

PREHISTORIC FISHING ALONG THE DANUBE

Considering the significant body of knowledge concerning the archaeozoology of the central Carpathian Basin (present-day Hungary) and the Iron Gates Gorge of the Danube (where the river forms the border between Romania and Serbia), largely publicized in the works of the late Sándor Bökönyi, relatively little is known about fish exploitation, an important source of animal protein in ancient times. This may be explained, to a great extent, with the lack of water-sieved or even dry screened find assemblages from archaeological sites from either of these two regions. In this situation, the remains of small animals, such as most fish in the Danube, are almost certainly lost.¹ The first review of sporadically found fish remains recorded at archaeological sites in Hungary was presented fifteen years ago.² Since then, new excavations as well as the occasional use of water-sieving have yielded new information. The aim of this work is to review the current state fish bone studies in the Carpathian Basin and the Iron Gates section of the Danube river.

Overexploitation, habitat loss and pollution have severely hit fish stocks worldwide. While the destruction of marine habitats has received great publicity (partly because of its international implications), dwindling stocks of fresh water fish attracted attention only in the case of major catastrophes induced by industrial activity, such as the mass poisoning of alluvial biotopes in the Rhine near Basel (Switzerland) in November 1986 or all along the Tisza river (Hungary) in 1999, when 650 t fish were poisoned by cyanide.³ From a zoological point of view, only a relatively few endangered or extinct species have been monitored. A remarkable exception is sturgeons, the largest fish in the Danube, which were relatively common until dams were built in the Iron Gates. The dams effectively cut off the migration route of endangered beluga sturgeon and other anadromous fish. Further upstream, sturgeon shoals thinned out as the river was regulated and walled off from the floodplain.⁴ Large-scale commercial navigation along the Danube also had a negative impact as it became necessary to keep the riverbed clean of sand and gravel deposits. By the mid-20th century, beluga sturgeon seldom swam upstream beyond the Iron Gates. The same human interference with river systems has also affected the entire aquatic ecosystem, including smaller bodied, less spectacular fish species. Diachronic changes in the composition of fish fauna are, therefore of interest in understanding the relationship between natural habitats and human subsistence activity. Prehistoric fishing represents the earliest point in such studies. Although fishing was presumably important during the Mesolithic and even earlier periods, to date only a few such settlement remains have been known from the Carpathian, with no convincing evidence of large-scale fish exploitation. Sporadically occurring fish bones may be observed more consistently from the early Neolithic onwards, as people apparently exploited the alluvial habitats in which they increasingly settled practicing agricultural production.

The reconstruction of prehistoric fishing is a multidisciplinary task. Chapters in this summary article, therefore were drafted with regard to the following aspects relevant to the subject:

1. Ichthyoarchaeological properties explain *which species* were exploited and how reliable is their representation (*Chapter 3*).

¹ *L. Bartosiewicz: A régészeti feltárás finomításának lehetőségei (Possibilities in the refinement of archaeological recovery). RégFüz 2 (1983) 37–54.*

² *I. Takács – L. Bartosiewicz: Data to the history of fish exploitation in Hungary. Paper delivered at the*

4th Conference of the ICAZ Fish Remains Working Group, 1987, York, England.

³ *www.transnationale.org*

⁴ *C. Woodard: Singing the Danube blues. Christian Science Monitor, May 11, 2000.*

2. The palaeohydrological reconstruction of alluvial habitats helps in identifying locations *where* fishing may have taken place (*Chapter 4*).
3. Familiarity with fish behavior points to *seasons* when various fish could be most easily targeted (*Chapter 5*).
4. Ethnohistoric records of artisanal fisheries reveal basic *attitudes* towards fish exploitation (*Chapter 6*).

This outline is intended to provide an interpretive framework, showing the complex interactions between nature and society as reflected in the prehistory of fishing. The review of each of the four topics was based on the inclusion of additional data from natural and social sciences respectively, since the disciplinary boundaries between these areas of research often overlap.

Material and method

This summary is based on an analysis of data available in the literature, as well as unpublished data (especially from water-sieved assemblages) by the author. Most of the published fish bone materials originate from excavations where finds were collected only by hand and the naked eye due to both real limitations (especially time, labor and money) and the conservative attitude by some archaeologists. The advantage of hand-collected fish bone assemblages is that being inevitably selected by size, they are directly comparable to similar materials published in the literature. Thus a general framework may be outlined within which more detailed but less numerous analyses of water-sieved materials from recent excavations can be interpreted.

Due to the general character of this paper, its chronological scope ranges within the Mesolithic to the Bronze Age. Water-sieved assemblages, as well as radiocarbon dates are available only for a few settlements. These included Schela Cladovei⁵ (Iron Gates Gorge, Danube river) with Mesolithic and early Neolithic (Criş/Starčevo culture) occupations, Ecsegfalva 23⁶ (Tisza/Berettyó river) an early Neolithic (Körös culture) settlement, Győr-Szabadrét-domb⁷ (Danube/Rába river) a largely Copper Age (Boleráz group) site and Tiszaug-Kéménytető⁸ (Tisza river) a Middle Bronze Age (Nagyrev culture) tell.

The geographical distribution of sites included in this study is rather heterogeneous. In contrast with the title, some assemblages from the tributaries of the Danube, especially the Tisza river, have also been included, as alluvial habitats typical of the same overall landscape in most of the Carpathian Basin, especially the plains. These sites are characteristic of Neolithic subsistence,⁹ and as such deserve particular attention. The two major areas available for study, the sections of the Danube in Hungary and in the Iron Gates, are shown in *fig. 1*.

A few sites reviewed here represent the prehistory of a lower section of the Danube in the aforementioned Iron Gates region between Romania and Serbia. On the other hand, the upper reaches of the river, located in very different environmental and cultural settings in Austria and Germany, were beyond the focus of the present study.

A relatively small set of assemblages was recovered using water-sieving. These collections offer better sight of taxonomic richness, however, are not directly comparable to previous, hand-collected assemblages from Hungary without a significant risk of inter-site interpretational bias. A target-oriented experiment has shown that, bone fragments measuring less than 19 mm, tend to be lost with great probability when finds are collected exclusively by hand.¹⁰ Unfortunately, as is clearly shown by water-sieved bone assemblages,

⁵ Bonsall *et al.* 2001, 16.

⁶ A. Whittle – L. Bartosiewicz – D. Borić – P. Pettitt – M. Richards: In the beginning: new radiocarbon dates for the Early Neolithic in northern Serbia and south-east Hungary. *Antaeus* 25 (2002) 114–117.

⁷ Bartosiewicz *et al.* 1994.

⁸ A. M. Choyke – L. Bartosiewicz: Bronze Age animal exploitation in the Central Great Hungarian Plain. *ActaArchHung* 51 (1999–2000) 43–70.

⁹ I. Takács: Fish remains from the early Neolithic site of Endrőd 119, in: S. Bökönyi (ed.): *Cultural and Landscape Changes in South-East Hungary I*. Budapest 1992, 301–311.

¹⁰ L. Bartosiewicz: Water-sieving experiment at Örménykút, Site 54, in: *Járó – Költő* 1988, 267–274.

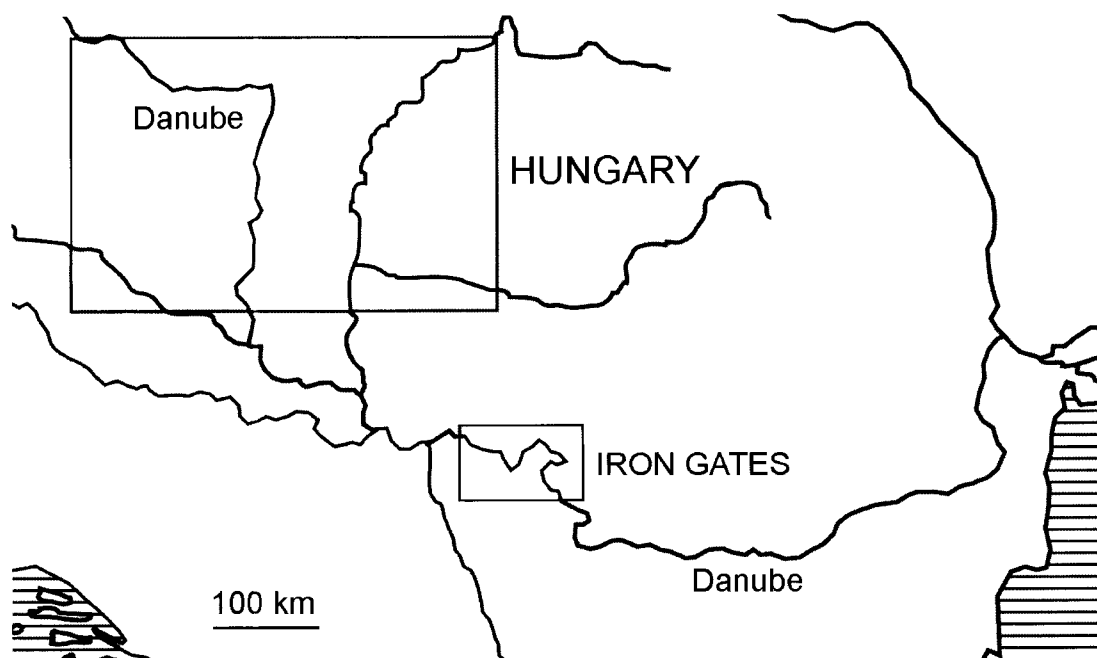


fig. 1. The location of study areas along the Danube

the overwhelming majority of fish remains from prehistoric sites in Hungary would fall way below this size criterion.

Given the multitude of taphonomic factors that distort even the consumption refuse from archaeological sites, the reliable reconstruction of prehistoric aquatic habitats, ancient fishing and cultural attitudes to fish stocks is a near impossible task. In order to create a frame of reference within which these more complex phenomena may be interpreted, data on 32 present-day traditional fishing communities were integrated within this study. This set of data was hoped to provide an interpretative/contextual framework within which prehistoric relationships between humans and aquatic animals may be translated into sociocultural meanings.¹¹ Ethnoarchaeology uses analogy as an interpretative tool and for developing appropriate research strategies in archaeology.¹² It explores relationships between behavior and material culture often disregarded by ethnologists, and to attempts to establish how features of known behavior may be recognized in archaeological remains.¹³ Archaeologists often rely on analogical reasoning¹⁴ in testing hypotheses of non-observable ancient behavior by seeking modern parallels.¹⁵ Of the two different types of analogy used in archaeology, formal and relational, recently the first has been successfully used in the interpretation of archaeoichthyological assemblages from the north-western coast of Scotland.¹⁶ *Formal analogy* is based on the assumption that if two phenomena have two or more attributes in common, they probably share other attributes as well. Formal analogy is useful when no historical documents are available. A typical example is the reconstruction of prehistoric processes based on their material correlates in modern populations.¹⁷

¹¹ L. R. Binford: Smudge pits and hide smoking: the use of analogy in archaeological reasoning. *American Antiquity* 32 (1967) 1–12.

¹² W. R. Belcher: Butchery practices and the ethnoarchaeology of South Asian Fisherfolk, in: W. Van Neer (ed.): *Fish exploitation in the past*. Tervuren, Koninklijk Museum voor Midden-Afrika, *Annalen, Zoologische Wetenschappen* 274 (1994) 169–176.

¹³ C. Kramer: Introduction, in: C. Kramer (ed.): *Ethnoarchaeology*. New York 1979, 4–7.

¹⁴ Wylie 1985.

¹⁵ R. Ascher: Analogy in archaeology. *Southwestern Journal of Anthropology* 17 (1961) 317–325.

¹⁶ Cerón-Carrasco 2002.

¹⁷ Wylie 1985.

Most of the fishing communities used in analogous reasoning in this study were documented in Oceania¹⁸ along the Pacific Coast of Asia.¹⁹ The next largest group of ethnohistoric observations represents Atlantic Europe²⁰ and North America,²¹ (including two Pacific communities). Fewer ethnographic data are available from Latin America,²² while Africa²³ was represented only by two studies. The geographical distribution of these ethnographic data, is shown in *Table 1*.

¹⁸ *T. Akimichi*: Perception and function: traditional resource management in three Pacific Islands. *Resource Management and Optimization* 4/36 (1981) 1–378; *T. Akimichi – K. Ruddle*: The historical development of territorial rights and fishery regulations in Okinawan Inshore Waters, in: *Ruddle – Akimichi 1984*, 37–88; *G. B. K. Baines*: Traditional resource management in the Melanesian South Pacific: a development dilemma, in: *Berkes 1989*, 273–296; *J. Carrier*: Marine tenure in Papua New Guinea, in: *McCay – Acheson 1987*, 142–167; *K. B. Foster – J. J. Poggie Jr.*: Customary marine tenure and mariculture management in outlying communities of Pohnpei State, Federated States of Micronesia. *Ocean and Coastal Management* 20 (1993) 1–22; *R. E. Johannes*: Traditional marine conservation methods in Oceania and their demise, in: R. Johnson (ed.): *Annual Review of Ecology and Systematics*, 9. Palo Alto, Annual Reviews 1978, 349–364; *R. E. Johannes*: Worlds of the Lagoon: Fishing and Marine Life in Palau District of Micronesia. Berkeley 1981; *J. J. Kalland*: Sea tenure in Tokugawa Japan: the case of the Fukuoka Domain. in: *Ruddle – Akimichi 1984*, 11–36; *M. P. Sissenwine – P. Mace*: ITQ's in New Zealand: the era of fixed quotas in perpetuity. *Fishery Bulletin* 90 (1991) 147–160; *L. Zann*: Traditional management and conservation of fisheries in Kiribati and Tuvalu atolls, in: *Ruddle – Johannes 1985*, 53–78.

¹⁹ *P. Alexander*: Sea tenure in Southern Sri Lanka, in: A. Spoehr (ed.): *Maritime Adaptations: Essays on Contemporary Fishing Communities*. Pittsburgh 1980, 91–112; W. Belcher personal communication quoted, in: *Acheson – Wilson 1996*, 583; *F. Berkes*: Marine inshore fishery management in Turkey, in: *Proceedings of the Conference on Common Property Resource Management*. National Research Council. Washington DC 1986, 63–83; *M. Gadgil*: Social restraints on resource utilization: the Indian experience, in: J. A. McNeeliey – D. Pitt (eds): *Culture and Conservation: The Human Dimension in Environmental Planning*. Dublin 1985, 135–154; *S.-B. Han*: *Socio-economic Organization and Change in Korean Fishing Villages: A Comparative Study of Three Fishing Communities*. PhD Dissertation, Michigan State University. Ann Arbor, University Microfilms 1972; *B. Nietschmann*: Torres Strait Islander Sea resource management and sea rights, in: *Ruddle – Johannes 1985*, 127–154; *K. Ruddle*: Solving the Common Property Dilemma: Village Fisheries Rights in Japanese Coastal Waters, in: *Berkes 1989*, 168–184; *P. Vondal*: The common swamplands of Southeastern Borneo, in: *McCay – Acheson 1987*, 231–249.

²⁰ *K. O. Martin*: Play by the rules or don't play at all, in: R. Andersen (ed.): *North Atlantic Maritime Cultures*. The Hague 1979, 277–298; P. Dürrenberger – G. Pálsson personal communication in: *Acheson – Wilson 1996*, 579–594; *S. Jentoft – T. Kristoffersen*: Fishermen's co-management: the case of the Lofoten fishery. *Human Organization* 48 (1989) 355–365; *R. Van Ginkel*: Plunderers into planters: Zealand oystermen and the enclosure of the marine commons, in: J. Boissevain – J. Verrips (eds): *Dutch Dilemmas: Anthropologists Look at the Netherlands*. Assen 1989, 89–105.

²¹ *J. M. Acheson*: Government regulation and exploitative capacity: the case of the New England ground fishery. *Human Organization* 43 (1984) 319–329; *J. M. Acheson*: The lobster gangs of Maine. Hanover 1988; *F. Berkes*: Common property resource management and creole Indian fisheries in Subarctic Canada, in: *McCay – Acheson 1987*, 66–91; *H. P. Bishop*: The emergence of hunting territories among the Northern Ojibwa. *Ethnology* 9/1 (1970) 1–15; *R. Brightman*: Conservation and resource depletion: the case of the Boreal Forest Algonquins, in: *McCay – Acheson 1987*, 121–141; *M. Dewar*: *Industry in Trouble: The Federal Government and the New England Fisheries*. Philadelphia 1983; *R. K. Nelson*: A conservation ethic and environment: the Koyukon of Alaska, in: *Williams 1982*, 211–228; *W. F. Royce*: Managing Alaska's Saknon fisheries for a prosperous future. *Fisheries* 14/2 (1989) 8–13; *N. M. Williams*: A boundary to cross: observations on Yolgnu boundaries and permission, in: *Williams 1982*, 131–153.

²² *D. P. Leveil – B. Orlove*: Local control of aquatic resources: community and ecology in lake Titicaca, Peru. *American Anthropologist* 92 (1990) 362–382; *J. R. McGoodwin*: Mexico's conflictual inshore Pacific fisheries: problem analysis and policy recommendations. *Human Organization* 46 (1987) 221–231; *D. Miller*: The evolution of Mexico's spiny lobster fishery, in: *Berkes 1989*, 185–198; *C. G. M. Robben*: Conflicting discourses of economy and society in Coastal Brazil. *Man* 29 (1994) 875–900; *M. Southon*: Competition and conflict in an Ecuadorian Beach seine fishery. *Human Organization* 48 (1989) 365–369; *D. K. Sutherland*: *Economic Success in a Belizean Fishing Village*. Boulder, Westview 1986.

²³ *J. Rowntree et al.*: Fishery management in the Northern Nile Delta Lakes of Egypt: the case of Hosha. *Food and agriculture organization of the United Nations, Studies and Reviews* 61 (1984) 542–555; *Thomas 1996*, 287–314.

Continent	Number of fisheries
Asia	8
Oceania	9
Europe	4
North America	5
Central/South America	4
Africa	2
Total	32

Table 1. The geographical distribution of artisanal fisheries used in the ethnographic analogy

Data describing attitudes to present-day fish stocks data were synthesized using a factor analysis (Varimax rotation, latent roots ≥ 1). The purpose of this calculation was to establish basic relationships between various aspects of artisanal fish management. In the absence of written sources, such trends, hypothetically, would enhance our understanding of the prehistoric archaeoichthyological record.

Archaeoichthyological finds

The archaeozoological study of fish remains has several aspects. These include the representativity of samples, as well as the biological features of various fish species which have a bearing on both bone preservation and the culture-historical interpretation of ichthyoarchaeological finds.

THE FREQUENCY OF FISH REMAINS IN ARCHAEOZOOLOGICAL ASSEMBLAGES

Most archaeozoological collections in Hungary contain an amazingly small portion of fish bones, largely attributable to the fact that, with a few recent exceptions, animal remains have always been collected exclusively by hand. The lack of dry screening of water-sieving may have a detrimental effect on the representation of entire classes of vertebrates, not to speak of even smaller animals such as land snails or arthropods.²⁴

In addition, depending on the scope and nature of excavations, the number of animal bones recovered from sites also tends to vary broadly. Given these great differences in assemblage sizes, the stochastic relationship between the decimal logarithms of the number of all identifiable specimens ($\lg \text{Non-fish NISP} = x$, including mammalian and bird remains) and the number of fish bones represented in an assemblage ($\lg \text{Fish NISP} = y$) is best expressed by

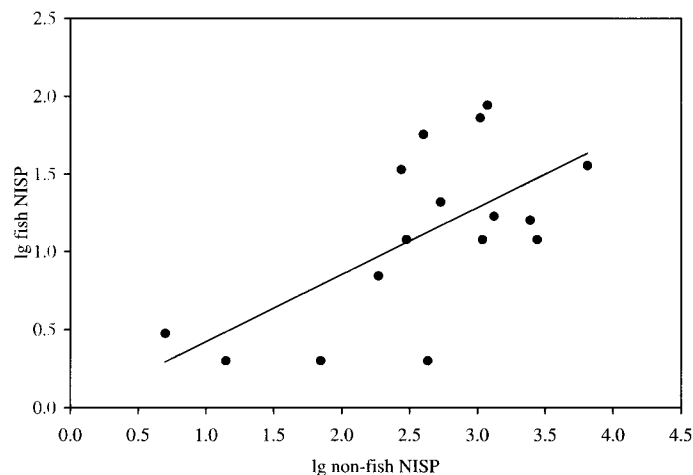


fig. 2. The occurrence of fish bones in hand-collected faunal assemblages

²⁴ I. Takács: Collecting biological finds from the well of a medieval village, in: *Járó – Költő 1988*, 275–282.

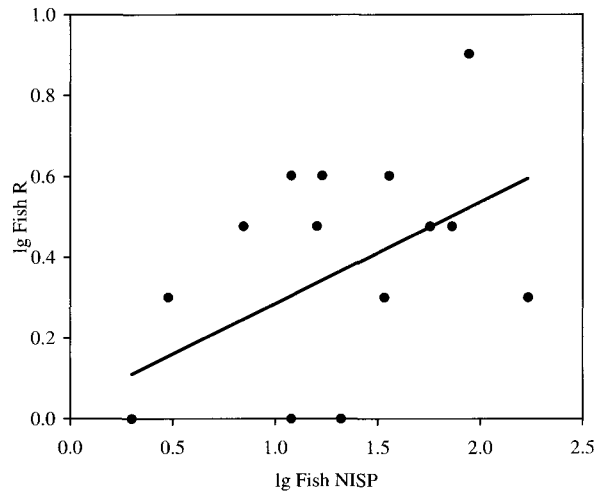


fig. 3. Relationship between taxonomic richness and assemblage size

the linear regression between these two variables for the 16 prehistoric fish bone assemblages plotted in (fig. 2). Assemblages containing only a single, non-identifiable fish bone were not included in this calculation. Decimal logarithms improve the linearity of this equation by reducing the heteroscedasticity of data. The trend shown in fig. 2. may be described using the following equation:

$$\lg \text{ Fish NISP} = 0.431(\lg \text{ Non-fish NISP}) - 0.007$$

$$(r = 0.641)$$

The significant but low correlation ($P \leq 0.010$) as well as the low regression coefficient indicate that the recovery of additional bones from fish follows a clearly regressive trend for hand-collected fish bone assemblages. This means that (as would be the case with mammalian remains as well), increasing sample sizes yield ever more fish bones: the probability of encountering new specimens is not in a linear proportion with assemblage size. Statistical parameters of the overall picture, however, are somewhat distorted by the occurrence of single fish bones in numerous assemblages aligned at the bottom of the graph. This phenomenon points to the tremendous difference in the probability by which fish vs. larger mammalian bones are found when no form of fine recovery is practiced.

TAXONOMIC RICHNESS

Along similar principles, the so-called taxonomic richness (lg Fish R, the number of taxa identified) of fish bone assemblages may be appraised as a function of fish bone sample size (lg Fish NISP; fig. 3). Although, given the small number of fish bones to begin with, the representation of various species would be difficult to compare in numerical terms, the few major hand collected assemblages show at least trends in the presence of fish remains as a function of assemblage size.

$$\lg \text{ Fish R} = 0.251(\lg \text{ Fish NISP}) - 0.035$$

$$(r = 0.512)$$

Archaeoichthyological remains originating from a greater variety of fish species originate from settlements represented by large assemblages. Increasing the size of archaeoichthyological assemblages, however, yields only a declining number of new taxa, and this trend is statistically significant ($P \leq 0.050$). This is expressed by the low regression coefficient. To some extent, therefore, the inventory of fish remains, thus, would be more characteristic of sample size than the differential richness of the studied samples: in random samples the least frequent fish species would be the least likely to occur.²⁵

²⁵ D. K. Grayson: Quantitative Zooarchaeology.

Studies in Archaeological Science, New York 1984.

TAPHONOMY AND INTERSPECIFIC DIFFERENCES IN OSTEOLOGY

This review is built around the osteological evidence for fish, predominantly from the Danube and its tributaries in Hungary. These remains, recovered from archaeological sites, must also be discussed in terms of taphonomic bias and taxonomic identifiability.

The taphonomic process incorporates the entire sequence of *post mortem* changes that define the character and composition of zoological assemblages. Owing to its roots in aquatic ecology²⁶ and palaeontology,²⁷ taphonomic research has had an appeal to archaeozoologists, since in reality, the manifestation of ancient cultural phenomena in archaeoichthyological remains is distorted by these *post mortem* changes in the original fish skeleton. Taphonomic loss is related to ancient human activity, a host of natural effects and, last but not least, the archaeologists themselves. The simplified sequence of the taphonomic process is summarized in *Table 2*.

Source of data	Selective process	Interpretation
<i>Biocoenosis</i>	not relevant	= living fish community, "ichthyofauna"
↓	biostratonomy	= primary human action (fishing, processing, consumption, disposal) and pre-depositional natural effects (scavengers, weathering)
<i>Thanatocoenosis</i>		= dead "community"
↓	fossil diagenesis	= post-depositional natural effects
↓	survey and excavation	= secondary, modern human action
<i>Archaeological assemblage</i>	storage, curation	
↓	documentation, analysis	
<i>Publication</i>		

Table 2. Overview of the taphonomic process effecting fish remains

Ancient, "primary" human effects themselves, of the utmost interest to the archaeologist, form part of biostratonomy. They are a source of bias from the viewpoint of faunal history, but offer perspectives on important culture historical questions:

1. *mode of procurement* (selective fishing defined by human preference of technical limitations may distort the picture of the early exploitation of alluvial resources)
2. *age and size criteria* (these may have an influence on which fish were targeted within the populations available)
3. *differential deposition* (very large fish, such as sturgeon, were dismembered and parts transported, again selectively)
4. *carcass processing* (loss due to anatomically differential bone structure and degrees of butchering)
5. *mode of deposition* (well defined, protected features vs. scattered surface finds, scavengers' access to the remaining evidence: dogs, pigs and rodents may transport/gnaw fish bones)

Post depositional natural effects on the thus deposited bone are described by the generic term fossil diagenesis. They include the effects of:

1. *mechanical damage* (changing surface conditions, soil pressure, mechanical erosion may all damage delicate fish bone)
2. *soil pH and possibly autolysis* by decaying fish fats (acidic soils and in some cases, fatty acids²⁸ tend to dissolve bone, while basic soils preserve them)

²⁶ E. Wasmund: Biocoenose und Thanatocoenose. Biosozologische Studie über Lebensgemeinschaften und Totengesellschaften. Archiv für Hydrobiologie 17 (1926) 1–116.

²⁸ M. Mézes – L. Bartosiewicz: Fish bone preservation and fat content. Offa 51 (1994) 361–364.

²⁷ I. A. Efremov: Taphonomy: a new branch of paleontology. Pan-American Geologist 74 (1940) 81–93.

3. *exposure to and transport by water* (alternating exposures of fish bone, especially at coastal sites, may cause additional loss)
4. *heat fluctuations - crioturbation* (extreme heat and cold are most damaging near the surface)
5. *activity by living organisms – bioturbation* (burrowing animals, plant roots)

Excavator's decisions act as the last set of filters on this body of information:

1. *research policy* (preferential funding, contract archaeology)
2. *choice of excavated area* (partial excavation, rescue work etc.)
3. *spatial aspects of sampling* (contiguous surfaces, trenches, test pits)
4. *recovery techniques* (hand-collection, screening, flotation/water-sieving)
5. *data management and evaluation* (documentation, storage and publication)

Depending on size and anatomical features, this multitude of taphonomic factors has a differential effect on various fish. Interspecific comparisons between different species are made difficult by the different skeletal characteristics fish. The remains of very small species fall victim not only to primary effects such as digestion by humans and animals,²⁹ but are at a disadvantage during most of the taphonomic process. They are particularly sensitive to the precision of recovery. At the other extreme, it is chiefly large and compact dermal scutes of sturgeon which show up even in hand-collected assemblages, which otherwise contain few fish remains. They are arranged in dorsal, lateral and ventral rows along the body of the fish and differ both in size and shape by anatomical location.³⁰ Similarly to the great number of vertebrae, dorsal fin rays and other serial features of the fish skeleton, these remains are extremely difficult to interpret in quantitative terms, not to speak of the insurmountable bias inherent to the reconstruction of the Minimum Number of Individuals (MNI).

ARCHAEOICHTHYOLOGICAL CHARACTERISTICS

When only hand-collected assemblages are available for study, mostly the remains of various sturgeons (*Acipenser* sp.), large carp (*Cyprinus carpio* L. 1758), catfish (*Silurus glanis* L. 1758), pike (*Esox lucius* L. 1758), and sometimes pikeperch (*Stizostedion lucioperca* L. 1758) may be identified. Small bone fragments are not only rare, but they may also originate from bones of these same species.

Fishing potentially yielded an abundant supply of animal protein in prehistoric subsistence economies in the Carpathian Basin, but the species available for consumption were defined by the composition of the local "ichthyofauna" of various alluvial habitats as discussed below. In spite of wet sieving, mostly the remains of these characteristically large fish species could be identified at the recently excavated Körös culture settlement of Ecsegfalva 23. A major difference was, however, that the presence of young individuals from large fish such as pike could also be established³¹. The rest of that material (as was often the case with other, carefully excavated sites) was made up by small-size species and/or specimens of the carp family (*Cyprinidae*). These two groups of fish small-sized remains, however, clearly illustrate the importance of sieving in obtaining archaeoichthyological assemblages that offer a sound and reliable basis for interpretation even from a taphonomic point of view.

Familiarity with the range of fish ages/sizes represented by the archaeoichthyological remains at a site helps fine-tuning the reconstruction of roles various species played in the diet. The mass measurement of bones may be used in reconstructing the dietary role of fish.³² On the basis of standardized osteological measurements, sometimes the length of fish can be directly estimated (using coefficients or regression equations), as is the case with Beluga sturgeon,³³

²⁹ A. K. G. Jones: Fish bone survival in the digestive systems of pig, dog and man: some experiments, in: D. C. Brinkhuizen – A. T. Clason (eds): Fish and Archaeology. BAR IntSer 294 (1986) 53–61.

³⁰ R. W. Carsteel: Fish remains in archaeology. London – New York – San Francisco 1976.

³¹ Bartosiewicz, unpublished data.

³² L. Bartosiewicz – R. Cerón-Carrasco – F. Gyulai: Számítógépes méretbecslések őskori halmaradványok alapján (Computerized size estimations using prehistoric fish remains). Halászatfejlesztés 19 (1996) 212–220.

³³ Bartosiewicz – Takács 1997.

pike³⁴ and catfish.³⁵ Although similar comparative growth curves for wild carp have not been available, patterning in the size distributions of modern record specimens representing the feral form offer some insight in the sizes those animals reached during prehistory, especially in large, open waters, such as the Danube near Schela Cladovei,³⁶ on the basis of other species whose skeletal remains could be studied in detail.³⁷

The more generalized, additional use of biometric size reconstruction in estimating the dietary roles of various fish is severely hampered by the difficulty of reliably counting the minimum number of individuals in fish bone assemblages. In this situation, familiarity with the size ranges of live fish could be of help in interpreting the list of species at least in an impressionistic/descriptive manner. The main dimensions of species relevant to this study are summarized in *Table 3*.

	Species	Total length, m	Live weight, kg
Beluga sturgeon	<i>Huso huso</i> Linné 1758	2–3 (max. 10)	80.00–100.00 (max. 1000.00)
Russian sturgeon	<i>Acipenser gueldenstaedti</i> Brandt 1833	2.00–2.50	80.00–100.00
Ship sturgeon	<i>Acipenser nudiventris</i> Lovetzky 1828	2.00	40.00–50.00
Stellate sturgeon	<i>Acipenser stellatus</i> Pallas 1771	1.50–2.00	30.00–50.00
Sterlet	<i>Acipenser ruthenus</i> Linné 1758	1.00–1.20	15.00–16.00 (max.)
Carp	<i>Cyprinus carpio</i> L. 1758	max. 1.00	30.00
Bream	<i>Abramis brama</i> L. 1758	0.15–0.40	0.20–0.40
Barbel	<i>Barbus barbus</i> L. 1758	0.70–0.80	4.00–5.00
White bream	<i>Blicca bjoerkna</i> L. 1758	0.25–0.35	max. 1.00
Crucian carp	<i>Carassius carassius</i> L. 1758	0.20–0.50	3.00–5.00
Undermouth	<i>Chondostroma nasus</i> L. 1758	0.20–0.40	0.20–1.00
Orfe	<i>Leuciscus idus</i> L. 1758	0.35–0.70	0.50–1.50
Knife	<i>Pelecus cultratus</i> L. 1758	0.25–0.50	0.30–1.00
Roach	<i>Rutilus rutilus</i> L. 1758	0.10–0.35	0.05–0.20
Rudd	<i>Scardinius erythrophthalmus</i> L. 1758	0.20–0.35	0.20–0.40
Tench	<i>Tinca tinca</i> L. 1758	0.25–0.60	0.30–2.50
Vimba	<i>Vimba vimba</i> L. 1758	0.25–0.30	0.20–0.40
Catfish	<i>Silurus glanis</i> L. 1758	2.00–2.50	150.00–200.00
Pike	<i>Esox lucius</i> L. 1758	0.50–1.50	5.00–25.00
Pikeperch	<i>Stizostedion lucioperca</i> L. 1758	1.00–1.50	15.00–20.00

Table 3. Characteristic dimensions of fish species known from archaeological assemblages³⁸

Naturally, it is possible, that a massive and steady supply of small fish provided more animal protein than the odd, large specimen. Prolific small Cyprinids must have been much more easily available than formidable beasts, often heavier than humans. Large catfish or majestic Beluga sturgeon must have had a cognitive significance to the inhabitants of prehistoric settlements along the Danube. With all the fish species of large size under discussion here, the frequency and actual size of the largest specimens landed depends on the reproductive capacity and growth characteristics of the respective fish stocks.³⁹ Since 1800, for example, the estimated 1.84 kg average annual decrease in record sturgeon body weights was found to be statistically significant.⁴⁰ The large, 181 kg specimen caught at Paks (Hungary) in 1987

³⁴ L. Bartosiewicz: Osteometrical studies on the skeleton of pike (*Esox lucius* L. 1758). *Aquacultura Hungarica* 6, Szarvas 1990, 25–34.

³⁵ I. Takács: Segédlet szubfosszilis harcsák testnagyságának kiszámításához a fő vázalkotók méretei alapján (Hilfe zur Berechnung der Körpergrösse von subfossilen Welsen aufgrund der Abmessungen der Hauptgerippekomponenten). *MMMK* 1986–1987, 105–126.

³⁶ L. Bartosiewicz – I. Takács – I. Székelyhidy: Problems of size determination in common carp (*Cyprinus carpio*), in: W. Van Neer (ed.): *Fish exploitation in the past*. Tervuren, Koninklijk

Museum voor Midden-Afrika, *Annalen, Zoologische Wetenschappen* 274 (1994) 55–60.

³⁷ I. Székelyhidy – I. Takács – L. Bartosiewicz: Ecological and diachronic variability in large-sized catfish (*Silurus glanis* L. 1758) and pike (*Esox lucius* L. 1758) in Hungary. *Offa* 51 (1994) 352–356.

³⁸ *Berinke* 1966.

³⁹ L. E. Miranda – M. W. M. Wingo – R. J. Muncy – T. D. Bates: Bias in growth estimates derived from fish collected by anglers, in: R. C. Summerfelt – G. E. Hall (eds): *Age and growth of fish*. Ames 1987, 211–219.

⁴⁰ *Bartosiewicz – Takács* 1997.

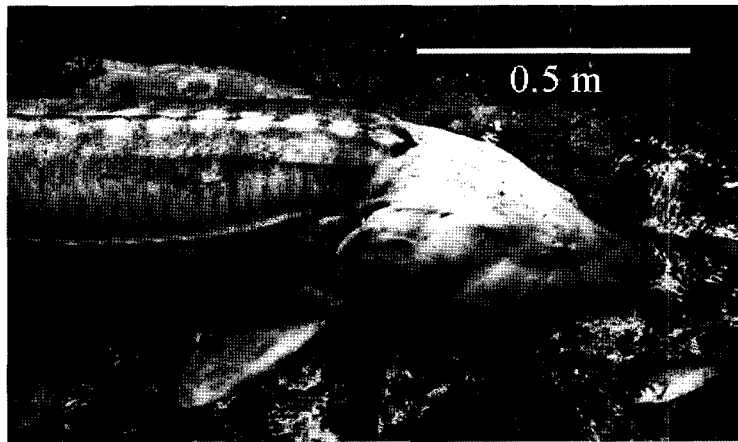


fig. 4. Sturgeon, weighing 181 kg, caught at Paks (Hungary) in 1987

(fig. 4), nearly two decades after the closure of the Iron Gates 1 dam,⁴¹ may have attained this respectable size after having been trapped upstream, behind the hydroelectric installation.

On the other hand, a size increase in carp is the natural consequence of large domestic carp going feral and cross-breeding with wild stock, leading to its genetic extinction. Wild carp is gone now in Europe (fig. 5), although the bones of extremely large prehistoric wild carp are known, for example, from prehistoric site of Schela Cladovei.

Habitat reconstruction

As opposed to terrestrial animals, fish are directly and inseparably bound to their respective aquatic habitats. It is the quality of water that directly regulates food supplies (depending on the place of each species within the complex aquatic food chain), and has a major impact on both the timing and success of reproduction for every kind of fish. The properties of water are influenced by climatic, topographic and hydrographic conditions, which act together in determining the suitability of habitats for the variety of fresh water species that live in various branches of rivers and their respective floodplains in the Carpathian Basin.

WATER PROPERTIES

Climate and topography influence aquatic life through the quantity of oxygen dissolved in water (y , mg/l). This is a function of current speed (x_1 , m/s) and water temperature (x_2 , °C).

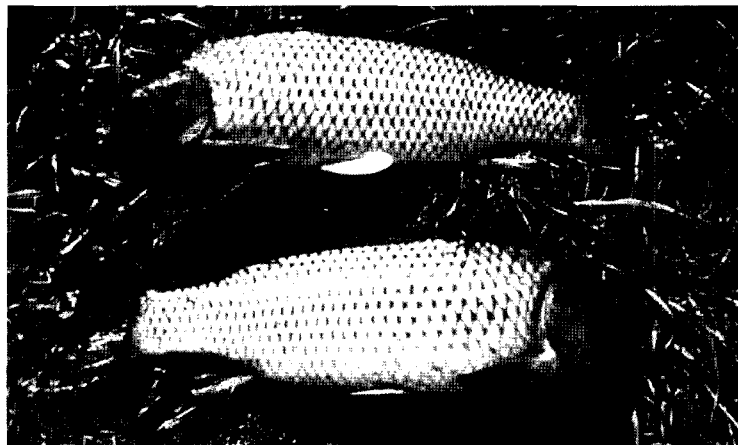


fig. 5. Wild carp photographed by E. K. Balon in the Slovakian section of the Danube in 1955*

⁴¹ K. Pintér: Magyarország halai (The fish of Hungary). Budapest 1989, 24.

* E. K. Balon: The common carp, *Cyprinus carpio*: its wild origin, domestication in aquaculture, and

selection as colored nishikigoi. Guelph Ichthyology Reviews 3 (1995) 1–55.

According to empirical data,⁴² this relationship may be expressed by the following regression equations:

$$\begin{array}{lll} X_1 = \text{speed of current:} & y = 1.953x + 1.984 & r = 0.943 \\ X_2 = \text{temperature:} & y = -0.221x + 13.669 & r = -0.979 \end{array}$$

The regression coefficients of “x” values express the phenomenon that every additional 1 m/s in water velocity increases dissolved oxygen content by almost 2 mg/l in rivers, while a 1 °C rise in temperature would result in a 0.2 mg/l loss. Such habitat differences not only influence fish behavior: they may directly determine which species are available for fishing.

TOPOGRAPHY AND CHANGES IN WATER QUALITY

As the speed of the river is greater towards its source (and its temperature tends to decrease with increasing altitudes), the further upstream fish move, the better the circumstances for spawning. Aeration parameters in various sections of a river are summarized after Harka⁴³ in *Table 4*.

River section	Water velocity, m/s	Summer temperature, °C	Dissolved oxygen, mg/l
Spring (krenon)	>1.5		>5.5
Mountain (ritron)	1.5–2	13	4.5–5.5
Lower mountain (hiporitmo)	1–1.5	16	4.0–4.5
Foothill region	0.7–1	20	3.5–4.0
Lower foothill (epipotamon)	0.5–0.7	20	3.0–3.5
Plain (metapotamon)	<0.5	25	2.5–3.0
River mouth (hipopotamon)		>25	<2.5

Table 4. General changes in water parameters along a river’s course⁴⁴

Alluvial habitats, defined by the parameters of water as listed above also differ in at least the percentual composition of various species in their fish fauna. To what extent this is reflected in an archaeoichthyological assemblage, is also a matter of differential fishing, preservation and recovery, the aforementioned three strongest selective processes in taphonomy. Short-range migrations of fish shoals also connect different sections of the same river, which reduces the environmental indicator value of these species.

Such finer details are unlikely to be directly manifested in the archaeoichthyological record, unless fine recovery techniques are applied. These sites represent different, lower foothill (epipotamon), plain (metapotamon) and, to some extent, river mouth (hipopotamon) habitats. As mentioned before, fish bone assemblages from the upper reaches of the Danube in Austria and Germany were not studied.

Owing to the immense difficulty of precisely quantifying fish remains (not least due to complex taphonomic situations such as the aforementioned natural deposition, selective preservation and partial recovery), emphasis in this was laid on the presence/absence evaluation of species and the environmental interpretation of those identified. The species composition of fish remains from 5 water-sieved assemblages can be compared to each other in *Table 5*.

⁴² Péntes – Tölg 1977, 327, Table 4; Harka 1993.

⁴⁴ Harka 1993.

⁴³ Harka 1993.

Species	Győr–	Tiszaug–	Ecsegfalva	Schela	Schela
	Szabadrét-domb	Kéménytető	23	Cladovei	Cladovei
	Copper Age	Bronze Age	Neolithic	Mesolithic	Neolithic
Tench <i>Tinca tinca</i> L. 1758	+	+	+		
Crucian carp <i>Carassius carassius</i> L. 1758	+	+			
Pikeperch <i>Stizostedion lucioperca</i> L. 1758	+		+		
Knife <i>Pelecus cultratus</i> L. 1758	+				
Rudd <i>Scardinius erythrophthalmus</i> L. 1758	+				
Pike <i>Esox lucius</i> L. 1758	+	+	+	+	+
Catfish <i>Silurus glanis</i> L. 1758	+	+	+	+	+
Carp <i>Cyprinus carpio</i> L. 1758	+	+	+	+	+
Roach <i>Rutilus rutilus</i> L. 1758	+	+	+		+
Bream <i>Abramis brama</i> L. 1758	+		+	+	+
Barbel <i>Barbus barbus</i> L. 1758	+		+	+	+
White bream <i>Blicca björkna</i> L. 1758		+			
Orfe <i>Leuciscus idus</i> L. 1758			+	+	
Vimba <i>Vimba vimba</i> L. 1758			+		
Undermouth <i>Chondostroma nasus</i> L. 1758				+	
Sturgeon sp. <i>Acipenseridae</i>				+	+
Sterlet <i>Acipenser ruthenus</i> L. 1758				+	+
Total NISP	1685	2472	2195	1196	1961

Table 5. The presence of various species identified in five water-sieved samples

Species identified in all five assemblages are marked by shading. Remarkably, these ubiquitous species include the fish (the “trinity” of pike, carp and catfish) whose large specimens are also known in almost all hand-picked fishbone collections. All three occupy a central position in this list. The diagonal pattern displayed by the various fish species begins with tench in the upper left corner and ends with sterlet in the lower right corner. The minimum requirements of dissolved oxygen by these characteristic freshwater fish species (as well as that of pikeperch) are as follows⁴⁵:

Tench (<i>Tinca tinca</i> Linné 1758)	0.7 mg/l
Pikeperch (<i>Stizostedion lucioperca</i> Linné 1758)	2.0–3.0 mg/l
Sterlet (<i>Acipenser ruthenus</i> Linné 1758)	3.0–3.5 mg/l

The high value of (non-anadromous) sterlet indicates, why other oxygen-loving and anadromous species of sturgeons seek rapid rivers during the spring for spawning, and why water temperature is of decisive importance in the timing of their migration, as much as in the reproduction of even more sedentary fresh water fish species. Tench, on the other hand, located at the bottom of the list, is a small Cyprinid that well tolerates warm, stationary waters owing to its low requirement of dissolved oxygen.

Of the settlements examined in this table two sites, located in different parts of Hungary (Tiszaug–Kéménytető and Ecsegfalva 23), each represent a metapotamon type habitat. Tiszaug is located almost directly on the river, while the other Ecsegfalva 23 lay off the main stream of nearby tributaries. While Győr–Szabadrét-domb also falls in the metapotamon category, it is located near the largest inland delta in Europe, the Szigetköz region, that was a wetland area richly supplied by a web of various branches of the Danube. It may be looked upon therefore as a transitional habitat between the metapotamon and hipopotamon categories. It is important to note, however, that at this point, the Danube returns to itself,

⁴⁵ Péntzes – Tölg 1977, 327.

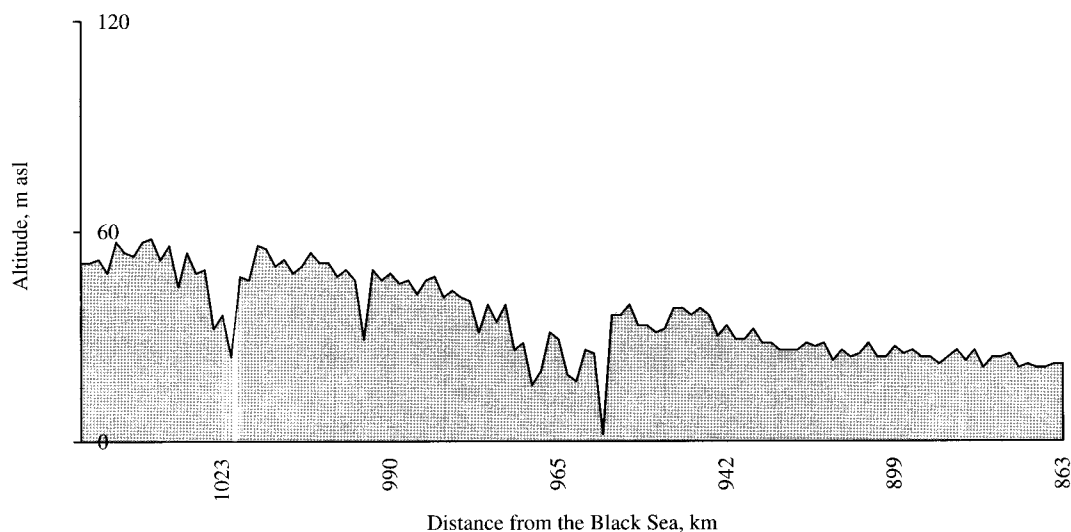


fig. 6. Pre-regulation longitudinal section of the lower Iron Gates
(based on 1872 data by Rinaldo)

rather than opening into the sea. An important feature, brackish waters, therefore is missing. It is the speed of the water that is most reminiscent of a “real” river delta. Owing to their special location downstream from the Iron Gates, the two chronologically distinct units originating from Schela Cladovei represent an entirely different habitat, most similar to a lower foothill (epipotamon) situation. Of all the identified fish species, the presence of undermouth would be most indicative of this habitat.

RIVERBED GRADIENTS AND THE INTENSITY OF DISCHARGE

As has been pointed out, aside from climate, the speed of water defines alluvial habitats through the quantity of oxygen dissolved. The velocity of water is directly related to topography. Even within the relatively even area of the Great Hungarian Plain, the evolution of a mosaic-like environment seems primarily related to local vertical variations in the landscape, i. e. the relative height of the water table. This important parameter defines aquatic habitats, soil formation, flora and fauna alike.

In the case of large rivers, such as the Danube, the effect of topography is even more dramatic. The *ca* 2300 m³/s average discharge of the Danube at Budapest more than doubles to over 5600 m³/s in the Iron Gates gorges. Before the construction of the Iron Gates 1 dam, this latter, *ca* 130 km long section of the Danube displayed extremely dynamic changes in water levels. Minimum discharge was 1400 m³/s, while 16 000 m³/s values were also measured.⁴⁶ Prior to dam closure, the riverine environment of the Iron Gates gorges was characterized by strong currents, hard substrates, and was rich in nutrients, aquatic plants, insects and invertebrates that sustained rich and varied fish resources.

The Danube was confined to a width of only 170 m in the Khazan gorge. As shown in *fig. 6*, depths at this section varied between 0.5 and 50 m before the river exited to the plain. In the lower part of the Iron Gates gorges, near Turnu-Severin in Romania, the riverbed has a very steep gradient, falling 8 m in only 20 km. By contrast, over the 935 km between Schela Cladovei and the Black Sea, the riverbed declines overall by only 34 m.⁴⁷ Thus the net gradient is three orders of magnitude different (40% *vs* 0.037%) not to mention the considerable differences in topography and relief between these two sections of the Danube Valley.

Prehistoric findspots suggest that understanding habitat preferences of sturgeon may point to locations where certain types of fish could be caught most efficiently – information whose intimate knowledge must have been essential to prehistoric fisher folk. Lake sturgeon in Canada

⁴⁶ Bancila et al. 1972, 9.

⁴⁷ C. C. Giurescu: Istoria pescuitului si a pisciculturii în Romania (The History of Fishing and Pisciculture in Romania). București 1964.

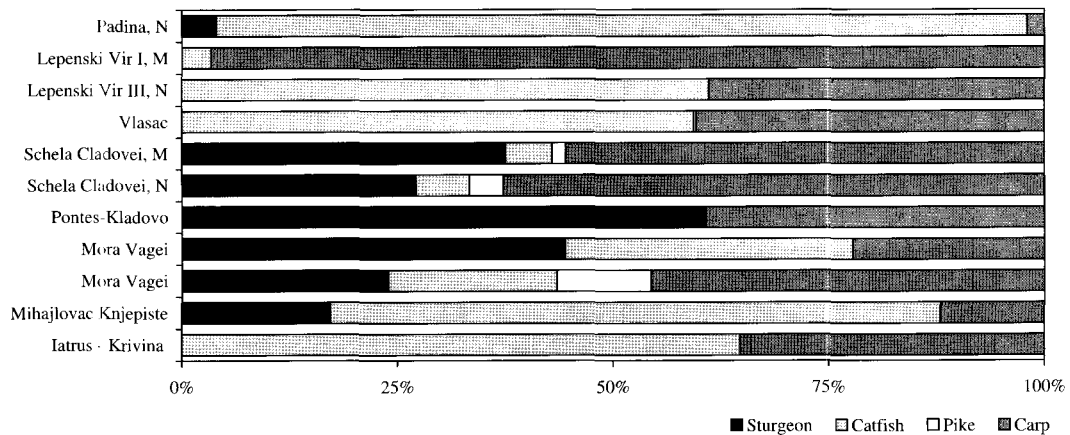


fig. 7. The relative frequency of sturgeon bones in hand-collected fish assemblages along the Iron Gates section of the Danube

spawn in rivers at depths of *ca* 0.5–5 m, in areas of swift water or rapids at the foot of low falls that slow down further migration.⁴⁸ Given the mass movement during the spawn run, such places must have been packed with sturgeons of all sorts in the Iron Gates gorges as well, making them increasingly vulnerable to human predation. This hypothesis seems to be supported by the differential proportion of from large fish in hand-collected archaeozoological assemblages at different locations within the Iron Gates. When appraising data in *Table 6*, it should be born in mind that fish bone finds indicate catch (i.e. consumption), rather than entire fish populations.

Sites (proceeding downstream)	Acipenserid	Catfish	Pike	Carp	Varia
Padina, Neolithic ⁴⁹	64	1502		32	1053
Lepenski Vir I, Mesolithic ⁵⁰		3		86	154
Lepenski Vir II, Mesolithic ⁵¹		5		1	47
Lepenski Vir III, Neolithic ⁵²		22		14	364
Vlasac, Mesolithic ⁵³		2283	11	1552	5241
Schela Cladovei, Mesolithic ⁵⁴	315	46	13	466	817
Schela Cladovei, Neolithic ⁵⁵	131	30	19	303	251
Pontes-Kladovo, Early Medieval ⁵⁶	34			22	
Mora Vagei, Neolithic ⁵⁷	8	6		4	
Mora Vagei, Roman Period ⁵⁸	11	9	5	21	
Mihajlovac Knjepiste, Neolithic ⁵⁹	10	41		7	183
Iatrus – Krivina (Roman) ⁶⁰		11		6	17

Table 6. The number of bones representing large fish species in hand-collected assemblages from the Iron Gates

⁴⁸ S. Needs-Howarth: Lake sturgeon fishing at Prehistoric Iroquoian sites near Lake Simcoe, Ontario. *Archaeofauna* 5 (1996) 147–154.

⁴⁹ A. T. Clason: Padina and Starčevo: Game, fish and cattle. *Palaeohistoria* 22 (1980) 142–173.

⁵⁰ Bökönyi 1969.

⁵¹ Bökönyi 1969.

⁵² Bökönyi 1969.

⁵³ Bökönyi 1978.

⁵⁴ Bartosiewicz et al. 2001.

⁵⁵ Bartosiewicz et al. 2001.

⁵⁶ Bartosiewicz 1996.

⁵⁷ Bartosiewicz, unpublished.

⁵⁸ Bartosiewicz, unpublished.

⁵⁹ S. Bökönyi: Animal remains of Mihajlovac–Knjepište, an early neolithic settlement of the Iron Gate Gorge. *Balkanica (Hommage a Nikola Tasić à l'occasion des ses soixante ans)* 23 (1992) 77–87.

⁶⁰ L. Bartosiewicz – A. M. Choyke: Animal remains from the 1970–1972 excavations of Iatrus (Krivina), Bulgaria. *ActaArchHung* 43 (1991) 181–209.

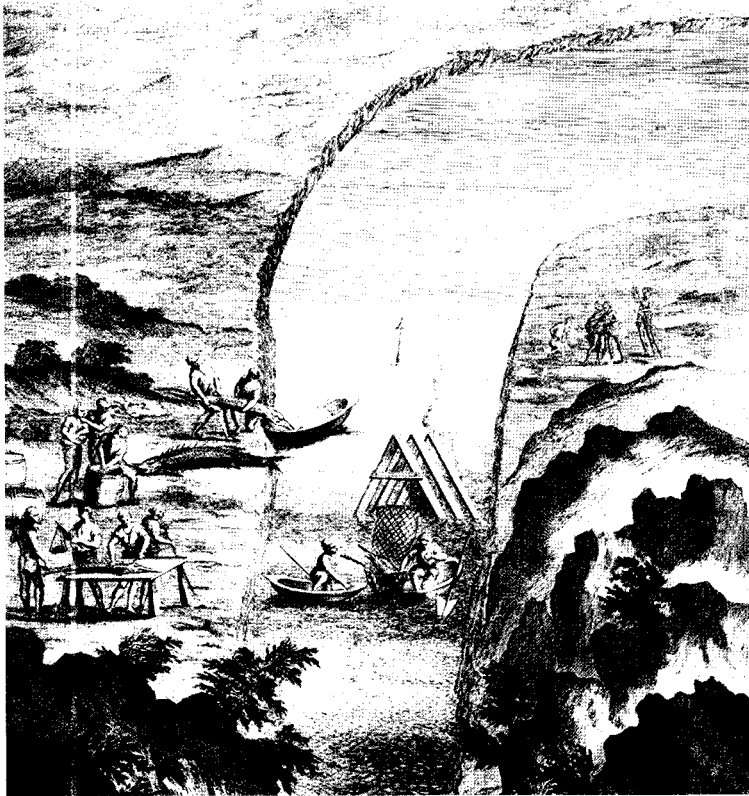


fig. 8. Sturgeon fishing at the exit of from the Iron Gates gorges in Marsigli's 1726 book.
Note the landscape changes downstream, toward the top of the picture

The trend suggested by this table is even more clearly expressed in percentual terms, summarized in *fig. 7*.⁶¹ The historical landscape relevant to this situation may be appraised in an excellent early 18th century picture published by Marsigli,⁶² an Italian military engineer and polyhistor, who travelled along the Danube (*fig. 8*).

Seasonality

Seasonality in fish and, in fact, all animals may be most precisely appraised on the basis of stable⁶³ incremental structures (e.g. otoliths, mussel shell).⁶⁴ The open vs. closed state of growth rings in fish vertebrae makes distinction between summer/winter catch, to some extent, possible, but is a poor indicator of age itself, owing to the possibility of bone remodelling that may result in the resorption of growth rings. In the absence of the serial laboratory study of these features, inferences concerning seasonality were drawn from the presence and absence of certain fish in the find material.

Interspecific differences in spawning temperatures, as well as the presence of off-season stragglers meant that all fish species known from archaeological assemblages in the Danubian region, even anadromous sturgeons, were available year round. The use of their bones as seasonal indicators in archaeological assemblages, therefore, is limited to probabilistic interpretations. Evidently, all fish could be most successfully targeted during the spawning season, and their indicator value may be critically evaluated on the basis of this empirical observation.⁶⁵ Most species seek shallow waters near riverbanks as well as residual waters for spawning, where they become more visible and easily fall victim to human predation. This may have been especially important in prehistoric times, when the success of fisher folk was

⁶¹ *Bartosiewicz 1996, Bartosiewicz 1997.*

⁶² *L. F. Marsigli: Danubius Pannonico-Mysicus. vol. VI. Amsterdam – The Hague 1726.*

⁶³ The perpetual re-modeling through life makes bones ill-suited for this purpose.

⁶⁴ *A. Wheeler – A. K. G. Jones: Fishes. Cambridge Manuals in Archaeology, Cambridge 1989.*

⁶⁵ *Bartosiewicz et al. 1994, 110.*

at least as dependent on the intimate knowledge of animal behavior as on the technology by which hunting and fishing equipment were produced.

In short, the sheer presence, rather than the age or size represented by the archaeological remains of various fish species, thus may be assigned with greater probability to their respective season of spawning. Regardless of the actual season, for example, groups of migrating sturgeon, tended to include individuals of different ages and sizes.⁶⁶ The present-day spawning schedules of fish identified at prehistoric sites in Hungary are listed in *Table 7*.

Species		Spawning time	Water temperature
Beluga sturgeon	<i>Huso huso</i> Linné 1758	March–May	9 °C
Russian sturgeon	<i>Acipenser gueldenstaedti</i> Brandt 1833	April–May	8–18 °C
Stellate sturgeon	<i>Acipenser stellatus</i> Pallas 1771	April–May	10–17 °C
Ship sturgeon	<i>Acipenser nudiiventris</i> Lovetzky 1828	April–June	10–17 °C
Starlet	<i>Acipenser ruthenus</i> Linné 1758	April–June	12–17 °C
Carp	<i>Cyprinus carpio</i> L. 1758	April–May	18–20 °C
Bream	<i>Abramis brama</i> L. 1758	April–June	12–13 °C
Barbell	<i>Barbus barbus</i> L. 1758	May–June	17–19 °C
White bream	<i>Blicca björkna</i> L. 1758	April–June	16–17 °C
Crucian carp	<i>Carassius carassius</i> L. 1758	May–June	17–18 °C
Undermouth	<i>Chondostroma nasus</i> L. 1758	April–May	–
Orfe	<i>Leuciscus idus</i> L. 1758	May–June	–
Knife	<i>Pelecus cultratus</i> L. 1758	April–May	–
Roach	<i>Rutilus rutilus</i> L. 1758	April–May	10–15 °C
Rudd	<i>Scardinius erythrophthalmus</i> L. 1758	April–May	15–18 °C
Tench	<i>Tinca tinca</i> L. 1758	May–June	22–25 °C
Vimba	<i>Vimba vimba</i> L. 1758	April–May	–
Catfish	<i>Silurus glanis</i> L. 1758	May–June	18–19 °C
Pike	<i>Esox lucius</i> L. 1758	February–March	7–10 °C
Pikeperch	<i>Stizostedion lucioperca</i> L. 1758	April–May	12–14 °C
Tench	<i>Tinca tinca</i> L. 1758	May–June	22–25 °C

Table 7. Spawning parameters of various large fish species identified at archaeological sites⁶⁷

Beluga, Russian and Stellate sturgeon swim upstream to the Iron Gates between January to June as well as October to December. These two periods also coincide with seasons of high discharge in this region (*fig. 9*),⁶⁸ when low water temperatures and high water velocity favour spawning. Sturgeon fishing between June and September only took place opportunistically in the Iron Gates when water temperatures were high and discharge low. Mátyás Bél, an 18th century Hungarian naturalist, documented the same two seasons in Hungary: spring fishing began in March and continued uninterrupted until June. The fall season for sturgeon lasted from August until December.⁶⁹ Temperatures within the same month may vary between different aquatic habitats. Regional variations between aquatic environments across Europe introduce additional noise into this system.⁷⁰

Historical and ethnographic aspects of fish exploitation

While large Acipenserid bones commonly occur in some Mesolithic and Neolithic archaeological assemblages, they seem to become rare by the late Middle Ages. In part, this may be explained by a shift in the focus of archaeological research: catch sites were more likely to coincide with the sites of consumption during prehistory.

⁶⁶ G. Roussow: Some considerations concerning sturgeon spawning periodicity. *Journal of the Fisheries Research Board of Canada* 14 (1957) 553–572.

⁶⁷ Berinkey 1967.

⁶⁸ Bancila *et al.* 1972, 19.

⁶⁹ Bél 1764.

⁷⁰ P. S. Maitland – K. Linsell: *Europas sötvattenfiskar*. Stockholm 1978; K. Curry-Lindahl: *Våra fiskar. Havs- och sötvattenfiskar i Norden och övriga Europa*. Stockholm 1985.

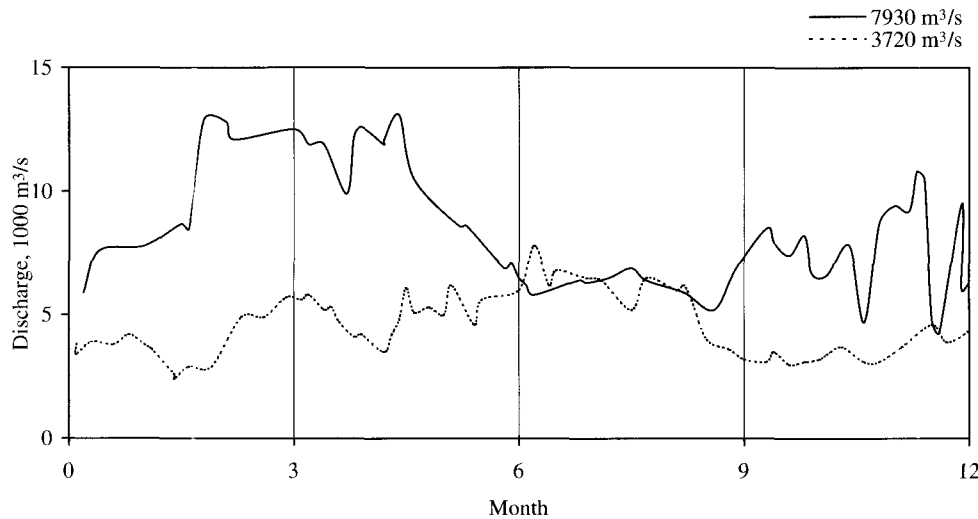


fig. 9. Seasonal fluctuations in the quantity of water at high and low mean annual discharge in the Iron Gates gorge

Catching large fish, such as sturgeon or catfish, in the mainstream of the Danube evidently required specialized techniques in comparison to simple forms of fish “gathering” (e.g. potting) that could be practiced anywhere in its floodplains of the Great Plain. The landing of such large individuals must have also required cooperative fishing techniques. Aside from the cultural difference to the apparently more opportunistic form of fishing practiced in the Great Plain, the presence of sturgeon in classical Starčevo assemblages from within the Iron Gates is also explained by the statistical fact that anadromous sturgeons are caught with greater probability in the lower sections of rivers. It must be mentioned within this context that, historically, sturgeons were known to have migrated upstream way beyond the Carpathian Basin into sections of the Danube located in present-day Austria and Bavaria.⁷¹

The extensive floodplains of the slowly meandering rivers and wetlands in the Great Plain offered completely different opportunities for fishing. After early summer floods receded, millions of fish of all sizes were trapped in pools where they could be simply gathered. Mátyás Bél, a 18th scholar, mentioned the unbearable smell of dead fish, left behind after major flood of the Tisza river.⁷² While it remains a question what the culturally determined reaction of prehistoric people would have been to this development in the environment,⁷³ it is quite conceivable that fish was a lot more common in the diet of most prehistoric sites would be suggested by the insignificant numbers of fish bones recovered from hand-collected settlement assemblages.

Sporadic occurrences of prehistoric fishing gear (e.g. fish hooks,⁷⁴ net remains⁷⁵) from prehistoric sites in Hungary also indicate that, while opportunistic forms of fishing must have been important, some fishermen also possessed special skills and they possibly worked in an organized, cooperative manner.

According to a kind personal communication by Eszter Bánffy, a Mesolithic find from the Lake Balaton region may possibly be interpreted as the remains of a coracle.⁷⁶ Other boats

⁷¹ A. Khin: A magyar vizük története (The history of Hungarian sturgeons). Budapest, Mezőgazdasági Múzeum Füzetek 2, 19:7.

⁷² Bél 1764.

⁷³ L. Bartosiewicz: “There is something rotten in the state...” Bad smell; in Antiquity. *Journal of European Archaeology* 6 (2003) 171–191.

⁷⁴ I. Zalai-Gaál: A Mórág-y-tűzködombi horog. A neolitikus “aktív” halászat kérdései a Kárpát-medencében (Die Angl von Mórág-y-Tűzködomb. Die Fragen der Neolithischen “aktiven” Fischerei im Karpatenbecken). *ArchÉrt* 110 (1983) 231–242; A. M. Choyke – L. Bartosiewicz: Angling with bone,

in: W. Van Neer (ed.): Fish exploitation in the past. Tervuren, Koninklijk Museum voor Midden-Afrika, *Annalen, Zoologische Wetenschappen* Vol. 274 (1994) 177–182.

⁷⁵ J. Makkay: Textile impressions and related finds of the Early Neolithic Körös culture in Hungary. Budapest 2001, 64–65.

⁷⁶ K. Bakay – K. Sági – N. Kalicz: Magyarország Régészeti topográfiája, I. Veszprém megye, keszthelyi járás (Archaeological Topography of Hungary, vol. I. Veszprém County, Keszthely District) Budapest 1966, 76. Keszthely, Site 1. Reference provided by E. Bánffy.

are also known both from the Mesolithic and the Starčevo culture in the Pannonian region.⁷⁷ In addition to general transport, such boats may have been used in fishing.

In the absence of written sources, however, social and cognitive aspects of prehistoric fishing can be studied at best using ethnographic analogies. It is at this point, that the prestigious body of literary data concerning ethnohistoric records on artisanal fishing, compiled by Acheson and Wilson,⁷⁸ was worth analyzing. The 11 dichotomic variables (presence/absence) recorded in these traditional fishing communities, represent attitudes to the aquatic resources and their exploitation by indigeneous communities around the world. Factor loadings of the two major factors (latent roots ≥ 1) obtained by their analysis are indicative of two fundamental dimensions that characterize artisanal fishing (*Table 8*).

Management attitudes	Factor 1 “traditional”	Factor 2 “commercial”
protection of breeding stock	0.791	-0.154
protection of young	0.614	0.357
conservation ethic	0.593	-0.334
size limits	0.560	0.500
seasonal limits	0.288	0.306
areas of fishing territory	0.123	0.302
fishing quotas	0.019	0.762
industrial fishing	-0.071	0.781
technology	-0.153	0.244
limited access	-0.294	0.402
protect from overcrowding	-0.457	-0.202
Latent root	2.092	2.151
% of total variance	19.0	19.6

Table 8. Latent roots expressing the relationship between attitudes to aquatic resources

As is shown by the greatest values on the first, bipolar factor⁷⁹ (encompassing 19.0% of the total variance), protection of the breeding stock and of young fish, conservation ethic and size limits form a closely related group. These are values shared by many indigenous groups in the developing world. By regulating how people fish, these communities have developed strategies best adapted to the chaotic population patterns that fish stocks tend to exhibit. Spawning, growth and mortality figures may have varied unpredictably even in prehistoric times (e.g. according to drought/flooding), which probably effected early subsistence economies more directly. This factor thus, represents “*traditional*” attitudes to fish management.

Factor loadings exceeding 0.5 on Factor 2 (19.6% of the total variance) also include size limits, associated with historical examples of industrial fishing (especially in the United States and Atlantic Europe) in which the protection of breeding stock was a low priority in the absence of a traditional conservation ethic. Size limits and fishing quotas characteristic of this attitude regulate stocks by the output, rather than the entire system of fish exploitation. This may be characterized as a “*commercial*” attitude.

In archaeoichthyological studies, our ability to transfer the abundant ethnographic information from its original framework to archaeology is of critical concern.⁸⁰ Archaeoichthyological assemblages, especially from prehistoric, are probably a product of traditional values that determined fish exploitation in ancient times. Paradoxically, however, fish remains from archaeological sites by definition represent output, i. e. fish that were

⁷⁷ M. Eric: Nova datiranja deblakovja colnov. Arheo 16 (1994) 74–78. Reference provided by E. Bánffy.

⁷⁸ Acheson – Wilson 1996, 582–583.

⁷⁹ H. H. Harman: Modern Factor Analysis. Chicago and London 1967, 100.

⁸⁰ R. Cerón-Carrasco: Of Men and Fish: Some aspects of the utilization of marine resources as recovered from selected Hebridean archaeological sites. PhD. Thesis, University of Edinburgh, 2002.

“not protected”. This is what makes the reconstruction of prehistoric attitudes to fisheries management difficult. Most interestingly, however, two variables, seasonal limitations and the areal definition of fishing territories played no direct role in determining these two basic types of attitudes. These seem to be equally independent from the two basic forms of fisheries management.

Conclusions

While it cannot be demonstrated that fishing played a key role in the lives of all prehistoric peoples living along the Danube, the potential significance of exploiting aquatic resources should not be neglected at sites where fish bones have been recovered.

Owing to their generally small size and concomitant poor resistance to a host of taphonomic factors, fish remains tend to be dramatically underrepresented at sites where the material is collected without screening or water-sieving. Therefore, due to the hand-collection of finds that still dominates in Hungarian archaeology, the majority of bones available to specialists overwhelmingly represent large-size fish, which leads to the selective representation for mature individuals of carp (*Cyprinus carpio* L. 1758), pike (*Esox lucius* L. 1758) and catfish (*Silurus glanis* L. 1758). It is noteworthy, however, that the remains of these important species also occur most systematically in water-sieved assemblages from a number of sites. They may thus be considered ubiquitous in appropriately large surfaces of water on the basis of their consistent presence in archaeoichthyological assemblages from Hungary.

In this sense, their dominance in almost all major hand-collected samples has been reconfirmed by refined methods of recovery. Water sieved samples often yield bones from the younger and therefore smaller individuals of these large species. This is a very clear trend in the case of pike, while (with the exception of a few diagnostic skeletal elements, such as pharyngeal teeth) the thus recovered bones of younger carp are extremely difficult to distinguish from those of small Cyprinid species, which provide the bulk of finds from the sieved residue of prehistoric settlement deposits.

As a result of the natural geography of the Carpathian Basin, a region covered by marshland throughout its past, new assemblages obtained using more refined methods turn out to contain a great variety of bones from small species belonging to the carp family (*Cyprinidae*). Sturgeons (*Acipenseridae*) in the Danube form another better known group, whose prehistoric remains occurred most typically at settlements in the Iron Gates gorge, characterized by a radically different, dynamic aquatic habitat.

Although species-level identification in many fish families (*Acipenseridae*, *Cyprinidae*) is limited to special elements, small fish from the Danube must have played comparable roles in most cultures. Their known differing habitat preferences, however, may be used in illustrating variability in their respective aquatic habitats.

Ethnographic examples were used in an attempt to distinguish between traditional and commercial attitudes to fishing. While the two factors represent only 40% of total variance, they indicate that, cognitive aspects of traditional fishing may be distinguished from the modern, market-oriented exploitation of aquatic fauna. The idea of “managing” environmental resources is unlikely to have existed in its contemporary sense during prehistory. Traditional fishing cultures show, however, that both ideological and technical limitations were placed on the input i.e. reproductive aspect of fish stocks, as opposed to commercial fishing more determined by criteria defined the output. Prehistoric fishing in Hungary must have been closer to the first type.⁸¹

⁸¹ I am grateful to Eszter Bánffy for having provided guidance in the archaeological literature pertinent to the subject of navigation. Figures from Marsigli's original work were kindly provided by Andrea Kreutzer of the Military Museum in Budapest.

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