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A NEOLITHIC SETTLEMENT ON THE DUTCH NORTH SEA COAST *c*. 3500 CAL BC

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AND PETER F.B. JONGSTE

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Contents

Preface *IX*
Leendert Louwe Kooijmans

PART I INTRODUCTION *1*

1 **Discovery and working method** *3*
Peter Jongste
Leendert Louwe Kooijmans

2 **Stratigraphy and chronology of the site** *19*
Joanne Mol
Leendert Louwe Kooijmans
Tom Hamburg

3 **Features** *39*
Tom Hamburg
Leendert Louwe Kooijmans

4 **The archaeological remains: a critical spatial approach** *67*
Milco Wansleeben
Leendert Louwe Kooijmans

PART II MAN AND MATERIALS *89*

5 **Graves and human remains** *91*
Liesbeth Smits
Leendert Louwe Kooijmans

6 **The Schipluiden pottery** *113*
Daan Raemaekers
Michiel Rooke

7 **Flint, procurement and use** *129*
Annelou van Gijn
Veronique van Betuw
Annemieke Verbaas
Karsten Wentink

8 **Stone, procurement and use** *167*
Annelou van Gijn
Rob Houkes

9 **Ornaments of jet, amber and bone** *195*
Annelou van Gijn

10 **Implements of bone and antler: a Mesolithic tradition continued** *207*
Annelou van Gijn

11 **Wooden artefacts** *225*
Leendert Louwe Kooijmans
Laura Kooistra

12 **Fabrics of fibres and strips of bark** *253*
Laura Kooistra

13 **Birch bark tar** *261*
Annelou van Gijn
Jaap Boon

PART III ECOLOGY AND ECONOMY *267*

14 **Coastal evolution of Delfland and the Schipluiden microregion in relation to Neolithic settlement** *269*
Joanne Mol

15 **Diatoms** *285*
Hein de Wolf
Piet Cleveringa

16 **Molluscs** *297*
Wim Kuijper

17 **Coprolites, macroscopic analysis** *301*
Mark van Waijjen
Caroline Vermeeren

18 **Pollen analysis and the reconstruction of the former vegetation** *305*
Corrie Bakels

19 **Botanical remains and plant food subsistence** *317*
Lucy Kubiak-Martens

20 **Roots, tubers and processed plant food in the local diet** *339*
Lucy Kubiak-Martens

20a **Analytical report on some archaeological charred residues from Schipluiden** *353*
Jaap Boon

21 **Wood and charcoal** *363*
Laura Kooistra

22 **Mammals** *375*
Jørn Zeiler

23 **Birds** *421*
Jørn Zeiler

24 **Background fauna: small mammals, amphibians and reptiles** *443*
Jørn Zeiler

25 **Fish** *449*
Dick Brinkhuizen

26 **Insects** *471*
Tom Hakbijl

PART IV SYNTHESIS *483*

27 **Schipluiden: a synthetic view** *485*
Leendert Louwe Kooijmans

25 Fish

Dick Brinkhuizen

The occupants of the Schipluiden dune caught fish – especially the three migratory species eel, flounder and sturgeon – in an estuarine environment. They also caught freshwater fish (mainly Cyprinidae) and marine fish (grey mullets, bass, roker), even in the last occupation phase, by which time the local environment had become largely dominated by freshwater conditions. This means that the occupants purposely continued to exploit the estuarine environment. Large quantities of remains of young herring and smelt in old wells reflect incidental marine ingressions in the early occupation phases. A concentration of remains of eel and a few cyprinids may imply fishing in the freshwater environment, but these species may also have been caught in the estuary.

25.1 Research questions

The abundant quantities of – on the whole – reasonably well-preserved fish remains constitute an important source of information in the study of the Neolithic occupation of the Schipluiden-Harnaschpolder site. The ichthyoarchaeological research whose results are discussed in this chapter focused on the following questions:

- Subsistence: which fish species were exploited, in what quantities and in what manner? What can be said about the diversity of the fishing activities?
- Character of occupation: what information do the caught fish species provide on the seasons in which the site was occupied?
- Landscape: what information does the composition of the fish fauna provide on the aquatic environment in the dune's surroundings and on the exploited ecozones?
- Did any changes take place in the aforementioned aspects in the course of the occupation period?

25.2 Methods

The fish remains were collected in the same ways and for the same purposes as the mammal and bird remains (sections 22.2 and 23.2): the manual recovery technique focused on the fraction >2 cm, and the fraction up to 4 mm was recovered via systematic sieving through sieves with a mesh width of 4 mm. In addition, 5-litre samples were sieved through sieves with mesh widths of 2 and 1 mm to recover the finest remains.

To what extent the manual collection objective was realised was not checked in the case of the fish remains, partly because the remains were not measured. We may assume that the principles outlined in chapter 4 for pottery and flint also hold for the fish remains. This is indeed evident from the range of identifications. The manually collected remains moreover comprise a relatively random and small proportion of the finer fractions, and, the other way round, some remains of >2 cm were overlooked during the manual shovelling.

As for the fine (1- and 2-mm) sieved fraction: fish remains were identified in three samples from pit fills and six samples from the aquatic deposits.

The fish remains were separated from the manually collected remains and the remains recovered from the 4-mm sieve by J.T. Zeiler during his work on the other faunal remains.

In view of the vast quantities of remains recovered and the limited time and means available, a selection was made of the fish remains, as was also done for the mammal and bird remains. Only the (easily) identifiable fragments of the manually collected remains and those of the remains recovered from the 4-mm sieve fraction were selected for further analysis. The same procedure was followed for the selected 1- and 2-mm samples. This does however mean that only the number of identified remains is known; the total number of remains was not determined.

The manually collected fish remains were identified to species, genus or family level by examining them with the naked eye. Attempts were made to refit fragments to minimise the consequences of fracture. Many fragments of the bones of sturgeon (*Acipenser sturio*) were thus refitted.

In view of their minute dimensions, the fragments recovered from the sieves were studied under a stereomicroscope with 3.6×, 6× or 12× magnification. The remains were identified with the aid of the author's collection of present-day fish skeletons.

The fish remains were not weighed, except for the sturgeon bones from the manually collected assemblage and the 4-mm sieve fraction.

Noteworthy characteristics such as traces of burning, slaughtering and gnawing were recorded in order to obtain information on taphonomic processes. Pathologies (skeletal deviations) were also recorded.

25.3 Material

25.3.1 Quantity

Tens of thousands of fish remains were collected, and they represent only a proportion of the total number of remains that had survived at the site. Extrapolation leads to a total quantity of more than 100,000 fragments in the >4 mm fraction. It is impossible to estimate even roughly the number of remains in the finer fractions. After the aforementioned selection step, 7701 remains, representing all the distinguished phases and contexts and the different fractions, were identified to species, genus or family level (table 25.1).

phase	1	1-2a	2a	2b	3	1-3	totals
collected by hand							
Units	15	68	913	319	201	96	1612
features	2	12	29	–	–	167	210
Totals	*17*	*80*	*942*	*319*	*201*	*263*	*1822*
4-mm mesh							
Units	–	294	44	1076	339	493	2246
features	–	–	–	–	–	265	265
Totals	–	*294*	*44*	*1076*	*339*	*758*	*2511*
1-mm mesh							
Units	77	36	196	129	–	–	438
features	–	75	1922	–	768	165	2930
Totals	*77*	*111*	*2118*	*129*	*768*	*165*	*3368*

Table 25.1 Fish remains presented according to recovery technique, context and phase.

25.3.2 Preservation

The fish remains were found concentrated along the flanks of the dune, where the (wet) conditions were most favourable for preservation (fig. 25.1). Very few fish bones were found higher up the dune, which is largely attributable to the less favourable preservation conditions in those parts. Fish bones will moreover have been crushed by trampling and have been discarded by the occupants in the dump zones bordering the dune.

In the areas where fish bones were found, conditions for their preservation proved to have been good to moderately good. In the case of the majority of the bones except those of sturgeon, the outside of the bone had survived reasonably well. Many of the sturgeon bones had flaked or totally disintegrated into scales. Almost all the bones of sturgeon and the largest individuals of the other species were severely fragmented, as a result of which only very few dimensions could be measured.

25.3.3 Contexts

The fish bones came from two different contexts. The first context is the succession of deposits (units) covering the flanks of the dune. The manually collected bones and the remains recovered from the 4-mm sieve together accounted for almost 4000 identifications. They were supplemented with more than 1000 identifications obtained for the sieved residues of eleven 5-litre samples. One of these samples (no. 898) contained a distinct concentration of remains.

The second context comprised the large features (pit fills) found on the dune. In total, 210 fish remains manually collected from 35 pit fills were identified. They were supplemented with 265 identifications obtained for a sample from one pit that was sieved through a 4-mm mesh width. Large (5-litre) samples from two features on the northwestern side of the dune and one on the southeastern side were passed through sieves with mesh widths of 2 and 1 mm. These samples yielded more than 2000 identified remains. So the units and features show reversed ratios of large and small remains. This is due to the exceptional specific formation processes of the feature samples concerned, which were taken from concentrations of fine fish remains that were identifiable as such in the field.

25.4 The fish

25.4.1 The species spectrum

Twenty species were identified in the total quantity of fish remains – the manually collected bones and the remains recovered from the various sieve residues. Tables 25.2 – 25.4 provide a survey of the numbers of remains and the percentages of the identified species per phase for each of the recovery techniques. The publications of Nijssen/De Groot (1987) and De Nie (1996) were used for the species' scientific names.[1]

The spectrum comprises fish species of saline and fresh water, some of which migrate between the two. In the fractions from all the phases that yielded sufficiently large samples, migratory species dominated, being represented by 80-90%. In migratory fish a distinction is made between anadromous and catadromous species.

Anadromous species are fish that spend the greater part of their lives in the sea or in the brackish water of estuaries, but swim up rivers to spawn. Some species spawn just above the transition from the brackish water, others in the fast-flowing water of the upper courses of rivers. Six of the encountered fish species are anadromous: sturgeon *(Acipenser sturio),* allis shad/twaite shad (*Alosa alosa*/*A. fallax*), smelt *(Osmerus eperlanus),* whitefishes (*Coregonus* sp.), salmon/sea trout (*Salmo salar*/*S. trutta*) and three-spine stickleback (*Gasterosteus aculeatus*).

Catadromous species spend the greater part of their lives in fresh or brackish water and leave that environment to reproduce in salt water. Two of the encountered species are catadromous: eel (*Anguilla anguilla*) and flounder *(Pleuronectes flesus).*

Six of the represented species are stationary freshwater fish that can also live in weakly brackish water (Redeke,

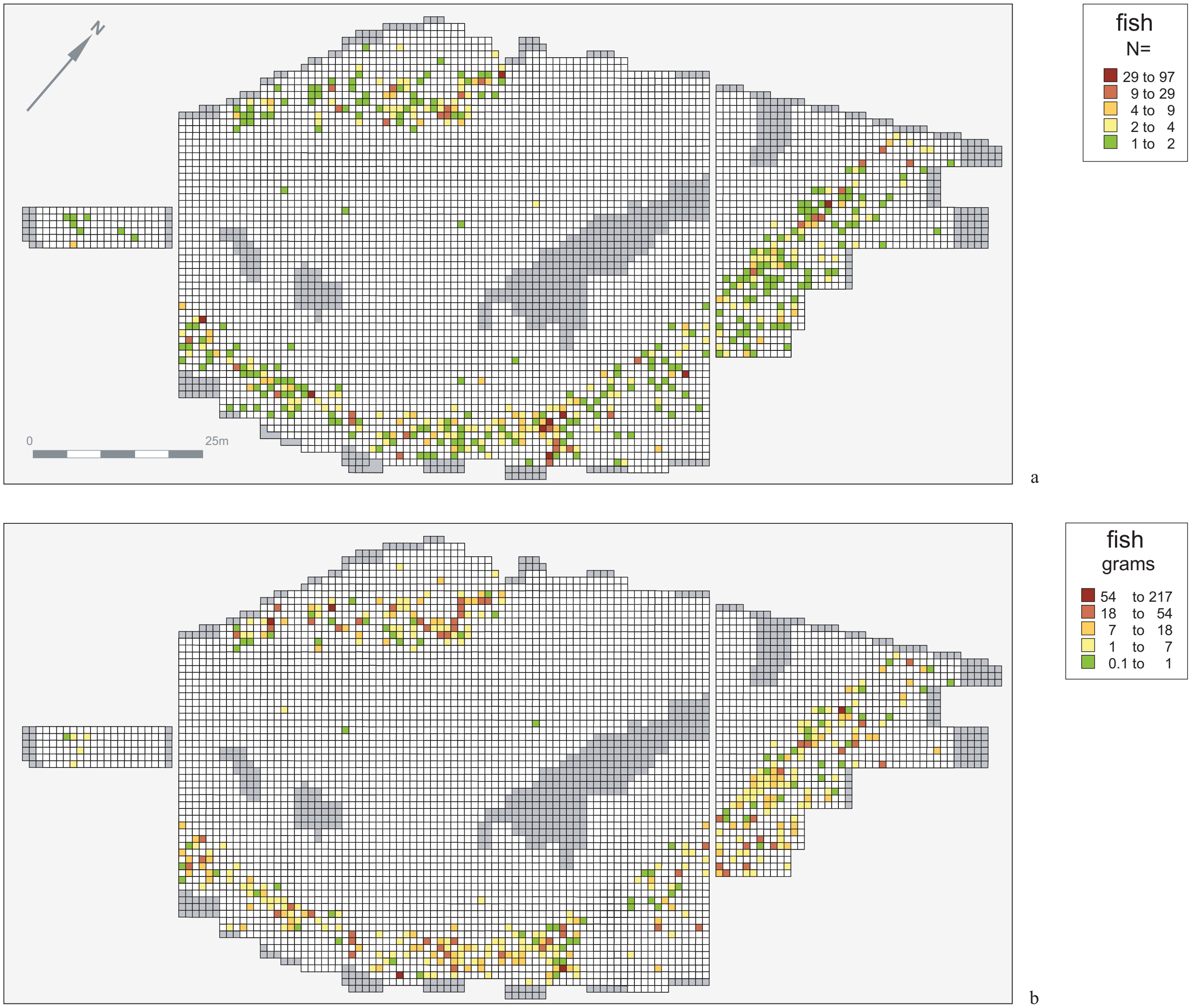


Figure 25.1 Distribution patterns of manually collected fish remains per square metre.
a number of identified bones
b bone weight

1941): pike (*Esox lucius*), perch (*Perca fluviatilis*) and members of the carp family (Cyprinidae): bream (*Abramis brama*), ide (*Leuciscus idus*), rudd (*Rutilus erythrophthalmus*) and roach (*Rutilus rutilus*). Most of the remains of this family could however not be identified to species level. The encountered species all commonly occur in stagnant or (gently) flowing fresh water – in the area known as the bream zone, which includes the basins of tidal rivers. Only modest numbers of remains of these species were found in all the fractions.

A freshwater fish species characteristic of the bream zone of which remains have been found at Neolithic sites, especially in the Rhine-Meuse-Scheldt basin, is the European catfish (*Silurus glanis*). No remains of this species were found at Schipluiden. Bones of large individuals would certainly have been encountered among the manually collected remains if this species had been caught and consumed. Evidently de European catfish did not occur in the waters fished by the Schipluiden occupants. It could be that the waters' salt content was too high for

		Units							selected features					other features					
	phase	1	1-2a	2a	2b	3	1-3	Totals	1-2	1-2a	2a	2	1-3	1	1-2	2a	2	1-3	Totals
	feature no.								13-585	12-48	12-36	10-140	18-350	N=1	N=2	N=7	N=2	N=16	
fresh water (stationary)																			
Abramis brama	bream	–	–	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–
Cyprinidae	carp family	–	–	1	–	–	–	1	–	–	–	–	–	–	–	1	–	1	2
Esox lucius	pike	–	–	2	–	1	1	4	–	–	–	–	–	–	–	–	–	–	–
Perca fluviatilis	perch	–	–	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–
	Subtotal	*0*	*0*	*5*	*0*	*1*	*1*	*7*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*1*	*2*
anadromous / catadromous																			
Acipenser sturio	sturgeon	15	59	896	299	180	90	1539	31	–	–	26	38	2	1	2	5	16	121
Anguilla anguilla	eel	–	–	1	2	3	–	6	–	–	–	–	–	–	–	10	–	–	10
Coregonus spec.	whitefishes	–	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–
Salmo salar / trutta	salmon / sea trout	–	–	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–
Pleuronectes spec.	flounder / plaice / dab	–	2	4	12	5	–	23	–	12	6	1	–	–	–	2		2	23
	Subtotal	*15*	*62*	*902*	*313*	*188*	*90*	*1570*	*31*	*12*	*6*	*27*	*38*	*2*	*1*	*14*	*5*	*18*	*154*
marine																			
Raja clavata	roker	–	–	2	–	–	1	3	–	–	–	–	–	–	–	–	–	–	–
Liza ramada	thin-lipped grey mullet	–	2	1	1	6	–	10	–	–	2	2	–	–	5	1	–	2	12
Liza ramada / aurata	thin-lipped grey mullet / golden grey mullet	–	–	1	2	1	3	7	–	–	2	–	–	–	–	–	–	2	4
Mugilidae	grey mullets	–	1	2	1	4	1	9	–	–	1	–	–	–	–	1	–	–	2
Dicentrarchus labrax	bass	–	3	–	2	1	–	6	34	–	–	–	–	–	–	1	–	1	36
	Subtotal	*0*	*6*	*6*	*6*	*12*	*5*	*35*	*34*	*0*	*5*	*2*	*0*	*0*	*5*	*3*	*0*	*5*	*54*
	Totals	*15*	*68*	*913*	*319*	*201*	*96*	*1612*	*65*	*12*	*11*	*29*	*38*	*2*	*6*	*18*	*5*	*24*	*210*

Table 25.2 Fish remains collected by hand; numbers of identifications presented according to context and phase.

this species. It is also possible, though less likely, that European catfish did occur in small quantities, but were not caught.

The represented marine species are roker (*Raja clavata*), bass *(Dicentrarchus labrax),* thin-lipped grey mullet (*Liza ramada*), herring (*Clupea harengus*), common goby (*Pomatochistus microps*) and members of the flounder family (*Pleuronectes* spec.).

Roker and bass may enter estuaries, but only the saline parts. The various species of the Mugilidae (grey mullets family) likewise live in the sea, but are known not to shun brackish and fresh water. About one third of the remains identified as deriving from 'grey mullets' could be attributed to the thin-lipped grey mullet.

Herring and allis shad/twaite shad live in schools of fish of the same size and age. A school usually consists of a single species, but sometimes the fish are joined by a few individuals of different species. They are known as pelagic species, which are fish that don't forage for food along the seabed, but at the surface of the water or a few metres beneath it. Schools of young herring may be encountered close to the shore and they are tolerant of brackish to fresh water. In recording fish populations in the river IJ and the Noordzeekanaal near Amsterdam, Melchers/Timmermans (1991) frequently encountered young herring.

The common goby (figs. 25.2 and 25.10) is a species typical of brackish water. The three species – common goby, sand goby and Lozano's goby – are now common along the Dutch coast. The common goby can live in the sea, but it is most often encountered in brackish water; the other two are marine species that can live in brackish water, too. The common goby is the smallest of the three, growing to lengths of at most 6.5 cm. The sand goby is the largest, reaching lengths of up to 10 cm (Nijssen/De Groot 1987). Gobies (Gobiidae) have so far not been encountered in archaeological contexts in the Netherlands. Their occurrence at Schipluiden was restricted to one feature (12-36), which contained 18 remains of this family, among which were three operculars of the common goby. The fact that remains of this family were found at Schipluiden we owe to the use of the fine-meshed 1-mm sieve. No remains of this family were found in the 2-mm fraction of the same sample (see fig. 25.6).

A number of ossa pharyngea inferiores and cleithra of right-eyed flatfishes (*Pleuronectes* spec.) were found to still possess sufficient characteristics to allow identification to species level. The remains in question all derive from

		N=							%						
		Units						feature	Units						feature
	phase / feature	1-2a	2a	2b	3	1-3	Totals	11-532	1-2a	2a	2b	3	1-3	Totals	11-532
fresh water (stationary)															
Abramis brama	bream	–	–	–	–	3	3	–	–	–	–	–	0.6	0.1	–
Rutilus erythrophthalmus	rudd	–	–	2	–	–	2	–	–	–	0.2	–	–	0.1	–
Rutilus rutilus	roach	–	1	–	–	1	2	–	–	2.3	–	–	0.2	0.1	–
Cyprinidae	carp family	10	4	113	7	25	159	4	3.4	9.1	10.5	2.1	5.1	7.1	1.5
Esox lucius	pike	1	–	7	3	3	14	–	0.3	–	0.7	0.9	0.6	0.6	–
Perca fluviatilis	perch	–	–	7	1	1	9	–	–	–	0.7	0.3	0.2	0.4	–
	Subtotal	*11*	*5*	*129*	*11*	*33*	*189*	*4*	*3.7*	*11.4*	*12.1*	*3.3*	*6.7*	*8.4*	*1.5*
anadromous / catadromous															
Acipenser sturio	sturgeon	25	3	342	188	80	638	106	8.5	6.8	31.8	55.5	16.2	28.4	40.0
Anguilla anguilla	eel	48	9	105	18	48	228	21	16.3	20.5	9.8	5.3	9.7	10.2	7.9
Alosa alosa	allis shad	–	–	1	–	1	2	–	–	–	0.1	–	0.2	0.1	–
Alosa alosa / fallax	allis / twaite shad	–	–	2	–	1	3	1	–	–	0.2	–	0.2	0.1	0.4
Coregonus spec.	whitefishes	8	2	13	3	12	38	4	2.7	4.5	1.2	0.9	2.4	1.7	1.5
Salmo salar / trutta	salmon / sea trout	2	–	23	–	4	29	–	0.7	–	2.1	–	0.8	1.3	–
Gasterosteus aculeatus	stickleback	–	1	–	–	–	1	13	–	2.3	–	–	–	0.1	4.9
Pleuronectes flesus	flounder	1	–	1	–	1	3	–	0.3	–	0.1	–	0.2	0.1	–
Pleuronectes spec.	flounder / plaice / dab	179	22	424	113	297	1035	87	60.9	50.0	39.4	33.3	60.2	46.1	32.8
	Subtotal	*263*	*37*	*911*	*322*	*444*	*1977*	*232*	*89.4*	*84.1*	*84.7*	*94.2*	*90.1*	*88.0*	*87.5*
marine															
Raja clavata	roker	2	–	7	–	2	11	–	0.7	–	0.7	–	0.4	0.5	–
Liza ramada	thin-lipped grey mullet	3	–	4	3	1	11	–	1.0	–	0.4	0.9	0.2	0.5	–
Liza ramada / aurata	thin-lipped grey mullet / golden grey mullet	4	–	3	1	2	10	24	1.4	–	0.3	0.3	0.4	0.4	9.1
Mugilidae	grey mullets	6	–	4	–	9	19	–	2.0	–	0.4	–	1.8	0.8	–
Dicentrarchus labrax	bass	5	2	18	2	2	29	5	1.7	4.5	1.7	0.6	0.4	1.3	1.9
	Subtotal	*20*	*2*	*36*	*6*	*16*	*80*	*29*	*6.8*	*4.5*	*3.5*	*1.8*	*3.2*	*3.6*	*11.0*
	Totals	*294*	*44*	*1076*	*339*	*493*	*2246*	*265*	*100*	*100*	*100*	*100*	*100*	*100*	*100*

Table 25.3 Fish remains from 4-mm sieve residues; numbers of identifications presented according to context and phase.

flounders (*Pleuronectes flesus*). In addition, a number of dermal denticles were found, in particular in the 1-mm sieve fraction. They are characteristic of flounders; plaice and dab have no dermal denticles. They are hence indisputable evidence of flounders, making it very likely that many of the other *Pleuronectes* spec. remains derive from this species. Perhaps even all the remains in question derive from flounders. For this reason, the *Pleuronectes* spec. have in the tables been listed under the heading of anadromous/catadromous species. As already mentioned, flounders are catadromous fish.

25.4.2 Dimensions

For a good estimate of the economic importance of the various fish species and an impression of the employed fishing methods it is interesting to know the dimensions of the most important fish species. To this end the total lengths were estimated of a number of large individuals of sturgeon, *Pleuronectes* spec., thin-lipped grey mullet and bass on the basis of the dimensions of certain skeletal parts. No efforts were made to estimate the lengths of other caught species such as salmon/sea trout, pike*, etc*. due to the absence of undamaged remains.

Sturgeon

For sturgeon, Desse-Berset (1994) uses two dimensions (1 and 2) of the palatopterygoideum to estimate an individual's length. In a present-day sturgeon with a length of 180 cm, dimension 1 is about 9.0 mm and dimension 2 about 14.7 mm. A very large, almost complete palatopterygoideum, whose dimension 1 was 12.4 mm and dimension 2 was 20.2 mm, was found in Unit 18 (no. 7455, fig. 25.3).

		N=								%							
		Units				features				Units				features			
	phase	1	1-2a	2a	2b	1-2a	2a	3	1-3	1,0	1-2a	2a	2b	1-2a	2a	3,0	1-3
	feature / find no.	4742	4215	sum	sum	12-48	12-36	898	17-332	4742	4215	sum	sum	12-48	12-36	898	17-332
fresh water (stationary)																	
Leuciscus idus	ide	–	1	–	–	–	–	–	–	–	2,8	–	–	–	–	–	–
Rutilus erythrophthalmus	rudd	1	–	4	–	–	–	1	1	1	–	2,0	–	–	–	+	1
Cyprinidae	carp family	9	17	21	23	–	15	27	2	12	47	11	18	–	1	4	1
	Subtotal	*10*	*18*	*25*	*23*	*0*	*15*	*28*	*3*	*13*	*50*	*13*	*18*	–	*1*	*4*	*2*
anadromous / catadromous																	
Acipenser sturio	sturgeon	1	–	5	2	–	3	–	1	1	–	3	2	–	+	–	1
Anguilla anguilla	eel	43	5	54	47	–	45	740	9	56	14	28	36	–	2	96	6
Alosa alosa / allax	allis shad / twaite shad	–	–	–	–	–	4	–	–	–	–	–	–	–	+	–	–
Osmerus eperlanus	smelt	–	1	12	7	1	916	–	83	–	3	6	5	1	48	–	50
Coregonus spec.	whitefishes	2	1	5	–	–	3	–	–	3	3	3	–	–	+	–	–
Salmo salar / trutta	salmon / sea trout	–	–	6	2	–	2	–	–	–	–	3	2	–	+	–	–
Gasterosteus aculeatus	stickleback	2	1	39	7	–	31	–	9	3	3	20	5	–	2	–	6
Gasterosteidae	sticklebacks	–	–	15	25	–	–	–	–	–	–	8	19	–	–	–	–
Pleuronectes flesus	flounder	5	6	6	3	12	31	–	10	7	17	3	2	16	2	–	6
Pleuronectes spec.	flounder / plaice / dab	12	4	29	13	62	495	–	37	16	11	15	10	83	26	–	22
	Subtotal	*65*	*18*	*171*	*106*	*75*	*1530*	*740*	*149*	*84*	*50*	*87*	*82*	*100*	*80*	*96*	*90*
marine																	
Clupea harengus	herring	–	–	–	–	–	52	–	1	–	–	–	–	–	3	–	1
Clupeidae	herring family	–	–	–	–	–	297	–	9	–	–	–	–	–	16	–	6
Liza ramada	thin-lipped grey mullet	–	–	–	–	–	3	–	1	–	–	–	–	–	+	–	1
Liza ramada / aurata	thin-lipped grey mullet / golden grey mullet	1	–	–	–	–	1	–	–	1	–	–	–	–	+	–	–
Mugilidae	grey mullets	1	–	–	–	–	1	–	–	1	–	–	–	–	+	–	–
Dicentrarchus labrax	bass	–	–	–	–	–	5	–	2	–	–	–	–	–	+	–	1
Pomatoschistus microps	common goby	–	–	–	–	–	3	–	–	–	–	–	–	–	+	–	–
P. microps / minutes / lozanoi	common / sand / Lozano's goby	–	–	–	–	–	15	–	–	–	–	–	–	–	1	–	–
	Subtotal	*2*	–	–	–	–	*377*	–	*13*	*3*	–	–	–	–	*20*	–	*8*
	Totals	*77*	*36*	*196*	*129*	*75*	*1922*	*768*	*165*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*

Table 25.4 Fish remains from 1- and 2-mm sieve residues; numbers of identifications presented according to context and phase.

This sturgeon must have been between 247 and 248 cm long.

Desse-Berset (1994) also introduced two dimensions (1 and 2) for the sturgeon's dentale for estimating an individual's length. The dentale's height is measured at two points. In a present-day sturgeon with a length of 180 cm, dimension 1 is about 8.1 mm and dimension 2 about 9.3 mm. In total, three measurable sturgeon dentalia were found at Schipluiden (nos. 4351, 3179 and 2926, fig. 25.3). The calculated lengths of the animals range from 185 to 367 cm (table 25.5).

It should also be possible to calculate a sturgeon's total length on the basis of the greatest length of the aforementioned skeletal elements. The dimensions of the excavated palatopterygoideum and the three dentalia are given in table 25.5.

The outcomes of the different calculations clearly differ substantially from one another. Which outcomes most closely approach the Schipluiden sturgeons' actual lengths is not clear at this stage. A length of 350 cm is feasible.

Hochleithner (1996) states that a sturgeon can grow to a total length of 6 m. What we do know for sure is that some of the sturgeons caught by the Schipluiden occupants were longer than 2 m, and that means that they were adult individuals (of a spawning age).

Eel

The dimensions of the eel remains show that the Schipluiden occupants caught eels with a body diameter of 2 to 3 cm.

Right-eyed flatfishes

To obtain an impression of the sizes of the caught flatfishes, the largest widths (in mm) of the posterior articular surface of the smallest and the largest specimens of vertebra I of *Pleuronectes* spec. were measured. Enghoff (1989) gives a formula for calculating the relation between the total length (TL) of *Pleuronectes flesus* and the aforementioned width

Figure 25.2 Remains of Gobiidae, including those of common goby (*Pomatoschistus microps*) (magnification 10×).

(W). This regression formula is: TL = 69.7268 × $W^{0.9068}$. The smallest and largest dimensions yielded lengths of 18.3 cm and 46.0 cm, respectively. The dimensions of two ossa analia from feature 12-36 yielded lengths of 25.4 and 28.5 cm according to the formula developed by Brinkhuizen (1989).

Thin-lipped grey mullet

Among the fish remains found at Schipluiden are also some thin-lipped grey mullet operculars. In the case of eleven of these operculars, the distance between the dorso-rostral corner and the bottom side of the articular cavity could be measured. A thin-lipped grey mullet's length can be calculated on the basis of this dimension.[2] The lengths of the Schipluiden individuals were found to range from 27.2 to 53.5 cm.

Find number 435 contained a very large penultimate caudal vertebra, with a length of 10.3 mm, of thin-lipped grey mullet/golden grey mullet. In a 48-cm-long present-day thin-lipped grey mullet this vertebra was found to be 7.4 mm

no.	skeletal element	measurement	result (mm)	multiplication factor based on recent sturgeon with a length of: 1800 mm.	940 mm.	estimated total length (cm)
7455	palatopterygoideum	m 1	12.4	200	–	248
		m 2	20.2	122.4	–	247
		gr. length	85.0	–	33.6	286
4351	dentale	m 1	–	222.2	–	–
		m 2	15.5	193.6	–	300
		gr. length	–	–	31.1	–
3179	dentale	m 1	13.8	222.2	–	307
		m 2	15.0	193.6	–	290
		gr. length	59.4	–	31.1	185
2926	dentale	m 1	16.5	222.2	–	367
		m 2	16.6	193.6	–	321
		gr. length	68.6	–	31.1	213

Table 25.5 Sturgeon (*Acipenser sturio*), total length of some individuals calculated on the basis of the dimensions of palatopterygoideum and dentale.

3916

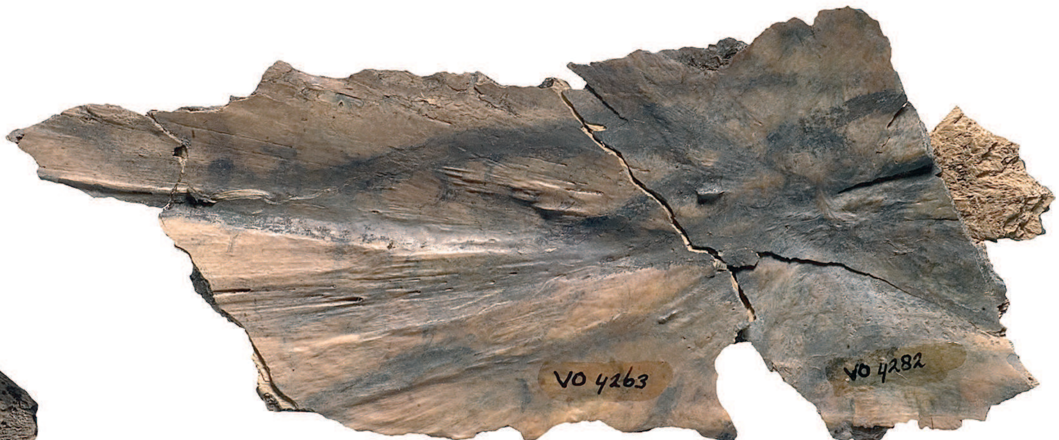
4351

3179

7455

2926

3842



4263 + 4282

974

no.	skeletal element	measurement	result (mm)	factor	estimated total length (mm)
7728	vertebra I	gr. width:	9.8	40.20	394
8329	vertebra I	gr. width:	11.4	40.20	458
598	quadratum L.	gr. width:	5.4	80.39	434
10179	operculare L.	gr. height:	43.9	11.14	489
10179	operculare R.	gr. height:	44.2	11.14	492
10179	operculare R.	gr. height:	40.8	11.14	455
6524	urohyale	gr. width:	6.1	117.41	716
8946	posttemporale L.	gr. length:	6.7	16.27	109

Table 25.6 Bass (*Dicentrarchus labrax*), total length of some individuals estimated on the basis of the dimensions of various skeletal elements.

long. Conversion shows that the excavated vertebra derives from a fish with a length of around 66.5 cm. This means that it must come from a thin-lipped grey mullet, because according to Nijssen/De Groot (1987), golden grey mullets have a maximum length of 45 cm. Thin-lipped grey mullets can grow to a length of 70 cm. The excavated vertebra hence represents a very large individual.

Bass
The fish remains include several fragments of bass that could be used to calculate the individuals' total length (table 25.6). Use was made of the dimensions of two present-day specimens with lengths of 41 cm and 68 cm. The calculated length of the largest Schipluiden bass is 71.6 cm. This is quite large, because Nijssen/De Groot (1987) quote a maximum total length of 80 cm.

25.4.3 Taphonomy
Cut marks
Cut marks and surfaces formed by cutting are not usually observed on fish bones. There where they are present, they are usually observed on the largest elements of large individuals. Among the Schipluiden fish remains were only two sturgeon bones showing what could be a surface formed in cutting (fig. 25.3, lower row). The first (no. 4282) fits one of the sturgeon remains of find no. 4263. Together they constitute the greater part of a left parietale, an element from the fish's cranium. This parietale showed a straight edge on the caudal side that may have been formed in cutting. If so, the bone was transversely cut from the medial side and then snapped. The second fragment is a cranial fragment of the first fulcral plate of a sturgeon's anal fin (no. 974). The plate seems to have been obliquely cut from both the left and the right side, because its edges are caudally partly straight. These surfaces may have been formed in cutting. No scratches were however visible at the edges of either piece under the microscope.

Traces of burning
Of all the identified fragments, only 301 (4%) showed traces of burning. Of the manually collected remains, 118 fragments (6.5%) are carbonised, calcined or show traces of burning. 152 (6.1%) of the remains recovered from the 4-mm sieve and 31 (1%) of those from the 1-2-mm sieves had been in contact with fire. These low percentages of burnt bone suggest that burning was of minor importance in the taphonomy of the fish remains. It is however very doubtful that this was indeed the case. Burning has a far more destructive effect on fragile fish bones than on for example mammal bones. The author's own experience has shown that thorough burning results in predominantly very fine crumbs. Such minute fragments will have been contained mainly in the finest sieved fractions. But as they could not be identified, and were hence not counted, the volume of this fraction is unknown.

Traces of gnawing
Traces of gnawing were observed on a very small number of sturgeon fragments, notably a pectoral fin ray (no. 2728), a large dorsal plate (no. 3245) and one left and one right

◂Figure 25.3 Remains of sturgeon (*Acipenser sturio*) (scale 1:1).

4351, 3179, 2926	dentales from the right side
3916	right cleithrum showing pathology
7455	palatopterygoideum
3842	spina pinnae pectoralis, pathologically deformed
974	fulcral plate with possible (straight) cutting edges
4263 + 4283	medial view of left parietale with possible cutting edge

opercular (no. 10,179). The marks observed on the first two elements were almost certainly made by dogs. This small amount of evidence does not mean that gnawing played no role in the taphonomy of the fish remains. Quite the contrary – many fish bones will have disappeared completely as a result of gnawing.

Vertebrae showing metabolic distortion
According to Wheeler/Jones 1989), when a mammal devours a fish complete with its head and tail, the fish's bones may suffer distortion during their passage through the gastrointestinal tract. The aforementioned authors illustrate this with some photos of distorted vertebrae recovered from medieval cesspits. They assume that the bones in question were flattened and distorted during the time they spent in the stomach and intestines. Beerenhout (1996) in this context speaks of vertebrae showing 'metabolic distortion'.

At Schipluiden, a total of 3280 vertebrae were identified. Twelve of those vertebrae (0.4%) showed signs of such metabolic distortion. Nine of the vertebrae concerned derive from *Pleuronectes* spec., one from smelt, one from whitefishes (C*oregonus* sp.) and one from bass (*Dicentrarchus labrax*). Interestingly, three of these vertebrae (two of *Pleuronectes* spec. and one of smelt) were found in the 1- and 2-mm sieve fractions of feature 12-36 (see 25.5.3).

25.4.4 Pathologies
Bones showing aberrant growth, signs of trauma or disease are commonly found in human, and sometimes other mammalian bone assemblages. Aberrant fish bones are however very rare in collections of fish remains and are usually misinterpreted as anomalous specimens. It should be stressed that little is known about which fish diseases can be detected in a study of fish bones, scales or other hard tissues. This contrasts markedly with the extensive literature on diseases and their imprints on human and other mammalian bones. There is however ample evidence showing that abnormalities in fish bones may be induced by parasites, spawning stress and changes in environmental conditions.

The Schipluiden fish bone assemblage included three bones showing pathologies (figs. 25.3-4). No. 3916 comprises a right postorbital and a dorsal fragment of a right cleithrum of a sturgeon showing an anomalous thickening of the bone on the medial side. No. 3842 is a ray from a sturgeon's right pectoral fin, which is proportionally too short and has a distorted distal end. Besides other fish remains, find no. 332 contained an eel's right dentale with abnormal proportions. The element may have become substantially shorter than normal due to an infection that affected the bone (fig. 25.4).

Figure 25.4 Eel (*Anguilla anguilla*), right dentale showing pathology (no. 332, magnification 6×).

25.5 FISHING
25.5.1 Representativeness of the samples and identifications
The identified fish remains cannot be easily interpreted in terms of answers to the set research questions. The great differences in the dimensions of the caught individuals, and hence of their remains, of course imply substantial differences in the species spectra and the ratios of the individual species between the assemblages collected according to the different methods. Differences in deposition processes have moreover led to remarkable differences between a number of contemporary find groups.

Manually collected remains versus sieved fractions (fig. 25.5)
Due to the differences in the fish remains' dimensions, the species spectra of the assemblages collected according to the different methods differ substantially, in both qualitative and quantitative terms (tables 25.2-4). Each fraction provides its own picture of the prehistoric fishing practices, and that was indeed one of the reasons for following the different sieving procedures.

The manually collected remains provide a very biased impression of the fishing practices. This assemblage is dominated by the (large) remains, predominantly bony plates, of sturgeons, representing 91%, with a weight of 4258 grams. The assemblage also contains some chance remains of other species.

The various sieved fractions provide essential complementary information (fig. 25.5): right-eyed flatfishes and sturgeon account for 28 and 46%, respectively, of the 4-mm residue, but they were represented by only a few fragments in the fifteen 5-litre samples. The remains of the relatively large marine fish such as roker, grey mullet and bass were also almost all found in the 4-mm fraction.

Small fish remains are underrepresented in this fraction as they could only be collected in the sieving through a smaller mesh width, and this of course holds in particular for all remains of small fish. Remains of herring, smelt and stickleback were recovered (almost) exclusively thanks to the sieving through a 2-mm mesh, and remains of

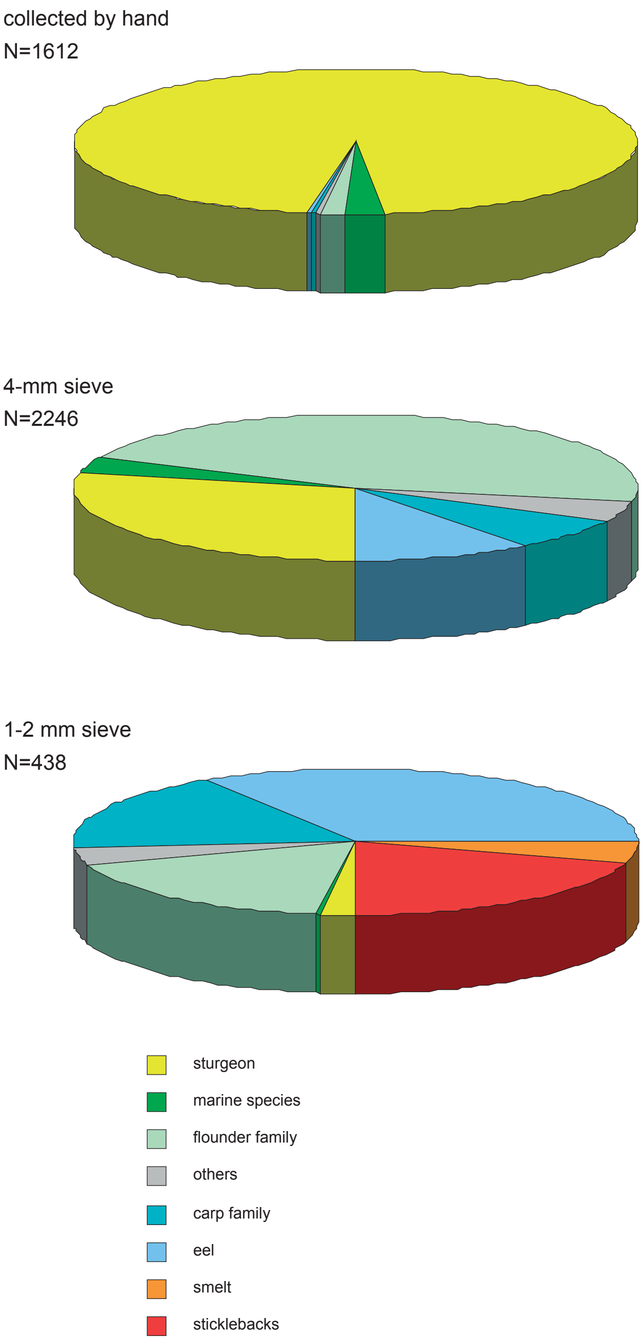


Figure 25.5 Species compositions of the assemblages of fish remains recovered by hand and by systematic wet sieving over a 4-mm mesh and compositions of selected, relatively rich samples sieved over 2- and 1-mm meshes. Remains from units only.

common goby were found only in the 1-mm fraction (fig. 25.6).

As the soil was sieved only after all clearly visible remains had been collected by hand, large remains are of course underrepresented in the 4-mm sieve residue, and this residue is for that reason not representative of this fraction. The total find population >4 mm (P) can however be easily calculated: P = M + 12S (see chapter 4). As the two fractions are both of the same order of magnitude (N= 1610 and 2246, respectively) and as M is totally dominated by sturgeon remains (96%), there is only little discrepancy: the sturgeon score increases by a few percent (from 28 to 32%) and the scores of all the other species decrease correspondingly by about 1/20 (fig. 25.7).

The results of the small number of samples that were sieved through the 1-mm mesh cannot be converted in a comparable simple manner. The volume of soil (55 litres as opposed to around 1000 m^3) cannot be used because these samples were selected for identification because they were relatively rich in finds. Neither can the find density of the only theoretically suitable common element – sturgeon remains – be used as the densities in the 4-mm fraction were a factor of 20 lower. The results of the fine fractions must hence be independently interpreted and may not be added to the results obtained for the other remains.

Differences in context and deposition

The remains recovered from the various units will on the whole represent the occupants' (different) fishing practices throughout many dozens of years. This holds for both the manually collected remains (M) and the remains recovered from the 4-mm sieve (S) through which part of the excavated soil was washed (see chapter 1). It does not hold for the analysed samples of the 2- and 1-mm sieve fractions (fig. 25.8 left), since most of these were taken from concentrations of fish remains, such as no. 898 (which is hence not representative of phase 3). Neither does it hold for at least two of the four samples from pit fills. The spectra that deviate from the average spectrum are attributable to single depositions of remains of specialist fishing expeditions (no. 898) or to a pit's functioning as a fossil trap (features 12-36 and 12-48). Herring, smelt and common goby were (almost) exclusively encountered in one or two pit samples. These exceptional depositions are responsible for the relatively high scores in the fine fractions of the pits as a group.

Marine fish – both large and small species – scored remarkably higher in the pit samples than in the samples from the deposits. In the case of the large marine species this proved to be largely attributable to one case (feature 13-585, table 25.2) of 34 manually collected bass remains, and of 24 grey mullet remains in a different pit fill (feature 11-532,

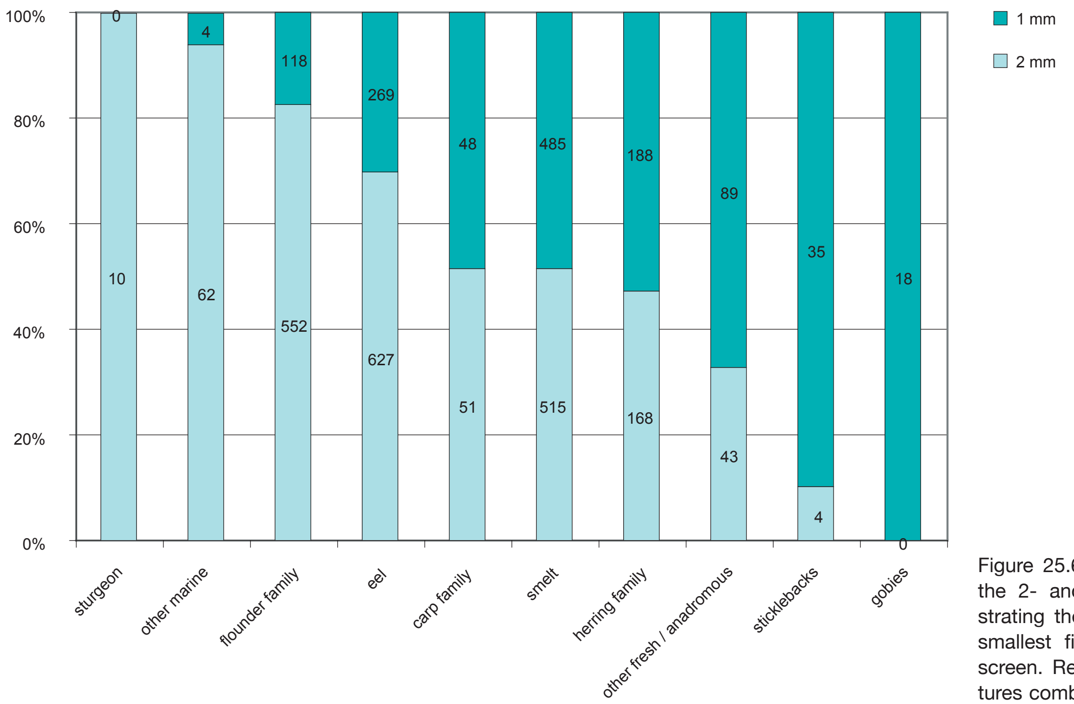


Figure 25.6 Species compositions of the 2- and 1-mm fractions demonstrating the selective recovery of the smallest fish species on the 1-mm screen. Remains from units and features combined.

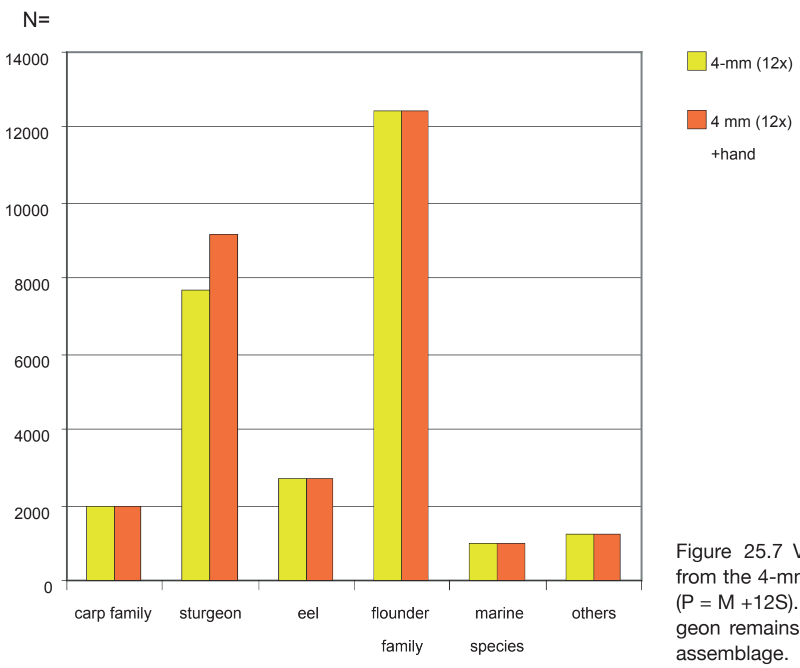


Figure 25.7 Volume-corrected composition of the fish assemblage from the 4-mm screen compared with the calculated total assemblage (P = M +12S). The remains collected by hand – almost exclusively sturgeon remains – have hardly any influence on the composition of the assemblage.

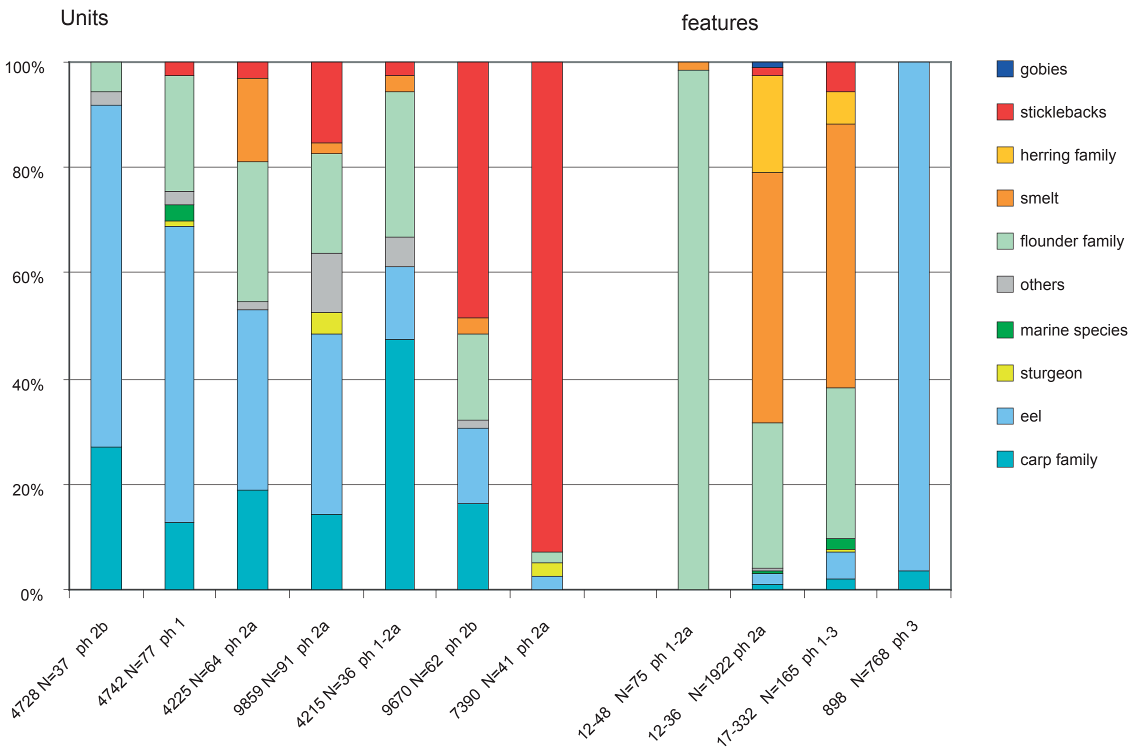


Figure 25.8 Species composition of all analysed 1- and 2-mm samples from units and features. Note the extreme diversity, pointing to a single-event deposition of at least more than half of the remains.

table 25.3). The remains could in each case derive from a single fish or a small number of individuals.

25.5.2 The species caught – the general picture

From the manually collected remains, the 4-mm sieve residues and the 1-mm sieved samples from the deposits it can be concluded that the occupants' fishing strategies focused on three species: sturgeon, eel and flounder. In all the sufficiently large fractions from all the phases these three species together account for more than 80% of the remains.

The relative importance of sturgeon is difficult to assess. Sturgeons are much bigger than the other fish, but on account of their long rows of bony plates they also produce larger quantities of waste, which is moreover readily identifiable, even in small fragments. This waste is however also brittle. These factors make it impossible to compare sturgeon remains directly with remains of other fish species. It is therefore better to consider the sturgeon remains separately from the 'fish total' (100%) of the calculations, and to specify their percentage relative to this calculation basis. The importance of sturgeon can best be assessed in the aforementioned calculated total population of remains (P = M + 12S, fig. 25.7).

The sturgeon percentages thus calculated vary substantially, but are almost all high, ranging from an exceptionally low 10% in phases 1-2a to 183% in phase 2a. These fluctuations are more likely to be attributable to differences in deposition and taphonomy than to differences in ecological and/or subsistence factors. In view of its size and the large numbers of remains, sturgeon may be assumed to have been an important source of animal protein at Schipluiden, as it was likewise to be in later times at the Vlaardingen settlements in the Rhine/Meuse estuary.

Flounder remains were prominently represented in the 4-mm fraction, amounting to 54-75% of all the fish remains, whereas eel remains were – to a slightly lesser extent – dominant in the 2- and 1-mm fractions. In view of the difference in their shapes it is not really possible to say which of the two species was the most important; neither can their importance relative to sturgeon be assessed.

The volume of the other fish species caught was relatively modest. The assemblage includes a small component of relatively large marine species, which will have swum into the estuary: grey mullets, bass, roker. Salmon and allis shad

Figure 25.9 Smelt (*Osmerus eperlanus*). Dentales retrieved from the 2 mm sieve (magnification 2×).

or twait shad were incidentally caught, too. On account of their size, they will have been of greater economic importance than is suggested by the number of surviving remains.

The same cannot be said of the freshwater component. The largest fish (pike and bream) were caught in only small quantities. The freshwater score is largely attributable to members of the carp family, probably predominantly roach and rudd.

25.5.3 Short-term depositions at random moments in time (fig. 25.8 right)

Feature 12-36, no. 7013 (phase 2a)

A rich concentration of predominantly very small fish remains was found in the secondary fill of a medium-sized unlined well (3.60 × 1.45 m). A 5-litre sample was sieved through a 1-mm-mesh sieve. The preservation conditions in the well had been good enough to ensure the survival of 38 branchialia (parts of the gill arch skeleton) of *Pleuronectes* spec. This means that the well became filled with sediment, and its contents cut off from the air, shortly after the fish had been deposited in it. Table 25.4 specifies the encountered species and the numbers of remains and percentages per species. Another eleven fish remains were collected from the well by hand.

The species spectrum of this well differs substantially from the general spectrum. Two other species are dominant among the 1922 identified remains: smelt (N=916) and members of the herring family (N=349). Among these remains are a relatively large number of bones of herring itself plus remains of a few small allis shads or twaite shads. The smelt had an estimated length of 10 cm. The number of left dentales (fig. 25.9) points to a minimum of 60 individuals. The herrings were 6 to 8 cm long; the remains represent at least 13 individuals. Almost all skeletal elements were encountered. Besides these herring and smelt remains the well also yielded a relatively large number of remains of two other small fish species: stickleback (N=31) and goby (*Pomatoschistus* species), including the common goby (N=18).

The third most frequently encountered species is *Pleuronectes* spec., represented by 526 identifications, including 31 of flounder, with calculated lengths of between 18.3 and 37.5 cm, *i.e.* of the same dimensions as the bones in the general assemblage.

Finally, the well assemblage also included some remains of grey mullets, salmon/sea trout, a small bass, eel, *Coregonus* and members of the carp family, plus the cranium of a very small sturgeon (3 fragments).

Well 17-332 yielded a smaller fish assemblage with a very similar composition.

These assemblages seem to be the outcomes of different deposition processes. The isolated, relatively large remains mentioned last in the above survey may be assumed to represent part of the fish remains that occurred scattered across the site. The numerous remains of right-eyed flatfishes of ‘normal’ dimensions could be the waste of a single specialist fishing expedition. The fact that almost all elements of their skeleton are represented suggests that the smaller fish (smelt and herring, but also allis shad/twaite shad, stickleback and common goby) ended up in the pit complete with their heads and tails. The question is whether this is attributable to a natural process or to activities of the occupants.

The remains themselves provide somewhat contradictory information in this respect. They do seem to have undergone the usual postdepositional processes. Eighteen fragments of different species, including five smelt vertebrae, are carbonised or burnt. This proportion of burnt bone does not differ from the overall percentage obtained for the 1-2-mm sieve fractions. Three vertebrae, including one of smelt, show metabolic distortion, pointing to consumption. The option that the remains represent the stomach contents of a fish-eating mammal, as Beerenhout

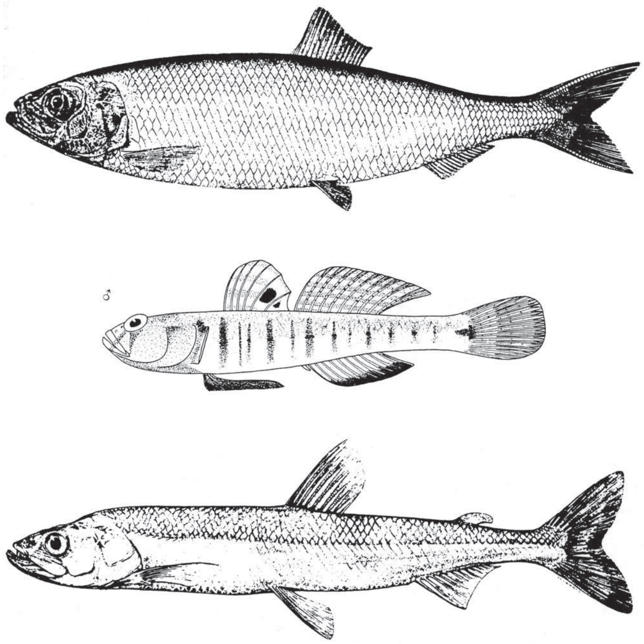


Figure 25.10 Herring (up to 40 cm), common goby (up to 6.4 cm) and smelt (up to 30 cm).Their remains – together with those of three-spine stickleback – are important indicators of salt incursions in the fills of some wells. After Whitehead *et al.* 1984-'86.

(1996) assumed for a similar case at Wateringen, is not very likely as the bones are not very fragmented. Moreover, at most only 8% of the vertebrae of the identified minimum number of 60 smelt individuals were found, so most of the vertebrae were missing. This could be attributable to consumption, but also to the sieving process. The best explanation for this concentration of remains of more or less complete small fish in this former well would ultimately appear to be that the assemblage was formed when a group of small fish became trapped in the well due to a natural process – flooding of the area with saline or brackish water at an extremely high tide.

The well's position makes this explanation quite plausible. It was one of the lowest-lying wells, at the periphery of the large concentration of wells, and the edge of its fill was intersected by a fence. The well was nevertheless dated to phase 2a, rather than phase 1, on the basis of the nature of its fill. As this is the only observed case of such a concentration of fish remains, and the well in question lay at a low position on the dune slope, we must conclude that tides that were so high as to cause the foot of the dune to be flooded by seawater were quite exceptional.

Schools of herring or smelt may well have been washed into the estuary and have become caught there during storm tides. Writing about the fish fauna of the Dutch Biesbosch area, Verhey (1961) mentions that many dead young smelt would sometimes be found when the water retreated from flooded pastures after a storm tide. It is quite conceivable that something similar happened in the first phases of the dune's occupation, and that the retreating water left behind dead fish in a depression, and possibly also on the ground around it. Any remains left on the surrounding ground will for some time have undergone various postdepostional processes such as burning and consumption by animals before secondarily ending up in the fill of the depression. The smelt, small herring, stickleback and common goby in this sample – and probably more in general too – are therefore to be interpreted as 'natural background fauna', and not as fished species (fig. 25.10).

Feature 12-48, no. 6085

A second noteworthy feature in which fish remains were found is feature 12-48 – a small, deep, low-lying pit that was interpreted as a deposition pit and was dated to phases 1-2a (chapter 3). This pit represents a remarkable archaeological phenomenon. Besides more than 60 mammal remains (section 22.3.7) and – at a deeper level – a large number of sloes (section 19.5.1), this pit also yielded fish remains – almost exclusively remains of right-eyed flatfishes (N=74), including 12 flounder remains. This also points to intentional deposition.

No. 898 (trench 16, Unit 10, phase 3)

This sample contained a concentration of well-preserved fish remains from the peat of Unit 10, *i.e.* from phase 3, to the northwest of the dune, at an exceptional location: at a relatively large distance (approx. 20 m) from the foot of the dune, outside the dump zone. The sample is the only one of its kind, but it is possible that we owe its discovery to an excavator with a particularly keen eye and that other, similar concentrations remained unobserved. A 15-litre sample was sieved through a 1-mm-mesh sieve.

Of the 768 identified remains, 740 (96.4%) derive from eel (717 of which are vertebrae) and 28 from cyprinids. From the most frequently encountered skeletal element we may conclude that the remains represent at least six eels and three members of the carp family. The sample seems to represent the remains of eel fishing, in which the odd cyprinid was caught, too. This fishing will have been done in a freshwater environment, for example using wicker traps. In phase 3 eel may have been caught in the dune's immediate surroundings.

25.5.3 *Fishing methods*

The wide variety of caught fish species implies that the dune occupants used several different fishing techniques. There is unfortunately virtually no evidence on the employed fishing techniques, but fish traps and fish weirs made of wooden

Figure 25.11 A 60-cm-long Atlantic sturgeon fished in February 1993 in Amsterdam harbour. It must be a specimen of a French reintroduction programme. The Atlantic sturgeon was fished in the Dutch lower river courses until the 19th century and has – after occasional catches until the mid-20th century – now disappeared from the Netherlands (De Nie 1996).

posts and nets are known from other Mesolithic and Neolithic sites in the Rhine-Meuse delta. Fish hooks are extremely rare.

Sturgeon

The fishing of the important – for very large – sturgeon (fig. 25.11) focused on fully grown individuals in the spawning season. Verhey (1961) states that sturgeons spawn in shallow water with a maximum depth of two metres and that sturgeons used to occur in shallow parts of the Nieuwe Merwede canal. The fish spawn on hot days, when they swim close to the surface of the water and sometimes jump above it. Only the males show this lively behaviour (Siebelink, 2004). The females are heavily loaded with roe, and swim just above the riverbed. The behaviour of sturgeons in the spawning season will at the time of the occupation of the Schipluiden dune have been no different from that observed by Verhey. This means that the settlement's occupants will have seen the sturgeons swimming close to the surface in the spawning season, and will have been able to catch them easily with a harpoon or a spear. A different way of catching sturgeon is described by Boddeke (1971), who was inspired by wooden posts found in a creek at Vlaardingen. He assumes that at this site, fish were caught in a double weir built in a small creek; when the tide fell, the entrance of the downstream weir would be closed with a wide-meshed net.

Eel

The fishing gear used to catch eel was most probably a light-weight osier trap of the kind that has been found at various Mesolithic and earlier Neolithic sites, such as Hardinxveld-De Bruin (5100 cal BC), Hoge Vaart (4800 cal BC) and Bergschenhoek (4200 cal BC). Small individuals of other species may also have been caught in such traps, as assumed in the case of sample 898. Such species may have been roach, but also smelt and three-spine stickleback.

Flounder

Flounders can be caught fairly easily, for example via 'flounder trodding' or with the aid of spears or a special flounder net (a rectangular knitted net) that is set up on a sandbank at low tide and checked for the presence of fish at the next low tide. The predecessor of such a net was an osier fence (a weir) permanently erected on a sandbank. Besides flatfishes, species such as roker, allis shad/twaite shad, grey mullets and bass may have been retained behind such a fence at low tide and collected for consumption.

25.6 The fished waters

The former physical-geographical conditions in the site's immediate and wider surroundings were determined in the landscape-genetic research (chapter 14) and the diatom analysis (chapter 15). The site was situated on tidal deposits several kilometres behind the coastline. At the southern periphery of the assumed territory was an estuary, via which the lower reaches of the Meuse and possibly also a branch of the Rhine flowed into the sea. A short distance to the east of the site was the boundary of the vast area of Holland peat. In the course of the occupation period the site's immediate surroundings became less susceptible to marine ingressions and the estuary appears to have become narrower.

We assume that the dune occupants caught their fish not too far from their settlement, that is, within the site territory over which they enjoyed exclusive or collective rights of use (*cf.* chapter 27). The size of that territory can be only roughly indicated, but even if we assume that it had a radius of only a few kilometres, it will have contained a good range of fishing waters in which all the aforementioned ecozones were represented. Do the results of the study of the fish remains tell us where the fish were caught?

The remains of freshwater fish imply that people fished in the fresh water, while those of marine fish tell us that they also caught fish in salt water. Either the dune occupants had access to both environments or the salt content of their fishing grounds varied throughout the period of occupation. In times when a river discharges large quantities of water, for example in spring due to the melting of ice and snow, the salt/fresh water boundary will move seawards. Fishermen then catch mainly freshwater and migratory fish. When little fresh water is discharged – for example in the summer – or in the event of storm floods, the salt water may penetrate deeper into an estuary. Besides migratory species, the catch will then also comprise marine species that tolerate brackish water.

Of particular importance in this context are the observations that provide information on the fishing practices reflected by the mixed samples from the deposits. Eels were caught in water in which members of the carp family were also to be found (no. 898) and there are two indications of specialist fishing for flounder (features 12-36 and 12-48). We moreover

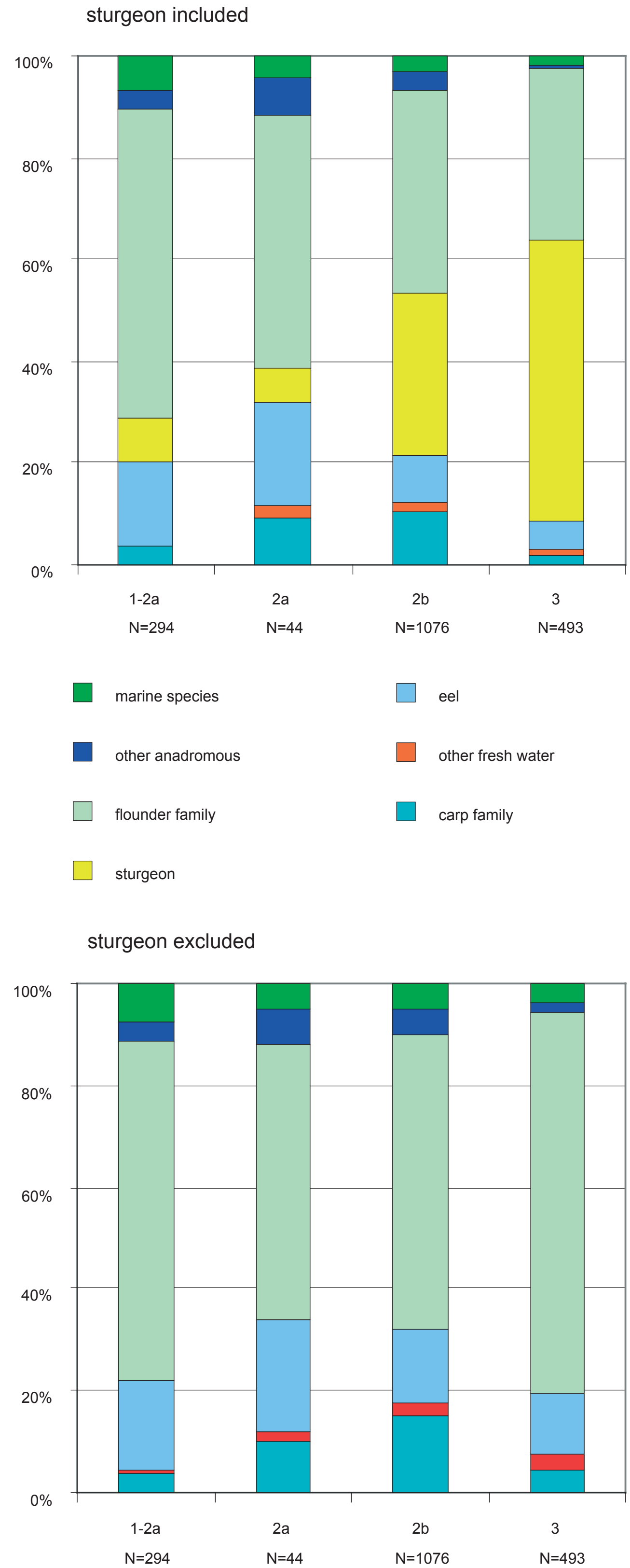


Figure 25.12 Trends in the composition of the fish assemblage from the 4-mm sieve residues through time. The ratio of species other than sturgeon (lower graph) remains constant. The increase in remains of sturgeon (upper graph) may be the result of differential preservation.

have evidence of marine ingressions and flooding with salt water in phase 2a. In addition to these observations and their interpretations we also know that prehistoric man usually purposefully focused on specific species using specialist fishing techniques. With each fishing method – certainly those involving untended facilities such as traps, weirs and nets – other fish will of course have been caught along with the intended species. This partly explains the great variety of species that were encountered in low percentages. The fishing activities however primarily focused on a restricted number of species, which were each caught at suitable locations using species-specific methods. In the case of the right-eyed flatfishes those locations will have been the shallow parts of the estuary itself and the mud flats when they were temporarily submerged. The sturgeons will have been caught in the smaller side creeks that provided access to the backswamps bordering the estuary. Eel may also have been caught in the estuary, especially in the autumn, when the adult individuals migrated to the sea to spawn. The various members of the carp family, pike and perch may have been caught there, too.

That the occupants indeed caught their fish in such a purposeful manner is confirmed by the fact that very few changes took place in their fishing practices throughout the occupation period, in spite of the substantial environmental changes that took place in the settlement's surroundings (fig. 25.12). This means that the occupants continued to exploit the brackish water, even though it lay further away from the site in later phases.

25.7 Seasonal evidence (fig. 25.13)

On the assumption that the annual cycle of Dutch fish in general, and their migratory behaviour in particular, was in prehistoric times comparable with their behaviour in present and historical times, statements can be made about the season in which certain fish species were caught. An important condition – which was met at Schipluiden – is that the fishing waters were directly connected to the sea. The small fish (herring, smelt, stickleback and common goby) whose presence in the archaeological record is assumed to be attributable to natural processes of course have nothing to do with prehistoric fishing practices.

From the following seasonal evidence it can be concluded that fishing was in all the occupation phases definitely a summer activity.

Sturgeon

Sturgeons are anadromous fish that spend the greater part of their lives in the sea and temporarily exchange saltwater for freshwater only in order to reproduce. Sturgeons swim up rivers to spawn in late spring. In the 19th century, sturgeons migrated in the Rhine from early May until mid-August, with

Figure 25.13 Seasons of presence in inland waters of the fish species identified at Schipluiden showing first of all that the site was occupied at least from April to October and, secondly, that fishing was mainly a summer activity.

a peak around the end of June. The fish were seen to make use of the tides in their journey upriver, and to cover substantial distances especially around low and high tide, when currents are minimal. At high water levels they would swim further upriver. They also swam further if there happened to be many fish in the estuary and the lower course of the river. Juvenile sturgeons were seen to migrate upriver along with the adult fish, but did not usually venture beyond the brackish water zone (Siebelink 2004). At Schipluiden, remains of both adult and juvenile individuals were found.[3] Magnin (1962, 155) writes the following about the occurrence of sturgeons in the brackish water of the Gironde estuary: "… here, we actually find sturgeons of all ages and all sizes and in different stages of sexual maturity.". This means that sturgeon remains can be interpreted as seasonal evidence only at inland sites such as Swifterbant and Hazendonk (Zeiler 1997) and not at a coastal site such as Schipluiden.

Flounder
Flounders are in principle catadromous. They reproduce in the sea in spring and then migrate into freshwater if it is freely accessible. They gather in autumn and then return to the sea to spend the winter there. So flounder remains constitute evidence of summer use of the site at Schipluiden.

Eel
Eels are likewise catadromous. They arrive in freshwater from the sea as elvers. In the wintertime, eels are lethargic and live in soft substrates on the riverbeds. If fishermen know where eels spend the winter, they can catch them with a special eel spear. Eels can be easily caught with traps in late spring, summer and autumn. They can be caught in large numbers in the autumn, when the adult individuals migrate to the sea to spawn.

Bass and grey mullets
Bass and grey mullets are heat-loving species that swim into the Dutch coastal waters from the south in spring and cross the Channel to waters off the southern English coast towards the winter. On their journeys, these species, especially thin-lipped grey mullets, may swim far upriver in the summer. So they can be caught in estuaries only in the summer.

Allis shad/twaite shad
Allis shad and twaite shad are both anadromous. According to Boddeke (1971), allis shad appeared in estuaries around April-May at the time of his study. Twaite shad would follow in June-July. The spawning grounds of allis shad were usually a little further upstream than those of twaite shad, which tended to spawn in freshwater just above the transition from brackish water.

Whitefishes
Verhey (1961) writes that, at the time of his study, whitefishes (*Coregonus oxyrhynchus*) made their appearance in estuaries as anadromous fish in the autumn and swam further upstream to spawn in the winter. That makes whitefishes one of the few fishes that may be interpreted as providing evidence of winter use of a site. The percentage of *Coregonus* remains found at Schipluiden is however fairly low. This means that the occupants did fairly little fishing in the late autumn and winter, or they did not fish in the deep main river stream where the migrating whitefishes were to be found.

Salmon and sea trout
Salmon and sea trout are also anadromous species. De Groot/Schaap (1973) write that Dutch river fishermen make a distinction between winter and summer salmon and what they call *jacobszalmen* (Jacob's salmon) on the basis of the fish's migration times, differences in weight, the development of the sexual organs and the associated physical condition. Winter salmon swim upriver from October until the end of April, summer salmon from May until the end of November. The *jacobszalm* is the smallest variety, with a length between 61 and 67 cm (Van Doorn 1971). These salmon swim upriver from early July until some time in November, with a peak around 25 July, the name day of the Apostle St. Jacob. From this evidence it can be concluded that salmon, unlike sturgeon, could be caught in rivers all year round. In the years 1870-1874 exceptionally small quantities of salmon were however supplied to the market of Kralingen in the months from September to March (Boddeke 1971, 173). Viewed in this light, large quantities of salmon remains must therefore be interpreted as evidence of summer use of a site, but salmon remains have not been found in large quantities at any of the prehistoric sites in the rivers area.

Sea trout are less particular about their choice of rivers than salmon, but they don't swim as far upriver as the latter. According to Redeke (1941), sea trout were caught mainly in the summer, in tidal rivers.

In the light of what has been said above it is remarkable that only very few remains of salmon/sea trout were found at Schipluiden. Evidently the fishing practices focused on more slowly flowing side gullies and smaller tidal creeks rather than on the broad, deeper main river stream in which the migrating salmon swam. The reason for this could be that the prehistoric occupants did not yet know how to make sufficient large, strong nets of the kinds used in salmon fishing with weirs, drift nets and seine nets in historical times.

Researchers such as Lepiksaar/Heinrich (1977) and Beerenhout (2001) have pointed out that bones of many oily fish species such as salmon and sea trout readily disappear due to dissolution by fatty acids released after their deposition (autolysis). Tchernavin, quoted by Wheeler (1978), writes that calcium is absorbed from a salmon's skull skeleton during its migration to its spawning ground. This makes the skull paper-thin. These processes however have no influence on the fraction of calcined vertebrae.

Smelt
Writing about the fish fauna of the Biesbosch area, Verhey (1961) stated that smelt swim upriver to spawn from early February until the end of April.

Three-spine stickleback
Some three-spine stickleback populations are known to live exclusively in freshwater. The species is however in principle anadromous if it has unhindered access to the sea. Sticklebacks migrate into freshwater to reproduce in large quantities in spring. They gather in the autumn and return to the sea to spend the winter there.

25.8 Trends

Only the non-specialist spectra obtained for the units can be used for identifying any changes that may have taken place in fishing practices as reflected in the composition of the fish remains. The spectra relating to the features are insufficiently representative. The dates obtained for the features are moreover less reliable.

A major handicap is that we have insufficient amounts of remains for the early phases (table 25.1). For phase 1 we have only a small sample of manually collected remains that consist exclusively of sturgeon bones. The clay of Unit 19 concerned was not sieved through a 4-mm-mesh sieve and only incidentally through a 1-mm-mesh sieve. This lack of evidence is partly compensated by a modest amount of evidence for phases 1-2a (Unit 19N). The later phases are well represented, except that we have no representative fine fraction sample from phase 3. Only for the 4-mm sieve fraction do we have a sufficiently large series of spectra, except that the sample from phase 2a is actually a little too small.

With due consideration for these factors it is surprising to see that the ratios of the species (excluding sturgeon) for the different phases are more or less the same, in spite of the fairly drastic environmental changes that took place in the dune's immediate and wider surroundings (fig. 25.13).

It is not so easy to obtain an impression of any changes that may have taken place in the relative proportion of the important fish species sturgeon. The 4-mm sieve residues show a distinct increase in the ratio of sturgeon and all other fish, from less than 10% to more than 50% of the remains. There are two possible explanations for this: an increase in economic importance and a higher degree of fragmentation of the sturgeon remains. The second option could hold for the difference between the clay of phase 2a and the colluvium of phase 2b, but the overall increase can hardly be explained by taphonomy alone, and must to some degree reflect increased importance.

The other fish remains show an absolute dominance of migratory species (80-90%), in particular *Pleuronectes* spec. (55-75%), in all the phases. The ratio of marine and freshwater species varies from 1:2 to 1:3.5, and is reversed only in the case of phases 1-2a. What is remarkable is that the environmental changes (switch to freshwater conditions) are not reflected by these fish remains.

As far as the 1-mm fraction is concerned, we only have a reliable impression of phases 2a and 2b. They show an absence of marine species and a low score of *Pleuronectes* spec., which is compensated by the scores of species with small remains such as eel, smelt and stickleback. Eel was of greater economic importance than is suggested by the fraction of large remains.

25.9 Comparison with other assemblages

Data relating to three Hazendonk settlements in the Rijswijk microregion are available for comparison. Those sites are Wateringen 4, Rijswijk Rijksweg A4 and Ypenburg. They are comparable with Schipluiden in terms of their environmental context and artefactual data, but differ substantially as regards the dimensions of the dunes supporting the settlements and the sizes of the sites themselves. The methods used to collect small faunal remains also differ considerably from site to site, and that implies differences in the fish spectra, too.

The fish remains of Wateringen comprise 26 manually collected bones and a sieved sample from a pit fill that contained 396 fragments (Beerenhout in Raemaekers *et al*. 1997).[4] Of those remains, 24 and 228, respectively, could be identified to species, genus or family level. Evidence of gnawing and metabolic distortion and the severely fragmented condition of the remains led the researcher to conclude that the sieved sample represents the stomach contents of a fish-eating mammal, probably an otter. This is however not really in accordance with the presence of remains of at least seven species with a varying ecology, and also burnt remains. Probably only part of the sample represents a stomach contents. The limited number of manually collected fish bones reveal an ichthyofauna that is comparable with that of Schipluiden, except that it includes a relatively large proportion of grey mullets.

During the emergency excavation of the Rijswijk Rijksweg A4 site (site 1) a total of 218 fish remains were collected by hand (Laarman 2004). No samples were taken for sieving. Almost all of the 207 identifiable remains derive from sturgeon and *Mugilidae*. The proportion of grey mullet remains is again remarkably high. According to Laarman (2004), these remains represent at least 54 individuals.

The data relating to Rijswijk-Ypenburg (De Vries, 2004) are the most directly comparable with those of Schipluiden. There, the fish remains were collected by hand and by sieving 3000 m^2 through a sieve with a 2-mm mesh width. In total, 2360 fragments were identified to species or family level.

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notes

1 One exception was made. As most of the skeletal elements of flounder, plaice and dab lacked species-specific characteristics, only few of their remains could be identified to species level. They can however without doubt be attributed to the group of 'right-eyed flatfishes'. In older nomenclature, the three species were all classed as belonging to the genus of *Pleuronectes*. According to the present nomenclature, dab however belongs to a different genus, but remains of flounder, plaice or dab that cannot be identified to species level are still interpreted as remains of *Pleuronectes* spec.

2 The formula expressing the relation between the total length of a thin-lipped grey mullet and the dimension described as the 'distance between the dorso-rostral corner of the opercular and the bottom side of the articular cavity of the opercular' was set up using the dimensions of two present-day specimens with lengths of 44 and 48 cm. The formula concerned is: individual's total length (in mm) = dimension (in mm) × 44.56.

3 The reticulate pattern of the lateral surface of the elements of the species' exoskeleton changes as the individual grows older (Mohr 1956). The elements of smaller (*i.e.* juvenile) individuals are thinner than those of larger (*i.e.* mature) individuals. The reticulate pattern of the former is finer and less rounded (sharp).

4 The numbers quoted in the text do not correspond to those given in the table. The latter numbers are the correct ones (oral comm. Raemaekers, 8 June 2005).

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Appendix

25.1 Glossary of the English, Dutch and scientific names of the fish species mentioned in the text.

English	Dutch	scientific
allis shad	elft	*Alosa alosa*
bass	zeebaars	*Dicentrarchus labrax*
bream	brasem	*Abramis brama*
carp family	karperachtigen	*Cyprinidae*
common goby	brakwatergrondel	*Pomatoschistus microps*
eel	paling	*Anguilla anguilla*
flounder	bot	*Pleuronectes flesus*
golden grey mullet	goudharder	*Liza aurata*
grey mullets	harderachtigen	*Mugilidae*
herring	haring	*Clupea harengus*
herring family	haringachtigen	*Clupeidae*
ide	winde	*Leuciscus idus*
Lozano's goby	Lozano's grondel	*Pomatoschistus lozanoi*
perch	baars	*Perca fluviatilis*
pike	snoek	*Esox lucius*
right-eyed flatfishes	scholachtigen	*Pleuronectidae*
roach	blankvoorn	*Rutilus rutilus*
roker	stekelrog	*Raja clavata*
rudd	rietvoorn	*Rutilus erythrophthalmus*
salmon	zalm	*Salmo salar*
sand goby	dikkopje	*Pomatoschistus minutus*
sea trout	zeeforel	*Salmo trutta*
smelt	spiering	*Osmerus eperlanus*
stickleback	stekelbaars	*Gasterosteus aculeatus*
sticklebacks	stekelbaarsachtigen	*Gasterosteidae*
sturgeon	steur	*Acipenser sturio*
thin-lipped grey mullet	dunlipharder	*Liza ramada*
twaite shad	fint	*Alosa fallax*
whitefishes	houtingachtigen	*Coregonus sp.*