**Marine fish in the Czech lands in the Middle and Early Modern Ages: A multi-disciplinary study**

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**Abstract**

Archaeoichthyological research is not well developed in Czech archaeology, partly because of the country’s landlocked position. Nonetheless, fishing, fish consumption, and the fish trade played important roles in the Czech lands in the Middle and Early Modern Ages. This paper presents, as a case study, detailed documentation and analysis of a few archaeological bone finds from Prague determined as imported marine fish, and introduces this specialised field of research more generally. Beyond the archaeological bone finds, we conduct an in-depth analysis of historical written records of the marine fish trade in the Czech lands. A basic review of current archaeozoological knowledge of marine fish finds, especially cod and herring, which played the most important role in the long-distance fish trade is also provided. An important contribution – the first of its kind in Czech archaeology – is the use of carbon, nitrogen and sulphur stable isotope analysis to determine the provenance of cod found at Prague Castle.

**Key words:** Herring (*Clupea harengus*, Clupeidae), cod (*Gadus* *morhua*, Gadidae), stockfish, long-distance imports, Lenten food, isotope

**1. Introduction**

**1.1. Aims and context of the research**

There is no strong and systematic focus on archaeoichthyology in the Czech lands, partly because of their inland location and the limited number of large bodies of natural water. The number of sieved archaeological samples processed by fish bone specialists is very low. The importance of fish may be underestimated, however, if evaluation is based on identified osteological material as significant finds and information escape detection. Nonetheless, fish consumption was undoubtedly an important part of human subsistence and diet even in the Czech territories, as indicated by medieval and Early Modern historical sources and by the few available osteological finds and related artefacts.

In this contribution, we apply multiple analyses to some new “exotic” discoveries of marine fish linked to Prague (Bohemia, Czech Republic), including taxonomic and osteometric investigations, size estimation, detailed photo-documentation of the bone finds (§4), and isotopic analysis to detect the provenance (§5). This focus inspired an in-depth historical study of trade and consumption of marine fish in the Czech lands, presented in the second part of the paper (§6). Finally,, we also situate Czech findings within the context of archaeozoological results from the coastal countries of northern Europe where archaeoichthyology is well established (see, e.g., Makowiecki 2003; Barrett and Orton 2016). The utility of such a combination of approaches has been demonstrated by many other publications, most recently in the central European context by Bartosiewicz and Gál (2021) and Bielichová et al. (2019), analysing fish finds from Hungary and Slovakia.

**1.2. Notes on the biology and distribution of marine fish**

Historically the most common subjects of the marine fish trade in the region, cod and herring belong to large families. Fish from the family Gadidae are primarily marine fish, distributed across the Arctic, Atlantic and Pacific realms (Nelson et al. 2016). The order Gadiformes includes only one exclusively freshwater species, the burbot (*Lota lota*), which also inhabits Bohemian rivers. The family contains four subfamilies with 20 genera and ca 56 species (e.g., Endo 2002; Nelson et al. 2016; Roa-Varón and Ortí 2009); for details of individual taxa, ecological requirements, and the main references, see especially Cohen et al. (1990). Today, as in the past (see §7.2), the Atlantic cod (*Gadus morhua*) is the most common and commercially important representative of the family Gadidae; in European waters of the Atlantic Ocean it is the only living species within the genus *Gadus* (Hislop et al. 2015). It is a large benthopelagic fish that feeds on smaller fish such as herring, which are abundant in the Arctic Ocean and the northern Atlantic Ocean, including the North and Baltic Seas. The family Clupeidae is presently divided into 6 subfamilies and includes ca 218 species classified within 64 genera. These fish are relatively small and primarily marine, but some taxa (e.g., some *Clupeonella* spp. and most of the *Alosa* spp.) are anadromous and migrate to a freshwater environment (Whitehead 1985; Nelson et al. 2016). Most clupeids form schools, feed on plankton near the surface, usually in coastal waters, and so are relatively easily captured.Together with some other clupeids, such as the European sprat (*Sprattus sprattus*) and the European pilchard (*Sardina pilchardus*), Atlantic herring (*Clupea harengus*) is the most common marine species of the family in the northern Atlantic Ocean and North and Baltic seas. Herring does not appear along the coasts south of the Bay of Biscay, which limits its possible provenance. In the past, the anadromous allis shad (*Alosa alosa*; details and references in Baruš and Oliva 1995a) migrated from the sea to the Elbe and Vltava rivers, which ultimately drain into the North Sea. Marine flatfish (Pleuronectiformes) could also have been imported relatively frequently into the Czech lands (see §6 and 7.4). Fish of the order Pleuronectiformes have an unusual body asymmetry and a benthic lifestyle on the seabed, where they often use camouflage. Catching these fish requires quite different fishing methods.

**2. Sites and material**

This paper presents an analysis of fish bone finds from four archaeological locations at two sites: three locations at **Prague Castle** (Northern Wing, Jiřské Square and Oktogon) and one at **Zbraslav** (now a district of the city of Prague). The sites are in the Vltava (Moldau) river basin: Prague Castle is ca 700m from the course of the river, and the Zbraslav site 200m away (Fig. 1). Information regarding further sites and finds is taken from previous work by some of the authors of this paper (RK, TP), and from the cited literature.

**Prague Castle**

The rescue excavation at the **Northern Wing** (also Northern Promontory) of Prague Castle carried out in 1987 by J. Frolík revealed several layers from various medieval and Modern periods. The whole collection of animal remains (n=4979) was analysed by Kovačiková et al. (2013). Important to our study is the formation of layers 601–606 in trench S VI, which represents midden deposits (Hurajčiková 2014). The layers of interest are associated with the operation of the stables of the senior steward, last evidenced in year 1571. A set of 57 small coins from the period prior to 1580 and found within the set of layers suggest its rapid formation and is fundamental for dating. The stable was replaced by an armoury, which is first mentioned in 1620 (Frolík and Nemeškalová 1999). The bones can therefore be dated to the late 16th to early 17th century (C) AD. Intrusions from other periods are highly improbable. The context provided 29 freshwater mussel and oyster shell finds and 2,664 bone finds including 62 fish bones (Kovačiková et al. 2013). Our study confirms various salmon/trout (*Salmo* sp.), carp (*Cyprinus carpio*), pike (*Esox lucius*), eel (*Anguilla anguilla*) and perch (*Perca fluviatilis*) bones and two cod (*Gadus*) vertebrae.

The rescue excavation at **Jiřské Square** at Prague Castle in 1987 by I. Boháčová, J. Frolík and J. Žegklitz (analysed archaeologically by Blažková-Dubská 2007) uncovered contexts representing the house of the armoury scribe dated to between the second half of the 16th and the early 17th centuries. Intrusions from other periods are highly improbable. Previous osteological analysis revealed 12 fish bone finds among 2,451 animal bones, including carp (*Cyprinus carpio*)(Šamata and Kovačiková 2001). Current reassessment of the fish bone material revealed the presence of a cod (*Gadus*) vertebra, which was discovered in fill layer 683 within a small cellar, the same context from which one of the earliest Czech osteological specimens of turkey (*Meleagris gallopavo*) was recently determined (Kyselý and Meduna 2019).

Rescue research at **Oktogon** at Prague Castle in 1987, led by J. Frolík and I. Boháčová (Bohačová 1992), provided a small set of bones, processed by J. Petříčková (Petříčková 1992), who selected 21 fish bones alongside mammal and bird bones. We determined these as various salmon/trout (*Salmo* sp.), carp (*Cyprinus* *carpio*), pike (*Esox* *lucius*), catfish (*Silurus* *glanis*) and maybe pikeperch (*Stizostedion* *lucioperca*) bones, and one cod (*Gadus*) vertebra. The fish bones originate from a single layer (no. 7) – a backfill formed by the rising and levelling of a ground during the construction of the building. This house is identified with the Supreme Burgrave's House of Prague Castle, whose function was restored after 1484 and which is first mentioned in 1513 (Homolka et al. 1978:130–132). The backfill undoubtedly consists of relocated material since it contains mostly artefacts from 9th–11th century, but an admixture of high medieval and Early Modern Age finds, corresponding to the time of building construction, was also present. The very low likelihood of cod and carp presence as early as in the 9th–11th century (see §6.2 and Hoffmann 1999 and Balon 2004) suggests that the entire set of fish bones dates from the late 15th or the early 16th centuries.

The described finds from Prague Castle derive from archaeological contexts associated with the buildings of the officials who operated the royal court. This includes people with high ranking (Supreme Burgrave) as well as people whose social status can be considered average (senior steward, armory scribe).

**Zbraslav**

Archaeological osteological material from Zbraslav, preselected by J. Petříčková, contained a fish find (ID 245), which was determined by us as a cod (*Gadus*) vertebra. It was also included in this study, although full contextual information for the finds is unavailable and the basic report does not mention this species (Petříčková 1997). Nevertheless, it was obviously acquired during archaeological excavation at the present-day main square in Zbraslav by M. Chytráček and J. Bernat in 1994 (Chytráček and Bernat 2000) and originates from an Early Modern Age context (as given by J. Petříčková in her notes). The socio-cultural situation which created the archaeological contexts for Zbraslav site is not possible to ascertain exactly, but the small town of Zbraslav belonged to the Cistercian Abbey of Zbraslav from the 13th to the 18th century.

**3. Methods**

**3.1 Osteological determination and size estimation**

The five marine fish vertebrae analysed here (see previous section), along with other archaeoichthyological material from the contexts at Prague Castle, were newly subjected to detailed determination, documentation and measurement. The identifications were supported by the comparative osteological collections from the Institute of Archaeology of the Czech Academy of Sciences in Prague and the Institute of Geology (Czech Academy of Sciences), the Royal Belgian Institute of Natural Sciences, and the Naturhistorisches Museum Wien. The taxonomic identification of the cod vertebrae finds was carried out with the help of reference skeletons and various images from the literature and digital sources (e.g., Tercerie et al. 2019; Conroy et al. 1993; Cannon 1987; Watt et al. 1997; http://fishbone.nottingham.ac.uk).

The determination of fish vertebrae is difficult if other similar and related species exist in the same area, which is the case of the family represented in this material. As the literature is limited, we summarise here a few notes regarding vertebrae morphology and the determination of the most commonly imported and consumed marine fish, gadids and clupeids that we found in the literature and during our research. Vertebrae within the Gadidae family are difficult – sometimes even impossible – to identify to the species level, although they can easily be recognised as “gadids” (Enghoff 2016). Gadid vertebral centra are generally robust and strongly ossified. They are as long as (or longer than) they are high, the notochordal foramen is very narrow but still recognisable, and the lateral surface bears one or more horizontal ridges or lines. The number and shape of horizontal ridges are more or less typical for each species or group of species (e.g., Watt et al. 1997). Furthermore, abdominal (thoracic, precaudal) vertebrae (with the exception of a few anterior-most) bear strong parapophyses (e.g., Svetovidov 1948). *Gadus morhua* bears 2–3 horizontal ridges interconnected by finer vertical or oblique bony lamellas. While the vertebrae of fish from related gadiform families present in the region (e.g., Macrouridae and Merluciidae) generally show a different pattern, some species in the Gadidae family (*Pollachius* spp., *Merlangius*, *Melanogramus*, *Gadus* spp.) are similar to *Gadus morhua*, but most are not so robust and bear different detailed traits, and others live in regions other than European seas or do not reach the size of the specimens under consideration (see §4.2). The vertebrae of the only freshwater member of the Gadiformes in the Czech lands – burbot (*Lota lota*) – are easy to distinguish morphologically from the vertebrae of *Gadus* (see literature in Methods, §3). After excluding some unlikely species, based on the morphological traits we are confident of determining the Czech finds as *Gadus morhua* (i.e., marine fish and therefore imported).

For body size estimation we used the methods given by Watt et al. (1997) and Enghoff (1983)(see Table 1 for details).

**3.2 Stable isotope analysis**

The value of stable isotopes to help determine the catch locations of fish remains is now well established (e.g. Barrett et al. 2008; Sisma-Ventura et al. 2018; Fetner and Iwaszczuk 2020), but nowhere is the approach more developed than in the context of Atlantic cod found on northern European archaeological sites. Here, differences in δ13C and δ15Nvalues resulting from variations in temperature, salinity, terrestrial nutrient input, and food web complexity allow relatively confident determination of eastern Baltic catches, and probabilistic distinction between catches from the western Baltic, North Sea, and various areas of the North Atlantic (Barrett et al. 2008; 2011; Hutchinson et al. 2015). Amongst other results, this method has shown that many of the earliest medieval finds of cod remains at sites around the eastern Baltic littoral represent imported North Atlantic stockfish, with locally-caught Baltic cod becoming more common in the later 14th and 15th centuries (Orton et al. 2011; 2019). Carbon stable isotope analysis hasalso recently been used to argue that some nominally freshwater fish recovered from 13th–14th century Chełm, south-east Poland, were actually caught in the brackish waters of the Baltic coast and imported long distances inland (Fetner and Iwaszczuk 2020). Analysis of sulphur isotope values is less well established in this context, but has the potential to distinguish between fish from waters with different levels of freshwater input, e.g. brackish coastal/estuarine waters *versus* more marine contexts, although freshwater values can vary widely (Nehlich 2015). In a previous study, sulphur isotope values in archaeological cod bones from the North Atlantic largely accorded with the expected ‘marine’ signature (i.e. δ34S > +15 ‰) whereas specimens from the North Sea and Baltic regions were much more variable, sometimes ranging as low as c. +9 ‰ but typically in the +10 to +15 ‰ range described as ‘estuarine’ (Nehlich et al. 2013).

Analysis of carbon(ẟ13C), nitrogen (ẟ15N), and sulphur (ẟ34S) isotope was undertaken on one of the Atlantic cod vertebrae from Prague Castle-Northern Wing (specimen 187) in order to estimate the most likely catch region(s). Collagen was extracted using a modified Longin (1971) method at the stable isotope facilities at BioArCh, University of York, UK. Briefly, 667mg of bone was demineralised in 0.6M HCl at 4ºC. The resultant pseudomorph was rinsed to neutrality with distilled water and gelatised in pH3 HCl at 80ºC for 48 hours. The gelatinised solution was Ezee™ filtered (Elkay Laboratory Products) to remove debris and subsequently lyophilised. For carbon and nitrogen isotope analysis, the freeze dried collagen was weighed out in duplicate 0.5mg aliquots and analysed on a Sercon 20-22 continuous flow isotope ratio mass spectrometer coupled to a Sercon GSL elemental analyzer at the University of York. Accuracy was determined by measurements of international standard reference materials within each analytical run. These were IAEA 600 ẟ13Craw = -27.7 ±0.3 ‰, ẟ13Ctrue = -27.77 ±0.043 ‰, ẟ15Nraw = 0.9 ±0.11 ‰, ẟ15Ntrue = 1 ±0.2 ‰; IAEA N2 ẟ15Nraw = 20.6 ±0.2 ‰, ẟ15Ntrue = 20.3 ±0.2 ‰; IA Cane, ẟ13Craw = -11.7 ±0.1 ‰; ẟ13Ctrue = -11.64 ±0.03 ‰. The overall uncertainty on the measurements of the sample was calculated based on the method of Kragten (1994) by combining uncertainties in the values of the international reference materials and those determined from repeated measurements of the sample and reference materials. These are expressed as one standard deviation. The maximum uncertainty for the sample was <0.2 ‰ for ẟ13C and <0.3‰ for ẟ15N. In addition, a homogenised bovine bone extracted and analysed within the same batch as the sample produced the following average values; ẟ13C = -23.2‰; ẟ15N = 5.7‰. This was within the overall mean value from 50 separate extracts of this bone sample, which produced values of ẟ13C = -23.04 ±0.66‰ and ẟ15N = 6.66 ±0.43‰. Analysis was performed for sulphur by Iso-Analytical Ltd. (Crewe, UK). The sample was analysed in duplicate by EA-IRMS (Europa Scientific 20–20) and was measured together with in-house control check samples of IA-R061 (barium sulphate, ẟ34Sraw= +20.29 ± 0.09, ẟ34Strue= +20.33), IA-R068 (soy protein ẟ34Sraw = +4.95, ẟ34Strue = +5.25‰) and IA-R069 (tuna protein ẟ34Sraw = +18.64, ẟ34Strue = +18.91‰) calibrated against international standard NB-127 (barium sulphide ẟ34S= +20.3 ‰) and IAEA-S-1 (silver sulphide ẟ34S= -0.30 ‰). For carbon and nitrogen isotope results, linear discriminant analysis was used to assign probabilities to different potential catch regions with the MASS package (Venables and Ripley 2002) in R 4.1.1 (R Core Team 2021), following Hutchinson et al. 2015**.** Prior probability of group membership was set as uniform, and leave-one-out cross-validation used to assess the reliability of group assignments. Reference data and region group definitions were the same as used by Hutchinson et al., with the addition of the ‘Kattegat/western Baltic’ group from Barrett et al. 2011**.** All carbon and nitrogen isotope reference values were from fish with estimated total lengths in the 500-1000 mm range, since isotope signatures appear to be less consistent in the largest fish (Barrett et al. 2011; Orton et al. 2011). Sulphur values were not included in formal analysis due to the more limited available reference data, but the Prague result was compared visually with data from Nehlich et al. 2013 (supplemented by Sayle et al. 2013 for Iceland) in order to help rule out possible source regions.

**3.3 Historical research**

The questions of fish use and the fish trade were also studied using various historical written records linked to the Czech Republic, with an emphasis on the earliest records (§6). Because we searched for and verified information in original historical sources rather than secondary reviews, links to and quotes from these sources are applied throughout the historical section of the paper. We particularly benefitted from the following historical sources, from editions given in parentheses, and from other written sources, all given in the list of references. This includes using several accepted abbreviations or acronyms, internationally known in historical scientific literature.

AČ - *Archiv český* (Kalousek and Teige eds. 1888–1889, 1909)

CDB I - *Codex diplomaticus et epistolaris regni Bohemiae* (Friedrich ed. 1904–1907)

CDB II - *Codex diplomaticus et epistolaris regni Bohemiae* (Friedrich ed. 1912)

CDM - *Codex diplomaticus et epistolaris Moraviae* (Boček ed. 1839)

CDLS - *Codex diplomaticus Lusatiae Superioris* (Köhler ed. 1856)

CIM - *Codex iuris municipalis regni Bohemiae* (Čelakovský et al. eds.) 1886–1948, 1960–1961)

FRB - *Fontes rerum Bohemicarum* (Emler ed. 1874)

LE - *Libri erectionum archidioecesis Pragensis saeculo XIV et XV* (Borový ed. 1878)

RBM - *Regesta diplomatica nec non epistolaria Bohemiae et Moraviae* (Emler ed. 1882)

Further acronyms or abbreviations are:

/CZ/ - indicates Czech words (names, terms)

C – century/centuries

y. – year/years

Original Latin or Czech names or terms are usually provided in quotation marks.

**4. Osteological analysis of Czech marine fish specimens**

**4.1. Determination and description**

Four vertebrae (A–D) determined as marine fish are analysed and presented in detail:

A - Prague Castle-Northern Wing, trench S VI/2, layer 602A (ID: 160): Whole centrum of caudal vertebra (evidently from the anterior section of caudal backbone) – maximally 15.6mm long and 17.8mm wide – is determined as cod, apparently Atlantic cod (*Gadus morhua*) (Photo 1-A).

B - Prague Castle-Northern Wing, trench S VI/4, layer 604A (ID: 187): Almost whole centrum of abdominal vertebra (probably posterior part of the abdominal backbone) – maximally 15.3mm long and 16.4mm wide – is determined as cod, apparently Atlantic cod (*Gadus morhua*) (Photo 1-B).

In fish, posteriorly located caudal vertebrae are generally smaller than precaudal vertebrae. So, the smaller size of find B (abdominal vertebra) compared to find A (caudal vertebra) suggests the presence of two individuals in the Northern Wing. The positioning of the two vertebrae in different fill layers also suggests two individuals.

C - Prague Castle-Jiřské Square, layer 683 (ID: 3098): Complete vertebral centrum anatomically located in the transition from the precaudal to caudal section of vertebral column. The centrum – maximally 13.4mm long and 15.7mm wide – is determined as cod, apparently Atlantic cod (*Gadus morhua*). The brownish colour of some parts of the spongiosis – more brown than other bones in the assemblage – may (but need not) be caused by heat or fire (Photo 1-C).

D - Prague Castle-Oktogon, layer 7 (ID: 25): Complete centrum and parts of arcs of caudal vertebra, anatomically located probably to caudal part of caudal backbone; the centrum is maximally 11.4mm long and 11.9mm wide. The vertebra is determined as cod, apparently Atlantic cod (*Gadus morhua*) (Photo 1-D).

E - Zbraslav (ID: 245): Caudal vertebra including parts of neural and hemal arches (apparently from middle part of the caudal backbone) – maximally 12.6mm long and 13.3mm wide – is determined as cod, apparently Atlantic cod (*Gadus morhua*) (Photo 1-E).

None of the analysed finds bore signs of processing, such as cutmarks or chops. The single cod vertebra determined at Prague Castle-Jiřské Square represents 8.3% of the 12 fish bones present. The two cod vertebrae found at Prague Castle-Northern Wing represent 3.2% of the 62 fish bones dated to the late 16th to early 17th centuries. The single cod vertebra determined at Prague Castle-Oktogon represents 4.8% of the 21 fish bones present.

**4.2. Size estimation of analysed cod**

The Atlantic cod can reach a length of up to 2m and a weight of 96kg, but catches are usually much smaller (Cohen et al. 1990; Gilbert and Williams 2002; Myers et al. 2021). The size of cod in medieval and post-medieval contexts in Poland, Denmark and Flanders have been estimated at 20–130cm (Lepiksaar and Heinrich 1977:87–88; Enghoff 2016; Makowiecki et al. 2016; Van Neer and Ervynk 2016). According to these authors, larger individuals (over ca 70cm) are common in Polish and Flemish materials but rare in Danish collections. Estimates of the body size – based on centrum lengths and widths – of the four cod vertebrae from archaeological contexts in Prague are given in Table 1.

The Czech finds represent relatively large individuals, but of a size not uncommon in Polish materials from the corresponding times. In the Baltic region, however, fish of such a size are regarded as targeted catches of the largest cod from the Baltic or as imports from the North Sea/North Atlantic in the form of stockfish (Makowiecki et al. 2016).

**5. Isotope analysis and provenance of marine fish**

The isotope data for specimen 187 from Prague Castle-Northern Wing are provided in Table 2. The collagen was within established quality criteria for carbon, nitrogen and sulphur analysis (De Niro 1985; Nehlich and Richards 2009), although note that the C:N ratio of 3.3 sits within the less conservative acceptance value indicating a potential <1‰ shift towards lower δ13C values in Atlantic cod according to Guiry and Szpack (2021). The results are plotted against published reference data from different regions in Figure 3, while the outcome of linear discriminant analysis on the carbon and nitrogen results is shown in Table 3.

Visually, the Prague specimen plots in the centre of the overall distributions of δ13C and δ15N values (Figure 3-A), just within the one-sigma confidence zone for Arctic Norway but also very close to the equivalent zone for the Kattegat and western Baltic, and almost within the extreme ranges observed for the Eastern Baltic and Atlantic Europe groupings. Linear discriminant analysis also points to an Arctic Norwegian origin (76% probability), but cannot rule out the Atlantic Europe (9%), Kattegat/western Baltic (6%), or even Newfoundland (7%) groups. The Eastern Baltic is unlikely, however (1%), and a Southern North Sea or Irish Sea origin can probably be ruled out (0.3%). These results should be treated with caution however given the limited reclassification success rates returned via cross-validation, which range from 93% success in classifying Eastern Baltic specimens back to the correct source, down to only 55% for Newfoundland.

The sulphur value of 9.1 ‰ for specimen 187, however, is very low compared to the reference data, falling into the range considered as ‘freshwater’ by Nehlich et al. (2013) and suggesting an origin in waters with a very significant freshwater input. Much higher δ34S values would be expected for Norwegian stockfish, which traditionally represent catches of migratory deep-water Barents Sea cod. This expectation is borne out by modern Barents Sea cod data reported by Nehlich et al. (2013)(28 specimens all with δ34S >16‰), as well as by the archaeological specimens, mostly falling in the +14 to +17‰ range. Even the exception, an archaeological outlier which might represent an individual from an Arctic Norwegian coastal population, has a δ34S value of c. +12‰, approximately 3‰ higher than the bone from Prague. Similar results are seen for Newfoundland and for specimens from Orkney, the Hebrides, and Iceland, representing ‘Atlantic Europe’. No sulphur data are available for cod from the rest of the latter broad group, however, which includes the Atlantic coasts of Ireland and southwest England.

Within the reference dataset, δ34S values similar to that from Prague are only seen at Cambridge (England / southern North Sea region) and at Selsø-Vestby (Denmark / Kattegat region). Low sulphur values for the southern North Sea are not surprising given its shallow depth and large, intensively farmed catchment, but the carbon and nitrogen results for specimen 187 nonetheless virtually rule out this source. The cod from Selsø-Vestby may provide a more useful indicative match.

Taken together, the isotope results are most consistent with a source in the Kattegat / western Baltic region, although we cannot rule out a relatively inshore catch from a region of Atlantic Europe not represented in the sulphur reference dataset. Sources in the Eastern Baltic, Arctic Norway, Newfoundland, or the southern North Sea are unlikely.

**6. Marine fish trade and utilisation in Czech historical sources**

**6.1. Terminology and categorisation**

When the history of fish trade and consumption is studied in historical sources, we come across fiscal terminology, i.e. the classification that was used to tax goods and trade. Apart from the taxonomic aspect, the fish were divided according to packaging or quantity, or method of preservation and storage, and it is important to be familiar with the terms used and their potential ambiguities. The first category was live fish, transported in mobile tanks (in Czech /CZ/ “voznice”), these were used for local freshwater fish only and mostly for short distances. Another category includes fish stored and conserved in wooden barrels, so-called “tuna”, “tunna” or “maisy”, “massy” /CZ/, but from the accounts it is difficult to determine if the barrel was filled with brine or not. At the same time, “tuna” was also a regionally variable measure of volume, moreover divided into standard and small (account from year (y.) 1371 from Kolín – “standard” tunna for 2 “hallenses” and small tunna for 1 “hallens” (small penny); CIM II: p. 447). Herring – commonly synonymised with Latin “alleces” (salted fish)[[1]](#footnote-1) – are almost always cited as tunna fish; of freshwater fish pike, pikeperch, eel, salted salmon and rarely “Prussian pike” and difficult to identify “halpfish” are cited as tunna as well (y. 1489, Kutná Hora; CIM III: p. 426). The conservation method was probably always salting, as follows from various notes (e.g., y. 1388, Most, “*gesalzen fissche oder herynge*” are measured in tunnas here; CIM II: p. 626). Herring were further categorised (“minyš”, “biliš”, etc.). Another category is dry fish (dried, smoked) recorded by volume, quantity or weight; the weigh unit used is “centýř” /CZ/ – approx. 60 kg (see duty on Prague bridge, in ca 1590; Teige 1910:354), the volume unit used is wagon (account from 1489 from Kutná Hora (CIM III: p. 426) or 1462 from Plzeň (CIM III: p. 253)). Marine stockfish (or “štokfiš” /CZ/) and flounder, and freshwater pikeperch and hard-to-define “cupka” /CZ/ belong to this category. Stockfish – the specific name applied to dried cod, traditionally prepared in northern countries, especially in Arctic Norway – probably always meant cod (or closely related marine fish). The term “allec” (salted fish, “slaneček” /CZ/) was used commonly, probably exclusively, for salted herring in early Latin records. If it was local fish, the author would use the term “pisces”, “pisces sallietures” or something similar. So allec most likely means real herring (i.e., marine fish) even in records as early as Cosmas´s notes on Gebhard (§6.2). It is noteworthy that Cosmas of Prague (Kosmas Pražský /CZ/) spent some time in Liège (Belgium), so must have been familiar with herring. “Sleď”, the present-day Czech term for herring, appeared only later (e.g., see list of Czech and Latin names of fish from the beginning of the 19th C in Presl 1823).

**6.2. Earliest historical records of herring and cod in the Czech lands**

The earliest mention of salted fish (“alleces”) is in Cosmas's Chronicle of the Czechs (*Chronica Boemorum*) dated 1119–1125. According to the chronicler, Bishop Gebhard had a habit during fast days “After dawn, he distributed 44 quarters of bread and so many salted fish or pieces of other food to the poor” (in original “T*empore quadragesimali…. quadraginta pannis quadrantes et totidem allecia, sive alicuius edulii partes dividit inter pauperes*”; Emler ed. 1874: 12). This mention refers to the year 1068. Around the same time, duty from fish (here referred to as “pisces”) is reported on the so-called Trstenice path between Bohemia and Moravia, one of the most important routes in medieval Czech lands, from where the Vyšehrad chapter was supposed to collect every second fish, in addition to the income from salt and bread (the account refers to the year 1088, although the available version of the document originates from the 12th century; CDB I: no. 387). The transport of fish between Bohemia and Moravia requires some method of conservation, but no more details were provided in written sources. It is also not possible to determine where the fish come from, though we can speculate either Poland or Hungary (the Hungarian salt is documented on the path).

We do not encounter salted fish in written sources for almost another century. Church institutions as promoters of liturgical dietetics were supplied by river fishermen, which could be sufficient to cover the needs of religious or canonical communities. The brief overview provides a number of fishermen illustrating intensity of fishing (Table 4).

Salted fish (“alleces”) appear again in 1204, when they are purchased using income from some villages of the Cistercian monastery in Plasy as the food for Advent and forty days Easter fasting (CDB II: no. 48). Similarly, presence of salted fish (“alleta coemenda”) is confirmed at the Cistercian monastery in Langheim, Bavaria to which Moravian village Doloplazy by Olomouc paid in 1233 (CDM II: no. 323; Zíbrt 2011:41). References to “alleces” continue in the following decades (see §6.4). Presence and trading of herring (alleces) are documented in some privileges: the first known is from 1269, when the right of herring trading was transferred from Německý Brod to Jihlava (and in 1279 it was given back)(privilege of Přemysl Otakar II; CIM II: no. 31). In the 14th century the knowledge of probable dried or simply salted herring is recorded in the saying “*belly as a backpack for herring*” (“*břicho jak krosna na herynky*” /CZ/; Máchal ed. 1908:134), as brined herring would be hardly transported in a backpack. The Czech terms “minyš” and “šonský”, which should be soaked when sold, as mentioned in the beginning of the 16th century (Winter 1906:928), probably also belong to this category of dried herring. The “šonský” fish highly probably originates from Skåne (Scania, or Schonen in German), south Sweden, possibly directly from Skåne Market – a major market for herring in medieval Europe (Jahnke 2000). This corresponds with frequent occurrence of “Schonisch heyringis” in historical notes in regions north of Bohemia, such as accounts by the Teutonic Order in Baltic areas in the 14th and 15th C (Joachim ed. 1896:84; Ziesemer ed. 1913:30). Smoked and wind-dried herring are also mentioned – undoubtedly in 1578 (Beckovský 1879:313). In the 14th–15th centuries the term “herink” appears as the name for field (y. 1370; CDM IX: no. 43), forest (y. 1379; Truhlář 1880:23), or village (y. 1422; AČ 26: p. 186–187). It could be derived from the owner´s name at the time: the cognomen “Herink” was used by burghers (y. 1374; Menčík ed. 1898:109) as well as priests (y. 1380; LE II: p. 162), or the knightly family of Herink of Semonice from the 14th century (Sedláček 2002). Other examples of the name containing this marine fish are the persons Pawlik Hering and Mathie dicto Heryngk (the end of the 14th C; Profous 1947:612). In 1274 the term stockfish appears for the first time as a nobiliary particle in the nickname “Stokvisch” of the brothers Frank and Albert, locators of Bruno, the Bishop of Olomouc (RBM II: no. 863). Nevertheless, using the name cannot be taken as a reliable proof for the presence of the fish species.

The first occurrence of cod seems to be recorded as early as 1371, in the reeve of Kolín town incomes flowing from a warehouse of imported fish. Here a “staffil”, a fish offered on the market, together with herrings, is mentioned. The staffil was stored overnight on piles, and not in barrels as herring were. We synonymise the staffil with a dry cod or other cod-like fish since it was undoubtedly traded over long distances, and river fish are given in different category of goods in this source (CIM II: no. 447). Furthermore other fish traded at this time (e.g., pike) were knownby other names. Stockfish is reliably documented in Karlštejn in 1423–1434, where different types of stockfish of different prices are distinguished: a “kopa” (60 individuals) of cheaper smaller (normal?) “štokfiš” is for the same price as three individuals of “štokfiš magnis” (Pelikán ed. 1948:48). In later centuries, the trade developed (§6.4–§6.5).

**6.3. Marine fish as Lenten food**

Fish are the essential component of the Advent and Lenten diets avoiding food from terrestrial warm-blooded animals. In the Middle and Early Modern Ages, there were regular Friday fasts (Friday was even called a fish day) and a forty-days pre-Easter fast (Lent). If we follow the historical accounting sources, then the regular weekly supply counted mainly on local production. For example, in the accounts of the Augustinian monastery in Třeboň (1367–1369), expenditures on fish occur continuously throughout the year. In the accounts of Karlštejn Castle (1423–1434) expenditures can be traced twice a week, including every Friday, and fish are explicitly marked as “pisces recentes”, which means fresh. It was much more difficult to prepare themselves for a long fast, as it falls in the early spring period, when river or pond fishing was limited. It was therefore necessary to buy preserved fish. We learn about alleces as a fasting meal in the report on Bishop of Prague Gebhard at the turn of the 11th–12th centuries and from the Cistercians in Plasy (y. 1204), who were supposed to get alleces for the needs of Advent and pre-Easter fasting (see §6.2). John of Jenštejn, the Archbishop of Prague in the years 1379–1396, allegedly rejected eating pike and valuable fish and ate only herring soaked in water so that they lost their taste (FRB I: p. 445). In the previously mentioned Třeboň, herring were bought only once a year, always in the pre-Easter period. In Karlštejn, they were bought almost daily during the long fast; spending on herring stops before the Easter Triduum when it is replaced by spending on sheep, cattle and pigs. According to the writer and theologist Petr Chelčický, the fasting meal consisted of up to three fish courses, and, in addition, herring and “vyzina” (sturgeon meat)(Zíbrt 2011:100–101). The necessity of acquiring herring stocks is also found in historical correspondence. For example, the proximity of fasting was the reason for re-sending herring within southern Bohemia (January 26, 1472; AČ 8: no. 519) or the nobles exchanged pikes and “štokfisch” for a more pleasant fasting (y. 1478; AČ 9: no. 907). The significance of fish can also be illustrated by the dietary rules from 1638–1649 on the domain of the Martinic family, one of the most powerful families in Bohemia, which informs us that herring and carp were two staple fish. We can furthermore infer the dominance of herring for certain periods and relative rarity of stockfish and flatfish (“plotejsci” /CZ/). Herring were reserved for the long, forty-day fasting period; the full allotment was one herring or portion of carp per day. Pike, cod or flatfish, on the other hand, were given just as a supplement.

**6.4. Herring routes and trade**

Herring reached Bohemia from several directions and proveniences. A well-documented route is the Elbe (Labe) waterway. For the first time, we meet it in the supplement to text B of the so-called founding document of the Litoměřice chapter (after the year 1218) mentioning a duty of herring (alleces) imported by waterway ( herring are a later addition; the older text A and the original version of text B contain only duty from salt; CDB I: no. 55). The journey continued through Mělník, where the payment for four boats with salted herring (alleces) is confirmed in the year 1274 (“*Nauium cum….allecibus…*”; CIM II, č. 22), and further on the Vltava river to Prague, the power and administrative centre of Bohemia. The trade with herring (alleces) is described in detail in the customs tariff of Pirna (a town in modern-day Germany, close to the northern borderline of Bohemia) from 1325; the waterway from Magdeburg (Germany) to Děčín (northern edge of Bohemia) and on to Bohemia is explicitly mentioned here (CIM II: no. 132). A little later, an income from fish and herring is documented in Czech towns on the Elbe waterway: in Ústí nad Labem (y. 1348) and again in Litoměřice (y. 1348 and 1352)(CIM II: nos 282 and 330). These fish were therefore apparently imported from the North Sea or adjacent regions.

Herring came from the same direction. The land route for herring is documented in the northwest-Bohemian towns of Most (y. 1388, 1390, 1501, explicitly from the German lands; CIM II: nos 626, 638, CIM III: no. 554) and Louny (y. 1400, includes also mentions of meat from sturgeons; CIM II: no. 729). Herring called “flemiš” (apparently from Flanders, “Vlámsko” /CZ/) are mentioned in the beginning of the 16th century (Winter 1906:928).

Probably since the 13th century, herring (alleces) were also imported to Bohemia via the Oder waterway, i.e. from the direction of the Baltic Sea. A duty on fish and herring is documented in Lusatian Görlitz (Zhořelec) on the Lusatian Neisse river flowing to the Oder river (y. 1298; CDLS I: no. CII) and in the warehouse in the Bohemian town Bělá pod Bezdězem, far from the Elbe river but in a line between Görlitz and Prague (y. 1337; CIM IV/1: no. 44). The route of transport to Bohemia from the East, or from the Southeast, is documented by the duty on unspecified fish on the Trstenice path between Moravia and Bohemia around the year 1100 (see above), and also by the customs tariffs, including duty on herring (alleces), from Olesno in Silesia (1226), where the route from Kuyavia (Kujawy) to Moravia is mentioned explicitly (Skrzydło and Jaskulska 2018). Within Bohemia, this route is documented first in Německý Brod (today’s Havlíčkův Brod) and Jihlava (y. 1296; CIM II: no. 31) and then in Kolín (stock of herring, y. 1327; CIM I: no. 144; a little later with the documented origin of fish from Prussia, y. 1371; CIM I: no. 447). During the 14th to 16th centuries we can trace the northeast route in customs or warehouses in Hradec Králové (y. 1396; CIM I: no. 690), Litomyšl (y. 1490; CIM IV/2: no. 559), Pardubice and Chrudim (y. 1507; CIM IV/3: no. 730), Kolín and Kutná Hora (y. 1482, 1489, here again the fish from Prussia; CIM III: nos 426, 457).

There is no doubt the Czech lands were generally supplied from the North-West, North, and North-East, but the supply of the southern half of Bohemia is questionable. Undoubtedly, part of the herring went to south Bohemia through Prague, i.e. from the North (see the record from the Rožmberk´s (Rossenberg´s) estate from 1526; AČ 8: no. 350). However the warehouse and customs in south-Bohemian towns Plzeň and České Budějovice may also mean a journey from the West. In České Budějovice, the fish and herring trade is documented in 1364 (CIM II: no. 412). In 1390, České Budějovice is documented to be one of three towns in Bohemia (along with Most and Kolín) with the right to run a warehouse, where goods, including herring, did not have to pass through Prague (CIM II: no. 638). Let us add that Havel alleciator, a herring merchant, is mentioned in České Budějovice in 1363–1369 among the richest men (Köpl ed. 1901: nos 119, 147, 148). In Plzeň, the warehouse and customs of herring, stockfish and other fish are documented in 1462 (CIM III: no. 253).

The price of marine fish could vary over the centuries. In the beginning of the 17th C, the duties on individual commodities collected in Prague by “*officialis piscium salsorum*” included 3 kreutzers (“krejcary” /CZ/) per tunna of herring, 3 kreutzers per kopa (60 individuals) of “štokfiš”, 3 kreutzers per kopa of “runtfiš” and 12 kreutzers per tunna of salmon (Vojtíšek 1919:164).

**6.5. Cod and herring for Prague and Prague Castle**

For the whole period of the Middle and Early Modern Ages, we have not concrete, direct information on purchase or consumption of fish in Prague Castle. There are no accounts of purchases for the kitchen, as known from other places, such as the courts of Rožmberk family in south Bohemia (Brůžek and Hrdlička 1997; Hrdlička 2000). For example, an isolated written report on the journey of Petr of Rožmberk to Prague Castle from 1535, describing various details, does not mention any fish (Brůžek and Hrdlička 1997). That is why we have to build our views on fish consumption in the Prague Castle on indirect accounts. The Latin-Czech dictionary for Ladislav Pohrobek, the Czech king (1453–1457), cited herring, salmon, trout, sturgeon and eel. The preserved records on the activities of merchants controlling Prague’s foreign trade in the 16th and 17th centuries inform about the supply of the courts of leading aristocratic families, but again only in general.

By the end of the 14th century, the first herring warehouse was established on the Cattle Market in the New Town of Prague, and the large “herring shed” (“slanečková bouda”, “nýdrlák” /CZ/) existed here until the 18th century (Figure 5). In Early Modern Age Prague, herring trade and consumption became particularly important as it is documented in “The book of the herring merchant on the New Town of Prague” (“Kniha slanečkářů na Novém Městě pražském” /CZ/) written in 1600–1735 (Barabášová 2021; Figure 6). Foreign merchants – factors (agents) from Germany, selling conserved marine fish in Prague, are well documented in the 16th century. In the first half of the 16th C, the import of herring was dominated by merchants from Frankfurt an der Oder located on the Oder river, which flows into the western Baltic Sea, but in the end of the same century merchants from Saxony in a wider sense, i.e. from towns on or near the Elbe river flowing into the North Sea, began to assert themselvess. The preponderance of merchants from Saxony persisted in the beginning of the 17th C, although Lusatian merchants from Frankfurt an der Oder were still active (Winter 1892b:421–422; Janáček 1955:161–166; Barabášová 2021:170; see also §6.3). In the 17th century, the port city of Hamburg, the centre of European trade, provided connections between Prague and western European markets and also participated in the direct supply of the Prague market, mainly with salted fish (Dvořák 2010:152), though merchants from Silesia are also mentioned (Vojtíšek 1919:166). In any case, in the 16th–17th centuries the fish for Prague, including cod, came from the north, at least partly using the Elbe–Vltava and Oder river routes, which means they came from or went through the region of the western Baltic or the southern part of the North Sea. The quantity and importance of sea fish was considerable, as suggested by the duty paid to competent institutions and the existence of a specialised warehouse building for storage and sale of the tunna fish (called “Ungelt” in the Old Town of Prague and “nýdrlák”, or “underlák” in the New Town of Prague; for details see Janáček 1955; Dvořák 2010; Buňatová 2013; Barabášová 2021). The goods traded in the first half of the 17th century included, among others, typical salted herring (“slaneček” /CZ/), herring preserved in another way (“pytlinky” /CZ/), cod, fish oil. To rich customers, the merchant Matyáš Festa also supplied caviar (y. 1640) and Jan Batista de Pauli from Poli and his brother Jan Dominik supplied caviar and “sardele” (probably anchovies) together with unspecified sea fish (y. 1631)(Dvořák 2010:78, 84, 85). We can expect that fish from the sources mentioned in this paragraph were also bought for Prague Castle. Nonetheless politics changes history; in the end of the 18th century the import of foreign fish was even forbidden by Josef II, so the herring trade in the Czech lands temporarily declined (Vojtíšek 1919:169; Kubásková et al. 2020:29).

**7. Discussion**

**7.1. Osteological evidence of marine fish in Czech materials**

A relatively rich spectrum of freshwater fish such as pike, catfish, and various cyprinid and percid species is recorded in some Middle–Modern Age Czech contexts (Kuna et al. 2013; Sůvová 2006, 2010a,b, 2014; Kyselý 2002, 2015; R. Kyselý and T. Přikryl pers. obs.). However, fish determined as marine species have so far been recorded at only a limited number of archaeological sites. Paragraphs §4.1 and §4.2 describe cod finds from four locations in Prague, but this case study is not the only evidence from Bohemia. A larger collection comes from Náměstí Republiky in Prague (Kočár et al. 2009; Sůvová 2010b, 2019), where bones assigned as *Gadus* sp. were found in layers dated to the late 13th century to the early 15th century (n=11), the late 15th century to the 17th century (n=120)(here found together with flatfish, n=33), and the 18th century to recent times (n=4). The original report (Sůvová 2010b) is presented as preliminary, but we can count on earlier occurrences of gadids than the Prague Castle finds suggest (at the latest in the early 15th C). Also of interest from Náměstí Republiky is the consistent share of cod/flatfish among the fish in sieved material in assemblages from the late 13th to early 15th century (3.2%) and late 15th to 17th century (3.4%). It is highly probable that the relatively large number of flatfish bones found at Náměstí Republiky are from marine species imported alongside cod, rather than from local catches of anadromous *Platichthys flesus* (see §7.1, §7.5). More detailed analysis of these finds could yield a large amount of new data and some interesting discoveries.

**7.2. Cod in European context**

The determination of the Czech archaeological finds of gadid vertebrae as cod (*Gadus morhua*) is consistent with the species compositions of archaeological assemblages in Northern Europe – the source region of marine fish imports in the Middle–Early Modern Ages – as well as its representation in current marine fishing (Cohen et al. 1990). In Northern Europe, historically and archaeologically, cod and herring are often the dominant or exclusive representatives of their respective families, Gadidae and Clupeidae. The exclusive presence of *Gadus* *morhua* among marine gadiformes is recorded in medieval Poland (Makowiecki 2003) and it is the dominant gadiform in high medieval England (e.g., Barrett et al. 2004). In England, imported cod do not really appear in significant numbers until the mid-13th century (Barrett et al. 2011; Orton et al. 2014), and only become more plentiful than herring in the 15th C (Kowaleski 2016). The nature of the cod trade is revealed by large amounts of its remains being the only present species in the content of one of the storage barrels and dominating among gadids in another barrel found in 16th century wreck of a merchant vessel that sank in the Dutch Wadden Sea (Brinkhuizen 1994).

Another archaeoichthyological problem is distinguishing whether the fish were preserved in some way or distributed fresh, and consequently the question of imports (see difficulties of determination of stockfish and related debates in Barrett 1997; Perdikaris and McGovern 2009; Van Neer and Ervynk 2016; Makowiecki et al. 2016). However, thanks to the position of the Czech lands in central Europe, far from any sea, we assume that marine fish were preserved in some way before exporting. In medieval Europe, fish of the cod family (Gadidae) were often decapitated prior to drying (or salting and drying) for long-range trade. The simply dried product, called stockfish, typically retained only vertebrae and cleithra or other elements of the pectoral girdle. The extent of backbone removal from the trade product depended on the width of the fish, and also on the place and date it was produced. Smaller fish were left with a larger part of their backbones (Brinkhuizen 1994; Barrett 1997, 2016; Hufthammer 2016). However, other styles of preservation are also known. Cod in the Baltic region could be dried and traded whole, what historical accounts concerning Polish and Prussian territories refer to as “rundfisch” (Hoffmann 2009). Another type of dried fish commodity produced in Eastern Baltic, known as “strekfusz” (Hoffmann 2009), may also be detected archaeozoologically (Makowiecki et al. 2016). Apart from typical preservation by cold drying, preservation by smoking or salting is also possible (e.g., Barrett 2016), but as with herring importation in frozen or fermented form is highly improbable (although fermentation – a typical method in Norway – is known from deep prehistory; Boethius 2018). None of the marine fish vertebrae studied is deformed in the way that can be caused by acidification during the fermentation process described by Boethius (2016:Fig. 9). The brown colour of one cod vertebra (Prague Castle-Northern Wing) could hypothetically originate from heating during curing, but this interpretation is unsure. In Czech written sources, there are no descriptions of the appearance of fish listed as stockfish; except perhaps the simile of Martin Luther to paunchy stockfish in a satirical piece from 1707 (Hrubý 1901:277), which seems to exclude fish fillets or chops and suggests a whole (not split) or almost whole body. An exclusive presence of vertebrae among cod finds at Prague Castle and Zbraslav could point to stockfish in its usual sense. In addition, the size of the Prague cod, estimated at between ca 75cm and ca 105cm long (§4.2; Tab. 1) corresponds to the size of cod consumed and traded as stockfish in northern regions. Such a size is common in Poland and Flanders (Makowiecki et al. 2016; Van Neer and Ervynk 2016) and among imported cod found at sites around the eastern Baltic (Orton et al. 2019). Furthermore, the terms “rundfisch” and “strekfusz”, suggesting other kind of conservation, are absent or almost absent in the historical literature concerning Czech territory (see “runtfiš” mentioned in Vojtíšek 1919:64; §6.3). However, four of five analysed Czech vertebrae originate from the caudal part of the backbone and one from abdominal part of the backbone but probably from its posterior part (§4.1), which suggests a preparation including a removal of the head and perhaps also the cranial part of the backbone. This anatomical composition corresponds to data from London which shows a shift to heavily caudal-dominated assemblage from about the 15th C interpreted as supplying by more split-fish (Orton et al. 2016). So the image is not clear and it is also necessary to stress that number of here analysed Czech finds is too low, thus further work is yet to be done for reliable conclusions on the nature of the traded cod.

Dried cod, popular in Britain and continental Europe for purposes as diverse as Lenten fare and military rations, were imported to there from Arctic Norway by the 13th century (Barrett et al. 2011; Orton et al. 2014). During the Viking Age dried cod originated in the North East Arctic were imported to the settlement of Haithabu dated 9th-11th C (Star et al. 2017). According to Makowiecki et al. (2016) it is conceivable that the first cod consumed in Poland’s medieval towns were imported stockfish, and the same may be true for Estonia and Sweden (Orton et al. 2011). Historical records show stockfish of the North Atlantic origin were traded into the towns of the southern Baltic region probably from the 13th century onwards. Inventories of the Teutonic Knights in Poland records stockfish consumption as early as in 1379 (Makowiecki et al. 2016). In any case, by the 16th century the trade with cod was already well established as shown by both foreign and Czech (§6) historical accounts. The dating of the finds largely overlaps substantiallywith the reign of Emperor Rudolf II, when the relatively stable period and renaissance lifestyle gave the opportunity for trade and various imports, and places them prior to the trade-disrupting Thirty Years' War. For these reasons, the presence of cod vertebrae at Prague Castle in the 16th/17th century is not surprising. Czech historical records do not present cod as a dominant species among fish, but as a more or less regular part of imports and consumption from at least the 15th century (§6.2). In this view, the presence of four cod individuals in four archaeological contexts in three distant locations of Prague Castle – representing 3.2% of all fish bones in Northern Wing, 8.3% in Jiřské Square and 4.8% in Oktogon – together with its presence in Prague-Náměstí Republiky and Zbraslav, is undoubtedly not a random occurrence. Together with written sources, these finds bear witness to common and systematic supply from a coastal region or regions. The fact that Western Baltic or Kattegat – the probable origin of one of the finds from Prague Castle-Northern Wing (§5) according to stable isotopes – is not a typical area for stockfish production makes the situation questionable. If we accept the Western Baltic or Kattegat we can consider the large Prague cod a targeted catch (see §4.2 and Makowiecki et al. 2016). Although the details of curing of Prague cod cannot be reliably read from the bone finds, we expect they were imported dried which is typical preservation of this species included in all styles mentioned (“stockfish”, “rundfisch”, “strekfusz”; Hoffmann 2009).

**7.3. Herring in European context**

Herring (*Clupea harengus*) was one of the most important fish fished in northern Europe. The species related to herring, sprat (*Sprattus sprattus*) and especially pilchard (also known as sardine)(*Sardina pilchardus*) and shads (*Alosa* sp.), were regionally important at certain times but do not play a major role (Barrett 2016). In early medieval Haithabu (Danish Viking Age, the 8th–11th centuries) in north Germany, 5337 bone finds of *Clupea harengus* were present among fish bone remains, but no *Sprattus*, *Sardina* or *Alosa* was determined (Lepiksaar and Heinrich 1977:24–27). Other works also show exclusive presence of herring among Clupeidae in northern Germany (Benecke 2000). *Alosa* or other non-herring clupeid species are occasionally archaeozoologically recorded in medieval materials from various sites in Poland (Makowiecki 2003, Makowiecki et al. 2016), Denmark (Enghoff 2016) or York (Harland et al. 2016), but incomparably less than *Clupea harengus*.

The large-scale herring trade seems to began during the Viking Age. The long-distance trade is identified by archaeogenomic analysis of herring samples dated between 800-850 AD (Atmore et al. 2022); the excpected origin of fish is in the Kattegat or western Baltic (similarly to origin of Prague cod samples) but their bones were found in Truso, eastern Baltic coastal site in Polish. An inland find of herring is known from a 10th–11th century layer at Grzybowo, a stronghold of the Piast dynasty in Greater Poland, 250km from the Baltic Sea as the crow flies; evidence from eight other Polish sites far from the Baltic Sea (180–375km) are dated more widely, to the 9th–14th centuries (Makowiecki et al. 2016). A note on herring traded from Krakow to northern Hungary perhaps as early as 1300 AD (given by Hoffmann 1999) shows that herring trade reached far to the south within continental Europe. Although direct (osteological) evidence of marine fish is unknown from medieval sites in Hungary, quantities of bones of marine fish, including herring, cod, and pleuronectiformes, dated back to the 14th–15th centuries AD were found in adjacent Austria (Galik et al. 2015; Bartosiewicz and Gál 2021). Supply of herring to inland consumers in the area from northern France to the Baltic began only from around AD 1000, and from the 12th century onwards herring production and trade increased significantly (van Neer and Ervynck 2004). The earliest Czech historical records known, from the early 12th century (§6.2), use the Latin terms “allec”, “alleces”, which mean salted fish. These terms are however widely considered to mean herring (§6.1) and are synonymised with the German word herring (and its other German and Czech variants) in later centuries (widely used from 14th C).

Herring were preserved by various combinations of salting, drying and smoking (Locker 2010; Barrett 2016; §6). Unlike cod, herring (as well as eel or salmon) are too oily to be preserved for long-term storage by drying alone (for exact values of fat share see Locker 2010: 62). Smoking can prolong the usable life of herring for a short time, so for long-range trade they were (chronologically) first dry-salted and later brined in barrels (Hoffmann 1999). Barrelled herring, gutted and pickled in brine, can endure up to two years. This cure was first produced in the Baltic Sea region, certainly by the 12th–13th centuries (in the region of Rügen or Rujána /CZ/), but perhaps even earlier (according to Polish records), and adopted around the North Sea only in the late fourteenth and fifteenth centuries (Barrett 2016; Makowiecki et al. 2016). So in the 11th–12th centuries (see Czech records on Gebhard; §6.1, §6.2), barelled herring in Czech lands probably had a Baltic origin. However, we can consider imports in simple dry-salted form (cf. term allec, meaning salted fish). Preservation in vinegar was also already known in fourteenth century western Europe(Dire 2011). Importing dried or smoked herring – although aless durable form of conservation – is also possible, and in Czech lands is documented in later, 16th century, records (§6.2, §6.5). On the other hand import in fresh, frozen or fermented form is, like for cod, improbable. We have yet to mention preparation of fish sauces of various types, archaeologically and historically known especially from the Roman Empire. The basic (unfiltered) type of the sauce (called hallex or allec in the Roman period) contained fish bones and so is detectable archaeozoologically. Thus it was found that in western Europe it had been prepared from smaller herring individuals and sprats (Barrett 2016; van Neer and Ervynk 2004, 2016; Van Neer et al. 2010). In Czech historical sources we have no indication for import of fish sauces so early. However, as is known from later, Early Modern Age recipes (Hrdlička 2000:197; Beranová 2007:101, 150; Kubásková et al. 2020:83), various local fish were mashed to produce pâté. In the past, apart from use in ecclesiastical contexts as Lenten food, herring was normally eaten by the poor, which may have been true from very early times as Gebhard´s custom suggests (§6.1, §6.2). On the other hand cod could be more expensive, especially large specimens (§6.2), and this may have been the case for those found in Prague Castle.

**7.4. Flatfish and other seafood in Prague and the Czech territory**

Although early written records show no flatfish or at most only small numbers, records from the late 16th and 17th centuries interestingly suggest that marine flatfish could have been more abundant than cod and comparable with herring. Some 454 cod, 4,882 herring and 2,896 flatfish (“plotýsi” in Czech) were consumed at the castle in Jindřichův Hradec between 1626 and 1643 (Hrdlička 2000:195). Even earlier, in 1578, at a banquet of the Rožmberks, 350 stockfish (“štokfišů” /CZ/), 1,000 flatfish (“platejskův” /CZ/), 780 dried or smoked herring, and 4 tunnas (barrels) of pickled herring were among the food consumed (Beckovský 1879:313). The customs office in the Old Town of Prague (Ungelt) was entrusted to Hanuš Plateis of Plattenstein in 1597 (Buňatová 2013:62–63), but again, the family name does not necessarily imply the actual presence of the flatfish. Doubt can be cast upon some historical records of flatfish as the Czech terms (platýs, plotýs, plotejs, plotejsek, also ryba Matky boží or halbfisch) are not clearly defined in the written records, but are usually considered to mean flatfish (see Andreska 1997; Hrdlička 2000:195; Barabášová 2021). For example, in a report by Václav Vratislav of Mitrovice dated 1599 (Vratislav z Mitrovic 1777) *plotejs* is compared to a large rounded marine fish with a long tail, very probably a ray, a description which excludes any common Czech freshwater fish. Furthermore, the presence of a flatfish is confirmed by bone finds from Prague-Náměstí Republiky, dated to the 15th–17th century (§7.1). The fish were almost certainly imported with cod rather than caught in Czech rivers (see note on Ferdinand I in §4.4). The large quantities of traded flatfish are possible as pleuronectiforms sometimes form a significant share of marine catches in coastal regions, and can predominate in some archaeological contexts (see, e.g., findings from Flanders, Poland and Denmark; Van Neer and Ervynck 2016; Makowiecki et al. 2016; Enghoff 2016).

Fish are not the only subject of food imports from a marine environment. Other seafood is represented by significant quantities of oysters (*Ostrea edulis*), found for example in the same archaeological contexts as the cod vertebrae (§2) at the Northern Wing (n=25, Kovačiková et al. 2013). This mollusc is also determined at other Prague Castle locations (Lumbeho zahrady, Kanovnická Street; Oravec 2021), at Náměstí Republiky in Prague (Kočár et al. 2009; Sůvová 2019), and at other sites in Bohemia and Moravia (Špaček 1977:130; Bláha 1998:155; Foster-Čiháková and Kamenická 2006:373; Kalousová 2010; Sůvová 2019; Dejmal 2020), and is mentioned in historical literature (Winter 1892a:134; Beranová 2007:102; Hrdlička 2000:195), but seems to be limited to the Early Modern Ages, perhaps at the end of the High Middle Ages. However, unlike cod and herring, oysters are considered a delicacy, and one that originated in the Mediterranean and was therefore difficult to transport frozen from southern and western Europe as far as the Czech lands. Anyway, the large quantity of oysters relative to cod and other aquatic foods reflects the high social status of the inhabitants of the Northern Wing of Prague Castle.

**7.5. Problem of anadromous flatfish and clupeid**

The anadromous European flounder (*Platichthys flesus*) – the only indigenous Czech flatfish (Pleuronectiformes) – with its exotic nature, could have made an attractive catch. So may be mistaken for marine flatfish. Historical proof of the presence of *Platichthys flesus* is known from the 16th century AD, but its migratory path from the sea is unlikely to have reached the Vltava river and Prague as catches from the region are unknown (Andreska 1987:103; Oliva 1995b). In any case, the fact that according to the earliest evidence from the 16th century one was once transported alive in a box from the catching grounds at Ústí nad Labem (near the northern border of Bohemia) to Prague as a gift for Ferdinand I, the Holy Roman Emperor (1503–1564), suggests its rarity and marginal occurrence. The last exemplar of *Platichthys flesus* was caught in 1914 at the mouth of the Ploučnice river (Andreska 1987:103; 1995c:444–447; Oliva 1995b)(Figure 4).

Allis shad[[2]](#footnote-2) (*Alosa alosa*) – the only freshwater clupeid fish in the Czech rivers (Elbe and Vltava) – may have been abundant in the German section of the Elbe in the past (see records from Meissen (Míšeň /CZ/) by J. Handsch; Andreska 1987:102–103) and a recipe using it is given in the 16th century study by J. Handsch (Andreska 1987:81). It is osteologically very similar to herring and hence easily mis-identifiable but it migrated to Bohemia only sporadically and imports of cured (salted) freshwater catches caught in the German part of the Elbe are improbable in the past. So we do not expect it in Czech archaeo-osteological material. By contrast, due to the importance of herring trade in the Middle Ages and the presumed quantities of herring imported and consumed, the presence of this species in Czech archaeological materials can be expected, although its visibility is reduced by small size of the bones and bone fragility caused by conservation methods.

**8. Conclusion**

Archaeoichthyology can be studied using various methods, providing different, complimentary types of information. This multi-disciplinary paper has presented and discussed a selection of such results from the Czech lands. The importance of fish is seen in various human activities from past centuries, including local fishing practices, specialised methods of catching migratory fish, the construction of fishponds from the Early Middle Ages, but also the importation of sea fish from coastal regions. Fish was cured in various manners for the purpose of trade. Herring (*Clupea harengus*) – historically documented (as “allec”) in Bohemia from the 11th century AD – was imported mainly in salted form (from the 14th century documented in barrels), but from the 16th century smoked herring are also proven. Cod (*Gadus morhua*) appeared in the Czech lands later, from the 14th century AD at the latest according to written sources and from the early 15th century AD according to archaeological bone finds. It was typically conserved and traded as stockfish, that is fish dried following removal of the entrails, head and sometimes the cranial section of the backbone. Anatomically, all five Czech osteological finds (vertebrae) of cod analysed in detail in this paper conform to this method of conservation. The cod bone finds from the late 16th to early 17th century at Prague Castle represent specimens of considerable size (total length of ca 75–105cm). The historical sources show several trade routes from the coast to Bohemia, mainly from the North Sea and Baltic Sea. The cod found at Prague Castle might have reached Prague markets and Prague Castle by the Elbe–Vltava river route, or by the Oder river and then overland, as supported by historically documented agents from Saxony and Lusatia selling marine fish in Prague in the 16th and beginning of the 17th centuries. Isotopic analysis suggested the Kattegat or western Baltic as the most likely catch location for one of the cod from Prague Castle-Northern Wing. Other regions included in the comparison, the eastern Baltic, Arctic Norway, Newfoundland, and the southern North Sea are unlikely. If this provenance is correct, the relatively large size of the cod would place them in a category of targeted catches. Marine fish and other seafood was never a staple of the diet in landlocked Bohemia and some such foods were accessible only to the rich, as may have been the case for the Prague cod which can be linked to people with high or average social status in Prague Castle. In particular, the presence of large cod seems to correspond to their unique context, as do the oyster shell finds from one of the investigated contexts at Prague Castle. Nonetheless, marine fish consumption and trade played an important role even in inland Central Europe. As written sources show, fish consumption had greater significance in clerical and monastic contexts, and supplementation of the diet by marine fish increased during Lenten periods. In conclusion, fishing, trading in fish, and curing, cooking and consuming fish were important aspects of life and livelihood for significant portions of society. As such, we believe it is valuble to pay special attention to the analysis of fish bones, studying the written records, and seeking to bring together the diverse available archaeo-osteological, biometrical, isotopic, biological, and historical information, as we have attempted in this paper, the first of its kind within archaeological, historical and zoological literature concerning the Czech territory.

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**Author contribution**

All authors contributed to the study concept and design. The research on fish bone remains was performed by RK and TP. MA and DO are responsible for carrying out and interpreting the stable isotope analysis. The analysis of historical written records was performed by PM. The section on archaeological contexts and some historical records were formulated by JF. Biological aspects were described by TP and RK. Discussion and conclusion was conducted by RK with help of other authors.

**Conflict of interest**

Michelle Alexander (member of author collective) is an associate editor of *Archaeological and Anthropological Sciences*. Otherwise, the authors declare that no competing interests exist.

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**CAPTIONS**

**Table 1** Total lengths (TL) of the cods represented in the material from the Prague excavations calculated according to various methods. The values are given in cm.

**Table 2** Stable isotope data and quality controls for specimen PRA187 (Prague Castle-Northern Wing, ID 187)

**Table 3** Results of linear discriminant analysis on δ13C and δ15N values from specimen 187 at Prague Castle-Northern Wing and a reference dataset of archaeological cod remains (Barrett et al. 2011; Hutchinson et al. 2015)
A. reclassification success rate for each region, based on leave-one-out cross-validation.
B. probabilities of group membership for specimen 187 based on stable carbon and nitrogen isotope values alone

**Table 4** The number of fishermen in early medieval villages in Bohemia. A selection of the earliest records from historical sources

**Fig. 1** a – Map of the Czech Republic with the position of the archaeological sites (black dots) at Prague Castle (1) and Zbraslav (2); b – Position of the Czech Republic in Europe (grey area). Grey lines represent state boundaries; blue lines represent rivers

**Fig. 2** Photo-documentation of five cod (*Gadus morhua*) vertebrae found in Early Modern Age contexts at Prague: A – Prague Castle-Northern Wing (ID: 160); B – Prague Castle-Northern Wing (ID: 187); C – Prague Castle-Jiřské Square (ID: 3098); D – Prague Castle-Oktogon; E – Zbraslav (ID: 245), see §2, §4.1. Each vertebra is depicted from six aspects: a – right lateral view; b – left lateral view; c – dorsal view; d – ventral view; e – anterior view; f – posterior view. Photo: T. Přikryl

**Fig. 3** Stable isotope results for Prague Castle-Northern Wing specimen 187 in comparison to published reference data.

A. δ13C and δ15N values for the Prague specimen (large red dot) against reference data for cranial bones from archaeological cod with estimated total length 500-1000mm. Data from Barrett et al. 2011 and Hutchinson et al. 2015; see sources for sampling locations; ellipses represent one-sigma confidence zones.
B. δ34S result for Prague specimen (vertical red line) against reference data for archaeological cod bones from Nehlich et al. 2013 and Sayle et al. 2013. Approximate freshwater / estuarine / marine ranges are from Nehlich et al. 2013. Filled markers represent cranial bones, likely to have been caught close to deposit location; hollow markers represent post-cranial or unspecified bones that might theoretically have been traded; all specimens from the Newfoundland group are cranial

**Fig. 4** Flatfish (*Platichthys flesus*) – vanished member of Czech fauna. Photo-documentation of the last known catch of the migratory flatfish in the Czech lands. This young specimen was caught at the confluence of the Ploučnice and Labe rivers during the spring of 1912. It is now stored in the Regional Museum in Teplice; specimen number Z 6102. Total length 250mm. For more detail, see Flasar (1975) and Flasar and Flasarová (1975)

**Fig. 5** An engraving by Folpert van Ouden Allen from 1685 showing a view of Prague from south. In the rectangle there is a detail of “the herring shed“ (“slanečková bouda” /CZ/) desribed as "Niderlag der Kauffleut auff der Neustatt" (taken from bottom legend under number 116). In 1367, the New Town of Prague received the privilege of trading sea fish. Shortly afterwards, a fish warehouse was built in Gothic style on the square which functioned until the end of the 18th century; the building was demolished in 1863. Source: Wikimedia Commons

**Fig. 6** Herring merchants. Illustration (dated 1619) in *The book of herring merchants on the New Town of Prague* (Prague City Archives, Manuscript Collection, sign 7962, fol. 34r.)

1. Other terms appearing in Czech historical literature are singular “allec” and “hering”, “herink”, “herynk” or its other variants. We note that the term allec was used for fish sauce in Antiquity (see works on Roman period materials by van Neer and others in Discussion, §7.4) but in Czech medieval written records from the context it undoubtedly means an individual salted fish . [↑](#footnote-ref-1)
2. In Czech called “placka”, in the past also “podmořanka”, “odmořanka”, “podhořanka”, “lososnice”, in German also called “Ziege”. In 18th–19th century scientific name *Clupea alosa* was also used for the species (Andreska 1987:102; Hanel and Novák 2001: 36; Whitehead 1985). Last known catch in Bohemia is from 1871, in Elbe by Lobkovice (Oliva 1995a:410). [↑](#footnote-ref-2)