noted above against exploitation of lake sturgeon in (deep) lake waters, there are strong arguments in favour of riverine exploitation. Even outside the spawning season a river provides more opportunities for netting and somehow confining the fish. During the spawning-run the sturgeon are already concentrated in a group, and it would be even more efficient to intercept them with fish-traps, nets or spears. spawns. spawning-run sturgeon were caught in fish-traps by eighteenth century native people on a river in the boreal forest region of northern Ontario (Michalenko et al. 1991). More recently they used spears or 92 m long and 20.5 or 23.0 cm aperture set nets, which they checked once or twice a day (Michalenko et al. 1991:450-451).

If there was indeed a river-resident population of lake sturgeon in the Nottawasaga, it is possible that lake sturgeon were caught outside the spawning season. Large numbers of sturgeon remains, however, are more likely to have been the result of a spawning-run catch. The closest spawning locations of either a river-resident or lake-resident population are in the Nottawasaga River. There are no significant barriers that form obvious spawning locations on the main part of the Nottawasaga River today (Buritt, personal communication 1995). There are, however, ripples close to the mouth of the Nottawasaga River at Montgomery Rapids that may have provided a suitable spawning ground, especially at lower water levels (Robin Craig, personal communication 1995, Fred Dobbs, personal communication 1999). There is also a set of riffles or small rapids north of Baxter, some distance south of the branching of the Pine River (Fred Dobbs, personal communication 1999), and between Baxter and Alliston, around the branching of the Boyne River (Fred Dobbs, Robin Craig, personal communication 1995).

If there was a river-resident population, its spawning location may have been known to the occupants of the Barrie, Dunsmore and Carson sites. The mouth of the Nottawasaga would have been the most convenient and predictable place for humans to intercept spawning-run sturgeon of the Georgian Bay population, even if they didn't actually spawn at Montgomery Rapids. Indeed, early archaeological investigations (Hunter 1906:30) noted an “Indian camp” at this location.

**Salmonidae**

Lake trout, lake herring and lake whitefish spend most of their time in the pelagic zones of lakes, where they often concentrate in large numbers or in known zones (McCrimmon 1958). In spring and early summer they move below the thermocline, where they remain until the upper waters cool. In autumn they home to near-shore locations (McCrimmon 1958). In the middle of this century, 50 percent of the shoreline of Lake Simcoe was considered good spawning habitat for lake trout (McCrimmon 1958). Georgian Bay also supports large numbers of Salmonidae.

As was noted above, very few lake trout, lake whitefish or lake herring vertebræ were found in many features, indicating at least some emphasis on these lake-dwelling taxa. Contemporary sport fishers catch lake trout and yellow perch from the ice in January, February and March by angling or spearing (MacCrimmon and Skobe 1970:32, 50). Lake whitefish and lake herring can also be found on shoals in spring after breaking up of the ice. Lake trout occur in surface waters immediately after ice melt (Scott and Crossman 1973:225). During summer, these fish are generally too dispersed and occupy waters too deep to be caught efficiently and in significant numbers without nets. In early October, lake trout approach the shore, and in mid-October they spawn over shoals close to shore (MacCrimmon and Skobe 1970:54) (Table 7). Somewhat later, in mid-November and late November, respectively, lake whitefish and lake herring also spawn over shoals close to shore (MacCrimmon and Skobe 1970:38; Scott and Crossman 1973:239, 269). Spawning concentrates large numbers of both species in
shallower waters that would be accessible using canoes and
gill-nets or spears (MacCrimmon and Skobe 1970:50, 54;

Needs-Howarth and Thomas have argued (1998) that it is
unlikely that many resources would be allocated to a
lacustrine fishery during the highly productive spring spawn
season of other taxa; extensive exploitation of these
Salmonidae species was probably mostly limited to their
autumn spawning season. This is in accord with the ethno-
historic sources (Sagard 1939:186). An autumn Lake
Fishery may have offered some overall advantages over the
Spring Spawning-run Fishery in terms of timing. As Cleland
argues, “while the spring fishery may have come at a good
time to relieve late winter food deficits, it could not forstall
them” (Cleland 1982:779). In an Iroquoian context, the
autumn Lake Fishery occurs after the corn harvest, thus
avoiding conflicts with labour requirements for horticulture.

Other taxa
The longnose sucker prefers deeper, cooler waters and
would be most easily accessible during the spawning-run
(Table 7). White suckers do occur in Lake Simcoe, but also
extend into shallower lake and downstream habitats
(MacCrimmon and Skobe 1970:66). Older white suckers
occupy deeper waters further from shore (MacCrimmon
Proportional element size data indicate that the majority of
longnose and white suckers from the archaeological
collections are mature. White suckers co-occur in features
with fish that were probably part of the Spring Spawning-run
Fishery, but also with fish that were more likely part of the
Generalized Warm Weather Fishery. The literature confirms
that “some late spawning suckers may have overlapped early
with spawning lake sturgeon” (Harkness and Dymond
1961:39). White sucker may, therefore, have been obtained
together from the Nottawasaga River with lake sturgeon and
longnose sucker during a period of overlap in their
spawning-runs in early May, or together with spawning
yellow perch from Lake Simcoe, or together with brown
bullhead and/or smaller sunfish at any time during the warm
weather (Needs-Howarth and Thomas 1998). Given their
size and their frequent co-occurrence with lake sturgeon, it
is suggested here that most suckers are part of the Spring
Spawning-run Fishery. Suckers on their spawning-run are
easily speared (Cleland 1982:774).

Northern pike co-occur with brown bullhead and yellow
perch in many of the major features examined. Northern
pike spawn after the ice melts (Scott and Crossman
1973:357) and finish spawning in the Lake Simcoe drainage
by early May (MacCrimmon and Skobe 1970:92). The later
part of the spawning-run may just overlap with the start of
the spawning-run of yellow perch and suckers (Table 7).
However, northern pike size distribution and consistent co-
occurrence with brown bullhead (see Chapter 6) suggests
that northern pike were exploited throughout the warm
seasons as part of the Generalized Warm Weather Fishery,
most probably in fish-traps.

Neither the channel catfish (Ictalurus punctatus) nor the
bullheads are noted for spawning migrations (Scott and
Crossman 1973). It is likely that brown bullhead was caught
throughout the warm seasons in river, stream and wetland
habitats. Given bullhead nocturnal feeding habits and
generally solitary nature (except when schooling with
juveniles), it is likely that this species was primarily caught
using passive technology like fish-traps, trap-nets and gill-
out that brown bullhead could also have been caught on a
haired line without hooks. The co-occurrence of brown
bullhead with yellow perch in many major features supports
the hypothesis advanced by Needs-Howarth and Thomas
(1998) that perch exploitation was not necessarily limited
to the spawning season.

Centrarchidae do not tend to engage in extensive spawning-
runs (Scott and Crossman 1973, 589-603, 703-6, 716-7). It
is likely that these fish were exploited throughout the warm
weather. Exploitation may have coincides with their summer
spawning time, but may not have been aimed specifically at
spawning-run exploitation.

Yellow perch are a cool water species that swim in size-
graded schools. Schools of younger fish swim closer to
shore than schools of larger, more mature fish (Scott
and Crossman 1973:759). This schooling habit makes smaller
yellow perch susceptible to capture in nets and inshore fish-
traps. Yellow perch may not have occurred in the Nottawasa-
ga River in the past (Fred Dobbs, personal communication
1995). Yellow perch engage in extensive spawning-runs into
the rivers and small streams around the lake in late April and
May (MacCrimmon and Skobe 1970:101) (Table 7), where
they can be caught using nets or weirs. Unless some fish
were released alive, refuse from spawning-run seine-net
catches is expected to lack bones from small, sexually
immature individuals. Yellow perch could have been caught
together with other species during the spring spawning-run,
but since their availability is not as tied to the spawning
season as that of some other taxa, like the lake sturgeon,
Salmonidae or suckers, they were probably also an
important component of the Generalized Warm Weather

Walleye generally live in cool, large, turbid lakes, large
streams or rivers at moderate depth (Table 7). The walleye
is a sight predator and lives in schools, sometimes with white
suckers (Scott and Crossman 1973:772). It is also often
associated with yellow perch, northern pike, muskellunge
and smallmouth bass (Scott and Crossman 1973:772).

There are several likely locations of capture of walleye. If
population densities were greater in the past, walleye may
have been found in what are now considered marginal
habitats. Today, walleye are rare in Lake Simcoe. The
resident population used to spawn in the Holland River, at
the south end of the lake (MacCrimmon and Skobe 1970),
but sometime after the mid-1930s they started to spawn in the
Talbot River, on the east side of the lake, possibly as a
result of deteriorating water quality in the Holland River (Michael McMurtry, personal communication 1998). These locations are quite far from the sites, even by canoe. The Nottawasaga system appears a more probable location for exploitation than either the Holland or Talbot rivers.

The Nottawasaga River is a nursery for young fish of the resident walleye population in Nottawasaga Bay (Robin Craig, personal communication 1998). The adults live in the bay, and only come to the river to spawn in Minesing Swamp. The main part of the river is unsuitable spawning habitat (Robin Craig, personal communication 1998). As noted earlier, an influx of groundwater in Minesing Swamp, however, causes the water there to be very clear. In spring, the groundwater keeps the muddy river water in the main channel (Robin Craig, personal communication 1998). The walleye spawn in this shallow, clear, moving ground water, where they are very visible. Walleye often move into tributary rivers as soon as the rivers are ice-free and while the lake is still ice-covered, several weeks before spawning (Scott and Crossman 1973:771). Because the distance from Nottawasaga Bay to the spawning location is quite far, some of the mature fish may move into river in October and November so that they are ready to spawn in the swamp as soon as the ice breaks up (Robin Craig, personal communication 1998). When conditions are right, the spawning group rushes into shallow water and stops while they release their spawn and eggs (Scott and Crossman 1973:771).

Contemporary walleye spawning-runs are often very large, with fish crowding a shallow part of a river, where they can be easily speared or netted. After spawning, some fish linger in the rivers, but most return to open water and disperse. In autumn walleye once again return to the shoals of the lake shore (MacCrimmon and Skobe 1970:107-111). It has been suggested that some walleye at the Hubbert site were captured together with lake trout in autumn (Thomas 1996b:116).

Depending on flow conditions and other obstructions, such as beaver dams, it is possible for spawning walleye of the Nottawasaga Bay resident population to reach Willow Creek, where they can also be easily taken (Robin Craig, personal communication 1998). There is also a resident population in Little Lake, which spawns in riffles upstream from the lake (Robin Craig, personal communication 1998). The fish here are easy to catch, more concentrated than in the swamp, though less abundant. Little Lake is, as the name indicates, quite small, and is unlikely to have been the source for the oldest of our fish. These are most likely from the Nottawasaga Bay population, possibly by way of Willow Creek (Robin Craig, personal communication 1998).