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THE FISH FAUNA OF EARLY-MEDIEVAL LAYERS OF THE VEGETABLE MARKET EXCAVATION SITE IN SZCZECIN, POLAND

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Background. The more than 10-metre deep archaeological site called the Vegetable Market (Kraut Markt), located near the Pomeranian Dukes' Castle in Szczecin, was explored in 1953–1964. The site was found to contain 20 early-medieval sediment layers and a layer overlying the basement consisting of riverine mud. Historically, the layers spanned a period from the second decade of the 10th to the beginning of the 5th decade of the 13th century.
Materials and methods. The dig yielded numerous cultural artefacts, including fish remains examined during this study. The present paper summarises continuation of research on fish bone remains. The research allowed to identify a total of 10 085 bones in 725 labelled collections. The identified bones of 20 fish species were compared with bones of the extant known fish species, belonging to individuals of various size. The analysis made it possible to estimate the lowest abundance and weight of the fish present at the archaeological site examined.
Results. The assemblage of 20 species, the remains of which were present in sediment of the site, turned out to be dominated, in terms of abundance, by carp bream (26.4%), followed by zander (17.5%), roach (15,9%), tench (9,5%), wels catfish (9.6%), northern pike (6.3%), European perch (6.0%), sturgeon (3.1%), and asp (2.2%), the total fish weight being dominated by sturgeon (31.3%), followed by wels catfish (27.0%), zander (15.3%), carp bream (10.6%), northern pike (5.1%), tench (4.2%), roach (2.2%), asp (2.1%), and European perch (1.1%). The remaining 11 species (twaite shad, European chub, ide, rudd, zope, white bream, Baltic vimba, ziege, crucian carp, European eel, and ruffe) contributed much less both to the abundance and to the weight.

Key words: archaeological excavations, early Middle Ages, fish remains

INTRODUCTION

The present paper is aimed characterising the fish species represented by bone remains found in early-medieval sediment layers of the archaeological excavation site in Szczecin, known as the Vegetable Market (Kraut Markt). The dig is located in Szczecin, in the vicinity of the Pomeranian Dukes' Castle, on the left bank of the western branch of the Odra River. This paper summarises studies, carried out in continuation of earlier research during which the fish bones were identified anatomically and assigned to individual species (Kłyszejko et al. 2004). This part of the study involves a comparison between the identified bones from the archaeological site in question with bones of known fish species, yielded by individuals of various weight, occurring at present in the Odra estuary, i.e. in the area adjacent to the Vegetable Market.

The study's objective is to obtain insight into the size structure of the fish within individual species so that the amounts of fish consumed by inhabitants of the early-medieval Szczecin can be estimated.

MATERIALS AND METHODS

The Vegetable Market archaeological excavation site covered 100 m^2; the dig was deep enough (more than 10 m) to reach the basement. The site revealed 29 early-medieval sediment layers (IV–XXXII) of a total thickness of 7.7 m as well as the oldest layer (XXXIII) overlying the basement and consisting of about 1-m thick riverine mud. The layers span a period starting from the second decade of the 10th century until the beginning of the 5th decade of the 13th century (Dworaczyk et al. 2003). The layers were found to contain numerous artefacts of material culture, including fish remains (Wieczorowski 1962, Wesołowski 1963, Leciejewicz et al. 1972, Rulewicz 1974, 1994).

During exploration of the site, carried out within 1953–1964 by the Polish Academy of Sciences' Archaeological Laboratory, Institute of Material Culture

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in Szczecin (at present Polish Academy of Sciences' Archaeological Laboratory of Institute of Archaeology and Ethnography in Szczecin), a collection of 725 labelled assemblages of fish bones was accumulated. All the assemblages contain more than 13 200 fish bone remains, 10 085 of which (76.2%) were identified. The number of identified bones varied, depending on a layer, from 13 in layer IV to 1934 in layer VII; the number of fish species identified based on the bones ranged from 5 in layer IV to 16 in layer VII (Table 1). All the fish bones identified in the Vegetable Market sediment layers were left by 20 fish species; the number of bones left by individual species varied from 1 bone left by ziege to 3297 bones left by carp bream (Table 2) (Kłyszejko et al. 2004).

Comparative analyses of bone remains retrieved from the Vegetable Market early-medieval layers were carried out within individual assemblages. Subsequently, the data from individual layers and from the entire dig were pooled and analysed in their entirety.

This paper compares the fish bones identified earlier (Kłyszejko et al. 2004) with a series of corresponding bone elements of the extant fish species represented by individuals differing in weight. That provided a basis on which to estimate the probable lowest quantity of fish represented by the fish bone collection, individual weight of the fishes, and the total weight of each species represented in the collection (Kaj 1957, Makowiecki 1993, 2003, Marciniak 1996, Chełkowski et al. 1998, 2001, Filipiak and Chełkowski 2000).

To estimate the abundance and weight of the sturgeon the remains of which were present in the collection analysed, three specimens of the species kept in museums were used. Two of those specimens, weighing 60 and 136 kg, are kept at the Faculty of Food Sciences and Fisheries, Agricultural University of Szczecin, the third specimen (84 kg individual weight) being displayed by the Fisheries Museum in Świnoujście. The abundance and weight of the remaining fish species were estimated based on skeletal bones of fish differing in individual weights. Bone sizes of fish of known weight were compared with the identified bones found in the dig; the results were interpolated to estimate the quantity and mass of fish in the Vegetable Market. By way of example, comparisons of the cleithrum from the left shoulder of wels catfish (Fig. 1) and of the preopercular bones of the left part of the viscerocranium of zander (Fig. 2) are described in detail.

Table 1

Summary of research materials retrieved from the Vegetable Market

Item No.	Layer	Number of bone assemblages	Number of bones identified	Number of fish species
1	IV	5	13	5
2	V	7	73	10
3	VI	4	22	6
4	VII	83	1934	16
5	VIII	43	379	11
6	IX	31	224	13
7	X	44	529	12
8	XI	13	240	11
9	XII	13	83	11
10	XIII	16	180	10
11	XIV	13	134	9
12	XV	19	112	11
13	XVI	17	283	13
14	XVII	12	229	9
15	XVIII	14	934	10
16	XIX	16	979	15
17	XX	15	259	11
18	XXI	53	657	12
19	XXII	22	271	14
20	XXIII	9	120	11
21	XXIV	55	439	13
22	XXV	16	60	9
23	XXVI	35	136	10
24	XXVII	7	30	7
25	XXVIII	51	488	14
26	XXIX	26	653	15
27	XXX	9	90	10
28	XXXI	34	302	13
29	XXXII	34	213	13
30	XXXIII	9	19	6
	Total	725	10 085	20

Table 2

Number of identified bones, retrieved from early-medieval Vegetable Market layers, assigned to individual fish species

No.	Species	Number of bone remains
1	*Acipenser sturio* L., sturgeon	308
2	*Alosa fallax* (Lacepède, 1803), twaite shad	2
3	*Esox lucius* L., northern pike	475
4	*Abramis ballerus* (L.), zope	49
5	*Abramis brama* (L.), carp bream	3297
6	*Aspius aspius* (L.), asp	190
7	*Blicca bjoerkna* (L.), white bream	4
8	*Carassius carassius* (L.), crucian carp	21
9	*Leuciscus cephalus* (L.), European chub	18
10	*Leuciscus idus* (L.), ide	45
11	*Pelecus cultratus* (L.), ziege	1
12	*Rutilus rutilus* (L.), roach	1308
13	*Scardinius erytrophthalmus* (L.), rudd	13
14	*Tinca tinca* (L.), tench	858
15	*Vimba vimba* (L.), Baltic vimba	8
16	*Silurus glanis* L., wels catfish	769
17	*Anguilla anguilla* (L.), European eel	66
18	*Gymnocephalus cernuus* (L.), ruffe	5
19	*Perca fluviatilis* L., European perch	498
20	*Sander lucioperca* (L.), zander	2150
	Total	10 085

The comparative analyses of fish bones or other bone remains, e.g. bony plates of the sturgeon, retrieved from the Vegetable Market early-medieval layers, were aided by the following publications: Suworow (1954), Lebedev (1960), Urbanowicz (1965), Ninua (1976), Desse et al. (1987), Rolik and Rembiszewski (1987), Baruš and Oliva (1995), Hochleithner (1996), Kottelat (1997), Kolman (1999), and Brylińska (2000).

An example of a comparative analysis

The analyses carried out during the first stage of the research (Kłyszejko et al. 2004) showed the Vegetable Market layer IV to have supplied 5 labelled bone assemblages with 13 identified bone remains from 5 fish species (Table 1). Table 3 summarises the results of the comparative analysis. The first assemblage from layer IV contained the tench cleithrum left by a specimen the weight of which was estimated at 1.3 kg. The second assemblage contained 2 bones of zander: the articular bone and the preopercular one, left by a specimen the weight of which was estimated at about 1.0 kg. The third assemblage contained 2 bones of northern pike: the cleithrum and the maxilla from 2 specimens of weights estimated at 2.0 and 5.5 kg; the assemblage contained also the cleithrum of a carp bream specimen weighing about 1.5 kg, a pectoral fin ray of an about 4.0 kg wels catfish specimen, and the parasphenoid bone of an about 3.5 kg zander individual. The fourth assemblage revealed 1 vertebra of an about 6.0 kg northern pike as well as the ceratohyale, parasphenoid, and a vertebra left by 3 zander individuals weighing about 1.3, 2.0, and 3.0 kg, respectively. In the fifth assemblage, it was only the palatine bone that was identified as having been left by a wels catfish specimen the weight of which was estimated at 25 kg.

As shown by the layer IV data, northern pike remains were present in 2 assemblages and consisted of 3 bones left by 3 specimens of a total weight estimated at about 13.5 kg. The tench remains consisted of 1 bone left by an about 1.25 kg specimen. The carp bream remains consisted, too, of a single bone left by an about 1.5 kg individual. The wels catfish remains, in the form of single bones, occurred—one each—in 2 bone assemblages and were left by 2 specimens of a total weight estimated at 29 kg. Zander remains were identified in 3 assemblages and consisted of 6 bones left by 5 specimens weighing from 1.0 to 3.5 kg (total weight of 10.8 kg). To sum up, a total of 13 bones identified in the Vegetable Market layer IV was left by 12 fish specimens of a total weight of 56 kg.

RESULTS

Comparisons between bones present in the archaeological collection and those belonging to contemporary fish individuals of different weight made it possible to estimate the abundance and weight of the fish the remains of which had been left at the site. Results, broken down by species, are shown in Table 4.

One of the objectives of the comparative analysis was to determine the abundance (number of individuals) of fish based on the identified bones found in different early-medieval layers of the Vegetable Market. The entire collection of 10 085 identified bones (Tables 1, 2) allowed to estimate that they had been left by 5530 fish individuals

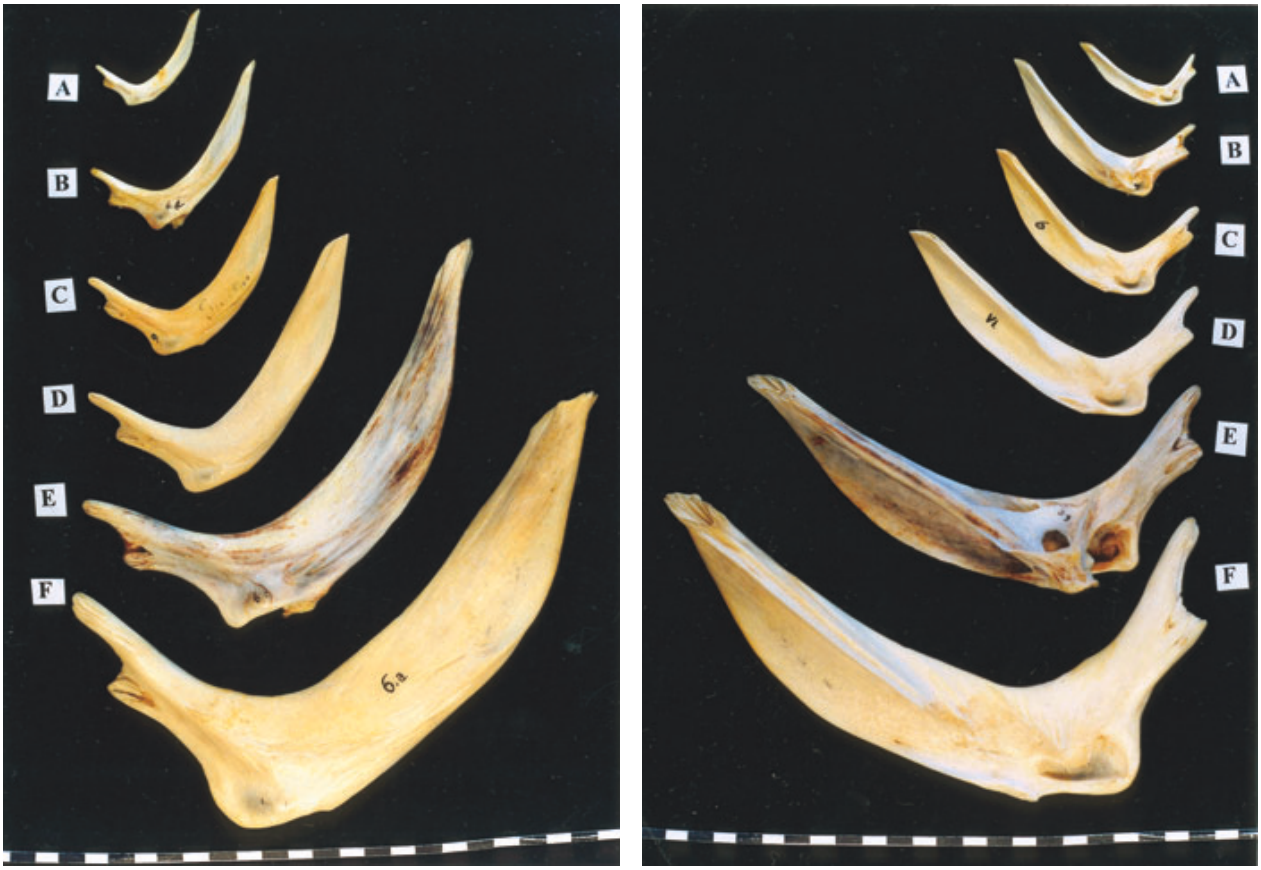

Fig. 1. Comparative materials: left cleithrum bones of the European wels catfish, *Silurus glanis* L., individuals weighing: A, 0.40 kg; B, 1.19 kg; C, 2.57 kg; D, 5.10 kg; E, 21.10 kg; F, 32.30 kg (outer- and inner view)

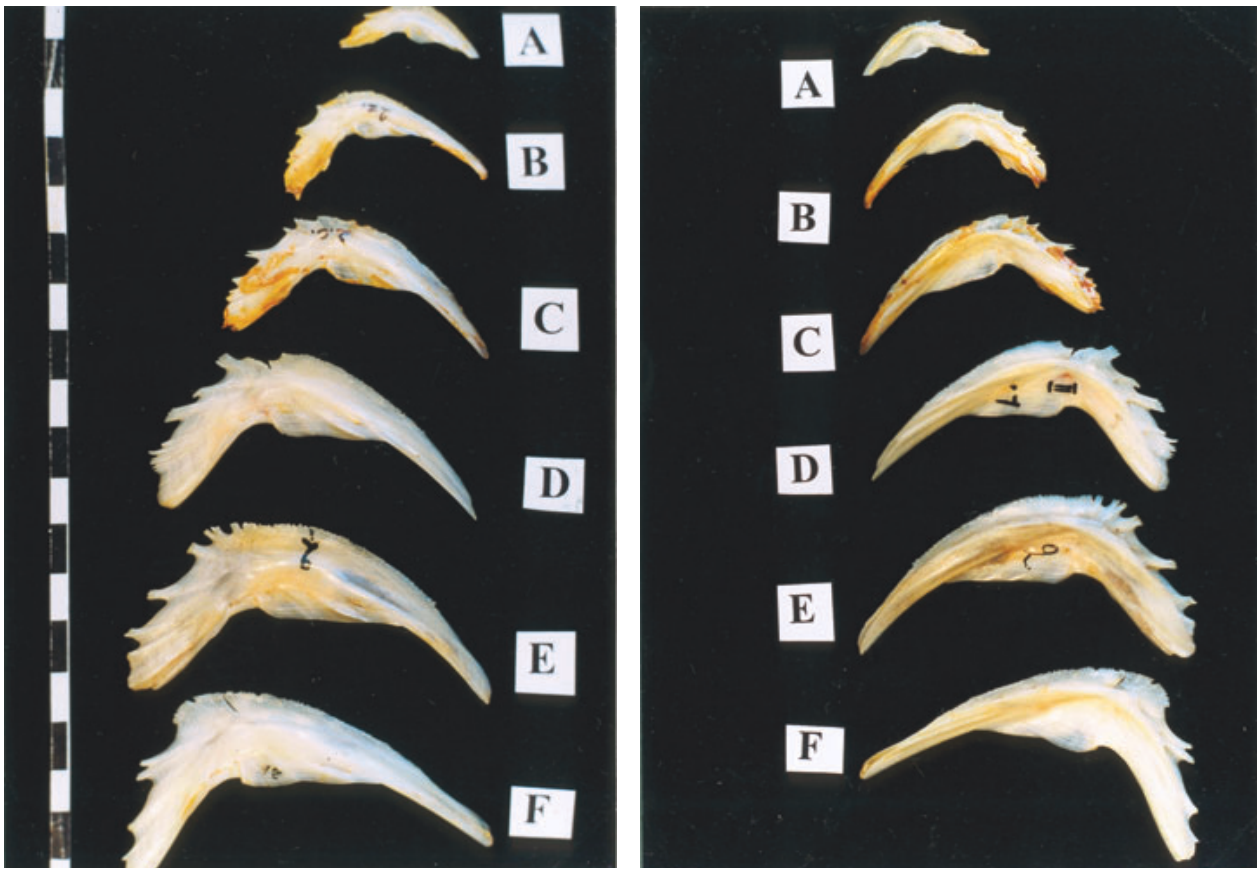

Fig. 2. Comparative materials: left preopercular bones of the zander, *Sander lucioperca* (L.), individuals weighing: A, 0.46 kg; B, 0.80 kg; C, 1.86 kg; D, 3.01 kg; E, 4.96 kg; F, 6.20 kg (outer- and inner view)

Table 3

Results of comparative analysis of fish bone remains, related to results of fish identifications in the Vegetable Market early-medieval layer IV

Identification analysis									Comparative analysis										Total	
Item No.	Species	Bone	Bone assemblage					Total	n	m	n	m	n	m	n	m	n	m	Abundance [inds.]	Weight [kg]
			1	2	3	4	5		1		2		3		4		5			
1	*Esox lucius*, northern pike	cleithrum			1			3					2	2.0	1	6.0			3	13.5
		maxilla			1									5.5						
		vertebra				1														
2	*Abramis brama*, carp bream	cleithrum			1			1					1	1.5					1	1.5
3	*Tinca tinca*, tench	cleithrum	1					1	1	1.3									1	1.3
4	*Silurus glanis*, wels catfish	soft ray palatinum			1		1	2					1	4.0			1	25.0	2	29.0
5	*Sander lucioperca*, zander	articular bone		1				6			1	1.0	1	3.5	3	1.3			5	10.8
		ceratohyale				1										2.0				
		parasphenoid			1	1										3.0				
		preopercular		1																
		vertebra				1														
	Total, identified		1	2	5	4	1	13											12	56.1
	Total, non-identified			1	7			8												
	Grand total		1	3	12	4	1	21												

n, fish abundance [No. of inds.],
m, fish weight [kg]

Table 4

Abundance and weight of individual fish species in different early-medieval layers of the Vegetable Market, as estimated by comparative analysis

Layer	*Acipenser sturio*				*Alosa fallax*				*Esox lucius*				*Abramis ballerus*				*Abramis brama*			
	n	Σ*m*	$\bar{x}$	range	*n*	Σ*m*	$\bar{x}$	range	*n*	Σ*m*	$\bar{x}$	range	*n*	Σ*m*	$\bar{x}$	range	*n*	Σ*m*	$\bar{x}$	range
IV									3	13.5	4.5	2.0–6.0					1	1.5		
V	4	62.0	15.5	12.0–20.0					1	5.5							7	7.3	1.0	0.5–2.5
VI	3	55.5	18.5	17.0–20.0													4	6.0	1.5	0.5–2.5
VII	26	575.0	22.1	20.0–60.0					37	93.3	2.5	0.3–8.0	6	1.4	0.2	0.1–0.4	214	285.2	1.3	0.2–5.0
VIII	10	285.0	28.5	15.0–50.0					6	9.7	1.6	0.8–3.0					59	34.3	0.6	0.2–1.2
IX	4	62.0	15.5	12.0–20.0					5	19.3	3.9	0.8–5.0					35	39.3	1.1	0.5–3.0
X	6	150.0	25.0	15.0–50.0					4	10.2	2.6	0.7–4.0	4	3.8	0.9	0.7–1.3	119	108.5	0.9	0.1–3.5
XI	5	182.0	36.4	17.5–60.0					9	8.4	0.9	0.4–5.0	5	4.0	0.8	0.5–1.1	30	44.9	1.5	0.5–3.3
XII	3	52.0	17.3	12.0–25.0	1	0.4			2	8.8	4.4	0.8–8.0	5	4.8	1.0	0.7–1.3	23	30.3	1.3	0.5–4.0
XIII	2	70.0	35.0	25.0–45.0					2	3.5	1.8	1.0–2.5					44	52.3	1.2	0.2–2.8
XIV	3	150.0	50.0	30.0–80.0					3	9.9	3.3	0.8–5.0					23	26.6	1.2	0.8–2.5
XV	10	290.0	29.0	15.0–45.0					1	2.0			1	0.8			24	37.6	1.6	0.6–2.0
XVI	1	150.0							3	6.8	2.3	1.3–4.0	3	3.6	1.2	0.9–1.4	59	79.8	1.4	0.2–4.6
XVII									2	4.3	2.1	1.8–2.5					48	62.0	1.3	0.1–4.0
XVIII	3	185.0	61.7	50.0–75.0					24	96.2	4.0	0.3–14.0	6	8.3	1.4	0.9–2.0	133	185.2	1.4	0.2–1.3
XIX	3	187.5	62.5	17.5–50.0	1	0.5			33	94.9	2.9	0.2–6.0					103	148.0	1.4	0.4–5.0
XX	4	295.0	73.8	30.0–175.0					20	54.6	2.7	0.6–7.5	2	1.8	0.9	0.8–1.0	44	71.6	1.6	0.6–3.5
XXI	17	792.0	46.6	10.0–200.0					34	107.1	3.2	0.4–8.0					105	160.9	1.5	0.4–3.0
XXII	6	193.0	32.2	13.0–50.0					11	23.0	2.1	0.8–5.0					47	75.8	1.6	0.6–3.5
XXIII	6	300.0	50.0	20.0–120.0					2	5.3	2.6	1.3–4.0					24	38.6	1.6	0.2–3.5
XXIV	23	797.0	34.7	13.0–150.0					30	106.1	3.5	1.0–10.0	2	2.2	1.1	0.9–1.3	76	129.5	1.7	0.2–3.5
XXV	3	60.0	20.0	15.0–30.0					5	12.5	2.5	0.3–6.0					9	13.8	1.5	0.5–2.5
XXVI	8	223.0	27.9	15.0–80.0					7	24.0	3.4	1.0–8.0					23	38.0	1.7	0.5–3.5
XXVII	2	105.0	52.5	25.0–80.0					1	5.5							4	4.7	1.2	0.6–2.3
XXVIII	1	17.0	17.0						27	62.8	2.3	0.8–8.0					62	101.6	1.6	0.6–5.0
XXIX	2	28.0	14.0	13.0–15.0					34	60.9	1.8	0.5–6.0	1	0.6			62	87.0	1.4	0.4–4.0
XXX	1	50.0	50.0						11	16.7	1.5	0.8–2.8					12	13.7	1.1	0.7–1.8
XXXI	8	205.0	25.6	10.0–50.0					21	53.8	2.6	0.3–12.0	2	2.4	1.2	1.2	41	62.1	1.5	0.4–3.5
XXXII	6	265.0	44.2	15.0–100.0					11	46.3	4.2	1.0–10.0					27	42.7	1.6	0.2–3.0
XXXIII	2	100.0	50.0	25.0–75.0					1	4.0										
Total	172	5886.0	34.2	10.0–200.0	2	0.9	0.5		350	968.4	2.8	0.2–14.0	37	33.6	0.9	0.1–1.4	1462	1988.0	1.4	0.1–5.0

n, number of individuals; Σ*m*, total weight (kg); $\bar{x}$, mean weight [kg]

Table 4 (ctnd)

Layer	*Aspius aspius*				*Blicca bjoerkna*				*Carassius carassius*				*Leuciscus cephalus*				*Leuciscus idus*				*Pelecus cultratus*			
	n	Σ*m*	$\bar{x}$	range	*n*	Σ*m*	$\bar{x}$	range	*n*	Σ*m*	$\bar{x}$	range	*n*	Σ*m*	$\bar{x}$	range	*n*	Σ*m*	$\bar{x}$	range	*n*	Σ*m*	$\bar{x}$	range
IV																								
V	1	4.0							1	0.8														
VI																								
VII	18	55.4	3.1	0.8–6.0									3	2.9	1.0	0.6–1.3	4	7.0	1.8	1.2–2.5				
VIII	7	21.3	3.0	1.5–5.0					1	0.5			2	2.5	1.3	0.7–1.8								
IX	2	10.5	5.3	5.0–5.5									1	0.6			2	2.3	1.1	1.0–1.3	1	0.5	0.5	
X	5	17.8	3.6	2.0–7.0													3	2.6	0.9	1.0–1.2				
XI	5	21.5	4.3	2.0–6.5									1	0.8										
XII	2	6.5	3.3	2.5–4.0																				
XIII													1	1.5			3	4.0	1.3	0.8–1.0				
XIV	1	2.0																						
XV													1	1.8			1	0.8						
XVI	3	10.8	3.6	3.5–3.8													1	2.5						
XVII	1	4.5																						
XVIII	7	23.5	3.4	1.8–5.5																				
XIX	11	35.7	3.2	0.2–8.0					2	2.3	1.1	1.0–1.2	4	6.3	1.6	0.5–2.3	3	4.0	1.3	1.0–1.5				
XX	4	13.3	3.3	2.5–5.0													3	3.7	1.2	1.2–1.3				
XXI	5	16.0	3.2	2.0–5.0													1	2.0						
XXII	9	31.5	3.5	2.0–6.0	1	0.2							1	1.5			5	5.9	1.2	1.1–1.5				
XXIII	1	2.3											1	1.3										
XXIV	6	18.2	3.0	1.8–5.0					1	0.8			2	2.6	1.3	1.3								
XXV	2	9.0	4.5	4.0–5.0																				
XXVI																								
XXVII																								
XXVIII	10	28.1	2.8	1.1–5.0					4	1.3	0.3	0.2–0.8					1	1.0						
XXIX	10	29.8	3.0	1.3–5.0	3	1.2	0.4	0.3–0.5	3	3.2	1.1	0.9–1.2					3	3.2	1.1	1.0–1.2				
XXX	3	10.2	3.4	1.2–5.0																				
XXXI	4	12.5	3.1	1.8–5.0					1	0.4							3	2.9	1.0	0.8–1.1				
XXXII	2	7.0	3.5	3.0–4.0					4	4.3	1.1	0.8–1.3					5	5.3	1.1	0.8–2.2				
XXXIII																								
Total	119	391.0	3.3	0.1–8.0	4	1.4	0.4	0.2–0.5	17	13.3	0.8	0.2–1.3	17	21.6	1.3	0.5–2.3	38	47.0	1.2	0.8–2.5	1	0.5		

Table 4 (ctnd)

Layer	*Rutilus rutilus*				*Scardinius erythrophthalmus*				*Tinca tinca*				*Vimba vimba*				*Silurus glanis*			
	n	Σ*m*	$\bar{x}$	range	*n*	Σ*m*	$\bar{x}$	range	*n*	Σ*m*	$\bar{x}$	range	*n*	Σ*m*	$\bar{x}$	range	*n*	Σ*m*	$\bar{x}$	range
IV									1	1.3	1.3						2	29.0	14.5	4.0–25.0
V	18	7.4	0.4	0.5–0.7					5	8.5	1.7	1.3–2.0					9	109.0	12.1	7.0–25.0
VI	1	0.3	0.3						2	2.3	1.1	1.0–1.3					2	42.5	21.3	20.0–22.2
VII	323	180.9	0.6	0.0–1.1	5	1.8	0.4	0.2–0.5	54	68.8	1.3	0.5–3.0	3	1.9	0.6	0.3–0.8	83	1053.0	12.7	1.2–40.0
VIII	59	34.3	0.6	0.2–1.1					11	11.0	1.0	0.4–1.4					35	348.2	9.9	0.7–35.0
IX	24	15.4	0.6	0.3–1.1					7	10.5	1.5	0.6–2.0					34	462.5	13.6	1.5–50.0
X	29	12.6	0.4	0.1–0.9	1	0.4	0.4		13	9.8	0.8	0.2–3.0					36	461.0	12.8	0.5–30.0
XI	8	2.9	0.4	0.2–0.5					6	8.8	1.5	0.7–2.0					16	118.0	7.4	0.3–22.0
XII	3	1.2	0.4	0.2–0.7					1	1.3	1.3						4	37.0	9.3	4.0–15.0
XIII	17	5.6	0.3	0.2–0.5					9	6.7	0.7	0.9–2.0					8	75.5	9.4	1.5–20.0
XIV	6	2.6	0.4	0.3–0.6					5	6.3	1.3	1.0–1.5					12	83.2	6.9	0.2–20.0
XV	8	4.0	0.5	0.2–0.7					3	4.7	1.6	1.3–2.0					8	105.8	13.2	2.0–30.0
XVI	22	7.8	0.4	0.1–0.8					9	12.6	1.4	0.8–2.5					3	24.0	8.0	4.0–12.0
XVII	15	5.0	0.3	0.1–0.7					1	2.3	2.3						2	40.0	20.0	15.0–25.0
XVIII	25	11.5	0.5	0.2–1.0					16	23.8	1.5	0.8–2.8					11	59.8	5.4	0.5–17.5
XIX	40	16.0	0.4	0.1–0.8					12	24.0	2.0	1.0–3.5	1	2.0	2.0		14	84.6	6.0	0.5–25.0
XX	17	6.4	0.4	0.2–1.0					7	9.3	1.3	0.8–2.5					9	70.0	7.8	1.0–16.0
XXI	54	30.3	0.6	0.1–1.1					24	28.0	1.2	0.4–2.8	1	0.4	0.4		35	224.0	6.4	0.5–30.0
XXII	25	9.4	0.4	0.1–0.9	1	0.4	0.4		14	21.3	1.5	0.5–3.0	1	0.4	0.4		12	102.0	8.5	1.5–27.5
XXIII	13	5.4	0.4	0.1–1.1					8	8.7	1.1	0.1–2.5					6	27.0	4.5	1.0–12.0
XXIV	42	14.0	0.3	0.1–0.8					34	51.0	1.5	0.6–2.5					28	290.3	10.4	0.5–45.0
XXV	7	2.6	0.4	0.1–0.7					4	8.9	2.2	1.6–3.0					5	47.0	9.4	4.0–27.0
XXVI	11	4.5	0.4	0.1–1.1	1	0.5	0.5		27	46.9	1.7	0.8–3.0					10	135.0	13.5	3.5–22.5
XXVII	2	1.7	0.9	0.6–1.1					9	10.1	1.1	0.7–1.6					7	95.8	13.7	1.2–30.0
XXVIII	41	13.4	0.3	0.1–0.7	2	1.0	0.5	0.4–0.5	82	107.0	1.3	0.3–3.5	2	0.7	0.3	0.2–0.4	48	333.3	6.9	0.3–45.0
XXIX	27	9.2	0.3	0.1–0.6	1	0.4	0.4		76	101.1	1.3	0.2–2.8					33	222.5	6.7	0.2–35.0
XXX	10	3.7	0.4	0.2–0.6	1	0.4	0.4		14	15.1	1.1	0.2–2.0					5	8.7	1.7	1.0–3.0
XXXI	17	6.0	0.4	0.1–1.0					37	52.2	1.4	0.5–6.5					28	198.8	7.1	0.2–32.0
XXXII	15	6.0	0.4	0.2–1.0	1	0.4	0.4		28	37.2	1.3	0.3–3.4					26	187.3	7.2	0.3–27.5
XXXIII									4	4.1	1.0	0.5–1.4					1	5.0	5.0	
Total	879	419.6	0.5	0.1–1.1	13	5.2	0.4	0.2–0.5	523	702.8	1.3	0.1–6.5	8	5.3		0.2–0.8	532	5079.4	9.5	0.2–50.0

Table 4 (ctnd)

Layer	*Anguilla anguilla*				*Gymnocephalus cernuus*				*Perca fluviatilis*				*Sander lucioperca*				Total abundance		Total weight	
	n	Σ*m*	$\bar{x}$	range	*n*	Σ*m*	$\bar{x}$	range	*n*	Σ*m*	$\bar{x}$	range	*n*	Σ*m*	$\bar{x}$	range	*n*	%	kg	%
IV													5	10.8	2.2	1.0–3.5	12	0.2	56	0.3
V									4	1.5	0.4	0.1–0.7	5	13.8	2.8	1.8–3.5	55	1.0	220	1.2
VI													3	5.5	1.8	1.0–2.5	15	0.3	112	0.6
VII	4	7.2	1.8	1.2–2.5	4	0.3	0.1	0.03–0.125	44	31.4	0.7	0.2–1.0	169	491.5	2.9	0.3–8.0	997	18.0	2857	15.3
VIII									5	2.6	0.5	0.3–0.8	62	177.3	2.9	0.8–8.0	257	4.6	926	4.9
IX	2	2.5	1.3	1.0–1.5					2	1.3	0.7	0.5–0.8	35	99.3	2.8	1.0–8.0	154	2.8	726	3.9
X									9	5.2	0.6	0.4–0.8	57	197.2	3.5	0.8–8.0	286	5.2	979	5.2
XI									12	7.7	0.6	0.2–1.0	21	59.5	2.8	0.8–7.0	118	2.1	458	2.4
XII									2	1.2	0.6	0.4–0.8	15	44.0	2.9	1.5–5.0	61	1.1	187	1.0
XIII									4	1.6	0.4	0.2–0.6	23	57.8	2.5	0.5–7.0	113	2.0	278	1.5
XIV									3	2.4	0.8	0.8–0.8	17	43.8	2.6	1.0–5.5	73	1.3	327	1.7
XV									1	0.2	0.2		23	68.8	3.0	0.4–6.0	81	1.5	516	2.8
XVI	1	0.4	0.4		1	0.0	0.0		11	7.8	0.7	0.3–1.2	25	60.1	2.4	0.6–10.0	142	2.6	366	2.0
XVII	1	0.4	0.4						11	7.9	0.7	0.1–1.5	31	96.3	3.1	0.4–3.5	112	2.0	223	1.2
XVIII									21	13.0	0.6	0.2–1.0	50	163.4	3.3	0.6–10.0	296	5.4	770	4.1
XIX	4	4.5	1.1	0.6–1.5					23	15.6	0.7	0.1–1.0	79	263.1	3.3	0.4–11.5	333	6.0	889	4.7
XX									4	2.7	0.7	0.2–0.9	25	70.8	2.8	1.0–6.0	139	2.5	599	3.2
XXI	3	2.4	0.8	0.4–1.3					16	9.6	0.6	0.2–1.0	88	276.9	3.1	0.9–7.0	383	6.9	1649	8.8
XXII									12	7.0	0.6	0.1–1.0	27	91.8	3.4	1.5–10.0	172	3.1	563	3.0
XXIII	1	0.2	0.2						5	2.6	0.5	0.2–0.8	11	27.0	2.5	0.8–4.0	78	1.4	418	2.2
XXIV	3	4.3	1.4	0.8–2.0					14	9.7	0.7	0.1–1.0	49	140.4	2.9	0.9–8.0	310	5.6	1566	8.4
XXV									1	0.5	0.5		13	38.0	2.9	1.0–5.5	49	0.9	192	1.0
XXVI	2	3.5	1.8	1.0–2.8					4	1.4	0.4	0.2–0.5	20	69.8	3.5	1.3–7.0	113	2.0	546	2.9
XXVII													2	4.5	2.3	1.5–3.0	27	0.5	227	1.2
XXVIII	12	16.4	1.4	0.5–3.5					38	27.5	0.7	0.2–0.9	24	63.8	2.7	0.8–8.0	354	6.4	775	4.1
XXIX	8	9.1	1.1	0.5–2.5					46	27.4	0.6	0.2–1.0	32	99.7	3.1	0.5–8.0	341	6.2	683	3.6
XXX									5	4.1	0.8	0.4–1.0	10	28.0	2.8	0.8–6.5	72	1.3	151	0.8
XXXI	7	11.3	1.6	0.6–3.5					23	14.0	0.6	0.3–0.9	28	57.9	2.1	0.5–6.5	220	4.0	679	3.6
XXXII	1	2.5	2.5						9	7.0	0.8	0.2–1.0	18	54.5	3.0	1.0–8.0	153	2.8	665	3.6
XXXIII									3	2.8	0.9	0.8–1.0	3	8.3	2.8	2.0–3.5	14	0.3	124	0.7
Total	49	64.7	1.3	0.4–3.5	5	0.3	0.06	0.03–0.125	332	215.3	0.7	0.1–1.5	970	2883.0	3.0	0.3–11.5	5530	100.0	18727	100.0

Table 5

Contribution (%) of different species to abundance and weight of fish the remains of which were retrieved in selected archaeological sites located on the shores of River Odra estuary

No.	Species	Vegetable Market (this study)		Wolin Miasto (Pit 6)		Wolin Port (Pit 8)	
		abundance	weight	abundance	weight	abundance	weight
1	*Acipenser sturio* L., sturgeon	3.1	31.4	2.0	35.3	8.9	76.0
2	*Clupea harengus* L., herring			3.4	0.2	0.7	–
3	*Alosa alosa* (L.), Allis shad			0.1	–		
4	*Alosa fallax* (Lacepède, 1803), twaite shad	+	–	1.3	0.2		
5	*Coregonus lavaretus* (L.), common whitefish			–	–		
6	*Salmo salar* L., Atlantic salmon			–	0.3		
7	*Salmo trutta* L., sea trout			–	0.1	0.2	0.2
8	*Esox lucius* L., northern pike	6.3	5.2	2.4	2.9	3.7	1.6
9	*Abramis ballerus* (L.), zope	0.7	0.2	0.1	–	0.1	–
10	*Abramis brama* (L.), carp bream	26.4	10.6	26.2	14.8	22.7	4.2
11	*Aspius aspius* (L.), asp	2.2	2.1	0.6	0.7	0.6	0.3
12	*Blicca bjoerkna* (L.), white bream	0.1	–	–	–		
13	*Carassius carassius* (L.), crucian carp	0.3	0.1	–	–		
14	*Leuciscus cephalus* (L.), European chub	0.3	0.1	0.3	0.1		
15	*Leuciscus idus* (L.), ide	0.7	0.3	0.6	0.3	0.6	0.1
16	*Pelecus cultratus* (L.), ziege	+	–	–	–		
17	*Rutilus rutilus* (L.), roach	15.9	2.2	11.3	1.9	7.8	0.4
18	*Scardinius erytrophthalmus* (L.), rudd	0.2	–	0.2	–		
19	*Tinca tinca* (L.), tench	9.5	3.8	1.7	1.0	0.9	0.2
20	*Vimba vimba* (L.), Baltic vimba	0.1	–	0.2	0.1	0.1	–
21	*Silurus glanis* L., wels catfish	9.6	27.0	0.3	1.2	0.5	0.7
22	*Anguilla anguilla* L., European eel	0.9	0.3	1.7	1.0	1.3	0.3
23	*Lota lota* (L.), burbot			0.1	–		
24	*Gymnocephalus cernuus* (L.), ruffe	0.1	–	0.3	–	0.3	–
25	*Perca fluviatilis* L., European perch	6.0	1.1	15.4	3.6	13.4	0.9
26	*Sander lucioperca* (L.), zander	17.5	15.4	31.5	36.4	38.4	15.3
27	*Platichthys flesus* (L.), flounder			0.3	–		

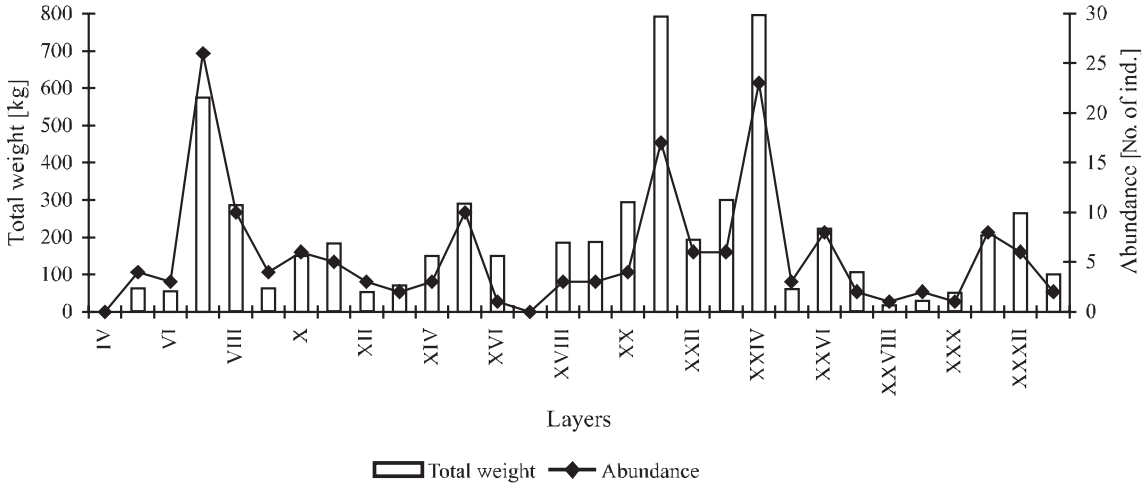

Fig. 3. Frequency of occurrence of the sturgeon, *Acipenser sturio* L., and its estimated total weight in the early-medieval deposit layers of the Vegetable Market (total weight in kg; abundance in number of individuals)

(Table 4). The highest number of individuals was present in layer VII: the estimated 997 individuals belonging to 16 species included 323 specimens of roach, 214 carp bream, 169 zander, 83 wels catfish, 54 tench, 44 European perch, 37 northern pike, 23 sturgeon, and lower quantities of other species. The remaining layers contained remnants of 12 (layer IV) to 383 (layer XXI) fish specimens.

The respective contributions of individual fish species occurring in all the Vegetable Market early-medieval layers showed European perch, zander, and roach to be the dominant species, contributing 26.4, 17.5, and 15.9%, respectively. Wels catfish, tench, northern pike, and European perch contributed substantially as well: 9.6, 9.5, 6.3, and 6.0%, respectively. The contributions of sturgeon (3.1%) and asp (2.2%) were much lower. The remaining 11 fish species occurred sporadically (contributions not exceeding 1%) (Table 5).

In addition to the abundance, the weight of the fish was estimated as well. The total weight of the fish that had left identifiable bones at the site amounted to about 18 700 kg. Like in the abundance, layer VII contributed most (15.2%) to that weight, followed by layers XXI (8.8%) and XXIV (8.3%). Contributions of the remaining 27 layers were much lower and ranged from 0.3% in layer IV to 5.7% in layer X (Table 4).

Analysis of the partitioning of the total fish weight between individual species showed the highest contribution (31.3%) to be that of sturgeon, followed by wels catfish (27.0%), zander (15.3%), and carp bream (10.6%). Contributions of the following five species were much lower: 5.2% supplied by the northern pike, 4.2% by tench, 2.2% by roach, 2.1% by asp, and 1.1% by European perch. The remaining 11 species contributed less than 1% each (Table 5).

The sturgeon remains occurred in 28 early-medieval Vegetable Market layers. A total of 308 remains of the species was identified (Table 2). They were estimated to have belonged to 172 individuals the weight of which ranged from 10 to 200 kg; the total sturgeon weight was assessed at about 5886 kg. The abundance and weight of sturgeon differed widely between the layers, from single individuals present in layers XVI, XXVIII, and XXX to 26 in layer VII. Sturgeon was abundant also in layers XXIV (23 individuals) and XXI (17 individuals) as well as VIII and XV (10 individuals each). The total weight was at its highest in the following three layers: XXIV (about 800 kg), XXI (about 790 kg), and VII (about 570 kg). In the remaining layers, the sturgeon weight was estimated to have varied from 17 kg in layer XXVIII to about 300 kg in layer XXIII (Fig. 3).

As concluded from analysis of the bones identified, individual early-medieval sediment layers differed widely in terms of both the abundance of fish and in individual and total weights of various species (Table 5).

DISCUSSION

In this study, comparative analyses of fish bone remains retrieved from the Vegetable Market early-medieval layers allowed to estimate the abundance and weight of the fish. Similar studies on numerous bone remains collected from early-medieval sediment layers were carried out by Chełkowski et al. (1998, 2001) and by Filipiak and Chełkowski (2000) in the Odra River estuary shores at Wolin Port (Pit 8) and Wolin Miasto (Pit 6). While the Vegetable Market layers showed the highest contribution to be that of carp bream (26.4%), followed by zander (17.5%) and roach (15.9%), the Wolin Port remains were dominated by those of zander (38.4%), carp bream (22.7%), and European perch (15.4%); zander (31.5%), carp bream (26.2%), and European perch (13.4%), too, were dominant in the Wolin Miasto pit (Table 5). Sturgeon contributed 9.0% in Wolin's Pit 8, 3.1% in the Vegetable Market, and 2.0% in Wolin's Pit 6.

Of the three sites compared for northern pike occurrence, the highest contribution was that in the Vegetable Market material (6.3%),the contributions from Wolin's Pit 8 (3.7%) and Wolin's Pit 6 (2.4%) being lower. Roach con-

tributed most to the Vegetable Market fish finds (11.3%), the respective contributions to the Wolin's Pit 6 and Pit 8 being lower (11.3 and 7.8%). The highest tench contribution was recorded in the Vegetable Market, much lower contributions being those in Wolin's Pit 6 and Pit 8 (1.7 and 0.9%, respectively). The wels catfish contributed most to the Vegetable Market fish (9.6%), compared to much lower contributions in Wolin: 0.5% in Pit 8 and 0.3% in Pit 6. The European perch contributed most to the materials of the Wolin Miasto site (15.4%) and to those of Wolin Port (13.4%), much lower contribution being that found in the Vegetable Market (6.0%). The contribution of asp was at its highest in the Vegetable Market (2.2%), the species contributing much less to the materials from Wolin (0.6% at each site). European eel was most abundantly represented in Wolin Miasto (1.7%) and Wolin Port (1.3%), the lowest contribution being that in the Vegetable Market dig (0.9%).

The materials retrieved from the Vegetable Market early-medieval layers lacked remains of 6 species (herring, trout, salmon, whitefish, burbot, and flounder) that were present in the Wolin Miasto pit.

Despite the visible quantitative differences among the sites compared, the highest contributions among the cyprinids were those of carp bream (22.7–26.4%), roach (7.8–15.9%), and tench (0.9–9.5%), while zander (17.5–38.4%) and European perch (6.0–15.4%) contributed most among the percids.

The estimated contribution of sturgeon to the total mass of fish that had left their remains in the Vegetable Market proved the highest (31.3%), compared to contributions of the remaining species. Still higher was the sturgeon weight contribution at the Wolin Port site (76.0%). At the Wolin Miasto site, the sturgeon—with its contribution of 35.3%—was second to zander (36.4%). Noteworthy weight contributions at the sites compared include those of zander (15.3–36.4%), carp bream (4.2–14.8%), northern pike (1.6–5.2%), European perch (0.9–3.6%), wels catfish (0.7–27.0%), roach (0.4–2.2%), asp (0.3–2.1%), and tench (0.2–4.2%). Weight contributions of the remaining species were much lower at all the sites (Table 5).

Sturgeon is a migratory (anadromous) species. Individual specimens may grow to 320 kg (Kolman 1999) or even to 600 kg (Hochleithner 1996). However, an average individual weight of harvested sturgeon ranges within 10–50 kg. Based on the remains analysed, the sturgeon handled at the Vegetable Market site were estimated to weigh 10–200 kg, the high mean individual weight providing evidence that it was mostly large specimens that had been caught.

Having grown out in the Baltic Sea, the sturgeon migrated upstream the Odra River system via its estuary; after spawning, the fish descended to the sea along the same route. The periods and routes of sturgeon migrations must have been known to the early-medieval settlers who harvested the fish and mastered the difficult art of sturgeon capture. Sturgeon was doubtless abundant in early Middle Ages and, when caught, was an economically valuable commodity.

The bone remains-based estimations of fish weights showed the bones to have been left by individuals of different sizes, from small (juvenile) to large (adult) (Table 4). For example, the estimated individual weights of roach varied from 0.02 to 1.1 kg. The high mean individual weight of roach proves it was the larger roach that had been caught or, more plausibly, bones left by smaller fish had disintegrated (had been decomposed by mineralisation) and were not preserved in the collections (Marciniak 1996). However, the wide ranges of individual weights of the species harvested most frequently demonstrate that the early-medieval settlers used a diversity of fishing gear and techniques, as confirmed by the remains of various fishing gear found in the Vegetable Market layers (Rulewicz 1974, 1994). This is also indicated by the wreck of a large strake boat revealed on the bottom of layer XXXIII; according to Wieczorowski (1962), the boat was used in fishing operations.

CONCLUSIONS

Among the 20 fish species the remains of which occur in all the early-medieval layers of the Vegetable Market, those most abundant included carp bream (26.4%), followed by zander (17.5%), roach (15.9%), wels catfish (9.6%), tench (9.5%), northern pike (6.3%), European perch (6.0%), sturgeon (3.1%), and asp (2.2%). In terms of the total species weight, the collection was dominated by sturgeon (31.3%), followed by wels catfish (27.0%), zander (15.3%), carp bream (10.6%), northern pike (5.2%), tench (4.2%), roach (2.2%), asp (2.1%), and European perch (1.1%). Contributions of the remaining 11 fish species to both the abundance and total weight were much lower (less than 1%).

The presence of as many as 20 fish species of an economic importance, represented by more than 5500 individuals of a total weight of 18 800 kg demonstrates the importance of fisheries and fish in the diet of the inhabitants of early-medieval Szczecin.

The bones analysed showed a considerable variability in individual weights (from juvenile forms to adults) of the fish species represented, which could be taken as evidence that the fishermen used gear and techniques enabling them to harvest fish of a wide spectrum of sizes.

The presence of bone remains identified as belonging to 14 individuals of 6 species (of a total weight of about 125 kg) in the oldest layer XXXIII as well as the remnants of a fishing boat in that layer demonstrate the importance of fisheries and the major role of fish in diets of the inhabitants of the area since the beginnings of human settlement there, i.e. the 2nd decade of the 10th century.

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