

The evolution of the I.C.A.Z. Fish Remains working group from 1981 to 1995

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On the morning of the 28th of August, 1981, the founders of what was later to become the I.C.A.Z. Fish Remains Working Group (FRWG) met for the first time at the Zoological Museum of Copenhagen. The meeting, attended by 16 people (Table 1), took place at the request of a small group of scholars, notable among which were Inge Bødker and Knud Rosenlund of the host institution, which had for years felt the need for a more systematic analysis of fish bones retrieved (and often missed!) in archaeological sediments.

In retrospective, we can say that the Copenhagen Meeting was a truly productive one, both in terms of the nature (Appendix 1) and the treatment of issues. Introductory lectures were followed by a lengthy discussion open to all participants; such flexible, seminar-like contributions were regrettably lost in subsequent meetings, partly due to the drastic increase in the number of presentations. To compensate for this, starting with the second meeting, contributions became grouped into sessions of more or less similar content (Appendix 2). This arrangement was enhanced after the Stora Kornö Meeting allowing the organizers to set up priority topics for each conference, but we had to wait until this past conference to watch one of the priority subjects (i.e., overfishing in the archaeological record) develop into a significant portion of the conference.

The main goal of the Copenhagen meeting has, nevertheless, been maintained over the years. This was the participants' determination to create a true (and not just nominal!) working group, which encourages close contact among its members, and which would not only hold biennial meetings, but would also disseminate the information presented to the best of its ability while promoting contact with other groups, organisations and individuals both within and outside I.C.A.Z. The success of the «spirit of Copenhagen», 14 years after its inception, has

been so dramatic that it became a model for other Working Groups (in particular the Middle East and Bird Remains WG) and, perhaps, in the future, may pave the way as a model for a federal re-structuring of I.C.A.Z., which is undergoing a profound process of renewal at this very moment.

Turning to more mundane matters, the development of the FRWG seems to have been a mixture of gradual and punctuated processes (Table 1; Figure 1). After the initial Copenhagen «pulse», a second one exemplified by the Sophia Antipolis and Groningen conferences doubled the number of attendants and tripled the number of presentations (Appendix 2 & 3). The third pulse, starting with the York meeting and still ongoing, exhibited a gradual increase in the number of attendants doubling the number of contributions (Appendices 4-7). One might argue that both the Leuven and Madrid meetings, by their sheer size, could be considered as a fourth incremental pulse but we would rather consider them from the perspective that the FRWG has not yet stabilized, but is simply gaining momentum, due to its dynamic nature and the decisiveness of its members.

Since one of the aims of the FRWG was to create a forum of debate for the discussion and standardization of techniques, presentations on methods have always made up a substantial portion of the contributions offered at each meeting (Table 2; Figure 2). The Copenhagen conference, as a matter of fact, was basically conceived as a colloquium on methods (Appendix 1) and, except for the Groningen, Schleswig and Leuven meetings, methodological papers always ranked at the top of the list of topics (Figure 2; Table 2; Appendixes 1-7). A pervasive pattern throughout these years has been the somewhat erratic rise in contributions which were neither methodological nor descriptive «bone reports» (i.e., the «others» category in Fi-

MEETINGS	N.º PARTICIPANTS	PRESENTATIONS	PROCEEDINGS
COPENHAGUE	16	7	+
SOPHIA ANTIPOLIS	30	19	+
GRONINGEN	28	19 (5)	+
YORK	38	35 (3)	—
STORA KORNÖ	32	31 (6)	+
SCHLESWIG	33	37 (5)	+
LEUVEN	48	36 (6)	+
MADRID	57	50 (12)	+

TABLE 1

Main features of the eight I.C.A.Z. Fish Remains Working Group meetings. Presentations in brackets refer to posters. A graphic representation of these data appears in Figure 1.

gure and Table 2). Most contributions in this category are papers: a) dealing with fishing in the past, b) regional surveys; and c) the biology of fishes. By their very nature, a great many of these contributions include data from fields alien to archaeozoology and their progressive importance in successive meetings testifies to the growing interdisciplinarity within archaeoichthyology as well as the willingness of the FRWG to incorporate new ideas, data and scholars.

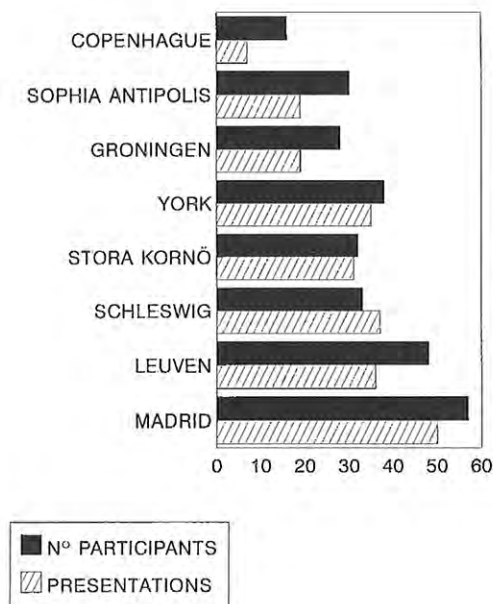


FIGURE 1

Meetings of the FRWG have also been witness to important developments. One such instance was the Sophia Antipolis conference where Jean Desse presented a much needed initiative: the «*Fiches d'identification osteologique pour les besoins de l'archeologie*» Project. Since then, the program has developed well beyond the realm of archaeoichthyology reaching researches in I.C.A.Z. and the natural sciences. At Copenhagen it was decided that the group should have a Newsletter. Through the years, thanks to the generous and anonymous effort of its editors, Knud Rosenlund and Dirk Heinrich, the Newsletter has been instrumental in keeping the FRWG alive and in promoting joint research among its members (note how many papers from later meetings have been presented by research teams from more than one country!).

I strongly believe that the most remarkable aspect of all these achievements, which include the publication of the proceedings from all but one meeting by relevant publishers (CNRS, BAR, Offa, etc.), is the fact that they were achieved in an atmosphere of honest friendship. The FRWG has never had individual leadership, strong hierarchy or the like. It has never felt the temptation of pulling out or taking over anything. It simply does not need to do that to keep on being what it is, namely, a united and cohesive group of friends. That cohesiveness is the secret of its strength. No more, no less (but by no means a modest achievement!).

To conclude, I look to the future and I want to draw attention to the single criticism of the FRWG: its eurocentrism. For historical reasons, the fish group was born in Europe (though one of the «founding fathers», the late Hanan Lerna, was Is-

MEETINGS	METHODS	REPORTS	OTHERS
COPENHAGUE	6	1	—
SOPHIA ANTIPOLIS	9	5	5
GRONINGEN	4	8	4
YORK	17	10	9
STORA KORNÖ	14	11	6
SCHLESWIG	12	13	12
LEUVEN	12	15	9
MADRID	13	14	23

TABLE 2

The presentations at the various Fish Remains Working Group meetings arranged according to content.
A graphic representation of these data appears in Figure 2.

raeli!) and the number of European members has traditionally outnumbered those from other continents (in the latest 4 newsletters we record 87 from Europe, 41 from the Americas, 6 from Asia, 1 from Africa and 4 from Australia and the Pacific). Logistics, in particular shortage of funds, have shaped a profound and, to a certain extent, unfair, asymmetry: all eight meetings have been held in Europe. This has prevented a lot of colleagues within the FRWG from attending even a single meeting. At this meeting Elisabeth Reitz & Elisabeth Wing were prevented from attending at the last minute

but, at least, we can feel proud that many Americans and even Foss Leach and Atholl Anderson, from our Spanish antipodes, could finally make it. On the horizon we have Panama. The 1997 meeting will hopefully constitute a landmark for the FRWG which is dangerously leaning into an strictly EFRWG (i.e., european FRWG) much to my general regret. I therefore want to end these remarks by telling all our non-European friends: come'n boys, it's your turn now! Happy meeting! Thank you!

APPENDIX 1

FIRST MEETING, København (1981)
(28-29 August)

1. A. K. G. JONES: *Reconstruction of fishing techniques from assemblages of fish bones.*
2. R. LIL JEGREN: *Taphonomy.*
3. J. DESSE: *Presentation of a new method of discrimination by x-ray diagnostics.*
4. D. HEINRICH: *Standardization of measurements and size/weight reconstructions of fish.*
5. N. NØE-NYGAARD: *Use of growth rings to determine age of fish and season of catch.*
6. H. LERNAU: *Fish remains from excavations in the Negev and the Sinai deserts and their connection with the Nile, the Mediterranean and the Red Sea.*
7. H. LERNAU: *Special methods for defining vertebrae of bony and cartilaginous fish.*

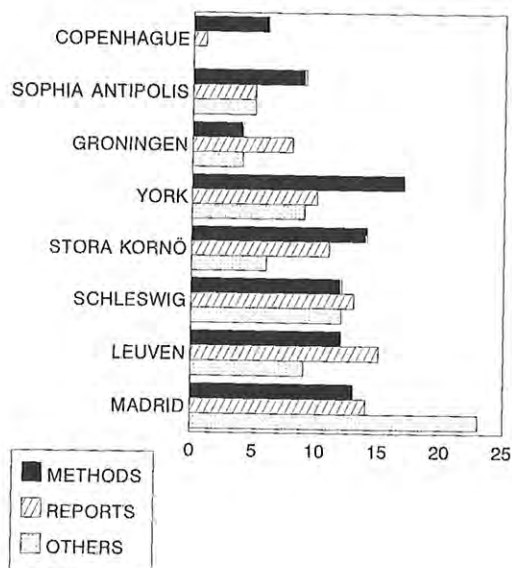


FIGURE 2

APPENDIX 2

SECOND MEETING, Valbonne (1983)
(14-16 October)

1. F. J. MEUNIER: *Sur la détermination histologique de vertèbres de poissons trouvées dans les sites archéologiques.*
2. G. DESSE: *Nouvelle contribution à la diagnose des pièces rachidiennes des poissons.*
3. A. MORALES MUÑIZ: *A study on the representativity and taxonomy of the fish faunas from two mousterian sites on northern Spain with special reference to the trout (Salmo trutta L., 1758).*
4. A. K. G. JONES: *Some effects of the mammalian digestive system on fish bones.*
5. J. DESSE: *Propositions pour une réalisation collective d'un corpus: fiches d'identification et d'exploitation métrique du squelette des poissons.*
6. O. LE GALL: *L'exploitation de l'ichtyofaune par les Paléolithiques. Quelques exemples.*
7. N. JUAN-MUNS: *Le problème de la signification des restes ichtyofauniques fossiles.*
8. S. M. COLLEY: *Some methodological problems in the interpretation of fish remains from archaeological sites in Orkney.*
9. T. TROLLE-LASSEN: *A preliminary report on the archaeological and zoological evidence of fish exploitation from a submerged site in mesolithic Denmark.*
10. K. ROSEN LUND: *The fish-bone material from a medieval Danish monastery and an 18th century mission station in Greenland. An investigation of materials with a known key.*
11. W. VAN NEER: *The use of fish remains in African archaeozoology.*
12. E. S. WING: *Faunal remains from seven sites in the Big Cypress national preserve.*
13. J. RIVALLAIN: *L'importance de la pêche dans les activités littorales du passé des Alladian, Côte d'Ivoire.*
14. A. BOISSIER: *Un habitat et un mode de vie traditionnels à l'étang de Salses (P.O., France). Exemples ethnographiques et implication archéologique.*
15. N. NØE-NYGAARD: *Seasonality determination, a tool in separating fish accumulations of mixed origin on Mesolithic island sites.*

16. J. RICHTER: *Indication of selection of different fish species at various seasons in the Neolithic.*
17. M. S. GORECKI: *Détermination des températures de développement durant le cycle de vie de certains poissons pour la mesure des rapports d'oxygène isotopique dans les otolithes.*
18. P. LAHTIPERÄ: *Measurements of Gadidae; problems and possibilities.*
19. M. LERNAU: *Nouvelles techniques de préparation et de rangement des collections de référence.*

APPENDIX 3

THIRD MEETING, Groningen (1985)

1. A. T. CLASON: *Fish and Archaeology.*
2. N. BENECKE: *Some remarks on sturgeon fishing in the Southern Baltic region in Medieval times.*
3. D. C. BRINKHUIZEN: *Features observed on the skeletons of some recent European Acipenseridae: their importance for the study of excavated remains of sturgeon.*
4. S. M. COLLEY: *Site formation and archaeological fish remains. An ethnohistorical example from the Northern Isles, Scotland.*
5. D. HEINRICH: *Fishing and consumption of Cod (Gadus morhua Linnaeus, 1758) in the Middle Ages.*
6. A. K. G. JONES: *Fish bone survival in the digestive systems of the pig, dog and man: some experiments.*
7. L. JONSSON: *Fish bones in Late Mesolithic human graves at Skateholm, Scania, South Sweden.*
8. A. LENTACKER: *Archaeozoology of Late Prehistoric Portuguese sites with marine and riverine resources.*
9. H. LERNAU: *Fish bones excavated in two Late Roman-Byzantine Castella in the southern desert of Israel.*
10. W. VAN NEER: *Some notes on the fish remains from Wadi Kubbaniya (Upper Egypt; Late Palaeolithic).*
11. W. PRUMMEL: *The presence of bones of eel, Anguilla anguilla, in relation to taphonomic processes, cultural factors and the abundance of eel.*

12. K. ROSENBLUND: *The sting ray, Dasyatis pastinaca (L.) in Denmark.*
13. M. SEEMAN: *Fish remains from Smeerenburg, a 17th century Dutch whaling station on the Westcoast of Spitsbergen.*
14. J. DESSE: *Les poissons du Grand Louvre.*
15. I. BØDKER-ENGHOFF: *New results from the classical shell midden in Ertebølle, Denmark.*
16. D. HEINRICH: *Some remarks on fish remains from late- and postglacial sites near Hamburg.*
17. I. BØDKER-ENGHOFF: *Fishing at Mesolithic Bjørnsholm, Denmark, compared with the neighbouring settlement: the Ertebølle locus classicus. Principally eel-fishing sites?.*
18. I. BØDKER-ENGHOFF: *Rare species of fish in the Mesolithic Bjørnsholm Shell-midden, Denmark - indicators of a warmer climate.*
19. L. JONSSON: *Middle Mesolithic Fishing strategies and the marine environment on the Swedish west coast.*
20. L. BARTOSIEWICZ: *Size reconstruction of pike, Esox lucius, L. .*
21. I. TAKÁCS: *Size reconstruction of catfish, Silurus glanis.*
22. M. COLBURN: *Cranial osteology of Redcar sunfish.*
23. M. DUTTING & B. BEERENHOUT: *Distribution analysis of the fish remains of a Roman Castellum at Velsen, the Netherlands.*
24. R. C. HOFFMANN: *Pike (Esox lucius) in late Medieval Culture: from illiterate empiricism to literate traditions.*
25. J. COY: *Saxon evidence from the river Thames.*
26. D. SERJEANTSON: *Fish Remains from a Monastic Site: St. Albans Abbey, Hertfordshire, England.*
27. N. PAAP & M. SEEMAN.: *Focussing on Fish eyes.*
28. D. BRINKHUIZEN: *Some remarks on seasonal dating of fish remains by means of growth ring analysis.*
29. A. ROJO: *X-rays to differentiate vertebrae from the Gadidae family.*
30. D. WARD: *A machine for processing clay to extract fish remains.*
31. J. COY: *Medieval documentation and the fish trade.*
32. R. NICHOLSON: *Fish remains from excavations near the river front at Newcastle, England.*
33. L. JONSSON: *Osteological evidence of medieval fish trade in Scandinavia.*
34. R. KEMP: *Fishing at Bylands Abbey, Yorkshire.*
35. J. DESSE & N. DESSE-BERSET: *Use and exchange of osteometric data for ichthyofauna.*
36. E. S. WING: *Comparative fish skeleton collections.*

APPENDIX 4

FOURTH MEETING, York (1987) (9-12 September)

1. P. V. ADDYMAN: *Fish out of water: An Archaeologist's view of Archaeoichthyology.*
2. K. M. STEWART: *Fish remains at Olduvai Gorge.*
3. W. VAN NEER: *Fish remains from a Holocene site in Wadi Howar, Sudan.*
4. V. L. BUTLER: *Natural versus cultural salmon bones: a preliminary assessment of the Dalles «Roadcut» remains.*
5. B. GHALEB: *Fish and Women on a Western Torres Strait Island, Northern Australia.*
6. I. TAKÁCS: *Fish exploitation in Hungary.*
7. M. ROSE: *Prehistoric Fishing in the Aegean.*
8. E. ROSELLÓ & A. MORALES: *Cultural typification of Spanish pre- and protohistorical sites through the study of fish assemblages: proposal of a new methodology of study.*
9. A. LENTACKER: *The mesolithic Muge shell - middens of Portugal.*
10. A. MORALES & E. ROSELLÓ: *Casual or intentional? Comments on fish taxa skeletal representation from Spanish archaeological settlements.*
11. E. S. WING: *A Modern midden experiment.*
12. A. E. BULLOCK: *Dispersal of Fish waste: a modern experiment.*
13. S. COLLEY: *Cooking fish on a fire: an experiment in differential burning.*
14. A. K. G. JONES: *Walking the cod.*
15. A. MORALES; E. ROSELLÓ; K. ROSENBLUND & J. L. LÓPEZ GORDO: *Spanish and Danish ichthyofaunal assemblages: patterns of diversity and abundance commented from a paleocultural perspective.*

APPENDIX 5

FIFTH MEETING, Stora Kornö (1989)
(5-9 September)

1. L. JONSSON: *An introduction to Stora Kornö and its village and the roots of an archaeoichthyologist.*
2. W. VAN NEER: *Fish remains from the Middle Palaeolithic site Bir Tarfawi (Eastern Desert, Egypt).*
3. N. BENECKE: *Seasonal dating of fish remains from the Hoabinian site Can-Cave (Vietnam).*
4. E. WING: *Prehistoric Fishing in the West Indies.*
5. R. LARJE: *Favourite fish dish of the Romans in Carthage.*
6. E. AURA TORTOSA: *A preliminary report about marine exploitation on the Andalusian coast: the Fish gorges from the Cave of Nerja (Málaga, Spain).*
7. B. WILKENS: *The importance of fishery in the economy of the Fucino Basin (Italy) from Upper Palaeolithic to Neolithic Times.*
8. D. HEINRICH: *Fish remains from Flem, a Stone Age settlement at Skuløy, Norway.*
9. M. STERNBERG: *La pêche et la consommation du poisson sur le site de Lattara (France, Héralut) du III^e au I^{er} s. AV. J.C. .*
10. E. GEHASSE: *Fish as salinity and tidal indicators at P14, a late Neolithic- early Bronze age site in the Netherlands.*
11. L. BARTOSIEWICZ: *Pre-depositional modifications on fish bone from Hungarian Excavations.*
12. W. PRUMMEL: *Fishing methods in Oldenburg (Holstein).*
13. P. LAHTIPERÄ: *Big Ling from Lofoten area from Stone age and Iron age.*
14. S. HAMILTON-DYER: *Fish in the Tudor Naval diet.*
15. R. HOFFMANN: *«Carpes pour le duc ...» The operation of fish ponds at La Perriere –sur-saune, Burgundy, 1338-1352.*
16. L. JONSSON: *Violet is nice. Comparative bone collections and the illustration of fish bones.*
17. I. TAKÁCS: *Osteomorphological studies on great sturgeon (Huso huso) from Hungary.*
18. L. JONSSON: *The Holocene History of western Sweden, geology, fishes, history of research.*
19. R. NICHOLSON: *Burnt fish bones: what value to archaeology?*

20. A. K. G. JONES: *How many fish bones do we need from a site?*
21. D. HEINRICH: *Some remarks on the term «Thanatocoenosis», especially «anthropogenic thanatocoenosis».*
22. A. ROJO: *x-Ray as a tool to identify the fish specimens of subfossil vertebrate from archaeological sites.*
23. A. LEAK: *An assessment of the value of the scales of the grayling Thymallus thymallus (L.) to the archaeologist for deriving information about the fish found in archaeological deposits.*
24. A. LENTACKER: *A Growthline study on the otoliths of Argyrosomus regius.*
25. B. BERENHOUT: *Velsen I: Indications of water pollution in Roman times.*
26. E. ROSELLÓ & A. MORALES: *Castillo de Doña Blanca: fish remains from the oldest phoenician site on the Iberian Peninsula.*
27. M. ROSE: *Polished otoliths from archaeological contexts.*
28. R. M^a ARNAY: *Osteometrical analysis of Sparisoma cretense.*
29. E. ROSELLÓ & A. MORALES: *Comparative osteomorphology of the sardine (Sardina pilchardus) and round sardinella (Sardinella aurita).*
30. S. STEN: *Medieval and post-reformative fish finds from urban contexts as indicators of fish trade.*
31. K. ROSENLUND: *Computerized estimates of fish size based on osteometric data: presentation of a program.*

APPENDIX 6

SIXTH MEETING, Schleswig (1991)
(3-7 September)

1. V. VOGEL: *Excavations in the ancient centre of Schleswig, the archaeological background to the conference-town.*
2. A. BULLOCK: *Evidence for the exploitation of fishes from Tudor deposits and the Little Pricke excavations in 1989, Surrey, England.*
3. I. BØDKER-ENGHOFF: *Fishing from medieval Holbaek.*

4. A. ERYNCK & W. VAN NEER: *Fish remains in medieval castles and towns (Flanders, Belgium): a preliminary survey.*
5. E. ROSELLÓ & A. MORALES: *Cartuja: Fish remains from a late medieval monastery in Seville (Spain).*
6. P. MOREL: *Medieval fish remains from a site near Basel.*
7. N. IVANOVA: *Fish remains from archaeological sites of the northern part of the Black Sea Region.*
8. D. C. BRINKHUIZEN & E. ROSELLÓ: *Laminak II: Marine fishes within a paleolithic limnetic ichthyocenosis from the Spanish Basque country.*
9. A. LENTACKER: *Fish remains from Saltés (Huelva, Spain).*
10. L. JONSSON: *Fish bone measurements, Gadi-formes. Review and proposals.*
11. W. VAN NEER: *Fish size reconstructions: How accurate should they be?*
12. D. HEINRICH: *Fish remains from Durankulak and from some other sites –are they biased by the excavator?*
13. J. STUDER: *Fish and water: influence of a lake on the distribution of ichthyological remains.*
14. M. MÉZES & L. BARTOSIEWICZ: *Fish bone preservation and fat content.*
15. R. G. COOKE & J. BORT: *A comparison between prehistoric and modern artisanal fishing in a small estuarine embayment on the Pacific coast of Panama.*
16. A. SÁNCHEZ MOSQUERA: *Fishing patterns in the continental coast of Ecuador.*
17. N. JUAN-MUNS: *Fishing strategy in the Beagle channel: an ethnoarchaeological approach.*
18. R. C. HOFFMANN: *The craft of fishing Alpine lakes, ca A.D. 1500.*
19. C. G. RODRÍGUEZ SANTANA: *The role of fishing in a prehistoric settlement on the island of La Palma (Canary Islands, Spain).*
20. B. BEERENHOUT: *What conclusions can be drawn from mature haddock bones in a neolithic coastal site in the Netherlands?.*
21. W. R. BELCHER: *Fish utilization in the Harappan civilization: a view from the type site of Harappa.*
22. D. SERJEANTSON; J. EVANS & S. WALES: *Fish in latter prehistoric Britain.*
23. L. JONSSON: *Fish processing before salting and drying - historical evidence from Scandinavia.*
24. M^a J. RODRIGO GARCÍA: *The paleoecological implications of the presence of *Melanogrammus aeglefinus* (L., 1758) in the transition Upper Pleistocene-Holocene levels in Nerja Cave (Málaga, Spain).*
25. I. SZEKELYHIDY; I. TAKÁCS & L. BARTOSIEWICZ: *Size variability by geographic regions of some fish species in Hungary.*
26. A. BULLOCK: *Cost tradeoffs of mesh size and sieving rate in environmental processing.*
27. R. LARJE: *Are dermestid beetles safe for fish bones?.*
28. D. C. BRINKHUIZEN: *Pathologies and anomalies in recent and subfossil fish bones.*
29. A. MORALES & W. VAN NEER: *Abundance indexes as potential discriminators of natural and anthropogenic paleoichthyocenosis.*
30. D. C. BRINKHUIZEN: *The diet of recent otter (*Lutra lutra*) from two regions in the northern Netherlands.*
31. W. PRUMMEL: *Bird and sea mammal catching during fishing.*
32. B. IRVING: *Possible evidence for Roman fish farming at Nicopolis ad Istrum, Bulgaria.*
33. S. HAMILTON-DYER: *Fish remains from Mons Claudianus –a Graeco-roman site in the Eastern desert of Egypt.*
34. R. C. HOFFMANN: *European subfossil carp (interim report).*
35. D. PATÓN & E. ROSELLÓ: *A computerized procedure for the classification of Mugilid remains from archaeological sites.*
36. Ch. RADTKE: *Medieval fishing with «herring-fences» in the Schlei.*
37. A. SÁNCHEZ MOSQUERA: *The evolution of Ecuatorian Archaeozoology.*

APPENDIX 7

SEVENTH MEETING, Leuven (1993)
(6-10 September)

1. J. H. BARRETT: *Bone weight and the intra-class comparison of fish taxa.*
2. O. LERNAU & M. BEN-HORIN: *Taphonomic curve and index: a preliminary exploration of a new concept.*
3. F. FALABELLA; M. LORETO VARGAS & R. MELÉNDEZ: *Differential preservation and recovery of fish remains in Central Chile.*

4. A. VON DEN DRIESCH: *Hyperostosis in fish*.
5. F. J. MEUNIER & J. DESSE: *Histological structure of hyperostotic cranial remains of Pomadasys hasta (Osteichthyes, Perciformes, Haemulidae) from archaeological sites of the Arabian Gulf and the Indian Ocean*.
6. L. BARTOSIEWICZ; I. TAKÁCS & I. SZÉKELY-HIDY: *Problems of size determination in common carp (Cyprinus carpio)*.
7. M. STERNBERG: *Reconstitution de la taille de Dicentrarchus labrax provenant de Lattes (II^{ème} Age du Fer-début de la romanisation)*.
8. J. DESSE & N. DESSE-BERSET: *Osteometry and fishing strategies at Cape Andreas Kastros (Cyprus, 8th millennium BP)*.
9. N. DESSE-BERSET: *Sturgeons of the Rhône during Protohistory in Arles (6th-2nd century BC)*.
10. O. LE GALL: *Quelques remarques sur l'adaptation à court et à long termes chez les poissons d'eau douce du sud de la France*.
11. R. COOKE & G. TAPIA RODRÍGUEZ: *Marine and freshwater fish amphidromy in a small tropical river on the Pacific coast of Panama: a preliminary evaluation based on gill-net and hook-and-line captures*.
12. L. BARTOSIEWICZ; E. HERTELENDI & A. FIGLER: *Seasonal dating of hand-collected fish remains from a prehistoric settlement in Hungary*.
13. W. R. BELCHER: *A regional approach to fish remains and seasonality in East Penobscot Bay, Maine*.
14. O. J. POLACO & A. F. GUZMÁN: *Fishes in some Spanish sixteenth century chronicles*.
15. T. DE JONG: *Fish consumption at Eindhoven Castle: archaeological remains versus historical sources*.
16. R. C. HOFFMANN: *Remains and verbal evidence of carp (Cyprinus carpio) in medieval Europe*.
17. L. VAN BUYTEN: *Données historiques sur le commerce de poissons à Louvain (Brabant, Belgique) au 18^{ème} siècle et leur apport à l'archéozoologie*.
18. S. CROCKFORD: *New archaeological and ethnographic evidence of an extinct fishery for giant bluefin tuna (Thunnus thynnus orientalis) on the Pacific Northwest Coast of North America*.
19. W. R. BELCHER: *Butchery practices and the ethnoarchaeology of South Asian fisherfolk*.
20. A. M. CHOYKE & L. BARTOSIEWICZ: *Angling with bones*.
21. W. Z. WENDRICH & W. VAN NEER: *Preliminary notes on fishing gear and fish at the late Roman fort at 'Abu Sha'ar (Egyptian Red Sea coast)*.
22. J. STUDER: *Roman fish sauce in Petra, Jordan*.
23. D. C. BRINKHUIZEN: *Some notes on fish remains from the late 16th century merchant vessel Scheurak SO1*.
24. R. CERÓN-CARRASCO: *The investigation of fish remains from an Orkney farm mound*.
25. D. HEINRICH: *Fish remains of two medieval castles and of an urban context- a comparison*.
26. W. VAN NEER & A. ERVYNCK: *New data on fish remains from Belgian archaeological sites*.
27. I. ZOHAR; T. DAYAN; E. SPANIER; E. GALILI & O. LERNAU: *Exploitation of grey triggerfish (Balistes carolinensis) by the prehistoric inhabitants of Atlit-Yam, Israel: a preliminary report*.
28. C. CARTWRIGHT: *Preliminary results of the study of fish remains from a 3rd millennium BC site, HD1, at Ra's al-Hadd, Oman*.
29. K. C. MACDONALD & W. VAN NEER: *Specialised fishing peoples in the Later Holocene of the Méma Region (Mali)*.
30. A. MORALES; E. ROSELLÓ & J. M. CAÑAS: *Cueva de Nerja (prov. Málaga): a close look at a twelve thousand year ichthyofaunal sequence from southern Spain*.
31. A. LENTACKER: *Fish remains from Portugal: preliminary analysis of the Mesolithic shell-midden sites of Cabeço da Amoreira and Cabeço da Arruda*.
32. B. IRVING: *Identification to family or species in ichthyofaunal studies. The importance of a filter where osteologically similar species share the same habitat niche: examples from the site of Saar, Bahrain*.
33. I. BØDKER-ENGHOFF: *Fishing from Denmark in the Ertebølle-period*.
34. H. HÜSTER-PLOGMANN: *Neolithic fish remains from the Zürich-lake region: difficulties and possibilities*.
35. N. JUAN-MUNS & C. RODRÍGUEZ SANTANA: *Sant Pere de Rodes (Empordà, Catalonia, Spain): an analysis of the eighteenth century ichthyofauna*.
36. W. VAN NEER; S. AUGUSTYNEN & T. LINKOWSKI: *Daily growth increments on fish otoliths as seasonality indicators on archaeological sites: the tilapia from late palaeolithic Makhadma in Egypt*.

Scaly Heads and tales: Detecting commercialization in early fisheries

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(Received 11 October 1995; accepted 28 December 1995)

ABSTRACT: Given the example of the widespread failure of North Atlantic fisheries in the 1990's, one might easily conclude that intensive large scale commercial cod fishing is a profoundly bad idea. How did communities all across the North Atlantic first become dependent upon large scale, interregional, «world-system» scale exploitation of fish stocks that ultimately have proved unable to withstand human demand and technology? Where and how did the transformation of subsistence fishing for local consumption take place? What zoological and archaeological indicators signal the beginning of commercialization in a locality? How can we compare developmental sequences in different areas? These questions may be even more complex than previously thought. This paper attempts to take a closer look at these issues and raise questions for future study in the varied North Atlantic areas in an effort to better understand the processes of commercialization and to come up with tangible signatures of commercialization against which data can be compared.

KEY WORDS: COMMERCIALIZATION, FISHERIES, NORTHERN NORWAY, PROTOCOLS, CUT-MARKS, RATIOS, FISHSIZE

RESUMEN: A la vista del colapso general de las pesquerías del Atlántico Norte en la década de los años noventa, se podría concluir que la pesca comercial intensiva a gran escala constituye una pésima iniciativa. ¿Cómo llegaron a tal grado de dependencia de un tal sistema interregional a gran escala las comunidades humanas, sistema que, a la postre ha sido incapaz de responder a nuestra demanda y tecnología? ¿Dónde y cómo tuvo lugar la transformación de la pesca de subsistencia? ¿Qué indicadores zoológicos y arqueológicos marcan los comienzos de la comercialización en un determinado lugar? ¿Cómo podemos comparar distintas secuencias de desarrollo en diferentes zonas? Estas y otras preguntas podrían ser mucho más complejas de lo que hasta ahora pensábamos. Nuestro trabajo pretende abordarlas en detalle así como formular nuevas preguntas que canalizen futuras investigaciones en las diferentes áreas del Atlántico Norte en un intento por comprender mejor los procesos de comercialización de la pesca y diseñar pruebas de contraste que permitan la eventual contrastación de nuestros datos.

PALABRAS CLAVE: COMERCIALIZACIÓN, PESQUERÍAS, NORUEGA SEPTENTRIONAL, PROTOCOLOS, MARCAS DE CORTE, PROPORCIONES, TALLAS DE PESCADO

THE NORTH NORWEGIAN EVIDENCE

Several generations of systematic collection of animal bones from sites of all periods in Northern Norway, and long-term research by scholars such as Pirjo Lahtiperä at the Zoological Museum in Bergen provide a series of potential test cases that allow us to address (if not answer) some of the basic questions surrounding commercialization. Some of these questions are conceptual. These

conceptual issues include the still uncertain definition of commercialization, the precise nature of local transitions from a subsistence to market economy in specific areas, the interaction of new trading possibilities with the political and social agendas of local elites, and the complex interactions of human intent and a changing natural environment. Other urgent research questions are practical and methodological. What are the key zooarchaeological signatures of a commercial

transition? How can we build a case for a commercial fishery rather than a subsistence one for a given site? How can we expand from such site-specific arguments to generate a set of techniques, indicators, and signatures that may be more universal in application?

Many scholars working with North Atlantic faunal collections have based arguments for commercialization in their particular area on sheer numbers of fish (Amorosi, 1991), cutmarks (Barrett, 1994), fish size and ratios (Bigelow, 1984; Amorosi, McGovern & Perdikaris, 1994). Particular approaches have led to convincing arguments for specific cases, but do yet provide a set of recipes we can all use?

WHAT IS «COMMERCIALIZATION»?

Before any methodological questions are addressed, it is interesting to explore how commercialization has been defined. Commercialization of fish or any other natural product is the end result of a process that gives human value and significance to a selected portion of an ecosystem. The transformation of marine resources into human «natural capital» that can be mobilized by local and distant elites to finance other projects and agendas parallels earlier transformations of wild herds into flocks and then into marketable wool, milk, and mutton. The conversion of what Cronon (1993) has termed the «first nature» of pre-industrial local subsistence into the «second nature» of a commercial capital asset involves linked changes in production, marketing, transport, diet and food ways, and most particularly in the political organization of space and time. Unlike the oceans of grain and mountains of hog bellies that passed through Cronon's Natural Metropolis of 19th century Chicago, the medieval conversion of the first nature of fish in the sea to the second nature of stockfish in the bishop's storehouse did not draw upon the Neolithic agricultural first nature, but upon an older northern maritime hunting and fishing tradition.

In North Norway, we have evidence for such a maritime hunting/fishing tradition extending back to the Older Stone Age. In the Northern Isles of Britain we have nearly as much time depth. In the Faroes, Iceland, and Greenland we have what were essentially first settlements in the Viking Age, with little or no in-place continuity with prehistoric

uses of land and sea. Given these different prehistories of the first nature of subsistence fishing, can we be sure that the transformations that produced the second nature of commercial fishing in the high Middle Ages were really all the same? Or should we expect this process to be manifested in many different ways and to be more region specific than universal and uniform?

The transformation from first to second nature is linked to the economic, political and historical development of both producers and consumers, and probably to long and short term changes in local and regional climate and current circulation as well. We are thus looking at an extremely complex interplay of humans and nature, and we might begin by being wary of simple, single-cause explanations or easy answers of any sort. This paper proposes no answers at all, hard or easy, but instead attempts to raise some issues that may lead to better questions.

Commercialization, when it refers to the stockfish production in the medieval North Atlantic, is essentially the generation of surplus fish. The profits and organization of this large scale fishing are controlled by the governing institutions of the state and church. Fish is used as a commodity that generates a cash profit from markets abroad. In order for us to approach this issue and try to establish whether we are looking at a site that is involved in commercial production there are a number of parameters and conditions that need to be met. Ultimately no one measure by itself can «produce» a commercial site. It would have to be a combination of factors and approaches. In the following sections I will address these issues separately and discuss their merit and potential.

NUMBERS OF FISH

The cod fishery and the production of stockfish in particular, has been the economic backbone of the Norwegian fishing industry for the last 1000 years. The Barent Sea north of Norway and Russia is the most important breeding ground for the cod population.

Some of the ancient roots of Norwegian trade and travel are attested to in king Alfred of Wessex's translation of Orosius in the early AD 890's. This source relates to the trading voyages of Ottar who was a North Norwegian chieftain from

Kvaløy. Ottar like many other northern chieftains considered the Swedish Norrland, Kola and the entire northern coast as their trading area. When did stockfish become a trading item to be taken along on these voyages? When did it cross the line from subsistence to market?

The production of stockfish by the 12th century became *the* key element in Norwegian interaction with Europe. But how did this start? The transition to a commercial economy is normally described as a «natural development» resulting from the intense internal restructuring of the secular and ecclesiastical domains in Norway at about A.D. 1050 (Urbanzyk, 1992). Distant urban markets, religious restructuring of the European diet and a chronic cash shortage in the newly reorganized Norwegian monarchy are often identified as the prime movers in the equation. Exploitation of northern cod stocks and northern Norwegians by large-scale market forces to the south thus can be made to explain both the situation in the 12th century and in the early 20th, and the transition becomes somet-

hing that just happened to a passively marginal population.

Or did commercialization in northern Norway give a new form to an old mode of trade? During the Iron Age, as observed in the faunal collection from Bleik in Andøya (Figure 1), the local people were certainly involved in an active intense fishery. The difference between the two eras, i.e., Iron Age and Middle Ages, lies in the focus and scope of the activity as well as the nature of the controlling elements. Norwegian cod in the form of stockfish can therefore stand in for the yams of the Polynesians—a resource that could be intensified, stored, and which could provide the basic fuel for chiefly ambition. In the Iron Age the pressures for generation of surplus were of a local nature. Surplus fish can feed the population under the chieftains control during the «bad» years and can be used as storable provisions during the long Viking voyages. Fish can also be added to the list of skins, furs and oil to be traded in foreign lands. Cod was probably used to form alliances with chieftains of nearby regions.

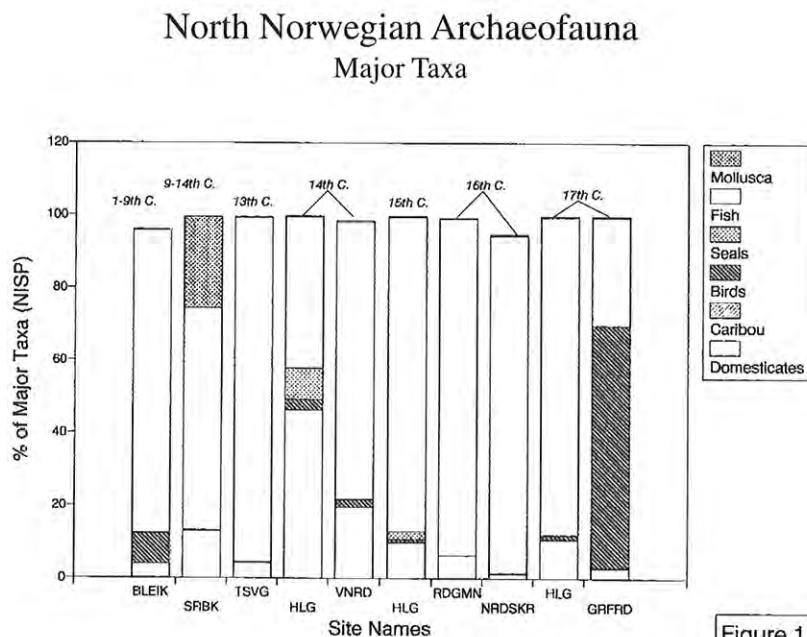


Figure 1

FIGURE 1

A Comparison of the major taxa of the 2nd century site of Bleik in Andøya with the 13th, 14th, 15th, 16th and 17th century sites of the Helgøy region (Torsvåg, Helgøy, Vanareid, Rodgammen, Nordskar, Grunfjord) and the inland farm mound of Sauerbekken (9th-10th century).

The profits and benefits from such ventures would directly benefit the chieftain and the people under his control. During the commercialization era, local power was not autonomous any more; the king and church were now the ultimate power foci. Taxation and tithes were now to be collected by the state for the state. Profits obtained from intense fishing became a domain of the new centralized government. The fledgling state had already created large debts to the church and it was in desperate need of new revenues that would generate profit. «Lofot-fish even before the middle of the 11th century had reached a volume which became economically interesting for regular tax policy of the kingdom» (Bjørge, 1986 b: 42).

Capital gain moved from the hands of local lords to the hands of the state. The forming of alliances and trading was now done on an international level going beyond alliances and generation of surplus to feed the population in a bad year. It was now geared to bring monetary profit to a state with growing needs and huge debt to the church. During the medieval period there was also a shift in settlement pattern and power distribution. The chieftain's farms faded and new centers developed. These centers were the seats for the local secular and church representatives. There was therefore a shift of focus from the chiefly farm to the church yard, and zooarchaeology is a key resource that brings out this manipulation of stockfish which marks the transition from a subsistence to a staple goods economy.

By late medieval times, the Lofoten fisheries provided a significant portion of the fish catch of Western Europe. By 1500, the once-independent fisher-farmers of the Lofoten and Vesterålen were caught up in debt-driven intensive winter fisheries and tied to economic fluctuations in markets thousands of miles away. This local transformation of marine exploitation from subsistence to market production was thus to have profound implications for the development of modern commercial fishing both in Norway and in the whole North Atlantic.

As Bjørge (1986) discusses, the reason that «the monarch's good graces» extended to this far-flung place in Lofoten must be put in a broader historical context. «The fast development of north European long-distance trade, initiated already at the turn of the 11th century must have stimulated the growth of dried fish production in Lofoten with Vågan as a natural center of this industry because fishing waters south of Lofoten have never played

an important role in connection with export» (Bjørge, 1986 b: 43).

When comparing the Iron Age site of Andøya, Bleik, that I have already mentioned, with the medieval sites of the Helgøy region and Vågan we see that the patterning is consistent (Figures 1, 2). The sites of Helgøy and Vågan are farm mounds and Bleik is a midden. The bone element count for these sites varies from 30,000 to 75,000 bones. Only bones identified to species have been used for these comparisons. As is evident from the data, fish, in particular cod, comprise the majority of most of the sites' archaeofauna followed by hali- but, ling and coalfish.



FIGURE 2
Map of Norway showing the archaeological sites mentioned in the text.

It is interesting to note that the historical and zooarchaeological data for the medieval sites correlate nicely. There is a peak of fish bones associated with the beginning of the Lofoten fisheries during the 13th and early 14th century, a time of trouble due to the preying of Russian raiders on Lofoten boats bearing trading goods bound for southern markets and the loss of labor due to the Black Death. Eventually the numbers rise during the 15th and 16th century and continue strong into the 1800's.

It is apparent therefore that when talking about commercialization in Norway, the numbers of fish alone are not the answer. If we look at the archaeo-

fauna of the Iron Age site of Bleik and compare it with the other medieval sites I mentioned, the patterning is identical. This patterning, however, means two different things depending on the period. Sheer numbers of fish does not equal commercialization and there is no magical threshold percentage to separate subsistence from commercial production. We cannot ignore the more general historical development of the area but must instead incorporate it, since the zooarchaeological data alone can give a skewed image of what really went on.

CUTMARKS, RATIOS AND FISH SIZE

A. Cutmarks

Can we find a signature for commercialization in cutmarks, fish size or ratios between head and tail elements? An informal cutmark experiment was conducted by the author this summer, where the cutmarks produced on codfish bone by a) a local fisherman, b) a decapitating machine on the fishing boat and c) the author, were analyzed. Five specimens were collected for each category. The average live length of fish was 60 - 65 cm.

After examination, two distinct groups of cutmarks were observed. The first was a *clear-cut* type that went through the vertebra (Figure 3); the second was a *cut and snap* type on the centrum faces (Figure 4). Both types of marks were produced by the fisherman and the machine while all the specimens I personally butchered showed only clear cuts that split the cervical (pre-thoracic) vertebra in half. This demonstrates that knives may potentially produce both types of cutmarks and that neither is indicative of industrial processing. This of course is only a limited study and further actualistic research is necessary for a fuller understanding of cutmark variability. Cutmarks can probably indicate processing of cod for stockfish, but not all stockfish is geared for the commercial market. Cod heads are not traditionally used in food preparation and are therefore removed from the body in a similar fashion to stockfish. When we consider the medieval commercial production of stockfish, the cutmark patterning might not be the answer. The same person who is the commercial fisherman is also the fisher-farmer who prepares the day's catch for his household. The patterning does not change. The only other possibility for difference in the cutmarks produced is if there is a

different knife blade. The iron blade of medieval knives did get dull soon and needed sharpening more often. A different set of cutmarks may not indicate commercialization patterning but rather an accidental occurrence.

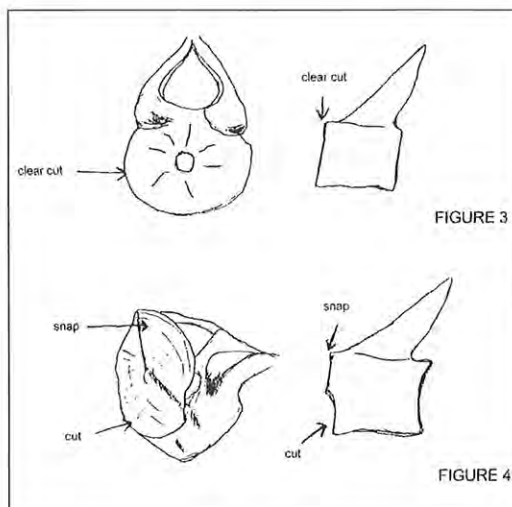


FIGURE 3

A drawing of a gadid vertebrae showing the «clear cut» type of cutmark.

FIGURE 4

A drawing of a gadid vertebrae showing the «snap & cut» type of cutmark.

B. Ratios

What about head and tail (in this context referring to the vertebral column) ratios? In this case I think two separate arguments can be built: one for the area of production and one for the area of consumption. When it comes to northern Norway, the preparation of cod for stockfish in medieval times was done near the farm or rorbu (fisherman's huts), close to the shoreline. The discarded material, i.e., head bones and entrails, does not all end up in the midden. Fish heads have been used for animal fodder and field fertilizer throughout the medieval period. The volume of refuse produced in the fishing season through the preparation of stockfish is usually so large that even though a lot of material leaves the area through human or animal agents (seagulls, foxes, etc.) there is a certain over-representation of head bones versus tail bones for example in the Icelandic material as seen in these tables (Table 1, 2, 3).

Fish Relative Percentages Based on NISP counts						
	H7	H9	H14	Mean	SD	CV
SPECIES						
Cod	91.58	100	91.82	94.47	4.79	5.07
Saithe/Pollack	2.48	0	1.79	1.42	1.28	89.93
Ling	3.96	0	3.32	2.43	2.13	87.60
Haddock	1.98	0	3.07	1.68	1.56	92.46
Whiting	0	0	0	0.00	0.00	ERR
Fish Cranial to Body Proportions Based on NISP Counts						
% Total Cranial	94.12	85.16	90.95	90.08	4.54	5.04
% Total Vertebral	5.88	14.72	9.05	9.88	4.48	45.31
Observed						
Ident. Cran.: Vert.	1.06	3.17	0.83	1.69	1.29	76.47
«Natural»						
Ident. Cran.: Vert.	3.1	3.1	3.1			
Observed- «Natural»	-2.04	0.07	-2.27	-1.41		
<i>Table borrowed from Russel, Amorosi & McGovern, 1986</i>						

TABLE 1
Fish Relative Percentages from the Upper Layers of Storaborg, Iceland.

Storaborg Middle Layers				
Fish Relative Percentages				
Based on NISP Counts				
	H 9/14	Mean	SD	CV
SPECIES				
Cod	90.63			
Saithe/Pollack	2.08			
Ling	5.21			
Haddock	0			
Whiting	2.08			
Fish Cranial to Body Proportions				
Based on NISP Counts				
% Total Cranial	88.19			
% Total Vertebral	11.81			
Observed				
Ident. Cran.: Vert.	2.29			
«Natural»				
Ident. Cran.: Vert.	3.1			
Observed- «Natural»	-0.81			
<i>Table borrowed from Russel, Amorosi & McGovern, 1986</i>				

TABLE 2
Fish Relative Percentages from the Middle Layers of Storaborg, Iceland.

Storaborg Middle Layers						
Fish Relative Percentages						
Based on NISP Counts						
	H17	H18	H19	Mean	SD	CV
SPECIES						
Cod	94.17	92.94	91.34	92.82	1.42	1.53
Saithe/Pollack	3.33	5.08	4.72	4.38	0.92	21.12
Ling	0	0.85	0.79	0.55	0.47	86.78
Haddock	2.5	1.13	3.15	2.26	1.03	45.63
Whiting	0	0	0	0.00	0.00	ERR
Fish Cranial to Body Proportions						
Based on NISP Counts						
% Total Cranial	93.3	71.6	84.79	83.23	10.93	13.14
% Total Vertebral	6.7	28.4	15.21	16.77	10.93	65.20
Observed						
Ident. Cran.: Vert.	1.88	7.16	4.09	4.38	2.65	60.59
«Natural»						
Ident. Cran.: Vert.	3.1	3.1	3.1			
Observed- «Natural»	-1.22	4.06	0.99	1.28	2.65	207.70
<i>Table borrowed from Russel, Amorosi & McGovern, 1986</i>						

TABLE 3
Fish Relative Percentages from the Lower Layers of Storaborg, Iceland.

The anomalous ratio between the cranial and post-cranial skeletal elements of the different species of fish in the Storaborg archaeofauna is an interesting one. Tables 1, 2, and 3 have been borrowed from «An Archaeofauna from Storaborg, Southern Iceland: An Interim Report» (Russell, Amorosi & McGovern, 1986). In these tables data on the skeletal ratios is presented in addition to the relative percentage of the different fish species. The sixth and seventh rows present the proportions of all cranial fragments to all vertebral fragments, and point to the over-abundance of cranial fragments (ca. 71%-94% of the total number of fish bones for each context). Of the cranial bones, only those identifiable to species level have been used in order to avoid the «noise» produced by small broken fragments. These are restricted to the denser and less fragile mouth parts and the otoliths.

These cranial fragments are likely most comparable in terms of recoverability and density to the gadid vertebral centrum. Of the vertebrae, only the larger elements of the gadid vertebral sequence have been used (11 cranial parts to 34 vertebral parts). This produces a ratio of 1:3.1 (Tables 1, 2, 3: row 9) (Russell, Amorosi & McGovern, 1986). Indeed, if we expect that where fish skeletons enter archaeological contexts in roughly equal ratios of head to body, and where preservation and recovery factors do not selectively discriminate against cranial or post cranial elements, the mean is -0.31, indicating an overall disproportionate predominance of head parts in most excavation contexts.

The over-representation of cranial elements alone does not necessarily represent commercialization. Stockfish is part of the local diet. The Norwegian and Icelandic fisher-farmers produce

stockfish both for individual consumption and for the market. Can we really tell which is which? A slightly different approach towards heads and tails is to compare the percentages generated from the cranial and post-cranial elements from cod to the percentages generated by the other significant (in terms of numbers) species. The way the two compare can potentially give us a better idea of whether we are looking at a taphonomic phenomenon or a commercial signature.

The argument can be a bit more straightforward when it comes to areas of consumption. Complete absence of head bones and presence of articulated portions of the vertebral column can be indicators that point to commercialization. Care must be taken to separate the presence of local fishing from the imported material and that is a site-specific scenario.

C. Fish size

There are some selected patterns, observed by many workers in a growing number of North Atlantic archaeofaunas, that point to a distinct difference between reconstructed lengths of cod and those observed in most modern stocks in the same area. The North Norwegian fish bone assemblage

from Storvågan indicates cod slightly smaller than those from medieval Icelandic sites in both the dentary and premaxillary reconstructions (Figure 5). Even though analyses are ongoing, some clear zooarchaeological trends are already apparent in the Storvågan collections (Figures 6, 7). The great variability in cod size in the early and late phases could reflect the influence of several ecological technological and consumption variables. The analysis is too preliminary to distinguish the particular variable accounting for the diverse cod size present at Storvågan at different times. The most important trend discernible at this time is that the relative mean lengths of cod whose bones were deposited at Storvågan over its long occupation largely ranged from 650 to 900 mm. The upper end of this size range compares well with the larger fish caught in Iceland (Amorosi, 1989) and Shetland (Bigelow, 1984) during the various pre-modern periods.

Other workers (Colley, 1983, 1990; Bigelow, 1984; Jones, 1991; Barrett, 1993) describe similar archaeological samples with mean reconstructed cod length around 90–100 cm from the Shetland Islands, Orkney, and Caithness. These distributions appear to extend back beyond the Norse period into the Pictish Iron Age in Orkney and Caith-

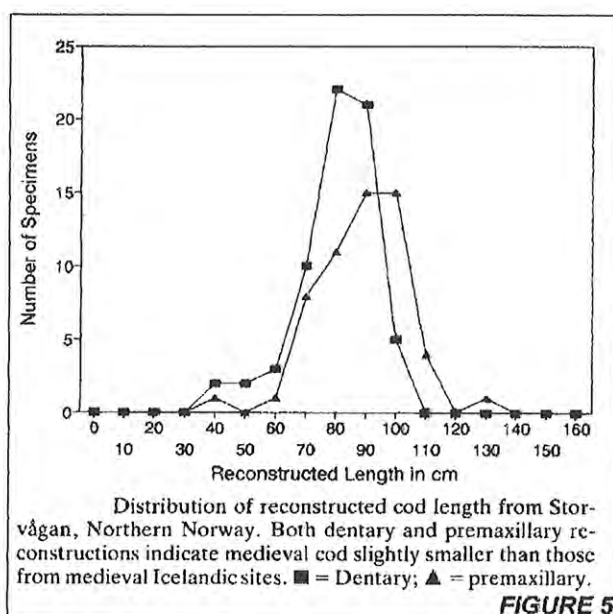


FIGURE 5

A distribution of reconstructed cod length from Vågan (Storvågan), Northern Norway.

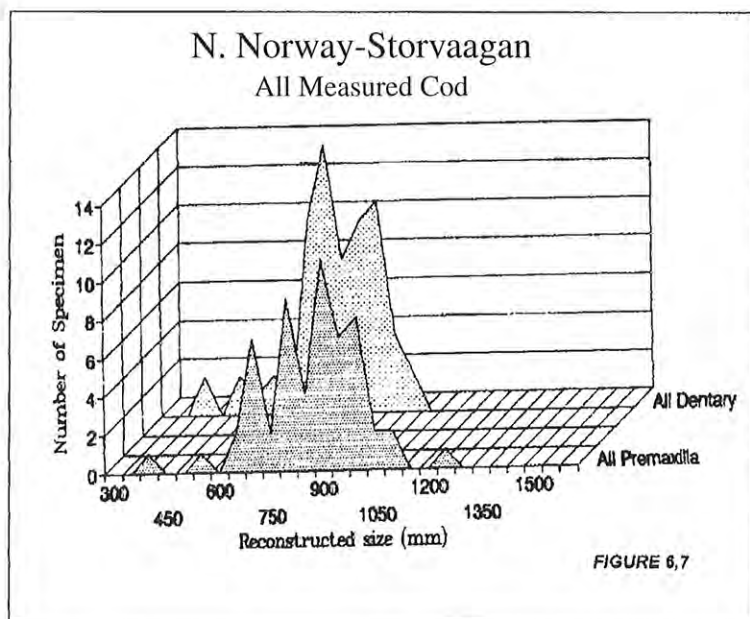


FIGURE 6, 7

FIGURE 6, 7

A graph combining two figures showing the measurements on the gadid dentary and premaxillary elements from the site of Storvågan.

ness (Colley, 1983, 1990; Jones, 1991). While sample sizes and conditions of preservation vary, it is apparent from this published data that a wide range of other researchers have also noted that large (presumably old) cod are widespread in the archaeological record. The existence of this distribution is not controversial, and appears to constitute a constant archaeological pattern that is neither local nor subtle. Application of varied osteometric techniques has indicated a fairly consistent patterning in reconstructed cod lengths (cf. Amorosi, McGovern & Perdikaris, 1994). Does larger size fish reflect a commercial catch or is it an artifact of environmental variables and fishing techniques? Ultimately a regional approach will result in a better contextualization of meaning for the patterning observed.

SITE AND DATA TYPES

Complete excavation of middens in different functional areas is at present being undertaken by the author in the area of Langenes in the Øksnes

Commune of Northern Norway (Figure 8). This work will concentrate not only on the bone material but on analyzing the entire midden composition. This will be done in order to identify and record the specific signatures of what middens from a seasonal *rorbu* (fisherman's hut) environment look like, versus the midden of a farm occupied year-round. While the 1995 test pits did produce quantities of fish, mammal, and bird bone, these are not sufficient to reasonably discuss commercialization at Langenes. This is not entirely because of sample size; it is important to excavate a fairly extensive part of the midden and not rely on a small column sample.

In the recent *Freswick Monograph* (Morris, Batey *et al.*, 1995), James Rackham builds a convincing case for the value of a combined vertical and horizontal excavating strategy. As Rackham points out, fish processing and mammal butchery and consumption may not take place in the same areas, and even on an architecturally simple «fishing farm» the horizontal dimension is archaeologically critical. As many have noted (e.g. Barker, 1983) column samples are necessarily narrow diachronic windows into change through time in a limited portion of a site.

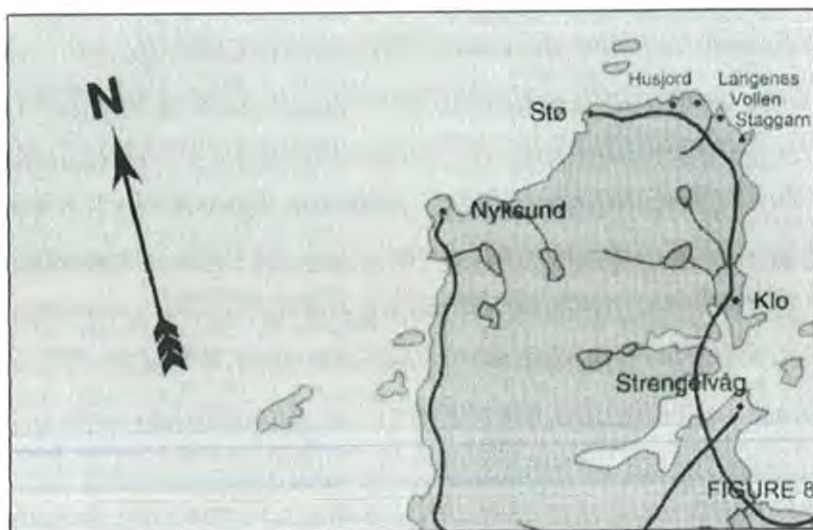


FIGURE 8

Map showing the project area of Langenes, Vesterålen, Northern Norway.

The critical issues of site organization and development of specialized processing areas are not likely to be addressed by narrow «telephone booth» excavations (Flannery, 1976).

The task is a difficult one especially since in this region there are two seasons of activity in the seasonal occupation areas, one during the winter fishing from January to April and another one during the summer when the ice has melted in the Russian peninsula and traders come down from Russia to buy fish. In order to account for that, the proposed overall research strategy takes a regional longitudinal perspective, following Bertelsen (1991), Crumley *et al.* (1991) and Bigelow (1991): a multidisciplinary investigation focused on long-term changes within a definable region rather than an emphasis on a single site or a narrowly restricted time period. Artifacts, site location, animal and fish bones, pollen, macroflora and soils from the Langenes area will all be integrated with the existing data from the other regions of Helgøy and Vågan (Storvågan) that I have already mentioned above. In this way I hope to eliminate «noise» factors characteristic of small scale column sample excavations and to investigate the changing impacts of humans on local resources and the effects and consequences of the development of large scale fisheries at a regional level.

CONCLUSIONS

In North Norway, archaeofauna dating to the 2nd century BC is dominated by gadid remains, and the relative percentages and other indicators look strikingly similar to collections dating to the 15th-16th century AD.

Single sites could easily be selected to «prove» commercialization in the early Iron Age. While early Iron Age Norwegians may have been fishing to provision complex local chieftainships with piscine staple goods, we may doubt that they were engaged in the same scale of fishing as their descendants supplying the Hansa. Equifinality is a major problem in archaeology and in zooarchaeology. We need a far more careful and systematic investigation of the phenomenon of commercial fishing what it is and what its archaeological and zooarchaeological residues can look like.

If we are to address these complex issues more effectively we need to:

1. Adopt a regional, rather than site-focused, perspective. One site is interesting but we need enough sites to form patterns. Patterns that appear on several sites, and several classes of sites are less likely to be taphonomic noise, and provide the basis for a regional interpretation of what was most certainly an inter-regional process.

2. Develop some general protocols for data collection and assessment. Large open area excavations and small column samples may both produce thousands of bones, but they are not archaeologically equivalent. We need to determine what sorts of questions are best suited to different types of collections -not all collections will allow investigation of all possible issues.

3. Integrate the zooarchaeological data into the historical and artifactual evidence for large scale interregional exchange. By using historical and artifactual data we can propose types of sites (cf. locations, Binford, 1980) which can be specifically linked to the commercial fishery. Bone data is invaluable, but it is only one category of evidence that bears on our common problem. Zooarchaeology cannot do this alone.

Medieval commercialization signatures at this stage still remain a headache in need of a proper cure. The cure will not come from pat answers and recipes. It will come through an in-depth understanding of regional development and the incorporation of archaeological, historical and environmental data.

ACKNOWLEDGEMENTS

Special thanks to Pirjo Lahtiperä for sharing her expertise and making many helpful suggestions. Thanks to Dr. Reidar Bertelsen, Dr. Inger Marie Holm-Olsen and Dr. Roger Jorgesen for allowing access to this material. Thanks to Dr. Tom McGovern without whose insightful comments this work would not have been possible. Thanks to Dr. Christian Keller for helping with the specimen photographs. I am grateful to Dr. Rolf Lie for permitting me to use the collections in store at the Bergen Zoological Museum. Thanks are also due to Dr. A. Morales for organizing this meeting, Tromsø University, the Øksnes Kommune fishermen and Hunter College.

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Salted fish and fish sauces from Masada. A preliminary report

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(Received 3 December 1995; accepted 28 December 1995)

ABSTRACT: Salted fish and fish sauces were produced and traded in large quantities in Roman times. This report deals with excavated evidence of fish products (salted fish, *garum* and *allec*) from Masada, a large Herodian fortress in the Judean Desert. The finds include remains of fish and inscribed amphorae, which were imported from Southern Spain. The sauce, *allec*, was of high quality as well as kosher. It fits well with other evidence of luxurious stores stocked by King Herod in Masada.

KEY WORDS: ARCHAEOZOOLOGY, MASADA, ROMAN PERIOD, ALLEC, GARUM

RESUMEN: Las mojamas y salsamentas fueron producidas y comercializadas intensamente en época romana. Nuestro informe comenta los restos arqueológicos evidenciadores de productos de esta índole (mojama, *garum* y *allec*) recuperados en la gran fortaleza de Herodes en el desierto de Judea llamada Masada. Los hallazgos incluyen restos de pescado y ánforas inscritas que fueron importadas de la España meridional. La salsa *allec*, al igual que el *kosher*, parece haber sido de óptima calidad lo que concuerda con evidencias de otro tipo que demuestran el almacenamiento de productos de lujo, por parte del rey Herodes, en Masada.

PALABRAS CLAVE: ARQUEOZOOLOGIA, MASADA, PERIODO ROMANO, ALLEC, GARUM

The purpose of this paper is to describe evidence for the presence of imported fish products at Masada, mainly fish sauces, a special Roman delicacy, in the context of the fortress' unique history in the Jewish and Roman world. This evidence falls into three categories: 1) fish remains; 2) jars which contained fish sauces and 3) inscriptions on jars (*tituli picti*) describing their contents.

MASADA

Masada is a fortress in the Judean Desert situated on an imposing rock facing the Dead Sea. It was built by King Herod (37-4 BCE) to serve as a winter palace and refuge in times of danger. For this purpose the fortress included large store-rooms stocked with many kinds of food. A Roman garrison held Masada from 6 CE, when Judea became a Roman province, until 66 CE when Jewish sicarii took it over. Three or four years after the fall of Jerusalem the Romans besieged and captured

Masada under the command of L. Flavius Silva but not before its 960 defenders had committed suicide. Josephus Flavius, a contemporary Jewish historian, described the nature and history of Masada in detail. He is the only written source for the story of Masada.

THE FISH REMAINS

Excavations in Masada by Yadin (1963-1965) yielded fish remains of two distinct categories: 1) scattered fish bones, and 2) contents of a jar.

1. 649 fish bones were found in different loci in the fortress, 327 of which could be identified (Table 1). 97% of these belonged to the family Scombridae (Mackerels and Tunnies), mostly well preserved vertebrae of small regular sizes (Table 2). This high percentage of scombrids is unique in Israel. Scombrid bones were found only in 6 additional sites (out of about 50) and then only in low

proportions of 0.05-6.9% (Table 3). We suggest that the scattered Scombrid bones belonged to salted fish imported to Masada, presumably in Amphorae (see below).

FAMILY	NISP
Carangidae	1
Mugilidae	1
Serranidae	8
Scombridae	317
TOTAL	327

TABLE 1

Scattered fish bones in Masada organized by family.
NISP = Number of identified specimens.

2. A flat base of a jar contained about 125 g of fine grains of soil mixed with fish remains. A sample weighing 2 g was examined and separated under a binocular microscope (x 8). It contained a large number of fish scales, broken fin spines, vertebral processes, ribs, neurocranial fragments and 1494 recognizable skeletal elements of fish (Table

4). The state of preservation of most bones was good, but many were extremely fragile and tended to disintegrate when handled. About 60% could be identified.

The minimum number of individual fish (MNI) in this sample was 28 (deduced from 28 first vertebrae). By extrapolation 125 g would contain the remains of at least 1750 fish. The largest bones were cleithra and dentaries, measuring about 7 mm. The size of vertebrae was 1.5 mm or less. Most vertebrae had a hollowed centrum and many consisted of transparent «shells» only, typical of young fish. The estimated sizes of the fish were 4-5 cm only.

Most of the bones belonged to the family Clupeidae (Herrings). Some skeletal elements were represented by two types of bones which seemed to belong to two closely related species. Thus, for instance, there were two similar types of maxillary bones, a «rough» one which belonged to *Sardinella aurita* (Round sardinella) and a «delicate» one which belonged to a species not represented in our reference collection. There were also a few bones which belonged to a similar fish, *Engraulis encrasicolus* (European anchovy) of the family Engraulidae.

SKELETAL ELEMENT	Scombridae	Thunnus sp.	K. pelamis	A. rochei	S. sarda	TOTAL
Articular	1					1
Quadratum		1				1
Hyomandibular					6	6
Operculum	2					2
Preoperculum	2					2
Scapula	6					6
First vertebra					2	2
Abdominal Vertebra	27				31	58
Caudal vertebra	14	168	1	1	36	220
Dorsal spine	3					3
Basioccipital	16					16
TOTAL	71	169	1	1	75	317

TABLE 2

Scombrid fish bones in Masada. Identifications and skeletal elements.

SITE	NISP	Scombrid bones	%
Kasarvit (1)	1725	1	0.05
Askelon (85) (2)	2109	7	0.3
Hatoula (3)	621	5	0.8
Acre (1)	250	3	1.2
Tell Abu Hawam (1)	173	4	2.3
Tamara (4)	360	25	6.9
Masada	327	317	96.9

TABLE 3

Remains of scombrids. Israel and Northern Sinai. (1) Unpublished data, (2) Lernau & Lernau, in press, (3) Lernau & Lernau (1994), (4) Lernau (1986).

ELEMENT	NUMBER
Neurocranium	
Part	99
Basioccipital	21
Posttemporal	6
Branchiocranium	
<i>Oromandibular region</i>	
Maxilla	37
Dentary	2
Articular	9
Quadrate	8
<i>Hyoid region</i>	
Hyomandibular	38
Opercular	20
Preopercular	9
Epihyal	4
Hypohyal	9
Urohyal	6
Appendicular skeleton	
Cleithrum	34
Vertebral column	
General	279
First vertebra	28
Abdominal vertebrae	354
Caudal vertebrae	522
Fins	
Spines	9
TOTAL	1494

TABLE 4

Skeletal elements in sample of *Garum*.

THE JARS

1) *Masada, Inv. 1039-1047*. Fragment of a round-bottomed jar in hard-fired red clay. This fragment held the remains of fish discussed above and was found in a room of the defensive wall of Masada not in the storerooms. The shape and fabric indicate that this is a locally made Syro-Palestinian baggy jar. This shape has a long history, from the Hellenistic to the Early Islamic periods. Petrographic analysis is consistent with a local origin. Micromorphological study of the non-faunal residues in the fish remains sediment show: 1) remains of vegetal material with residues of plant organs and amorphous organic fine material; 2) Selenite (gypsum crystals) cleavage fractures; and 3) sand with grains of quartz, feldspar, limestone and a grain of weathered mica-schist. The composition of the sand, especially the schist grain, indicate an origin foreign to the Eastern Mediterranean. Different origins for the jar and for its contents suggest that the fish sauce was originally imported to Masada in another container which has not been recovered. The fact that the sauce seems to have been mixed with sand, presumably in its place of origin, has not been satisfactorily worked at yet.

2) *Masada, Inv. 1047-650*. 15 joining fragments preserved part of a shoulder, wide neck and lower handle attachment of an imported amphora. The exterior surface was covered with a yellow slip. A bilingual inscription (Latin and Greek) in black ink was located on the exterior neck. The shape and fabric indicate that it belongs to Peacock and Williams' «Class 18», produced on the southern Spanish coast and used to carry fish-based products (Peacock & Williams, 1986). It is dated to the late first or early second century CE. In this section the clay matrix is reddish-tan in colour, fairly silty and rich in mica flakes. Detailed analysis of the composition of the clay matches an amphora classified by Peacock and Williams as «Class 14», originating from the southern Spanish coast and dating from the mid-first century BCE to the later second century CE. This type was also used for trade in fish-based products.

The discrepancy between the typological and the petrographic identifications of this amphora may well be the result of the absence of specific petrological descriptions in Peacock and Williams. In any case we assume with a great deal of certainty that this amphora was imported from Spain.

The inscription on the amphora reads the following:

Diplomatic transcript Reconstruction

1. GARUM [	1. Garum [
2. [symbol]	2. [symbol]
3. Δ[	3. Δ[
4. BACIAEΩ.[	4. Βασιλεωc[
5. ...P.O...[	5. ...p.o..[
6. A	6. A(mphorae) vel A(nnorum)[

According to this inscription the amphora contained *garum* (a fish sauce) «of the king»: Βασιλεωc. Since the jar has been broken after the now erased sigma, the name «Herod» could have followed the title, as it did in Latin in a series of inscriptions on fragments of wine jars also found in Masada. There, the genitive case, «of the King», stood for the «customer», the person who purchased the amphora, its present owner - namely Herod (Cotton & Geiger, 1989b).

3) *Masada Inv. 92-559/3*. A small fragment of an amphora, on which we find the letters Mu[, which could be expanded to yield Mur[jia, a fish sauce.

4) *Masada, Inv. 310-1129*. A small fragment of an amphora with the first line of a short inscription saying E]xcel(lens). This could refer either to wine, or to a fish sauce.

ROMAN FISH SAUCES

Garum, *muria* and *allec* were fish sauces popularized by the Romans, and widely consumed for about a millennium. Their nutritional importance was threefold: 1) they served as condiments in periods which were poor in tasty additives to food; 2) they preserved the nourishing elements contained in fish meat for prolonged periods of time; 3) they were used to conserve fish, meat, vegetables etc. Similar fish sauces are still prepared today in South Asia, e.g. Nuoc-Mam in Thailand (Curtis, 1991). Fish sauces were manufactured as a by-product in special fish-salting plants (salteries) located along the southern and northern shores of the Western Mediterranean and along the Atlantic shores of Spain, Portugal and Northern Africa (Ponsich & Tarradell, 1965). These installations combined proximity to rich fishing grounds with the production

of crude sea-salt in evaporation pools. The importance of fish sauce in an extravagant Roman cuisine may be gauged from Apicius' cooking book which took its present form c. 400 CE: at least ten different varieties of fish sauces were used in preparing the gourmet recipes (André, 1974).

We shall not discuss in detail the production of Roman fish sauces yet the differences between the types are important: *garum* was the main product, a salty, spicy, sometimes foul smelling clear fluid strained from small fish which had undergone a process of autodigestion in the sun. *Muria* was a salty liquid similar to *garum* but of lower quality. It was used for conserving vegetables, fruits, olives or fish rather than as a spice for its own sake. *Allec* was the residue of *garum*, a thick semi-liquid mash containing macerated meat, scales, bones etc. This was at first regarded as a cheap spice (Cato recommended it for slaves - *De Agricultura* 58), but later it gained a reputation of its own and became an expensive additive to different dishes (Curtis, 1991). It follows that excavated bony remnants of a fish sauce, as in Masada, are likely to be the remains of *allec*, not of *garum* or *muria*.

There are only a few ichthyo-osteological studies of remains of *allec*. They show two distinct patterns -one kind is made of many different species of fish of different sizes, while the second contains a limited number of similar fish, with regular small sizes. Driesch (1980) described the contents of a large number of broken amphorae found in Cerro del Mar in Spain, consisting of bones of 16 different kinds of fish. Lepiksaar (1986) studied *allec* found in an amphora in Salzburg, composed of bones of 24 kinds of fish but also invertebrates and a, probably intrusive, frog. The large variety of small fish and other organisms, some of them of low commercial and nutritional value, and the rough accompanying gravel, suggested to Lepiksaar a cheap sauce made of the contents of a fine net dragged in low waters without much sorting or cleaning.

Other studies show a different pattern. Thus Wheeler & Locker (1985) describe fish bones from submerged amphorae off the Sicilian coast. They all belonged to Clupeidae, some identified as *Sardina pilchardus*. These were relatively large fish, 10-17 cm long. Studer (1994) has recently described the contents of a «pilgrim's flask» from Late Roman-Nabatean Petra with thousands of very small bones, 99% of which seemed to belong to one Clupeid species (sardine or anchovy). A si-

milar type of *allec* from York, made exclusively of very small local Clupeids, was described by Jones (Jones, 1988).

It seems to us that high quality *allec* had to be made of very small fish with a high fat content. Schools of young fish could be caught for this purpose at the appropriate season and the soft, minuscule bones would go unnoticed by the consumer. In contrast, low quality *allec* (and presumably other fish sauce as well) was a by-product of the salted fish industry, made from left-over small fish without sorting, including contaminants like invertebrates and other organisms.

We suggest that the *allec* from Masada, which was made of very small and regular fish of a limited variety, was a high-quality product, itself a by-product of high-quality *garum*, both worth the expense of shipment from the shores of Western Europe to the luxurious winter resort of King Herod. In addition, the salted scombrids described above might well have been imported to Masada together with the sauces from the same production plants.

DATING THE REMAINS OF FISH SAUCES IN MASADA

The inscribed ceramic sherds and the remains of *allec* described above were each found in a different locus, in the same general area of the fortress. The sherds did not carry their own dates, and the archaeological contexts did not allow exact dating. Nevertheless it seems highly likely -but not entirely beyond doubt- that the fish sauces at Masada date to the Herodian phase of occupation. This assumption is based, in short, on the following considerations (detailed discussion will be found elsewhere [Cotton, Lerna & Goren, in press]): 1) The Sicarii could not be responsible for this kind of import. 2) The mention of the word βασιλεως «of the king» would fit no other occupants of Masada but Herod. 3) Herod's name, along with precise dates, appears on a series of jar inscriptions from Masada, which are similar, sometimes identical in style to the inscribed «*garum*» jar. 4) All the inscribed amphorae found in Masada carrying their own dates, were dated to between 27 and 14 BCE, attesting to large shipments of imported wine to Herod. 5) Many inscribed dated and undated imported amphorae carried luxury products from the western part of the Roman Empire. 6) The possibility that some of these amphorae were part of the army's supplies,

perhaps meant specifically for Silva and his staff, cannot be entirely ruled out. To some extent this depends on the length of the siege, which seems to have been much exaggerated (Roth, 1995).

KOSHER *allec* AND *garum*: FISH SAUCES PREPARED ESPECIALLY FOR JEWS?

The *allec* from Masada had another property - it was also kosher. The only kind of kosher fish sauce acceptable to Jews would be one made of fish possessing both fins and scales. Scaleless fish and all invertebrates are forbidden according to Jewish law (Lev. 11:9-11; Deut. 14:9-10). Jews, therefore, could safely use labeled fish sauces specifying the species from which they were made, e.g. GARUM SCOMBRI, or HA(LLEX) S(COMBRI) (Curtis, 1991). It seems to us significant that the *allec* described here contained only two kinds of fish, namely clupeids and anchovy, both of which were considered kosher. The original vessel in which the *allec* reached Masada might well have carried a label advertising its high quality and specifying the types of fish it was composed of - in other words its *kashrut* certificate. It is not at all inconceivable that Herod who ordered, or received as a gift, a special consignment of *Philonianum* from Italy, had ordered a kosher kind of *allec* to be sent to him to Masada. The presence of the word βασιλευς on the amphora which contained *garum* suggests that it was ordered by Herod himself, or sent to him as a present, and if we are right to assume that the «*kashrut*» of the *allec* was of importance, then it is plausible that this *garum* was kosher as well.

CONCLUSIONS

The storeroom complex of Masada is dated to the main building phase, c. 30 to 20 BCE. The presence of imported wine jars dated to 27 and 26 BCE, and the remains of a large shipment of wine from 19 BCE (Netzer, 1991) support this dating: it suggests that by 19 BCE at the latest Herod was stocking the storerooms. These stores rightly inspired Josephus to praise: «But the stores laid up within would have excited still more amazement, alike for their lavish splendour and their durability. For here had been stored a mass of corn, amply sufficient to last for years, abundance of wine and

oil, besides every variety of pulse and piles of dates» (BJ 7.295f., LCL translation). The importation of Italian wine (Cotton & Geiger, 1989a), apples from Cumae (Cotton & Geiger, 1989b), *garum*, *allec* and salted scombrid from Spain - in other words all the ingredients necessary for a proper Roman *cena* - demonstrates in concrete and palpable terms Herod's desire to emulate the tastes of the Roman aristocracy to the very last detail. This was part of the process of Romanization of local aristocracies in the Roman Empire (Edmondson, 1990). It fits well with other aspects of Herod's rule which equally show the influence of Roman things.

As we have seen, kosher fish sauces had to be of high quality, yet high-quality fish sauces were not necessarily kosher. The analysis of the remains of *allec* found on Masada shows that it was both kosher (only fish with scales and fins) and of high quality (small fish, no contaminants). This could be a coincidence, but it seems to fit into a general pattern according to which Herod tried to reconcile his Roman tastes with the demands imposed on him by the rules of the Jewish religion.

ACKNOWLEDGEMENTS

We would like to thank Ehud Netzer for permission to publish the fish remains from Masada, Barbara Johnson for typological identifications and Gila Hurvitz for assistance with all the items. We would also like to thank Wim Van Neer from the Royal Museum of Central Africa, Tervuren, Belgium, and Olivier Le Gall from the Institut du Quaternaire, Université de Bordeaux, France, for their help in identifying samples of the bones, and J. Edmondson of York University, Canada, for his generous advice.

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A medieval herring industry in Denmark and the importance of herring in eastern Denmark

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(Received 12 December 1995; accepted 4 January 1996)

ABSTRACT: Fishbones from the 8th-13th century AD site of Selsø-Vestby in Roskilde Fjord in Denmark were analysed. Part of the material apparently constitutes waste from a medieval herring industry. The importance of this clupeid in the eastern part of Denmark and the southern Baltic area seems to be documented by finds from other sites.

KEYWORDS: HERRING, HERRING INDUSTRY, VIKING AGE, MEDIEVAL PERIOD, PREHISTORIC FISHING, DENMARK

RESUMEN: Se valoran los restos de peces recuperados en Selsø-Vestby, un yacimiento localizado en el fiordo de Roskilde en Dinamarca, datado entre los siglos VIII-XIII d.C. Parte de los materiales representan desechos procedentes de una planta medieval de procesamiento de arenques. La importancia de este clupeido en el oriente danés así como en la zona meridional del mar Báltico parece venir confirmada a través de hallazgos procedentes de otros yacimientos.

PALABRAS CLAVE: ARENQUE, INDUSTRIA ASOCIADA AL ARENQUE, PERIODO VIKINGO, MEDIEVO, PESCA PREHISTORICA, DINAMARCA

INTRODUCTION, MATERIALS AND METHODS

The fishbone material which is the object of this analysis was excavated at the locality Selsø-Vestby. The site is situated in the eastern shore of Lake Selsø, which was earlier part of the Roskilde Fjord in Sjælland, Denmark. The cove at Selsø-Vestby formed an ideal natural harbour where, for instance, a fleet could be hidden during inactive periods. An excavation in 1994 revealed 36 pit-houses from the Viking Age which seem to have been abandoned in the beginning of 11th century, as well as remains from a subsequent medieval village which seems to have been established at the earliest in the beginning of the 12th century (Sørensen & Ulriksen, 1995).

Based on analyses of archaeological remains, especially pottery, the fishbones can be dated to the 8th-13th century AD. The part of the material which belongs to the Viking Age can be further separated into three phases (see Table 2).

Most of the bones were part of refuse thrown into abandoned Viking Age pit houses and were retrieved by sieving sediment through 4 mm mesh. Bulk samples were taken from medieval holes and pits with concentrations of fishbones and brought to the laboratory.

A representative part of the material was analysed in detail and the rest was simply examined to ascertain that the material analysed in detail was representative.

The fishbones were identified using the comparative fishbone collection at the Zoological Museum, University of Copenhagen, where the material is now kept.

RESULTS

Bulk samples

Sediment sample no. 56 AMP X 1, total weight 1239 g, was very rich in fishbones and only 10%

Skeletal element	Number left:right:unspec.
Hyoid arch:	
Hyomandibulare	2
Epihyale	34
Keratohyale	47
Hypohyale	+
Branchiostegale	+
Urohyale	134
Gill arches:	
not specified	+
Shoulder girdle:	
Supracleitræ	51
Cleithrum	182 : 195 : 88
Scapula	79
Coracoideum	219
Pinna pectoralis	+
Squama	+

TABLE 1

Bones of herring, *Clupea harengus*, represented in 10% of sample no. 56 AMP x 1. In addition, 21 pteroticum, dentale, maxillare, articulare, ectopterygium, præoperculare, operculare and suboperculare were found. Note: + means not counted but abundantly recorded.

of the sample was analysed. According to the excavators this sample belongs to a medieval village, but ^{14}C dates are not yet available.

Figure 1 shows the intact bulk sample, which is composed almost entirely of fishbones. All bones in the sample belong to herring, *Clupea harengus*. A closer study revealed that only a very limited selection of bones is represented, viz., bones from the hyoid arch, the gill arches, and the shoulder girdle. Of the hyoid arch bones, the hyomandibular is poorly represented (two bones), and the stylohyale and basihyale are absent; for the latter, this is probably due to their small size. Of the shoulder girdle bones, the posttemporal is missing (Table 1 and Figure 2). The hyomandibular and posttemporal connect the hyoid arch and shoulder girdle to the neurocranium. In addition, a lot of scales are present, as are a small number of bones from parts of the skeleton adjacent to the hyoid arch, gill arches and shoulder girdle.

To obtain an idea of the size of this herring find, the minimum number of individuals (MNI) of the sample was estimated. The most frequent bone is the right cleithrum, of which 195 were found in the 10% subsample (Table 1). On the basis of the foregoing, an MNI of about 1150 specimens can be estimated for the total sample. There are more sediment samples of this kind in the laboratory and still more sediment with herring bones remains at the site. All in all, a very large number of herrings must have been present in the site.

Species	8th-9th century	9th-10th century	10th-11th century
Herring, <i>Clupea harengus</i>	18%	3%	42%
Plaice/flounder/dab, <i>Pleuronectes platessa</i> / <i>Platichthys flesus</i> / <i>Limanda limanda</i>	49%	92%	38%
Gadids, <i>Gadidae</i>	33%	2%	17%
Garfish, perch, eel, <i>Belone belone</i> / <i>Perca fluviatilis</i> / <i>Anguilla anguilla</i>	1%	2%	3%
Number of identified bones	3485	251	860

TABLE 2

Results of the identification of fish bones from the Viking Age separated into three phases; further details in text.



FIGURE 1

Part of the untreated sediment sample no. 56 AMP x 1.

Such a large accumulation of herring bones could be the result of some kind of industrial activity. Most likely the herring were preserved according to a method which is still known today. A knife is inserted behind the head and the gills and adjacent parts are removed with a twist of the knife. This interpretation is supported by the absence of the two bones which connect the hyoid arch and shoulder girdle to the neurocranium. Immediately after this procedure, the fish is salted. The fish is cut to make the blood run out and ena-



FIGURE 2

The bones of herring, *Clupea harengus*, from sample 56 AMP x 1 belong to the hyoid arch, the gill arches and the shoulder girdle.

ble the salt to penetrate into the soft tissues. This method is still practised, especially in The Netherlands. In Skagen, one of the most important fishing towns in Denmark, there is a season every summer during which herrings are processed as described above for export to The Netherlands.

In order to compare the Selsø-Vestby material with refuse known to derive from the above-mentioned method, a woman employed in the herring industry was asked to process five herrings. Figure 3 shows one of the processed herrings. It turned out that the bones that are represented in Selsø-Vestby are precisely those that were removed by this process!



FIGURE 3

Recent processed herring showing the removed part of the gill region and the corresponding triangular notch in the fish.

The herring industry was also visited in order to see how the method is practised today. The newly caught herrings are placed on a belt conveyor and pass by the workers, who remove the gill region with a twist of their knives; the most experienced workers use a finger. The fish is held in the left hand with its head pointing away from the worker's body. After the removal of the gill region, the herring has a characteristic triangular notch behind the head. The herrings are then salted with handfuls of salt and packed into barrels which are topped up with a salty brine. The barrels are then ready for export. The waste is gathered and used as animal fodder in the form of fish meal.

Sieved samples

Sieving of refuse from the Viking Age pit houses resulted in fishbones which can be dated to three different phases, 8th-9th centuries, 9th-10th centuries and 10th-11th centuries. The result of the identifications are presented in Table 2. The most important groups of fishes seem to be flatfish, [among which only flounder (*Platichthys flesus*) has been identified to species], herring and gadids. Among gadids only cod, *Gadus morhua*, is of importance. From the 8th-9th centuries, one bone of saithe, *Pollachius virens*, was identified; from the 10th-11th centuries eight bones of haddock, *Melanogrammus aeglefinus* were retrieved. Garfish, *Belone belone*; perch, *Perca fluviatilis*; and eel, *Anguilla anguilla*, were identified from all phases. In addition, tench, *Tinca tinca*, and mackerel, *Scomber scombrus* were identified from the 8th-9th centuries, and unspecified cyprinids and salmon/trout, *Salmo* sp., from the 10th-11th century. In all phases, marine fishes dominate at 95%.

The herring bones from all these phases of Viking Age seem to represent whole skeletons, with various types of skeletal elements being equally represented.

DISCUSSION

Even though the location of Selsø-Vestby seems to have been determined by the presence of a natural harbour rather than by good fishing grounds (Sørensen & Ulriksen, 1995), many fishbones have been found.

Fishbones excavated in the pit-houses from the Viking Age indicate a rather varied marine or brackishwater fishing. The presence of seasonal species like garfish and mackerel indicate activity during the summer half-year. The most important species are flatfishes, gadids and herring. The frequency of herring is 18% of the identified bones in the 8th-9th centuries but reaches up to 42% in the 10th-11th centuries. The relative frequencies of fish from the 9th-10th century are very different from the two other phases, but the number of bones from this phase is so small that the differences cannot be regarded as significant. Therefore, this sample will not be discussed any further.

It looks as if the importance of herring increased throughout the Viking Age, an increase which

may eventually have produced a surplus that formed the basis of a herring industry as evidenced during the medieval period.

Seeman (1986) reports herring bones from a whaling station at Spitsbergen in the 17th century, where the bones from the back of the head are missing. These finds were interpreted as salted herrings, whose gills and adjacent parts had been removed – the same method as now evidenced for Selsø-Vestby. Seeman states that the method was invented by a Dutchman in the 14th century, but the find from Selsø-Vestby seems to be older. Eryvnyk & Van Neer (1992) also demonstrate processed herring, in this case from a Flemish abbey (1450-1550 AD).

The abundance of herring in the Øresund during medieval times and the famous herring markets in Scania are well known from written sources. Now we have demonstrated in Selsø-Vestby that this abundance goes back to the Viking Age. On other contemporaneous sites nearby in the eastern part of Denmark herring bones have been also found. At Birkely (8th-11th centuries), 3% of the total number of 1106 fishbones belonged to herring (Enghoff, 1995a) and the fishbone material from the chieftain's hall in Gammel Lejre (7th-11th centuries) contained 63% herring bones (total number of identified fishbones 1537) (Enghoff, 1995b). At both these Viking sites near Roskilde Fjord, all kinds of herring bones are represented, and there is no sign of processed herrings. This is also true for the medieval (13th-15th centuries) town of Holbæk (Enghoff, 1994a) on Sjælland, where herring bones constitute 19% of a total of 3843 fishbones, and in Tårnby Torv at the Øresund (Enghoff, 1994b), also medieval (14th-15th centuries), where herring bones not surprisingly amount to 71% (total number of fishbones: 2385).

Herring fishing seems to have been important during the medieval period not only in eastern Denmark but also further east in the region of the southern Baltic (Benecke, 1982, 1984, 1987; Lepiksaar & Heinrich, 1977; Hallström, 1979). Benecke (1982) reviewed the sites in the southern Baltic area; herring bones have been found only at some of these, but their absence, according to Benecke, might have methodological causes (i.e., no sieving of sediments).

CONCLUSIONS

In Selsø-Vestby at the Roskilde Fjord in Denmark, a herring industry developed during the medieval period. During the processing, the hyoid arch, gill arches and shoulder girdle were removed and the herrings must have been salted afterwards. What is now left at Selsø-Vestby is the waste of this industry. From the same site many herring bones from the Viking Age have been found, but these herrings have not been processed in this way. The same is true for other Viking sites in the area. In general, herring seems to be important in the eastern part of Denmark during the Viking Age and medieval periods. This applies also to the area of the southern Baltic.

ACKNOWLEDGEMENTS

The photographs were prepared by Geert Brovad, the tables by Knud Rosenlund and the English text was reviewed by Mary Petersen, all from the Zoological Museum, University of Copenhagen. Lone Bremer, Skagen, processed five herrings for me. Jens Ulriksen (National Museum of Denmark, Centre for Maritime Archaeology (NMF)) and Søren A. Sørensen (Museet Færgedgården) provided information on the excavation while Ole Crumlin-Pedersen (NMF) commented on the draft manuscript. I extend my sincere thanks to these persons. The Selsø-Vestby excavation and the subsequent analyses was funded by the Danish National Research Foundation.

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Identification of fish bones - how certain is it?

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(Received 3 December 1995; accepted 8 January 1996)

ABSTRACT: This paper emphasizes the need for any archaeozoological specimen to be identified not only as a function of its origin but also in relation to the degree of certainty in its assignment. It is argued that only in this way one can eventually reach an objective framework for intra- and interspecific sample comparisons of subfossil bone assemblages. A system of numerical codes is proposed whose feasibility and advantages are discussed with the help of several fish bone assemblages from Israel.

KEYWORDS: FISH, OSTEOLOGY, IDENTIFICATION, ARCHAEOLOGY

RESUMEN: Este trabajo enfatiza la necesidad de que cualquier resto arqueozoológico pueda ser identificado no sólo en función de su origen sino también del grado de certeza implícito en su clasificación. Sólo de este modo resulta posible alcanzar algún marco de referencia objetivo para llevar a cabo comparaciones intra e intermuestrales en yacimientos. Se propone, en concreto, un sistema de códigos numéricos, de fácil aplicación, cuyas ventajas se valoran sobre la base de una serie de huesos de peces procedentes de yacimientos israelitas.

PALABRAS CLAVE: PECES, OSTEOLOGÍA, IDENTIFICACIÓN, ARQUEOLOGÍA

INTRODUCTION

Fish bone identification is a difficult exercise in pattern recognition fraught with pitfalls. Factors which affect it include the state of preservation of the bones, the range of the comparative collection and the experience of the investigator, as well as several non-osteological considerations (Driver, 1992). There are three basic questions, or steps, in the process of identification of a specific bone or fragment thereof: 1) is it a bone of a fish? 2) which skeletal element is it? 3) which taxonomic group is it? The purpose of this paper is to suggest a practice for reporting identifications of fish remains, with an *explicit* reference to the confidence of the investigator in his or her answers to these questions. A structured and well-defined code which describes the conviction in the identification might add to the quality of the report.

WHICH SKELETAL ELEMENT IS IT?

The decision whether a subfossil bone belongs to fish might at times be difficult. This question is usually resolved by identifying the skeletal element. The number of bones of a fish is much larger than it is in higher vertebrates. Moreover, there is great variation in the morphology of homologous elements among different fish families. It follows that mere recognition of the skeletal element is difficult so that every assemblage of subfossil fishbones contains a number of fragments lacking enough features to accomplish even this. Sometimes there are well preserved bones with typical features, and yet one cannot identify the element. The richer the sampled environment is in terms of different species of fish, the more one would expect to be challenged with such bones. The proportion of these hard to identify bones in the assemblage should be reported and commented upon.

WHICH TAXONOMIC GROUP IS IT?

An «ideal» taxonomic identification is detailed to the level of the species. This might be possible for certain kinds of fish and/or certain skeletal elements. At times such precise identification is important, e.g. when one might expect several genera of the same family to appear in a sample, each with different interactions with the inhabitants of the excavated site. Other situations call for identification of the family only, with no additional meaning gained by the extra effort put into a more detailed diagnosis. These kinds of methodological considerations should also be reported.

CERTAINTY TOKENS

An identification should always be accompanied by a critical question: «how certain is it?» I suggest to indicate this certainty in an explicit manner, as a «certainty token» (CT) attached to each identified bone. The suggested CT is a two-digit number. The first digit indicates the degree of certainty in the identification of the *family*. The second stands for the *genus* or the *species*. «2» means «certain» (full confidence). «1» means «compatible with» (limited confidence). Identifications with lower degrees of certainty should probably not be reported.

Relevant certainty tokens are:

- «22» for a certain identification of family and genus-or-species.
- «21» for a certain identification of the family, and a diagnosis of the genus-or-species which is «compatible with...».
- «20» for a certain diagnosis of the family, with no further identification.
- «10» for a limited-confidence identification of the family only.

A *certain* identification of the genus or species implies a *certain* identification of the family (CT=22). In other words, CT=12 or 02 is meaningless. This will usually also be true for a limited-confidence diagnosis of the genus or species (CT=21 and only rarely CT=11). Non-osteological considerations may also affect the degree of certainty of a taxonomic identification. These relate

for instance to the distribution of certain kinds of fish, as will be shown below.

REPORTING CERTAINTY TOKENS

One may report certainty tokens for individual identifications or for summaries of studied assemblages. The following examples may be illustrative.

Examples for reporting individual bones:

1. *Right dentary* of Sparidae, *Sparus aurata* (CT=22). This complete, well preserved bone was found in Rosh-Zayit, a small site in northern Israel (Iron II). It showed a perfect fit with a recent specimen.

2. *First dorsal spine* of Balistidae, *Balistes carolinensis* (CT=22) from Atlit-Yam, a submerged early Neolithic village off the Mediterranean coast of northern Israel. The specimen comprises a small burned fragment of the spine.

Comment: Bones of the family Balistidae have unique shapes which are easy to recognize. There is only one species of this family in the Mediterranean and several in the Red Sea. Import of fish from the Red Sea to the Mediterranean coast in early Neolithic times is quite improbable. Therefore in this case, a reliable identification of the family, which was relatively easy even with a fragmented bone, carried with it an «automatic» identification of the species. This is an example of how non-osteologic considerations endow certainty to an identification.

3. *Left maxillary* of Serranidae, *Epinephelus* sp. (CT=21) from Tel Mikne (Iron I) situated close to the Mediterranean. A withered fragment.

Comment: The bone had definitive characteristic features of Serranidae and it seemed to be compatible with the genus *Epinephelus* which has several species along the Mediterranean coast. They occupy similar habitats and are caught with the same fishing gear.

4. *Left lower pharyngeal* bone of Cyprinidae (CT=20) from Gamla in the Golan Heights (Roman). A fragment.

Comment: Cyprinidae have characteristic, easily recognizable, lower pharyngeal bones. This fragment carried enough information to make the identification of the family certain. Fresh water bodies in the northern part of Israel today support 8

indigenous species of this family, but further identification was not achieved.

Examples for reporting assemblages (detailed reports of these assemblages are forthcoming):

1. *Bir Mazar* (Northern Sinai). A Roman-Byzantine settlement site on the main road leading from Egypt to Israel along the Mediterranean coast (Via Mare).

Number of fish bones examined	409
Identification of the skeletal element:	
Unidentified splinters	64
Unidentified but well preserved bones	1
Identified skeletal elements	344 (84.1%)
Taxonomic identification	154 (37.6%)

	CERTAINTY TOKENS				
	22	21	20	10	TOTAL
Serranidae				2	3
<i>Epinephelus fasciatus</i>		1			
Moronidae					1
<i>Dicentrarchus labrax</i>		1			
Sparidae				66	110
<i>Sparus aurata</i>		44			
Sciaenidae				3	12
<i>Argyrosomus regius</i>		9			
Cichlidae				4	1
<i>Tilapia sp.</i>		1			
Mugilidae			3	14	23
<i>Mugil sp.</i>		3			
<i>Liza sp.</i>		3			
TOTAL		62 40%	3 2,5%	89 57.5%	154

TABLE 1

Bir Mazar - Identified fish bones.

Comment: Taxonomic identification was achieved in a relatively small percentage of cases. A certain identification of the family was accomplished for about 42%. There were no certain identifications to genus or species. This is a small assemblage of bones dominated by sparids. The general state of preservation of the bones was poor, which accounts for the large proportion of low-confidence identifications. Sparid jaw bones are especially robust and retain enough features to allow identification down to species. The same is true for some bones of Mugilidae and of Sciaenidae.

This assemblage was almost exclusively made up of marine fish from the Mediterranean. The limited degree of confidence in the identifications seems sufficient for this conclusion which seems to be in agreement with the location of the settlement. However, the large proportion of unidentified bones (190 out of 344) leaves the possibility of unrecognized freshwater fish remains among them open.

2. *Tel-el-Heir* (Northern Sinai). A fortress dated to the Persian-Hellenistic period, adjacent to the ancient artificial «Eastern Canal» arising in the Nile.

Number of fish bones examined	766
Identification of the skeletal element:	
Unidentified splinters	174
Unidentified but well preserved bones.	4
Identified skeletal elements:.....	588 (76.8%)
Taxonomic identification	476 (62.1%)

Comment: This is a larger assemblage of fish remains with a much higher ratio of high-confidence identifications (92% for the family and 44% for genus or species). There is a good explanation for that. Catfish account for about 80% of the findings. These include species of *Clarias* which are found in fresh water bodies in Israel and Egypt, and of *Synodontis* which are found in the Nile. Bones of *Clarias* were mostly pectoral spines (114) and skull fragments (83). Bones of *Synodontis*

were mostly pectoral spines (129) and cleithra (29). These elements are tough, durable, and easy to identify. They also share a common characteristic, namely that fishermen were inclined to remove them shortly after the fish were caught. Reasons for doing so were different for these two kinds of fish: clarid heads were removed because they were heavy and useless for marketing. *Synodontis* pectoral spines were removed because they were (wrongly!) thought to be poisonous as they tended to produce lacerations which became easily infected and healed slowly.

The assemblage is therefore typical of a primary handling of fish near their location. The relatively high degree of certainty in the identifications endows high confidence in this conclusion which should help to elucidate the nature of the site.

	CERTAINTY TOKENS				
	22	21	20	10	TOTAL
Clariidae <i>Clarias sp.</i>	204				204
Mochokidae <i>Synodontis sp.</i> <i>Synodontis schall</i>	8	113 50		6	177
Sparidae				4	4
Cichlidae <i>Tilapia sp.</i>		56	4	18	78
<i>Mugil sp.</i> <i>Liza sp.</i>		3		10	13
TOTAL	212 44.5%	222 46.6%	4 0.8%	38 8.0%	476

TABLE 2

Tel-el-Heir - Identified fish bones.

DISCUSSION

Identification of fish bones is difficult. It is the groundwork for speculations and conclusions concerning the role of fish in an archaeological site. It is suggested that each identified subfossil bone be labeled with a «certainty token» which expresses

the confidence of the investigator in his or her diagnosis. Several factors influence this certainty and if they are explicitly addressed they may often contribute to a better understanding of the samples.

Vague expressions related to an identification such as: «uncertain», «quite certain», «likely», «questionable», «doubtful», «?», etc. are of little

value. An accepted alternative uses the following format: «Serranidae, *Epinephelus cf. aeneus*». The equivalent certainty token would be «Serranidae, *Epinephelus aeneus* (CT=21)» as in the above example. I am not aware of a similar notation for an identification with a limited-certainty of the genus or family. Another advantage of the certainty tokens is the simple transition from the individual tokens to the summary report of the assemblage.

Routine estimations of the «Certainty Token» make the investigator more careful and critical. They often integrate purely osteological factors with non-osteological considerations. These estimations may at times lead to meaningful discussions and conclusions. A report which includes data about the unidentified bones and about the confidence of the investigator in his or her identifications may be easier to evaluate and may lead to

better communication and cooperation among colleagues.

ACKNOWLEDGEMENTS

I would like to thank Prof. E. Oren from the Department of Archaeology, Ben-Gurion University, Beer Sheva, Israel, who made the bone material from Northern Sinai available for study and use in the examples contained in this publication.

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Medieval records versus excavation results -examples from Southern England

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(Received 29 December 1995; accepted 9 January 1996)

ABSTRACT: This paper briefly summarises the development of fish bone studies in the Wessex Region (especially Hampshire and Wiltshire) of Central Southern England during the 1980s and some attempts to use documents to aid interpretation of results from post-Saxon medieval deposits and, by contrast, Saxon deposits. A variety of medieval documentary sources mention fish and fishing. The kinds of medieval document available have been summarised, with special reference to the port of Southampton and surrounding areas of Central Southern England, and their usefulness for archaeologists and fish bone specialists explored. Certainly fish archaeologists cannot ignore the existence of contemporaneous documents in their interpretation of medieval fishbone results. Formerly, interpretation frequently attributed changes in species exploited or their sizes to ecological factors or changes in fishing practice when this could also be due to fluctuations in trade or a difference in buying practice. In the same way historians cannot ignore the archaeological results. It is the differences noticed when finds and documents are contrasted which sometimes lead to new insights.

KEYWORDS: FISH, SAXON, MEDIEVAL, BONES, DOCUMENTS, TRADE, ENGLAND.

RESUMEN: El trabajo resume el desarrollo de los estudios sobre restos de peces en la región de Wessex (especialmente Hampshire y Wiltshire) en Inglaterra centro-meridional durante la década de los ochenta así como determinados intentos por utilizar la información documental en la interpretación de los datos procedentes de depósitos medievales posteriores a la etapa sajona comparándolos con depósitos sajones. Una amplia gama de fuentes documentales medievales tratan sobre la pesca y el pescado. Repasamos los tipos de documentos con énfasis en el puerto de Southampton y áreas circundantes de la Inglaterra centro-meridional y valoramos su utilidad para arqueólogos y arqueozoólogos. Los arqueozoólogos no pueden ignorar la existencia de documentos contemporáneos de las muestras óseas que analizan al interpretar éstas. En el pasado, la tendencia ha sido a interpretar los cambios en la explotación de las especies o sus tallas en función exclusiva de agentes ecológicos o cambios en las técnicas pesqueras cuando ello podría asimismo haberse debido a fluctuaciones en el comercio o a diferencias en la estrategia de mercado. De igual modo, los historiadores no pueden ignorar por más tiempo los resultados de la investigación arqueológica. Son precisamente las discordancias entre muestras óseas e información documental las que conducen a plantear y resolver cuestiones de forma novedosa.

PALABRAS CLAVE: PECES, PERIODO SAJÓN, MEDIOEVO, HUESOS, DOCUMENTOS, COMERCIO, INGLATERRA.

INTRODUCTION

This paper replaces and expands an earlier one read at the York Conference in 1987. Although the writer left the Faunal Remains Unit, Southampton University, in 1989 and the work continues under Dale Serjeantson and Pippa Smith, much of the

1980s fish analysis is still unpublished by the excavators so it was felt that an update would be useful.

The finding of fish in excavations is unpredictable. Some medieval stratigraphy (both Saxon and post-Saxon) in Southern England yields rich supplies of fish bones, some scarcely any. Improving

excavation techniques to sample fish remains more reliably must be a part of every modern excavation strategy. The range of features sampled obviously plays a major role in controlling the sample obtained. Some small species turn up in cesspits and pits because faecal material has passed through the gut (Wheeler & Jones, 1989: 8). The concentration of pockets of small eel (*Anguilla anguilla*) and herring (*Clupea harengus*) bones in many excavations in Wessex is probably often an indicator of cess.

Like many bones, fishbones often survive better when swiftly buried, as in rubbish pits, whereas kitchen and other occupation areas may be kept clean and yield material only from crevices and drains or from layers which postdate their use as living quarters. Sieving strategies too are obviously of key importance and only a partial picture is revealed from unsieved excavations where trowelling mainly reveals large gadoids (Gadidae) and conger eel (*Conger conger*) (e.g. Coy, 1985).

SOUTHAMPTON'S SAXON AND LATER MEDIEVAL FISHBONES

Earlier analysis of mid-Saxon material from Melbourne Street in Saxon Southampton (Hamwic) included a list of those fish species that we were able to identify at the time (Bourdillon & Coy, 1980). Fish studies were then in their infancy at Southampton and there had been no routine sieving strategy during the 1970s when the Melbourne Street sites were excavated. Most of the fish remains originated from a single feature which had been carefully sieved by post-graduate students. At the time we came to two conclusions, both of which subsequently proved to be incorrect. We assumed that subsequent sieving would always produce results like those of the feature mentioned above. In fact routine sieving for 10 years at Hamwic never produced such a rich feature again. We also assumed, on the basis of quizzing local fishermen of the river Itchen, that all the species in the

Saxon excavations were locally caught. Although this may have been true of the ones we listed, subsequent work by Sheila Hamilton-Dyer on sieved samples from Saxon layers produced bones from herring, and it is likely that these were already traded by the Anglo-Saxons.

Results from the nearby post-Saxon settlement of medieval Southampton were again initially from unsieved samples but increasing attention was paid to retrieval strategies for fish, culminating in the enormous amount of sieving carried out at the excavations at St Michael's, the site of the medieval fishmarket (Coy & Hamilton-Dyer, unpublished). In this analysis it was possible to show clearly that only large gadoids were retrieved by trowelling whereas another 12 species were identifiable from sieved samples (Coy, 1989: 28, Table 2). The main problem in interpreting the «fishmarket» results was our inability at the time to compare the results with comparably well-sieved occupation sites in medieval Southampton. We did not know whether they were «different» and so could easily fall into the trap of finding what we expected to find in a fishmarket, having regard to existing documents. It would therefore be wise to leave a fuller interpretation of these results until comparable sieved results are available from other types of medieval site in Southampton.

By contrast, the excavations at nearby Winchester in the 1970s benefitted from intensive sieving for plant remains which produced as a by-product a good sample of fish bones. Medieval Winchester, in some ways has thus produced more reliable evidence on the effect of taphonomic factors on post-Saxon fish than medieval Southampton. Sieving at Winchester led to the retrieval of large quantities of common eel and herring bones, probably associated in some cases with cess. At Western Suburbs, fishbones tended to be found in pits but not in ditches, possibly as a result of either quicker burial, association with a higher density of bone or both. The species known from medieval Winchester Western Suburbs are basically those known also from medieval Southampton (Coy, forthcoming).

SPECIES	ARCH	1300 DOC	1426-30 DOC
<i>Petromyzon marinus</i>	--	lampereyes	—
Pleurotremata	SM	—	—
Rajiidae	SM	—	—
<i>Acipenser sturio</i>	—M	sturgoun	—
<i>Anguilla anguilla</i>	SM	—	—
<i>Conger conger</i>	SM	congres	congres
<i>Clupea harengus</i>	SM	arang, harang	heryng
<i>Sprattus sprattus</i>	—?	—	sprot (1430)
<i>Sardina?</i>	—?	sardeyn (oil)	—
<i>Salmo solar</i>	SM	salmoun	salmon
<i>Osmerus?</i>	—M	—	sperlyng
Cyprinidae	—M	—	—
Preserved fish	??	stockfyssh	stokfische
<i>Gadus morhua</i>	SM	cod, moreu, mulwell	meluel
Young Gadidae	SM	—	codling
<i>Melanogrammus aeglefinus</i>	—M	haddok	—
<i>Merlangius merlangus</i>	SM	—	whiting
<i>Trisopterus luscus</i>	—M	—	—
<i>Pollachius pollachius</i>	SM	—	poullock
<i>Pollachius virens</i>	—M	—	—
<i>Molva molva</i>	—M	leeng	lyng(e)
<i>Merluccius merluccius</i>	—M	—	haake
<i>Atherina sp.</i>	—M	—	—
<i>Belone belone</i>	—M	—	—
Triglidae	SM	—	—
??	—	gobettes?	—
<i>Dicentrarchus labrax</i>	SM	—	—
<i>Trachurus trachurus</i>	S-	—	—
Sparidae	S-	—	—
Labridae	SM	—	—
Mugilidae	SM	coignes	—
<i>Scomber scombrus</i>	—M	makerel(le)	makerel
<i>Scophthalmus maximus</i>	—M	—	—
Pleuronectidae	SM	—	—
<i>Solea solea</i>	S-	—	—

TABLE I

A comparison of archaeological and documentary results. KEY: ARCH = Archaeological results from S = Saxon and M = post-Saxon Medieval. DOC = documentary sources from Southampton, - see text. (—) species not found.

NAME IN TEXT	MODERN EQUIVALENT	ORIGINS
congres	conger eel	Jersey, Guernsey
heryng	herring	Suffolk, Norfolk
heryng sore	salt herring	Suffolk, Norfolk
salmon	salmon	Suffolk
sperlynge	smelt	Suffolk
meluel	cod	Brittany, Holland, Norfolk, Cornwall
codling	young Gadidae	Suffolk
whiting	whiting	Dieppe
poullok	pollack	Cornwall
lyng	ling	Brittany, Holland, Norfolk
stokfische	preserved Gadidae	local trading?
haake	hake	Brittany, Devon, Cornwall
makerel	mackerel	Dorset, Guernsey

TABLE 2
Species of Imported Fish in 1426-30 Southampton Documents.

As can be seen from Table 1, which lists the main species identified from Southampton Saxon (S) and post-Saxon medieval sites (M), a wider range of species was identified from the latter. At first we put this down to «more adventurous fishing», but for all medieval excavations in Southampton, in view of widely published information on trade in the post-Saxon port (e.g. Platt, 1973) we later came to assume that at least some of the species found in medieval excavations might be from trade. A large number of the fish bones found are of flatfish and placed in Table 1 as *Pleuronectidae*. These finds probably include plaice (*Pleuronectes platessa*); flounder (*Platichthys flesus*); and dab (*Limanda limanda*).

Although we were aware early on that medieval documents were unlikely to cover the full range of people who lived in Southampton it became clear that this was also true of archaeological excavation in the medieval town as the richer element of society with its stone buildings and well-defined properties and pits was always more visible. It is therefore likely that the post-Saxon results, unlike the Saxon ones which have covered a very wide range of settlement, do not cover some groups of people who lived at Southampton. This is the second reason for always including the Saxon Period results in any study. The first is because, as already mentioned, they are by contrast more likely to be related to local fishing.

SOUTHAMPTON AND ITS DOCUMENTATION

Southampton has a rich fund of archive material surviving, not only in the town but elsewhere. Since 1905, the Southampton Record Society and its successor, the Southampton Record Series of Southampton University Press, has provided a collection of edited material with translations of the Anglo-Norman and Latin texts (James, 1983).

References to fish themselves, fishmongers, fishmarkets, merchants who owned ships, people who stole, secreted, or resold fish, or those who saw it being illegally sold, are scattered through the documents. The major sources of importance for fish studies at Southampton belong to four categories of document which will briefly be discussed below. This list is not exhaustive and the writer is not a document specialist and is currently confined to published sources.

1. Borough Administration and Finance

The Oak Book shows guild ordinances dated to 1300 (Studer, 1910, 1911a). The Guild Merchant of Southampton was probably established by 1249 and these ordinances describe their trading privileges and the control of commerce. There are several ordinances about the sale of fish, for example, a translation of ordinance 64 states:

«Let no-one sell any fresh fish, either in the market or street, but the man who has caught it in the water.»

(Studer, 1910: 65)

Further ordinances mention the position of the fishmarket, fish sizes, and the price of salt herring. The Oak Book also contains a list of customs which suggests the species of fish commonly traded at this time (Studer, 1911a). This forms the «DOC 1300» column of Table 1. Studer also wrote a supplement explaining the language used in the Oak Book and gives a glossary (Studer, 1911b).

The fifteenth century Stewards books are of particular interest as they sometimes list foods purchased on particular dates and their costs. As well as food for banquets at the Guildhall there are lesser items of expenditure for feeding auditors and other small gatherings which in some ways are even more interesting. Some of the fish were probably locally caught fresh fish, e.g., gurnards (Triglidae); mullet (Mugilidae); and flounders (Giddens, 1935, 1939). One entry even states «fresh fish». The fish entries are sometimes replaced by those for capons, rabbits and sucking pigs. I cannot find any mention of gurnards and flatfish in the portbooks discussed below, although mullet are said to be listed in the Oak Book as «coignes», presumably «coins de mer».

Information on relative price and relative palatability may also be gleaned, for example, there appears to be much use of onions, mustard, and scented oil with stockfish!

Another late source is the 1454 Southampton Terrier, a survey undertaken to allocate responsibility for the maintenance of the town wall (Burgess, 1976). This identifies shops and workshops and makes it possible to find out who lived where and where the cellars were.

2. The Port Books

Here we get on to the really solid information for the fish specialist. Although of late medieval date these documents record practices which are likely to have been well established. A succession of portbooks has been published for the fifteenth century (Studer, 1913; Quinn, 1937, 1938; Cobb, 1961; Foster, 1963). The oldest and best are the first two which are records kept by Robert Florys, bailiff and collector of tolls and customs in 1426-7, 1429-30 and 1435-6, and show a conservatism

in still using the French language, probably against the current fashion. This may partly be because Robert Florys was a Channel Islander (he crops up again in section 4 below).

The port books list boats coming in and out of Southampton, their names, ports of origin, masters, loads, and dues paid. The piece below shows a typical entry, showing the keelage paid for the entry of the ship Trinity from Penzance in Cornwall and the amounts of fish and the customs levied on them the master's hake (*Merluccius merluccius*) and herring, as well as hake, pollack (*Pollachius pollachius*), ling (*Molva molva*), and «meluel» (cod, *Gadus morhua*) brought in by John Basse and John Gregry. The charges are in pence (d).

«Entre La trinite de Pensens, Mestre John Hykes, kylage ij d:

Le dit Mestre: v C de Haake - cust. xd; j barel de heryng - cust ijd.

John Basse: v C de Haake - cust. xd.

John Gregry: C de Haake - cust. ijd. demi C. de poullok - cust jd.;

demi C. de lynge et meluel - cust. jd.

(Studer, 1910: 16)

Quantities here are in «hundreds» and it is suggested by Foster (1963) that this was used colloquially to mean an English hundredweight (cwt) and that this usage could still occasionally be heard in Southampton at the time he was writing. Some fish are quantified differently. Some are measured and priced in lasts, which equal a boatload and vary with the species and type of preservation: e.g., 12 barrels of red herrings (Cutting, 1955). Stockfish are often in «bundles». In most accounts, salmon (*Salmo salar*) appear to be priced singly; conger, cod, ling, and mackerel (*Scomber scombrus*) per hundred; and hake in thousands (with the proviso on hundredweights discussed above).

In some cases the Southampton portbook entries are dated by the day and it is possible to work out seasonal effects on the fish trade. Later on two books were kept, one for Mediterranean carracks and galleys and one for all the others. There was extensive medieval trade between Southampton and the Mediterranean but I cannot deduce that this had much effect on the supply of fish, the products imported being usually more exotic (Ruddock, 1951). The origins of the fish coming in are wide. Table 2 gives a summary of what I think were the origins for 1426-30. Further study might reveal more on the activities of local boats and

merchants of which there is some evidence in the port books. Stockfish, for example, seems to be mostly associated with local boats.

By the end of the fifteenth century English fishing boats were searching further away. Gray (1992: 141) suggests that boats from the South-West were already fishing for Irish herring, cod, hake, and ling. In the same volume Starkey (1992: 163) suggests that the Newfoundland fisheries developed in the sixteenth century were built on the discovery of this abundance of fish in the late fifteenth century voyages of discovery. The European quota battles started here, the French and the Spanish being early competitors!

3. *The Brokage Books*

These show daily lists of goods passing in and out of the town compiled by the Bargate broker; the Bargate being the main gate on the North-South axis of the medieval town. According to Stevens & Olding (1985) who published the 1477-88 and 1527-8 books such detailed records are not available for any other English town. Others published are for 1439-40 (Bunyard, 1941) and 1443-4 (Coleman, 1960, 1961). They show tolls, names of carters and owners, and destination of outgoing goods. The broker liaised with the port bailiff and it often says 'paid at sea' if the owner has already paid at the port. If goods change hands, fees have to be paid again. The records often mention fish and there is some evidence that fish transport is at its height in Lent. Herrings, salmon, and hake are especially noticeable.

These records throw light on the extensive trading of fish inland, which we know occurred. According to Platt (1973: 78) 40 major towns could claim exemption from toll. The brokage books often mention the destination of goods as this decides the toll or absence of toll. Sometimes the owner of the material is stated e.g. Robert Florys, mentioned above.

Tying up with this, a wide range of marine species is gradually being recovered from excavations inland from Southampton (e.g. Coy, forthcoming; Coy, unpublished a).

4. *Wills and other Legal Documents*

The Black Book of Southampton covers wills and deeds between 1388 and 1620. It often links people with ships. Here in 1443, for example, is

the will of Robert Florys mentioned above. We learn that he was a merchant; that he traded in fish with his Guernsey kinsman Thomas Florys; and that he owned a house in the fishmarket (Wallis Chapman, 1912).

Legal documents often point to what people actually did rather than what they should have done. In one footnote here we are referred to a fourteenth century Mayor of Southampton who received a pardon for having sold herrings (among other things) to the King's enemies in Normandy under an earlier regime.

Some sixteenth and seventeenth century documents suggest that the breaking of the existing laws provided quite an income and it is likely that the frequent stress on certain ordinances connected with fish in the earlier Oak Book results from the frequent breaking of these ordinances. Laws in connection with food are quite a good guide to what people actually did or there would be no need to introduce the laws. In post-medieval times too there are many references to the site of the fish market because people are obviously trying to sell fish elsewhere. Fines for depositing refuse also suggest that they were breaking the laws on this as well.

RESULTS FROM SOUTHAMPTON'S HINTERLAND

The Beaulieu Abbey Accounts (Hockey, 1975) and research on the Bishopric of Winchester pipe rolls by Roberts (1986) suggest alternative sources of information about the supply of fresh freshwater fish (e.g. Cyprinidae) from fishponds and eels from eeltraps. As early as 1269, Beaulieu, near Southampton, had a base on the East coast of England near Great Yarmouth where herring were kippered or dried. Their own ship also traded elsewhere. Fishermen were also paid for the provision of eels from a site well inland on the River Thames.

Roberts has shown that an extraordinary burst of activity between c1150 and 1208 caused the construction by the bishops of Winchester of a number of important fishponds on their estates in southern England. The pipe roll information confirms that the freshwater fish from ponds was reserved exclusively for the bishops and their royal and aristocratic associates, and it was almost always eaten fresh (Roberts, 1986).

Household Accounts from as early as the 12th century AD may provide a record of purchases (Woolgar, 1992-3). These show some interesting discrepancies when compared with the port documents. The 1406-7 accounts for Richard Mitford, Bishop of Salisbury, include many references to flatfish - flounders, sole (*Solea solea*), plaice, and turbot (*Scophthalmus maximus*) - not found in the portbooks but widely represented on the archaeological sites. Rays (Rajidae), gurnards, and bream (in this association obviously marine Sparidae) are also listed. The rays are called «thornbacks». As Table 1 shows these species are not in the portbooks but again are represented on the archaeological sites.

CONTRASTING DOCUMENTS AND ARCHAEOLOGY

Table 1 draws up a list of species or groups of fish for which there is evidence of some sort at Southampton. The recorded finds from Saxon and post-Saxon medieval excavations are listed. Saxon ones are included as they may give a better picture of the species exploited locally (S). The overall post-Saxon medieval picture from a wide range of Southampton sites is also given (M). These results are derived from Bourdillon's forthcoming volume on Southampton Environmental Archaeology (Coy, unpublished b) with the addition of results for the fishmarket (Coy & Hamilton-Dyer, unpublished).

Set against these are the names given to these fish in the 1300 list of customs tariffs given in the Oak Book which we may assume are of fish utilised or brought into Southampton at this time. The DOC 1426-30 names come from the port books of that date.

Some fish mentioned in the documents have not been found or are very rare in the archaeological record, e.g., lamprey (*Petromyzon marinus*). There are three reasons for this: their remains do not preserve, they could not be identified, or it is not clear which fish are referred to in the documents.

But by far the largest discrepancy is the long list of species not in the Southampton Port Books which do occur on sites. These include Sharks (Pleuronotiformes); rays; common eel - which is ubiquitous on Southampton sites; freshwater fish (e.g. Cyprinidae); saithe or coley (*Pollachius virens*);

gurnards; bass (*Dicentrarchus labrax*); sea breams (Sparidae); wrasse (Labridae); all flatfish and a number of small species that are not economically viable. Some of the latter are probably present on site as the gut contents of the larger species.

Some of the fish listed above may have been locally or specially caught rather than imported through Southampton port and therefore not logged in the port books. To confirm this the Steward's book as discussed in 1. above mentions gurnards and flounders, and the Bishop of Salisbury, as discussed above, took in gurnards and a number of flatfish species, as well as thornbacks (presumably *Raja clavata* and related species with bucklers) and sea bream. In a similar way the thirteenth century information from Beaulieu Abbey and the pipe rolls discussed above suggest that freshwater fish and eels would be provided from fishponds or from specialised eel fisheries inland. Local inhabitants of both low-lying Hamwic, near the rivers Itchen and Test, and the later post-Saxon town nearby would have had no problems in catching their own eels.

The flatfish and rays in particular are so common on sites that their absence from portbooks was surprising but the household documents link them firmly with those in the medieval community, like the Bishop of Salisbury, able to afford fresh fish and control its source. Salmon and freshwater fish are also absent from the fishmarket finds (Coy & Hamilton-Dyer, unpublished).

There is some evidence for saithe from excavations in the medieval town and one dubious identification from the recent fishmarket excavations (Coy & Hamilton-Dyer, unpublished). But with all the trade recorded with the South West it seems unlikely that none appeared in the port and it is more likely that, as occurs even today, fish were not always identified correctly to species.

The differences between the Oak Book and the first port books are several. For example, although they are mentioned in the Oak book, I can find no specific references in the 1426-30 port books to haddock (*Melanogrammus aeglefinus*). Haddock, often of a large size representing fish over 3-4 kg, turns up on medieval excavations in Wessex. It is also in the Oak Book list mentioned above and in later port books. It is also likely that some of the categories listed in the 1426-30 port books (stockfish and muluel perhaps) included large haddock.

Conversely, the entries for pollack, hake, whiting (*Merlangius merlangus*), codling (young *Gadus morhua*), and «sperlyng» only appear in the

port book. But the evidence from elsewhere suggests that this means the Oak book list is wanting. Some species only appear even later - sprats (*Sprattus sprattus*) from 1430 and «brode» fish from 1469. I am assuming the last to be flatfish or perhaps rays. «Sperlyng» is usually translated as smelt (*Osmerus eperlanus*). «Gobettes» which appear in the Oak book are currently a mystery to me.

CONCLUSIONS

A wide variety of routes brought fresh and preserved fish into Southampton and its rural hinterland. Some of these routes and practices may have started during Saxon times and with care comparisons can be made. There are a number of problems to be addressed in this kind of study. First the identification of fish species from documents is far from secure. Second the origin of marine fish at Southampton is complex. For some species it will depend on the size of the fish as to whether we assume it was a young migratory form which came close inshore or a larger one fished from deeper water. Some species, such as flounders, may have come from estuarine areas near the port. These and eels may have justified permanent trapping structures. Some local fish may have been individually caught on lines rather than netted in bulk. The supply of the vast amounts of fish needed for non-meat days and for the longer period of Lent would have put pressures on the market to produce fish from other sources. These and other pressures would have decided whether or not fish were salted: for example, eels might sometimes be salted when they were too numerous to eat fresh (Roberts, 1986: 127).

By carefully contrasting the results from archaeological excavation and all available documents it should be possible to tease out the elements of this complicated story. Comparison between documentary and archaeological results can be a useful exercise for fish in the Medieval Period as both kinds of evidence are incomplete. The search is aided by the economic importance of fish in the medieval diet which caused it to be subjected to frequent inspection, taxing, and safeguards to ensure that profits were maintained. In Southampton the burgesses by their ordinances attempted to oversee the retailing of fish. Their failure resulted in the

imposition of a lot of rules and quite a good income from fines.

ACKNOWLEDGEMENTS

I am grateful to the staff of the University of Southampton Library, Special Collections, and to past and present staff of the Faunal Remains Unit of Southampton University. David Hinton drew my attention to the Beaulieu Abbey Accounts, Edward Roberts kept me in touch with pipe rolls, and Chris Woolgar of the Hartley Institute of Southampton University drew my attention to the household accounts of the Bishop of Salisbury.

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El pescado en la dieta de los Cartujos de El Paular en el siglo XVI

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(Received 16 October 1995; accepted 17 January 1996)

RESUMEN: El pescado ha sido tradicionalmente un elemento clave en la dieta de los cartujos, una orden monástica entre cuyos preceptos figuraba la abstinencia en el consumo de carne. Este estudio, basado en el análisis de documentos del monasterio cartujo de Santa María de El Paular en la provincia de Madrid, investiga el papel desempeñado por los peces en la economía y dieta de los monjes durante un corto lapso temporal del siglo XVI. Entre otros, mención detallada merece la variedad de especies consumidas, sus precios y lugares de origen, así como los modos de procesado de los diversos grupos considerados. No deja de ser una sorpresa, habida cuenta el corto periodo transcurrido desde entonces, la constatación de una serie de términos para los cuales no parece existir equivalente alguno en la actualidad.

PALABRAS CLAVE: PECES, COMERCIO, PROCESADO, ESPAÑA, SIGLO XVI, CARTUJOS

ABSTRACT: Fishes have traditionally been a basic element in the diet of the monastic order of the cartuja which, among other rules, did not allow their members to eat meat. This paper, based on the analysis of documents from the cartujan monastery of Santa María de El Paular in the province of Madrid, explores the role of fishes in the economy and diet of the monks during a short period of the XVI century. Particular attention has been paid to the variety of species consumed, their prices and places of origin, as well as the ways in which different groups have been processed. It comes as a surprise to learn about fish names and products for which no modern counterpart seems to exist at present.

KEYWORDS: FISH, COMMERCE, PROCESSING TECHNIQUES, SPAIN, XVI CENTURY, CARTUJAN

INTRODUCCIÓN

El Real Monasterio de Santa María de El Paular, de la orden cartuja, fué construido a fines del siglo XIV, poniéndose la primera piedra del edificio el 29 de Agosto de 1390, en el término de la provincia de Madrid a los pies de la sierra de Guadarrama. Fué erigido en el reinado de Juan I de Trastámara, aunque debido a su muerte, de manera imprevista, al mes siguiente, fué Enrique III el verdadero impulsor del Monasterio, al que tomó bajo su protección y favoreció con varios privilegios, eximiéndole del pago de ciertos impuestos y garantizando plena libertad de movimientos por sus tierras de realengo a sus moradores.

Las primeras referencias que tenemos acerca de él vienen consignadas en el Libro de Becerro, es-

crito en 1565, en el que aparece una amplia información de todas las bulas, privilegios, alvalás, etc., que le fueron concedidas por los Papas, Reyes y señores particulares, para su engrandecimiento.

Refiere de forma pormenorizada la situación del lugar elegido para la ubicación del Monasterio, describiendo sus excelencias y las ventajas que podía reportar a sus miembros, teniendo en cuenta lo importante que era para la orden el abastecimiento de pescado, dada la prohibición absoluta de consumir carne, ni siquiera en casos de extrema necesidad.

De ahí que sus fundadores eligen un lugar muy próximo al río Lozoya, famoso por sus truchas, y además les conceden su utilización con pleno derecho, prohibiendo su disfrute a cualquier otra persona ajena a la comunidad.

*«Quan umbrroso corre por este valle el Río Lozoya sobre claras piedras, entre verdes sauces, frondosos fresnos, alamos altos e mui vistosas praderias; y aunque es río pequeño minis-tramos mas abundancia de truchas que otros mui caudalosos Rios a sus vecinos y comarcas».*¹

El propio rey Juan I antes de fallecer tuvo la precaución de hacer una Escritura Pública, en la que hacía donación a la orden de sus Palacios y ríos.

*«... que dicen del Poblal; que habia en el valle del Lozoya, cerca de Rascafría, que es en el Arzobispado de Toledo, con todas sus pertenencias y con el Río que corre por el valle desde donde nasce fasta en el Aldea de Pinilla en tal manera que otro alguno non use de dicho Río, ni pesque en el sin mandado e licencia del Prior».*²

Esta Escritura no llegó a tener validez hasta que su hijo Enrique III dió efectividad a lo dispuesto por su padre, mediante un avala dado en Segovia el 22 de junio de 1391³, en los mismos términos que el anterior, solucionando de esta forma el aprovisionamiento de pescado.

Más adelante los Reyes sucesivos van confirmando estos privilegios.

También se favorece la construcción de un gran estanque dentro del recinto del Monasterio, que aún se conserva hoy día. D. Antonio Ponz en el año 1787 lo describe de esta manera:

*«Junto al Monasterio hay una espaciosa huerta de frutales y verduras, y en su recinto se encuentra un estanque, donde se conservan siempre porción de galápagos para regalar a los huéspedes, a los que también suelen servir las truchas que crían en el río».*⁴

Sánchez Corona en 1932 vuelve a decir:

*«... En ella existe un estanque navegable, todo él de piedra de sillería y diez charcas mas, donde se crían infinidad de truchas de sabrosa carne, de fama en todo el Valle».*⁵

METODOLOGÍA

Mi propósito al realizar este pequeño estudio, es el dar a conocer la importancia capital del pescado en la dieta de los cartujos, sus diferentes clases, lugares de aprovisionamiento, rutas que seguían hasta llegar a El Paular, formas de conservación, cantidades y precios; y, como corolario, conocer asimismo la industria pesquera en la Castilla del siglo XVI que estaba en pleno apogeo.

Esta información me ha sido posible conocerla gracias a los Libros de Cuentas que existían en todos los Monasterios, en los que se anotaban de forma sistemática y rigurosa todos los movimientos de entradas y salidas de dinero, no sólo por años y meses sino diariamente, especificando los géneros que adquirían o vendían, cantidades, precios, peso, etc., a veces lugares de procedencia y destino que se les daba, con lo cual se puede llegar a conocer con bastante exactitud la economía del momento y su evolución.

A lo largo de la lectura de uno de estos libros, concretamente uno de Procuración, he podido averiguar parte de su dieta, o por lo menos parte de los productos que tenían que adquirir mediante compra al no poder disponer de ellos en sus propias granjas y explotaciones, puesto que se refiere, fundamentalmente, a la fruta y el pescado.

Ya he apuntado anteriormente que en su origen esta casa estaba, por su situación geográfica, suficientemente abastecida de pescado, sin embargo con el tiempo, al ir creciendo en importancia y contar con un número más elevado de miembros (gracias a la prosperidad que llegó a alcanzar), se vieron obligados a buscar fuera de sus términos, otras fuentes de aprovisionamiento de este género para satisfacer sus necesidades, teniendo que llegar incluso a viajar hasta los puertos del norte de la península, especialmente los de Santander y Bilbao, lugares de salida natural al mar desde Castilla, y con los que se mantenía un tráfico intenso de mercancías con otros países, no sólo de pescado y salazones sino de otros productos manufacturados.

No se puede olvidar que, como el Monasterio estaba exento de pagar numerosos impuestos, podían moverse con gran libertad e ir a lugares apar-

¹ Bernardo de CASTRO, «Libro de Becerro». 1565. fol. 28 (v).

² Op. cit. fol. 33.

³ Op. cit. fol. 53.

⁴ Antonio PONZ, «Viaje de España». 1787. Tomo X. p. 96.

⁵ Manuel SÁNCHEZ CORONA, «Santa María del Paular». 1932. p. 36.

tados para buscar las mercancías que necesitaban sin que les resultara demasiado gravoso.

CLASES DE PESCADOS

Los pescados que llegaban a la casa, según se deduce del Libro de Procuración⁶, referentes a los años 1586 y 1587 son: besugo, sardina, merluza, salmón, lamprea, congrio, mielga, sáballo, mero, abadejo, pescado curadillo, de Bretaña, de Lequeitio y cecial. A partir de ellos he elaborado un cuadro en el que figura el nombre, estado en que llegaba a la casa, cantidad, precio por peso, peso de cada envío y los maravedíes que resultaban (véase Apéndice 1 y 2).

Besugo (*Pagellus bogaraveo*). Solamente se capturaba lejos de la costa en los meses de invierno, sobre todo en diciembre y enero⁷. Era el más apreciado en la costa cantábrica. Su tamaño de unos treinta centímetros de largo y el precio de tipo medio, parecido al del congrio. Durante el mes de diciembre hicieron gran acopio de él, alcanzando la cifra de 39 arrobas y 20 libras.

Sardina (*Sardina pilchardus*). De la familia de los clupeidos, como el arenque y el sáballo⁸. Se pescaba a lo largo de todo el año y llegaba fresca, en ocasiones, al Monasterio, otra destazada, en una ocasión descabezada y en otra asadera. Pescado también propio del Cantábrico, pero menos valorado que el anterior, seguramente por su gran abundancia y facilidad de captura⁹, llegando a servir incluso para la pesca de la merluza. Por esta razón su precio era bajo siendo algo más elevado el de las sardinas asaderas, costando 18 reales la arroba en enero, frente a los 11 del mes de octubre de ese mismo año.

Merluza (*Merluccius merluccius*). Gadiforme que abundaba en el Cantábrico y se pescaba cerca de la costa en verano y lejos de ella en invierno¹⁰⁻¹¹, midiendo alrededor de un metro de largo.

Su consumo se hacía unas veces fresca y otras seca, tomando esta variedad el nombre de cecial¹². Su carne era muy estimada, constituyendo uno de los principales factores de la economía española. El Paular consumía las dos variedades. El precio de tipo medio, no disponiendo de datos más que durante el invierno, por lo que no he podido averiguar si en verano resultaba más barato, dado que su captura debía ser más sencilla.

Es interesante reseñar que en noviembre de 1586 compraron dos tercios de merluza, lo que hace suponer que se trataba de una pieza muy grande porque pesó 9 arrobas y 21 libras (103 kg, aproximadamente), siendo lo normal que fueran mucho más pequeñas. Parece más lógico pensar que esos dos tercios se refirieran a los de una carga, y no a los de una pieza.

En la primavera de 1586 adquirieron dos variedades de pescados propios de río, especialmente del norte de la península: el salmón y la lamprea.

Salmón (*Salmo salar*). Salmónido migrador que se reproduce en agua dulce. La especie llega a tener un metro de largo. Solía llegar fresco al Monasterio y su precio medio era más alto que el de los tres anteriores. El que llegase fresco permite especular con una diferente distribución en el pasado que le habría permitido remontar los afluentes del Duero y poder pescarlo en la vecina provincia de Segovia.

Lamprea (*Petromyzon marinus*). De vida parecida a los salmones y también abundante en Asturias según cabe deducir del siguiente escrito:

«En las costas de Asturias y Montañas también se cogen bastantes Lampreas, y algunas de buen tamaño, como que exceden de cuatro libras».¹³

Las que llegaron a El Paular en una sola ocasión eran pequeñas, 47 exactamente, y no llegaban a una libra (300 g aproximadamente).

Congrio (*Conger conger*). Como la mayoría de los pescados reseñados, abundaba en toda la costa

⁶ AHN. Clero. Libro 19825.

⁷ Antonio SÁÑEZ REGUART, «Colección de producciones de los mares de España». 1993. Ministerio de Agricultura, pesca y alimentación. Edición preparada por I. García Fajardo y J. Fernández Pérez. p. 66.

⁸ *Op. cit.* p. 149.

⁹ *Op. cit.* p. 66.

¹⁰ *Op. cit.* p. 142.

¹¹ *Op. cit.* p. 64.

¹² *Op. cit.* p. 66.

¹³ *Op. cit.* p. 265.

APÉNDICE 1

Importaciones del puerto de San Sebastián en el año 1563:

pescado 709 cargas
bacalao 1417 y media carga
congrío 220 cargas
merluza 28 cargas
mielgas 82 cargas
sardinas 1120 millares
arenques 4 millares
salmón 53 barriles
atún 10 barriles

Pescados comprados por un hermano cartujo, este año de 1586:

sardina 8 arrobas
lampreas 134 libras
pescado 22 arrobas 1 libra
sábalo 137 libras
pescado de Lequeitio 12 arrobas 7 libras
congrío fresco 4 arrobas 2 libras
abadejo 24 arrobas 9 libras
sardinas descabezadas 1 banasta
pescado de Bretaña 12 arrobas 1 libra

AÑO 1586

	CANTIDAD	ESTADO	PRECIO	PESO	MARAVEDIES
Septiembre Pescado de Lequeitio	1 carga		92 reales quintal	15 arrobas	806
Octubre Sardinas	1 banasta	destazada		3 a. 10 l.	1674
Pescado sicial	1 carga (Frutos de Laguna)		2 ducados la arroba	10 a. 2 l.	7540
Pescado de Lequeitio	1 carga		80 reales el quintal	13 a. 10 l.	9115
Pescado de Lequeitio	1 carga		23 reales la arroba	10 a. 10 l. (1)	8420
Sardinas	2 banastas		19 marav. la libra	5 a. 26 1/2 l.	2946
Sardinas	1 carga	frescas	19 marav. la libra	9 a. 1 l. (2)	4422
Congrio	1 carga	fresco	1 real la libra	8 a. 21 l.	7106
Pescado de Breña	1 carga (Frutos de Laguna)		100 reales quintal	14 a. 1 l.	11934
Noviembre Mero	1		42 marav. la libra	13 l.	552
Merluza			24 marav. la libra	20 l. 1/2	492
Congrio	1 banasta		1 real la libra	6 a. (1)	5125
Merluza	2 tercios		23 marav. la libra	9 a. 21 l. (1)	5709
Mielga			1 real la libra	5 a 11 l.	4624
Diciembre Besugos	1 carga		46 marav. la libra	9 a. 4 l.	10568
Pescado de Lequeitio	1/3		23 reales la arroba	5 a. 10 l. (4)	4224
Besugos	1 carga		28 marav. la libra	10 a. 4 l. (1)	9703
Merluza	1 carga		21 marav. la libra	11 a. 2 l.	5817
Besugos	1 carga	en limpio destazados	1 real la libra	9 a. 21 l.	8364
Besugos	1 carga	destazada	1 real la libra	10 a. 16 l.	9044

AÑO 1587

	CANTIDAD	ESTADO	PRECIO	PESO	MARAVEDIES
Enero					
Pescado de Lequeitio	1/3		23 reales la arroba	6 a. 6 l. (4)	4879
Pescado de Bretaña	1/3		25 reales la arroba	7 a. 4 l.	6086
Sardinas	1 banasta	asaderas	18 reales la arroba	4 a. 10 l.	2635
Besugos de enero	2 cargas		36 marav. la libra	19 a. 16 l. (5)	17676
Febrero					
Lampreas	47 piezas		2 reales 1/4	1 a. 6 l.	9432
Sábalo			28 marav. empanar cada una		1316
Mielga			60 marav. la libra (6)		6120
Pescado de Lequeitio		curadillo	31 reales la arroba	1 a. 10 l.	5950
			54 reales el quintal	6 a. 4 l. (7)	2822
Marzo					
Mielga	1/3	de frutos de Laguna	10 ducados el quintal	6 a.	5610
Sábalo	1/3	fresco	50 marav. la libra	6 a. 1 l.	7550
Mielga	1/3	fresca de frutos de Laguna	106 reales el quintal	6 a. 1 l.	5610
Mero		destazado	28 marav. la libra	45 l.	1274
Sábalo			49 marav. la libra	5 l. 14 l.	6811
Pescado abadejo			56 reales quintal	3 1/2 a. (7)	1670
Congrio	1 banasta	fresco destazado	1 real la libra	4 a. 2 l.	3332
Sardinas	1 banasta	frescas	30 marav. la libra	4 a. 9 l.	3270
Abril					
Sábalo	1 carga	fresco	40 marav. la libra	11 a.	9200
Sardinas blanquillas	2 cargas		25 marav. la libra	211 a. 16 l. (1)	15216
Mayo					
Pescado curadillo	1/3		49 reales quintal	6 a. 9 1/2 l. (9)	2660
Pescado curadillo	1 banasta	descabezada	49 reales quintal	12 a. 17 l. (9)	5274
Sardinas *	1 carga	fresca	16 reales arroba	5 a. 6 l. (9)	2851
Sardina para casa	1 carga	fresco	14 reales arroba	9 a. 4 l. (1)	4394
Salmon			2 1/2 reales libra	98 1/2 l.	8372

AÑO 1587

	CANTIDAD	ESTADO	PRECIO	PESO	MARAVEDIES
Junio Salmón		fresco	60 marav. libra	62 l.	
Junio Pescado de Lequeitio De fuera	1 quintal		90 reales quintal		3060
Agosto Sardinas Pescado de Lequeitio	2 banastas 1 carga	frescas	15 marav. libra 1 ducado arroba 90 reales quintal	4 a. 1 l. 11 a. 8 l. (10)	2970 8967
Septiembre Sardinas Congrio Merluza	1 carga 1 banasta 1 banasta	frescas frescas frescas	18 marav. la libra 1 real libra 24 marav.	8 a. 13 l. 3 a. 15 l. 3 a.	3834 3060 1776
Octubre Sardinas Pescado de Lequeitio Congrio fresco Pescado cecial Pescado de Lequeitio Pescado de Lequeitio Sardinas Congrio	1 carga 1 carga 1 banasta 1 carga 1 carga 1 carga 1 banasta	frescas fresco cecial frescas fresco	12 reales $\frac{1}{2}$ arroba 90 reales quintal 21 reales arroba 2 marav. libra 98 reales quintal 98 reales quintal 11 reales arroba 30 marav. libra	9 a. $\frac{1}{2}$ 4 a. 15 l. (9) 7 a. 16 l. 4 a. 20 l. (11) 11 a. 3 l. 10 a. 12 l. 8 a. 10 l. 4 a. 21 l.	4037 3428 4027 2520 9165 8738 2484 3495
Noviembre Pescado curadillo para casa Pescado de Breña	4 cargas $\frac{1}{2}$ 1 carga		44 reales quintal 92 reales quintal	49 a. 7 l. (12) 10 a. 7 l.	1843 l 8041
Diciembre Besugos Pescado de Breña Pescado abadejo * Sardinas * Pescado de Lequeitio	1 carga 1 carga ($\frac{1}{3}$ de pescado) $\frac{1}{2}$ de pescado	curadillo desetubar	42 marav. la libra 24 reales arroba 12 reales arroba 6 reales arroba 24 reales arroba	220 l. (13) 7 a. 5 l. (10) 4 a. (14) 4 a. (10) 5 a. $\frac{1}{2}$	9240 5882 1632 2176 4488

- (1) Incluido el precio de las banastas, 3 cuartillas cada una
- (2) «Delante del Padre Don Pedro de Lerma que estaba en Segovia, este día»
- (4) De Gaspar de Ledesma, mercader
- (5) Quitados la tara de cada banasta, que pesaban 8 libras y costaban 2 reales
- (6) Sardina arenque macho. En primavera sube el río a desovar
- (7) Para Pinilla, papelero

- (8) «Pagose a Santander»
- (9) Para Francisco Pinilla, papelero de casa de Juan Rodríguez de Ledesma, sólo 2 veces
- (10) De Gaspar de Ledesma, mercader
- (11) Que se llama merluza
- (12) Del mesón de Amabisa
- (13) Destazado
- (*) Para Francisco Pinilla papelero

EQUIVALENCIAS DEL PESO Y MONEDA EN EL SIGLO XVI

Quintal: Peso de 100 libras, es decir, 4 arrobas equivalente. (1 quintal = 46 Kilos).

Libra: Peso antiguo de Castilla, dividido en 16 onzas equivalentes a 460 gramos. (1 libra = 1/2 Kilo).

Arroba: Peso de 25 libras, equivalente a 11 Kg y 502 gramos (cuarta parte del quintal). (1 arroba = 11'5 Kilos).

Maravedí: Valía la trigésima cuarta parte del real de vellón; perteneciente a los almorávides. El más corriente era de cobre pero también había de plata, de oro, nuevo y viejo. (1 peseta = 136 maravedís).

Real: Moneda de plata equivalente a 34 maravedís, equivalente a 25 céntimos de peseta. (4 reales = 1 peseta).

Ducado: Moneda de oro que se usó en España hasta fines del XVI, equivalente a 11 reales de vellón (siete pesetas, hoy). (1 ducado = 7 pesetas).

del Norte de la Península, pero especialmente en Galicia, Santander y Asturias. Al parecer, eran de gran tamaño, alcanzando los 2,5 m de largo y su peso de alrededor de 60 Kg. Constituía una de las partidas más numerosas en la dieta de los frailes.

Mielga (*Squalus acanthias*), tiburón de cuerpo largo y carne dura, muy apreciado por su textura y sabor. También procedía de los puertos del norte, aunque en Galicia abundaba esta variedad igualmente.

El tamaño de los ejemplares reseñados era grande (un tercio podía pesar unos 69 Kg aproximadamente); el precio elevado con respecto a las demás especies. Se solía consumir fresco y en salazón.

Sábalo (*Alosa alosa*), otro clupeiforme cuya pesca se remonta a la antigüedad. Mide unos 25 cm de longitud, de peso medio, y sólo lo adquirieron durante los meses de febrero, marzo y abril de 1587.

Mero, serránido de carne muy apreciada y gran tamaño, si bien las fuentes sólo especificaban que media más de medio metro¹⁴. Lo compraron en escasas ocasiones y en poca cantidad, unas 13 arrobas y 45 libras, siendo más caro el comprado en el mes de noviembre 1586.

Abadejo (*Pollachius pollachius*), semejante al bacalao sólo llegó a la casa en dos ocasiones, en marzo y diciembre de 1587; más barato en la última compra, dándose la circunstancia de que era «curadillo». Al parecer, en esta ocasión, no era

para consumo de la comunidad, sino para un vecino.

Pescado curadillo, se supone que es la misma variedad que el anterior, si bien el bacalao es el pescado curado por excelencia.

En estas cuentas, en dos ocasiones, especifica «frutos de laguna», que al igual que el pescado de Breñaña, no he podido averiguar, que significado tiene, ni a qué se refiere, por ser estos pescados propios de los mares.

LUGARES DE ORIGEN Y MEDIOS DE TRANSPORTE

Los centros más importantes de abastecimiento de productos manufacturados alimentarios, y especialmente los procedentes de la pesca, estaban situados en el norte de la península, concretamente en los puertos de Santander y Bilbao, que mantenían un floreciente comercio con otros países durante el siglo XV y XVI. Desde aquí distribuían sus mercancías por medio de rutas que unían entre sí las diferentes ciudades españolas durante el siglo XVI (Figura 1)¹⁵.

Hay varias descripciones de las rutas que seguían las principales corrientes comerciales. Una de ellas:

«Hacia el norte, los carros transportaban lana hasta los puertos de embarque de la costa

¹⁴ Diccionario Espasa Calpe (abreviado).

¹⁵ J. VICENS VIVES, «Historia de España y América. Social y Económica». 1977. p. 147.

*cantábrica y del País Vasco (cf. relaciones de Fuentelaencina (Guadalajara), nº 45, y de Brea (Madrid), nº 56). De retorno iban cargados con sal, pescado, hierro y herraduras».*¹⁶

Las mercancías se transportaban por medio de carros o recuas de mulas¹⁷, que conducían los arrieros. Luego los mercaderes hacían la distribución entre los interesados, directamente o por medio de la venta en los mercados de las ciudades, lo que era más frecuente. Tenían mucha importancia las subastas que se originaban en las lonjas de los puertos a la llegada de los barcos, costumbre que, a menor escala, continúa sucediendo hoy día.

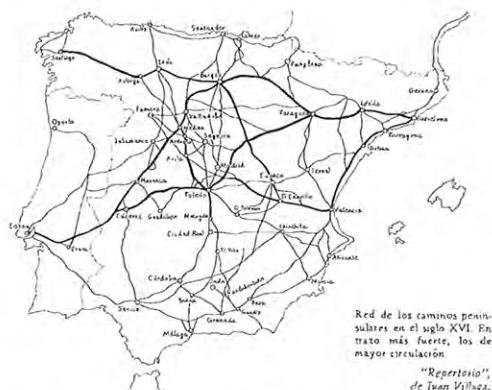


FIGURA 1

Red de los caminos peninsulares en el siglo XVI. En trazo más fuerte, los de mayor circulación. «Repertorio», de Juan Villaga.

Así cobraba gran importancia la organización de Carreteros de la Real Cabaña, que se dedicaban al transporte de mercancías de larga distancia:

«No es, seguramente, casual, que los pueblos que suministraban contingentes de pastores a la Mesta, fuesen también los centros de la carretera».

«... el del Norte tenía como elemento principal de transporte de lana, que recogían a partir de Segovia, llevándola a los lavaderos de Burgos, y de aquí a los puntos de embarque: Bilbao

*(por Orduña o Valmaseda), Laredo y Santander. Allí hacían acopio de sal, hierro y pescado que luego distribuían por el interior de la Meseta».*¹⁸

En otro lugar, hablando del congrio, describe mas o menos lo mismo, con respecto a los lugares de procedencia:

*«En nuestros Puertos del Septentrion se pescan en el día bastantes porciones de Congrios (la pesca del Congrio casi puede llamarse particular de estas Costas, pues en los Puertos de Casto de Urdiales, Laredo, Santander, Comillas y San Vicente de la Barquera es segura y abundante), y los arrieros y tratantes conducen muchos en fresco a las Provincias interiores».*¹⁹

A estos lugares acudía el Paular en busca de un seguro aprovisionamiento de pescado para el sustento de la comunidad. Esto se desprende de las referencias que se hacen en el Libro de Cuentas, al «pescado de Lequeitio», no sólo por la forma de llamarlo, sino por el hecho de que así consta en una Real Cédula que poseían, otorgada por el rey Felipe IV, dada en Madrid, el 26 de marzo de 1622, (ignoro si hubo otras en fechas anteriores), en la que dice textualmente, entre otras cosas:

«... fué servido mandar a las Justicias de la Ciudad de Segovia, y de las Villas de Buitrago, Talamanca, Vilbao, y su Puerto, que a la persona que tuviere cargo de proveer de mantenimientos al referido Monasterio, le den, y hagan dar el Pescado seco, y fresco, así de Mar, como de Río...»

*«... y que a causa de no encontrarse, ó tenerles mas conveniencia, suelen acudir a las Villas y Puertos de Laredo, Santander, Bermeo, Castro Real y otras partes...».*²⁰

Del frecuente intercambio que mantenían con la villa de Laredo, y de la forma en que solían adquirir el pescado, existe una fuente de información precisa, a través de un pleito que sostuvo El Paular, con dicha villa, en el año de 1733, sobre la venta de pescado: dos cargas de congrio y dos de besugo. Esta controversia surgió cuando el monasterio se negó a pagar el precio del pescado, que había resultado de la subasta, como era la costumbre

¹⁶ Nöel SALOMÓN, «La vida rural castellana en tiempos de Felipe II». 1982. Ariel. p. 115.

¹⁷ AHN. Consejos. Legajo 51152.

¹⁸ Antonio DOMÍNGUEZ ORTIZ, «El Antiguo Régimen: Los Reyes Católicos y los Austrias». Alianza. 1983. p. 93.

¹⁹ SAÑEZ REGUART, *op. cit.* p. 224.

²⁰ AHN. Consejos. Leg. 51152.

general, pero no como tenía por norma actuar en otras ocasiones, y como venía haciendo hasta el momento, que era abonar el precio que fuese estipulado por los Justicias o personas autorizadas. El arriero que conducía las cargas al ser detenido y requisada la mercancía, mostró extrañeza ante el hecho porque:

«... era novedad nunca practicada y contra el estilo que siempre ha habido».

«... suplica que ... se arregle la entrega y percepción de dicha Pesca, a la forma y modo que hasta aquí se ha practicado...»²¹

MÉTODOS DE PREPARACIÓN Y CONSERVA

El mayor acopio de pescado se hacía, como es lógico, en los meses de invierno, disminuyendo considerablemente en los de verano, limitándose a compras de salmón, sardinas frescas y pescado de Lequeitio. Esto hace suponer que consumían abundantes salazones, que unas veces sería elaborado por ellos mismos, y otras lo adquirirían ya en esta modalidad. En cualquier caso, el monasterio estaba situado en un lugar muy frío, donde abundaba la nieve gran parte del año, según se desprende de las relaciones de la época, lo que favorecía en gran manera la buena conservación de los alimentos perecederos.

El tratamiento y conservación del pescado para garantizar su transporte y posterior consumo, obedecía a técnicas utilizadas desde muy antiguo. En España tenemos referencias de esta actividad desde siglos anteriores a Cristo:

«Las conservas de Cádiz eran las más famosas: por lo menos desde el siglo V a.d. Cristo son mencionadas con gran aprecio por los autores griegos».²²

Lo más frecuente, eran secarlas al aire y al sol, en salazón, escabechado y ahumado. El auge de esta industria residía fundamentalmente en el carácter marítimo de la península, que hacía que una

gran parte de la población se dedicara a la pesca y sus derivados.

«Las condiciones geográficas de la Península y la riqueza pesquera de las variadas costas españolas, hicieron de España una de las Naciones más importantes en producción pesquera. Los siglos XV y XVI fueron los períodos de oro de esta industria. Numerosas embarcaciones extranjeras navegaron hasta los puertos españoles para comprar pescados salados. En 1581 se mantenía un intercambio comercial en el puerto de Guipuzcoa con franceses e ingleses. En él los vascos vendían bacalao, grasa de ballena, hierro y acero, y las naves francesas e inglesas introducían comestibles y otros productos de los que carecían las provincias vascas».²³

Otra razón que también influía en el mantenimiento de esta industria era el elevado consumo de pescado, por el hecho de que, como la religión católica era la oficial del reino, su población se veía obligada a consumir este producto durante largos períodos, como base de su alimentación.

Esta actividad pesquera se mantuvo floreciente hasta principios del siglo XVII, perdiendo interés a partir de esa fecha. (Vicens Vives la adelanta un poco)²⁴. Este decaimiento fué debido a la política seguida por la Corona, que redujo las inversiones en este sector, con lo que se vieron obligados a conseguir pescado a través de las compañías extranjeras²⁵. Otro motivo que contribuyó a este progresivo abandono, fué la pérdida de los derechos de pesca en el Mar del Norte, como consecuencia de las cláusulas del Tratado de Utrecht en 1713²⁶.

No todos los pescados se conservaban siguiendo las mismas técnicas, sino que se utilizaban las que mayores rendimientos producían, y eran más apropiadas para cada especie, variando incluso para una misma clase de pescado. Se observa que en el caso de la sardina, el método más corriente era el de «salazón», que consistía en curar con sal; también se hacía el «salpresado»²⁷, variedad que incluía una primera fase de salar y otra de desalar, y por último prensarlas y colocarlas en barriles, para facilitar su traslado, distribución y,

²¹ AHN. Consejos. Leg. 51152.

²² Antonio GARCÍA Y BELLIDO, «Veinticinco estampas de la España Antigua». 1977. Austral. p. 159.

²³ A. SAÑEZ REGUART, *op. cit.* p. 3.

²⁴ A. VICENS VIVES, *op. cit.* p. 139.

²⁵ A. SAÑEZ REGUART, *op. cit.* p. 10.

²⁶ A. SAÑEZ REGUART, *op. cit.* p. 67.

²⁷ A. SAÑEZ REGUART, *op. cit.* p. 30.

sobre todo, su conservación. Además el Paular recibía sardinas frescas, destazadas y descabezadas que seguramente venían ya preparadas para elaborarlas en escabeche, otra modalidad de conservación en la que se utilizaba como adobo el vino o vinagre, laurel y ciertos ingredientes.

La «salmuera» consistía en sumergir la pieza en agua con sal varias horas y secarla parcialmente al aire no debiendo quedar completamente seca. Este procedimiento se usaba en la conservación de la merluza, tomando en este caso el nombre de «cecial». El monasterio la compró así, en dos ocasiones.

Las lampreas admitían otra forma, que consistía en «empanarlo», resultando bastante cara (28 maravedíes cada pieza):

*«En Riva de Sella por la estación suele hacerse copiosa pesca de ellas, desde donde se conducen algunas en fresco a Madrid y otras poblaciones grandes, aunque no sin contingencia de que se echen a perder como sucede, no siendo empanadas. Supuesta la abundancia, podríamos hacer un artículo de comercio, atendida la justa estimación de la Lamprea; con tal de que los Naturales de nuestras Costas se dedicasen a beneficiarlas empanándolas al uso de Francia, donde es un ramo productivo».*²⁸

A través del libro de cuentas, citado frecuentemente, se puede comprobar que esta acción de empanar, fué la que se llevó a cabo al llegar la mercancía al monasterio, lo que hace suponer que en otras ocasiones también se ocuparían ellos mismos de hacer este tipo de conservas u otras similares. Esta técnica, aunque de origen francés, estaba muy extendida en la península.

En el caso del congrio, algunas veces se comercializaba fresco pero lo más común era salarlo para su perfecta conservación, no sólo para su consumo, sino para asegurar el traslado a los puntos de destino. Este pescado también admitía el «escabechado» y, de igual manera que la sardina, llegaba a la casa destazado, para su posterior elaboración, a la manera de la época:

«... con tal de no cortar los trozos miu gruesos, porque así no los penetra la sal y en la fritura quedan medio crudas sus partes interiores,

*de que resulta que se reblandecen y corrompen de modo que no es posible conservarse»*²⁹

La mielga, se consumía igualmente en salazón y en fresco.

Con el mero, se empleaba el «salpresado», como con otros muchos pescados:

*«... es decir, casi todos los que entraban en los puertos cantábricos»*³⁰

Por último, el bacalao, el pescado curado por excelencia, y que ha llegado exactamente igual hasta nuestros días, siguiendo las mismas técnicas, y consumiéndose en gran cantidad a lo largo de toda la historia. Hay mucha información sobre la procedencia, formas de captura y métodos de conservación en la obra de Sáñez Reguart:

*«La pesca de los bacalaos por los pescadores españoles, según Castro, data del siglo XV, época en la que llegarían hasta las costas de Escocia para la captura y salazón de este pez. La presencia de bacalaos en el comercio español aparece recogido en un documento sobre aranceles fechado en 1463 en el que se incluye este pescado entre los productos que introducían las naves vascongadas»*³¹

PESCADO DE LEQUEITIO Y DE BRETAÑA

Voy a referirme por último, a estos dos apartados citados frecuentemente en el libro de cuentas de Procuración, ¿a qué clases de pescados se refieren?

Ambas variedades tenían un precio similar, caro, y eran adquiridas en gran cantidad (en el mes de septiembre fueron unas 15 arrobas, equivalentes a 172,5 Kg.). Solamente una vez especifica que era curadillo, pero sin dar más pistas que permitiesen averiguar en que consistía. ¿Era todo ello bacalao, o en algún caso se referían a la ballena? Ambos eran muy apreciados, y producían unos beneficios muy cuantiosos a la industria pesquera de la época.

Al hablar anteriormente del florecimiento de la pesca durante los siglos XV y XVI, hice referencia al intercambio intenso de productos españoles con

²⁸ A. SÁÑEZ REGUART, *op. cit.* p. 265.

²⁹ A. SÁÑEZ REGUART, *op. cit.* p. 224.

³⁰ A. SÁÑEZ REGUART, *op. cit.* p. 211.

³¹ A. SÁÑEZ REGUART, *op. cit.* p. 39.

los de otros países, siendo a base del mismo la industria del bacalao y la ballena³². Esta última, aunque era propia de los mares del Norte, en la antigüedad, abundó en nuestras costas. García Bellido, afirma que ya Plinio en su *«Historia natural»*, hace una mención sobre este tema:

«Las ballenas penetran nuestros mares. Dicen que no se las ve en el Oceanus Gaditanus antes del invierno»³³

Esta afirmación está corroborada por otros autores, como Sañez Reguart:

«La captura tradicional de ballenas en la costa cantábrica data documentalmente del siglo XII. Sin embargo se remonta a siglos anteriores. Existen sellos municipales con dibujos alusivos a las ballenas en las villas de Bermeo, Guetaria, Ondárroa, Motrico, Fuenterrabia, Lequeitio, Laredo y otras, que muestran la antigüedad de esta práctica pesquera».

«... En 1381 en Lequeitio se dividía la lengua de la ballena en tres partes, dos se dedicaban a la reparación del muelle y la tercera a la Iglesia»³⁴

Aquí se demuestra, que en esta ciudad había una gran tradición de la pesca de la ballena, ¿pero es este el caso?, ¿a ella se refiere acaso este pescado de Lequeitio?

Estos bancos de ballenas que poblaban nuestras costas se trasladaron a otras zonas más alejadas, quizás porque nosotros mismos, a fuerza de capturarlas, las fuimos haciendo desaparecer esquilmandolas, o porque disminuyó su número por causas desconocidas, pero que como consecuencia de ello, los pescadores vascongados, tuvieron que adentrarse hacia el Norte para apresarlas:

«Había en este señorío y ría de Bilbao cien navíos de alto bordo y los naturales y dueños dellos yban en flótas formadas a lo mercantil a Levante, Bretaña y Flandes, y también yban a las pesquerías de bacallao a Terranova y a la de las ballenas a Noruega». 1540.³⁵

En este párrafo se menciona Bretaña, como zona de puertos de aprovisionamiento de pescado,

lo que coincide con las partidas de «pescado de Bretaña» que aparecen en el citado libro de cuentas, en las que no especifica nada más. ¿Sería exclusivamente bacalao lo que se traía de Bretaña y de Lequeitio, o también incluiría la ballena u otras especies?. Es posible pensar que esto fuera posible así, tomando en consideración el texto de Lois Tobio, en torno a este tema, al referirse a las luchas entre pescadores españoles e ingleses sobre el derecho de pesca en Terranova, que ilustran igualmente el comercio existente en aquella zona durante el siglo XVI:

«Cando os pescadores bascos e de outras nacionalidades escomenzaron a ir a Terranova na primeira metade do século XVI, ficaron abraidos da grande cantidade de baleas e bacallaus que ahí había e que xa Cabot notara. Era, pois, lugar atractivo. Abondan as testemuñas dos grandes beneficios que as dúas especies citadas proporcionaban até os derradeiros anos de século XVI. Os mariñeiros bascos, galegos e doutras partes do norte da península pescaban, de seguro, xa desde Edade Meia, a peixota, o linguado, o salmón e o arenque nas costas de Irlanda e no Mar do Norte...»³⁶

CONCLUSIÓN

Todos los pescados mencionados en el citado libro de cuentas de El Paular, eran los que se capturaban en la cornisa y mar Cantábrico.

En los meses de verano, disminuían las adquisiciones, comprando especies propias de río, mientras que en el invierno el acopio de pescado aumentaba en cantidad y variedad.

Recibían el pescado fresco y curado, resultando este más caro; por el contrario, la sardina, era la económica.

Estas partidas, comparadas con otras que cita Vicens Vives en su obra, referentes a las importaciones del puerto de San Sebastián en el año 1563, tienen grandes semejanzas, repitiéndose las mismas especies, y observando que la mayor cantidad de pescado adquirido es el bacalao³⁷.

³² A. SAÑEZ REGUART, *op. cit.* p. 37.

³³ A. GARCÍA Y BELLIDO, «La España del siglo primero de nuestra Era». Austral 1977. p. 160.

³⁴ A. SAÑEZ REGUART, *op. cit.* p. 37.

³⁵ A. SAÑEZ REGUART, *op. cit.* p. 67.

³⁶ TOBIO LOIS, «A Intervención de Gondomar nos problemas internacionais da pesca» Coruña. 1984. p. 15.

³⁷ J. VICENS VIVES, *op. cit.* p. 146.

No es posible afirmar, que todo el pescado que consumía la comunidad fuera solamente el que aparece en este libro de cuentas. Por un lado hay que contar con el que procedía del estanque, y el que se pescaba en el río Lozoya. Por otro, he constatado varias veces que algunas partidas se trataban de encargos para una tercera persona; por último, se conservan unos fragmentos de un Libro de Mayordomía³⁸, de la casa que poseían en Segovia, en el que aparece una serie de pescados que compró un hermano cartujo, para enviar al Paular, y que coincide exactamente con los estudiados en este trabajo.

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³⁸ AHN. Clero. Libro 19825.

Fish bone diagenesis in different soils

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(Received 21 December 1995; accepted 24 January 1996)

ABSTRACT: Fish bone decomposition was investigated using bones recovered after groups of cooked and uncooked fish had been buried in one of five locations for seven years. The results indicated that neither soil pH nor drainage was paramount in determining bone survival, and that fish bones were in general less likely to survive than similar sized mammal and bird bones. Within fishes, smaller taxa were not necessarily liable to preferential bone decay. Boiling dramatically reduced bone survival, but baking did not. Neither organic content nor C/N ratios proved useful in describing bone preservation. It is suggested that commonly used quantitative methods for estimating original fish assemblage composition (MNI and NISP) are frequently unhelpful, and that simple presence/absence counts by context or sample may be often more appropriate.

KEYWORDS: FISH BONE, DIAGENESIS, SOIL pH, C/N RATIOS, COOKING, QUANTIFICATION

RESUMEN: Investigamos la descomposición de los huesos de peces a través de una serie de ejemplares frescos y cocidos que fueron enterrados durante siete años en una zona de entre cinco seleccionadas y posteriormente excavados. Nuestros resultados indican que ni el pH edáfico ni la irrigación del suelo han sido factores claves para determinar la supervivencia del hueso y que, en general, los huesos de pescado sobreviven en mucha menor medida que los de aves y mamíferos de talla similar. Dentro de peces, los taxones de menor tamaño no parecen ser más susceptibles de una degradación preferencial que los de mayor tamaño. La cocción reduce drásticamente la pervivencia del hueso pero no así el asado. Ni el contenido orgánico ni las relaciones C/N parecen servir en la caracterización de los patrones de pervivencia. Sugerimos que los métodos clásicos de cuantificación de fauna encaminados a estimar la composición original de la muestra de peces (el número de restos y el número mínimo de individuos) pueden resultar de poca ayuda a tal efecto por lo que quizás sea más beneficioso recuentos simples basados en presencia/ausencia por contexto o muestra.

PALABRAS CLAVE: HUESO PEZ, DIAGÉNESIS, pH EDÁFICO, PROPORCIÓN C/N, COCINADO, CUANTIFICACIÓN

INTRODUCTION

Recent publications demonstrate a developing interest in biostratinomy –pre-burial modifications to death assemblages– among those working with archaeological fish bone. There have been a number of papers dealing with various processes which may influence the composition of a fish bone assemblage (for some examples: Jones, 1984; Butler, 1987; Nicholson, 1991 & forthcoming a; Stewart & Gifford-González, 1994). Particular attention has been paid to distinguishing «natural» from

«cultural» accumulations of fish bones. Unfortunately, in common with other branches of archaeozoology, this interest has so far not been accompanied by comparable studies into fish bone diagenesis –changes occurring after burial. Little is really known about fish bone decomposition, particularly regarding relative rates of decay between different fish taxa and between the different body parts, although there has been some evidence to suggest that bones from fatty or oily fishes are likely to be lost preferentially due to the autolysis of the fats and oils (Mézes & Bartosiewicz, 1994). Discussions concerning archaeologically

recovered fish bone assemblages often consider the possible extent of bone loss, and occasionally authors may suggest which taxa and/or skeletal parts may be under-represented. These interpretations are often based on the superficial appearance of the archaeological bone assemblage and/or upon untested, but commonly held, assumptions. Usually it is considered that small bones will degrade first; some bones (such as from herring) appear fragile and therefore less likely to survive archaeologically than larger bones (such as from gadids); see for example Bigelow (1984). Differences in the representation of body parts are often used to imply fish processing, particularly the production of stockfish (e.g. Wilkinson, 1979). It is obvious, however, that arguments based on archaeologically recovered material will always be circular. The reliance upon quantitative units, particularly Minimum Number of Individuals (MNI) and Fragment Counts (NISP), in the comparison and interpretation of fish bone assemblages is founded on the implicit assumption that some characteristics of the original assemblage species composition remain, and therefore that the excavated sample is a true representation of the originally deposited whole.

Clearly, the extreme diversity of body forms and skeletal organisation among fishes renders it extremely unlikely that decomposition will be uniform among this heterogeneous group. It is not sufficient to presume that bone size or bone density (g/cm^3) are the major determinants of bone preservation in the absence of independent evidence. To complicate the matter further, most fish caught for human consumption are likely to have been processed in one way or another - most likely by cooking. By observation alone it is not often clear whether a bone has been cooked or not, although exceptionally an archaeological context may prove conclusive (eg. Andersen & Malmros, 1984, where cod bones were recovered from charred food crusts within cooking pots). The effects of different cooking methods upon bone survival are poorly understood, yet, as it is likely that most fish prepared for human consumption would be cooked in one way or another, this question is clearly crucial to our understanding of the archaeological material. If cooked bone only survives in exceptional circumstances, then a recovered assemblage of fish bones may not be representative at all of the utilised resource.

Arguably, to make meaningful statements about fish bone assemblages we need, at the very least, to understand:

1. Whether bones of similar size from different taxa will decay at similar rates.
2. Whether small-boned species are likely to be drastically under-represented.
3. Whether some body parts are likely to be lost in preference to others.
4. How cooking affects rates of bone decay.
5. How variation in burial conditions affects bone loss.

The research presented in this paper represents a preliminary step towards a better understanding of fish bone decay by actualistic experiment. It forms part of a wider investigation of bone taphonomy undertaken by the author (Nicholson, 1991, 1992, 1993, forthcoming b).

THE EXPERIMENTS: METHODS AND MATERIALS

Burial

As a first step in looking at bone diagenesis, suites of animal remains were buried at 18 locations in the UK, encompassing a range of different soil types. The experiments were set up in the summer of 1987 and five sites were excavated in 1994. At each site a similar suite of remains was buried (Table 1), including the following fish: cod (one boiled, one complete); plaice (one baked, one complete); herring (one baked, one complete), whiting (one filleted). Of the baked fish, only the fins were charred. The fish species and sizes were selected on the grounds of ease of availability in quantity as well as their ubiquity on many British archaeological sites, making the experiments directly applicable to many archaeological assemblages. All of the five excavated sites were in North Yorkshire, UK, within a 50 Km^2 area; they had therefore experienced similar climatic events during the seven years that the remains were buried. Burials were at a depth of 0.32-0.45 m; at two of the excavated sites bedrock restricted the available depth of soil. The location and a brief description of each excavated site is given in Table 2, with more details of the soils presented in Table 3. Each site has been assigned a site number for reference.

IDENTIFICATION	DESCRIPTION	SOIL pH (Mean)	DRAINAGE	BURIAL(Depth)
Site 10	Heather Moorland	pH 4.0	Moderate-Poor	0.32 m
Site 14	Garden Soil	pH 6.8	Moderate-Good	0.43 m
Site 15	Deciduous Woodland	pH 3.9	Moderate-Poor	0.45 m*
Site 16	Chalk Wasteland (formerly cultivated)	pH 7.8	Well drained	0.36 m
Site 18	Urban Compost Heap (ongoing deposition)	pH 7.0	Moderate-Poor	see below

N.B. At site 15 while the burial depth was 0.45 m some two years after burial soil slip added extra material, so that the remains were excavated at a depth of 0.5-0.8 m. At site 18, the compost heap, organic matter was continuously added so that while the remains were buried in 0.25 m of well-rotted humus, with approximately 60 cm of unrotted vegetable matter placed above, at excavation the depth of humified material above the buried remains was 0.58 m. The surrounding matrix included ash, pottery fragments, eggshell and other non-organic material as well as humic soil.

TABLE 1
The sites: location, soil pH and drainage.

No.	DESCRIPTION	TREATMENT
2	Cod (<i>Gadus morhua</i>)	1 x None ⁺ ; 1 x boiled for 1 hour (including 25-30 min for the water to boil)
2	Plaice (<i>Pleuronectes platessa</i>)	1 x None ⁺ ; 1 x *baked for 20 min at 200°C and the edible flesh removed
2	Herring (<i>Clupea harengus</i>)	1 x None ⁺ ; 1 x *baked for 15 mins at 200°C and the edible flesh removed
1	Whiting (<i>Merlangius merlangus</i>)	Gutted and filleted

+Animals complete, with internal organs
* Baking resulted in charring of the skin and fins only

TABLE 2
Details of the fish buried at each site.

Recovery

Owing to the remote location of some of the sites water sieving on site was impractical. Excavation was exclusively by hand; once the topsoil had been removed excavation was by careful trowelling. When bones were seen entire soil blocks were lifted with the aid of metal plates and these blocks were excavated in the laboratory. Finally, all the soil taken to the laboratory was wet-sieved to 1 mm to aid the recovery of bones and scales.

Recording

Each skeleton was weighed after most adhering soil had been removed by gentle rinsing in tap water followed by drying at room temperature for 48 hours; this weight is termed «skeletal weight» below. Before washing, the bones were photographed and any adhering organic matter (for example fungal growths) and staining of the bones were noted. Bone fragments were recorded by size - a percentage figure indicating the proportion of the

Site Identification	Mean Moisture Content* (% Volume)	Mean Bulk Density (g/cm-3)	Mean Organic Matter (% weight)	Mean CaCO ₃ (% weight)#	pH
10 upper	46.1	1.1	9.6	0.8	3.5-4.5
10 lower	30.1	1.7	5.0		
14 upper	25.4	0.9	12.4	1.4	6.5-7.0
14 lower	21.1	1.2	6.3		
15 upper	29.4	1.1	8.2	1.0	3.3-4.5
15 lower	27.7	1.2	4.2		
16 upper	17.0	0.9	11.4	4.5	7.5-8.0
16 lower	18.1	1.0	6.7		
18 middle	25.4	0.8	8.8	2.1	7.0-7.3
18 lower	27.7	0.7	12.8		

* At time of excavation

These values may have been increased by the loss of air trapped in the soil

At site 18, the upper layer comprised poorly rotted vegetable matter, and so was not sampled

TABLE 3

Bulk parameters for the soil from the upper (or middle) and lower horizons at each site.

whole bone represented by the fragment (i.e. fragment size: 100 = complete, 50 = 1/2 bone). The proportion of each skeleton which was recovered, referred to below as «skeletal completeness», was calculated by the formula:

$$\text{Skeletal Completeness} = \sum n / 100 \times tb$$

where «n» is the fragment size (% of whole bone) of each recovered bone, and «tb» is the total number of major bones per skeleton.

This number enables direct comparison between skeletons of the proportion of bone material remaining, irrespective of the size of fish, in a way that skeletal weight does not. Bone «condition» was also recorded on a subjective scale of:

- 1 (excellent, as fresh),
- 2 (no longer greasy, but uneroded),
- 3 (some erosion, but bone generally complete),
- 4 (substantial erosion, some bone missing),
- 5 (extensive erosion, bone friable and incomplete).

Estimations of the possible extent of bone loss from a recovered archaeological assemblage are often based on some subjective assessment of assemblage «condition», not necessarily using a numerical score. In this study the extent of bone loss could be calculated, a circumstance very rarely encountered archaeologically. Therefore the value of using a subjective assessment of «bone condition» to predict the extent of bone loss could be examined.

All bones were then stored at 4°C until samples were taken for Scanning Electron Microscopy, thin section observation and chemical analyses. This paper will not deal with the microscopical aspects of this study.

Chemical Analyses

Changes to the chemical composition of the samples were examined by looking at changes to the ratio of organic: mineral material, and by CHN analysis of the organic «collagen» fraction, a technique often used to investigate bone diagenesis before isotopic analysis of collagen (see for example

Ambrose, 1990). Small samples of bone were taken, in the case of the fish (excluding the whiting) several vertebrae and one jaw bone (selection dependant upon survival) from each specimen were used. These samples were cleaned by air abrasion and by ultrasonication for 15 minutes in deionised water. Modern «control» samples were taken from freshly killed specimens. These bones had been deep frozen at -20°C before use, but were cleaned manually and ultrasonicated as above. The samples were then dried for 48 hours in a vacuum desiccator over silica gel, following which they were weighed. All samples were demineralised in 0.3M HCl for 7-14 days, or until they became fully transparent. After washing in deionised water to neutrality, the samples were placed in 0.125M NaOH for 24 hours to remove humic material and some lipids, before washing again and drying for 48 hours in a vacuum desiccator over silica gel. The dried samples were ground to as near to a powder as was possible, and submitted to Dr. G. Wolff in the Department of Oceanography, University of Liverpool, UK, for CHN analysis. A Carlo Erba 1106 CHN Elemental Analyser was used.

RESULTS AND DISCUSSION

Despite the relatively short burial period, there was considerable variation in the state of bone preservation both between individual taxa/treatments from the same site and between the same taxa/treatments from different sites. In most instances fish bone survived less well than mammal and bird bone from individuals of similar, or lighter, body weight (for further details concerning mammal, bird and fish bone preservation at these sites see Nicholson, forthcoming b). As illustrated by Tables 4 and 5 and Figure 1, which respectively present bone survival in terms of the proportion of bone visibly present («skeletal completeness»), the superficial appearance of the bones («bone condition»), and by overall bone weight per skeleton («skeletal weight»), fish bone preservation was very different at each of the five sites. At the extremes, almost no fish bone survived at the moorland site (Site 10); only both sets of cod otoliths and several cod vertebrae were recovered. Dense coverings comprising matted rootlets and fungal hyphae surrounded the areas where the fish would have been (illustrated in Nicholson, forthcoming

	Animal total body length and weight	Total n.° of bones considered	Site 10	Site 14	Site 15	Site 16	Site 18
Fresh Cod	445-460 mm 670-780 g	113	1	98	58	85	97
Boiled Cod	422-460 mm 665-735 g	113	2	16	13	38	44
Fresh Plaice	295-352 mm 230-340 g	113	0	93	60	58	92
Baked Plaice	321-340 mm 295-365 g	113	0	76	46	74	91
Fresh Herring	279-286 mm 145-160 g	98	0	89	39	71	90
Baked Herring	276-307 mm 155-205 g	98	0	56	5*	82	95
Filletted Whiting	300-360mm 220-325 g	113	0	44	42	58	95

* scores may be reduced by bones lost during excavation

TABLE 4
Mean «skeletal completeness» scores.

	SITE 10 Mean Range	SITE 14 Mean Range	SITE 15 Mean Range	SITE 16 Mean Range	SITE 18 Mean Range
Fresh Cod	5 5	2 2	3 2-4	3 2-4	2 2
Boiled Cod	5 5	5 3-5	4 3-5	4 3-5	3/4 3-5
Fresh Plaice	- -	3 2-4	3 2-4	3/4 3-4	2 2
Baked Plaice	- -	2 1-3	3 2-5	3 2-4	2 2
Fresh Herring	- -	3 2-4	3/4 2-5	3 2-4	2 2
Baked Herring	- -	3 3-5	3 2-5	2/3 2-4	2 2-3
Filleted Whiting	- -	4 2-4	3 2-4	3 3-4	2 2

TABLE 5

«Bone condition» scores (range 1: as fresh, to 5: extremely friable and degraded).

b). These fungal and root «shells» were not observed at any of the other excavated sites. The best bone preservation occurred in the compost heap, a finding which was initially of surprise to this author who had expected the warm, aerobic conditions within the compost heap to accelerate bone decomposition. Presumably the bones were preserved as a consequence of the rapid accumulation of humics within the bone structure, inhibiting bacterial action (and evident from the dark brown colour of the bones). Subsequent publication of the effects of humics on collagenase digestion (van Klinken & Hedges, 1995) supports this conclusion. Almost no bone was lost in the compost heap, and the excellent bone condition was similar to that observed from many organic-rich urban deposits. In this case it would appear that waterlogging was not the key to bone preservation, an explanation which is often used with regard to bone recovered from organic-rich urban deposits.

Despite their similar pH (3.5-4.5) and drainage (moderate –poorly drained), skeletons were very differently preserved in the moorland and woodland soils (Sites 10 and 15). Again, this finding indicates that neither pH nor drainage, either individually or in combination, sufficiently describes a burial environment in terms of its potential for bone preservation.

It was evident in every one of the burial environments that boiling dramatically reduced fish bone survival. Baking did not appear to have the same effect, at least for the methods, temperatures and heating durations used in these experiments. In most cases there were no clear differences in

preservational state between those individuals which had been baked when compared with similar individuals which had not been cooked. There was some indication that filleting accelerated bone decomposition, however direct comparison between the filleted and complete individuals (whiting and cod) was not justified because of the different fish sizes.

Fish scales were not found at any of the sites, however it is possible that a few fragments may have been recovered had flotation been employed as a recovery method. During excavation a «silvery» skin-like covering was visible over the heads of both the herrings at site 16 (chalk); however once exposed to the air this silvery disappeared. At all sites the cod, whiting and plaice otoliths survived well, although the tiny herring otoliths were rarely recovered. The preferential survival of otoliths over bone at Site 10 (acid moorland) was rather surprising, and may indicate the importance of micro-organisms in decomposition. The lack of organic material within otoliths, as well as their structural density, probably explain their preferential survival over bone. Any dissolution of their calcium carbonate matrix by the acidic groundwater appeared to have been minimal, and none of the otoliths appeared polished and eroded around the edges in the manner illustrated for mammal-digested otoliths by Jones (1986).

Although there was some correlation between the variables «bone condition» and «skeletal completeness» (for example a condition score of «2» indicated a «skeletal completeness» score of 90% or more) there was considerable variation within

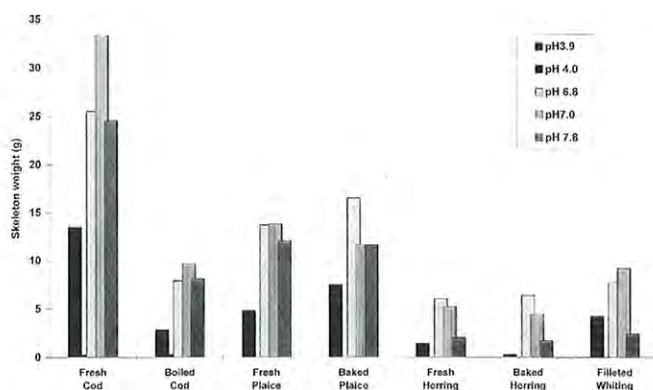


FIGURE 1

Total weight of bone by species/treatment and soil pH at each site.

the 3-4 range, moderate to poor condition. Mean condition did not clearly discriminate between skeletons from the acid woodland, the garden soil and the alkaline chalk, although «skeletal completeness» as well as «skeletal weight» clearly showed the first to be much less well preserved. Evidently some surviving bones may appear quite well preserved when, in fact, quite a considerable amount of bone loss has taken place. This fact was also clear from direct observation of the variation in bone condition within a skeleton, and is of direct archaeological relevance because differences in bone condition (however defined) are usually the only means by which preservation can be assessed. Other measures of preservation, such as those based upon differences in the representation of certain skeletal elements or comparison of bone weights, are only useful if it can be independently established that whole individuals were originally deposited, which is rarely the case. Archaeologically, very poorly preserved assemblages are likely to be unsuitable for detailed comparative study, particularly by interpretation of differences in species representation by NISP or MNI. It is therefore essential that such assemblages should be recognised.

Chemical analyses

As the superficial appearance (condition) of a bone did not appear to adequately indicate the overall state of preservation of an individual skeleton it was hoped that chemical analyses might provide a criterion for identifying poorly preserved assem-

blages - that is those in which quite a lot of loss has taken place, even though those bones which had survived appeared reasonably intact.

Calculation of the «collagen» content, and of the amounts of Carbon and Nitrogen within the «collagen», were made not only for the fish bones discussed in this paper but also for bird and mammal bones from the same burial experiments. While fish bone is the subject of this paper, the results from the mammal and bird bones are of relevance here. In almost every case the mammal (including small mammal) and bird bones showed «collagen» concentrations within the expected range for dry bone (roughly 25-30%), atomic C/N ratios within the expected range for collagen (2.9 - 3.6) and very similar values for the amount of C and N in the «collagen» (38-48% C, 13-17% N). By contrast, the fish bones produced very diverse results in all of the above three categories (see Table 6 and Figure 2). Some of this diversity may be explained by differences in fish bone design and composition; fresh cod bones had, for example, an organic content on average of only 13.4% (a low yield verified by thermal analysis). However, even with low «collagen» yields in the case of cod, the uncooked control samples from freshly killed fish all possessed C/N ratios and concentrations within the ranges given above. In comparison to other types of bone, it must be concluded that fish bone in general is subject to much more rapid diagenesis and loss of the organic fraction. This finding has implications for the suitability of ancient fish bone for a range of chemical analyses.

	% Organic	C/N Ratio
<i>Uncooked Cod</i>		
Fresh	13.4	3.37
Acid Woodland (Site 15)	11.0	3.49
Neutral Garden (Site 14)	9.2	3.74
Neutral Compost (Site 18)	15.5	3.35
Alkaline Chalk (Site 16)	10.4	3.78
<i>Boiled Cod</i>		
Acid Woodland	0.0	Insufficient Sample
Neutral Garden	0.0	Insufficient Sample
Neutral Compost	0.4	4.03
Alkaline Chalk	1.1	4.82
<i>Uncooked Plaice</i>		
Fresh	27.8	3.21
Acid Woodland	15.8	3.27
Neutral Garden	13.2	3.4
Neutral Compost	14.5	3.39
Alkaline Chalk	9.2	4.05
<i>Baked Plaice</i>		
Acid Woodland	27.4	3.33
Neutral Garden	11.9	3.19
Neutral Compost	20.1	3.38
Alkaline Chalk	9.1	3.91
<i>Uncooked Herring</i>		
Fresh	21.6	Missing
Acid Woodland	7.6	3.49
Neutral Garden	7.7	3.32
Neutral Compost	12.1	3.34
Alkaline Chalk	10.2	3.34
<i>Baked Herring</i>		
Acid Woodland	0	Insufficient Sample
Neutral Garden	2.3	3.53
Neutral Compost	10.4	3.23
Alkaline Chalk	12.6	3.41

TABLE 6
Fish bone «collagen» content and atomic C/N ratios. (Note that insufficient material was available for analysis from site 10, acid moorland).

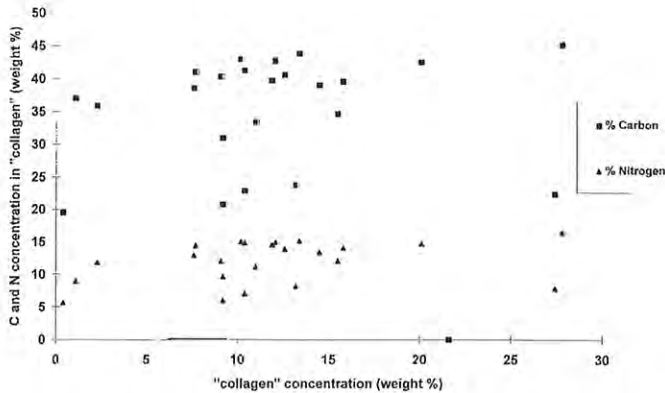


FIGURE 2
Carbon and Nitrogen concentration as % «collagen» weight, against «collagen» concentration, for fish bone from sites 14, 15, 16 and 18.

Those samples with C/N ratios outside the accepted range, so indicating extreme loss of the organic component, included all the boiled cod bones (several produced insufficient residue for analysis) as well as the uncooked cod bones from sites 14 (garden) and 16 (chalk). While the poor condition of the boiled cod bones was very evident upon excavation, it was not clear from looking at the uncooked cod bones from site 14 and 16 that the bones underwent extensive diagenesis; in terms of «skeletal completeness», both scored highly (98% and 85% complete), and in terms of «bone condition» both appeared well preserved. In this case, therefore, extensive changes to the organic fraction appear to have taken place in the bones without concurrent loss of bone, entirely the opposite of what might have been expected.

In other cases, for example the baked plaice bones from site 15 (woodland), an acceptable C/N ratio obscured a real loss of C and N, suggesting that some other non-organic component contributed to the «collagen» weight. Conversely, although containing only 2.3% «collagen» the baked herring bone from site 14 produced a C/N ratio within the range for collagen, and the small amount of remaining organic material contained 12% nitrogen and 36% carbon, suggesting that the small amount of organic material was still intact collagen. Although it was expected that bones from baked fish would be distinguished from bones from uncooked speci-

mens by the extent of collagen degradation - as illustrated after heating fish bone to 60°C (Richter, 1987) - this did not prove to be the case. It may be hypothesised that in this case baking did not alter the collagen fibrils in a manner sufficient to enhance hydrolysis.

Skeletal element representation

Figure 3 illustrates the skeletal part representation for the Gadidae (cod and whiting), plaice and herring, cooked and uncooked. For the purposes of this discussion the results from all of the sites have been combined to provide an overall view. Despite the different treatments, both the baked and uncooked plaice and herring show remarkable similarity in terms of the relative survival of skeletal elements. While bones of the cranium were generally least well preserved in both the baked and uncooked plaice, there was little other evidence of differential survival of skeletal parts. By contrast, the plots for baked and uncooked herring both reflected the preferential survival of the basioccipital, parasphenoid, ceratohyal, hyomandibular, subopercular and vertebrae. Bones of the cranium were again generally least well preserved. The lower number of baked herring vertebrae can largely be attributed to one site (Site 15, the woodland) where other evidence would favour an interpretation of poor recovery rather than poor preservation. Turning to the gadid fish, there was conside-

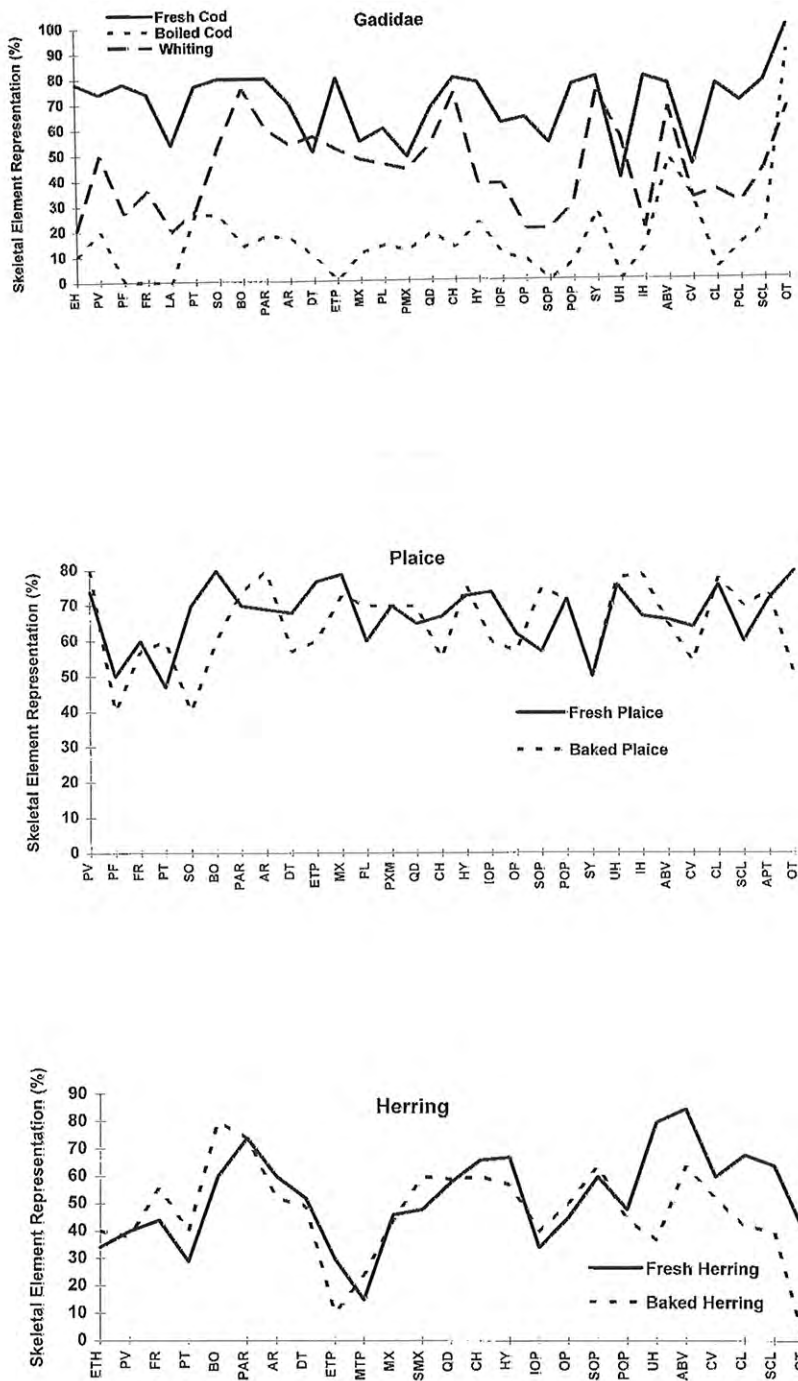


FIGURE 3
Skeletal element representation; a) Gadidae, b) Plaice, c) Herring.

rable variability between the specimens, not surprising perhaps given their different sizes as well as their different treatments. Where recovered, most of the uncooked cod skeletons were fairly complete, loss was greatest in the oromandibular region and the caudal portion of the spine. The basioccipital and parasphenoid proved to be among the most robust bones in both the uncooked cod and the whiting, while filleting appeared to be detrimental to the survival of vertebrae. Bone loss was severe among the boiled cod, and abdominal vertebrae proved to be the best represented bones. The preferential loss of vertebrae from the caudal region should be considered when methods of fish processing are discussed, as the preparation of stockfish, for example, involves the removal of the head and front (abdominal) part of the spine while leaving bones of the shoulder and caudal region in the dried or salted body, which is then exported. It is clear that absence of vertebrae from the caudal region cannot alone be cited as good evidence for the exportation of stockfish.

CONCLUSIONS

The aims of this paper have been broadly to enable a better understanding of variability within archaeologically recovered fish bone assemblages and to document the effects of different cooking methods on bone survival. Additionally, it was hoped that it would prove possible to distinguish by physical appearance, quantitative analysis or chemical means an assemblage in which a representative sample of bones have survived from an assemblage where a large majority of bones have decomposed.

Not surprisingly, bone diagenesis has been shown to be an extremely complicated subject. Even after just seven years, rates of bone decomposition were dramatically different within the soil environments used in this study and appear not to be solely dictated by soil pH and drainage. It has been argued elsewhere (Nicholson, forthcoming b) that microbiological considerations may be of paramount importance, and the build up of humic material within the bones buried in a compost heap may explain their excellent condition.

This study has also demonstrated that some methods of cooking (baking) may have little effect on bone survival (at least in the short-medium

term), while other methods (boiling) may dramatically reduce bone survival. The accelerated loss of cooked fish bone (particularly boiled bone) has obvious application to archaeology, as it may be assumed that most fish captured by humans were destined in one way or another for cooking, and that in many instances entire fish would have been cooked.

While some patterns of skeletal element loss appeared to be generally predictable, for example that among the Gadidae caudal vertebrae are likely to decompose more rapidly than abdominal vertebrae, other trends were less obvious. The numbers of individuals used in this study were insufficient to allow the construction of an «index» whereby diagenetically altered assemblages may be recognised by changes in skeletal element representation frequencies, but this must be a priority for future investigation.

It did not prove possible to characterise any but the poorest preserved assemblages by chemical means. Under the conditions of testing, the rate of breakdown of collagen in fish bone after burial was extremely variable, and difficult to predict either from the apparent condition of the recovered bones or from the type of burial environment. Loss of collagen, and changes to the composition of the «collagen» fraction sometimes did, but in many cases did not, reflect the apparent condition of the skeleton and the amount of bone loss which had taken place. Neither C/N ratios, C and N concentrations, nor «collagen» concentration proved to be a sensitive indicator of preservational state.

Contrary to common preconception, it has been shown that, despite their small bones, herring may be represented even in soils where many bones from much larger-boned individuals (such as Gadidae) have decomposed. The vulnerability of fish bone in comparison to other animal bone was confirmed by this study, a finding which warrants more consideration in archaeozoological discussions as it has direct bearing upon the methods by which bones are quantified and taxa compared. The use of relative abundance quantification techniques currently favoured - notably MNI, NISP and Meat Weights constructed from the above or from bone weights - are inappropriate or meaningless unless the pattern of bone loss is understood. This study has demonstrated that bone loss between taxa frequently does not follow easily defined rules, for example based on bone size or bone density, and based on easily measured parameters of the soil en-

vironment, such as pH and drainage. Consequently, it would seem reasonable to suggest that we may never be able to accurately establish the relative abundance of different taxa in an originally buried assemblage. In almost every archaeological circumstance it may be better to accept this fact, and therefore to abandon direct numerical comparisons in favour of an estimate of the frequency with which a species occurs in the contexts or samples under investigation. This use of relative frequency as an abundance measure has a tradition in zoology, and has been occasionally advocated and discussed in the archaeozoological literature, for example O'Connor (1985), and, specifically for fish bone, Wheeler & Jones (1989, 152-3). Given the weight of evidence indicating the vulnerability of fish bone, and its very diverse size, structure and composition, it is remarkable that the measure has so far found little support among archaeoichthyologists.

ACKNOWLEDGEMENTS

The author carried out this work as a Research Fellow funded by the Leverhulme Trust. The CHN analyses were carried out by Dr. G. Wolff and staff at Liverpool University, funded by a British Academy Award from the Fund for Applied Science in Archaeology, and attendance at the 8th Fish Remains Working Group meeting to present this paper was made possible by a travel award from the British Academy. The author gratefully thanks all concerned.

Many individuals contributed to the project, and thanks are due to Dr. Andrew Jones, who was instrumental at every stage of this project, from planning the experiment, through providing the compost heap, to commenting on an early draft of this paper. Mr S. Nicholson, Mr T. Holt, Mr. T. Strickland and The North York Moors National Parks Office also allowed me to bury on their land, and my father helped with much of the hard digging. Thanks also to Dr. Inge Bødker Enghoff for bringing certain relevant papers to my attention, and to Dr. Terry O'Connor for advising on aspects of the project.

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Fish exploitation in the Neolithic: some new data from Northern Central Europe

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(Received 26 December 1995; accepted 30 January 1996)

ABSTRACT: Fish remains from three Middle and Late Neolithic sites in the north-eastern part of Germany are discussed. At Niedergörne on the Elbe river and at Klessin on the Oder river species of the Cyprinidae, like bream (*Abramis brama*), roach (*Rutilus rutilus*), rudd (*Scardinius erythrophthalmus*), chub (*Leuciscus cephalus*), orfe (*Leuciscus idus*) and tench (*Tinca tinca*) dominate the fish bone material. From a zoogeographic point of view the presence of *Aspius aspius* at Niedergörne is remarkable. The ichthyological material from the site Löddigsee - a seasonal camp situated on a lake - comprises a high portion of pike bones (*Esox lucius*). The frequency distribution of the skeletal elements for this species suggests that only a part of the catch was directly consumed at this site while another part was slaughtered here and transported - as dried fish? - elsewhere for consumption.

KEYWORDS: GERMANY, FISH, NEOLITHIC, CYPRINIDAE, *Esox lucius*, FISHING, CONSUMPTION, TRANSPORT

RESUMEN: El trabajo valora los restos de peces procedentes de tres yacimientos del Neolítico medio y final en la zona nororiental de Alemania. En Niedergörne, en el río Elba, y en Klessin, en el Oder, la muestra está dominada por diversas especies de ciprínidos como la brema (*Abramis brama*), el rutilo (*Rutilus rutilus*), el escardín (*Scardinius erythrophthalmus*), el cacho (*Leuciscus cephalus*), el ido (*Leuciscus idus*) o la tenca (*Tinca tinca*). Desde el punto de vista zoo geográfico resulta llamativa en Niedergörne la presencia del aspío (*Aspius aspius*). Los restos ícticos de Löddigsee, un campamento estacional establecido junto a un lago, incluyen una gran cantidad de restos de lucio (*Esox lucius*). El patrón de representatividad esquelética de esta última especie sugiere que aquí se produjo un consumo directo de sólo parte de lo pescado y que el resto fué posiblemente transportado a otro lugar, quizás como salazón, al objeto de ser consumido allí.

PALABRAS CLAVE: ALEMANIA, PESCAO, NEOLÍTICO, CIPRÍNIDOS, *Esox lucius*, PESCA, CONSUMO, TRANSPORT.

INTRODUCTION

Little is known about the food economy of the lowlands of Northern Central Europe during the Middle and Late Neolithic. Only a few sites have yielded well excavated and documented faunal assemblages that allow a closer examination of the subsistence strategies of these periods (Benecke, 1994; fig. 39 ff.). Although the sites are located in a landscape which is rich in stretches of water, fish remains were rarely found in great quantities. This

is partly due to the bad conditions for bone preservation and the excavation techniques in particular the lack of sieving.

Neolithic fish remains from the lowlands of Northern Central Europe have been reported from Hüde I (Hüster, 1983), Bistoft (Heinrich & Lepiksaar, 1979), Siggeneben-Süd (Heinrich, 1983), Szczecin-Ustowo (Chełkowski, 1960), Dąbki (Iwaszkiewicz, 1985) and from Rzućewo (Nieza-bitowski 1928).

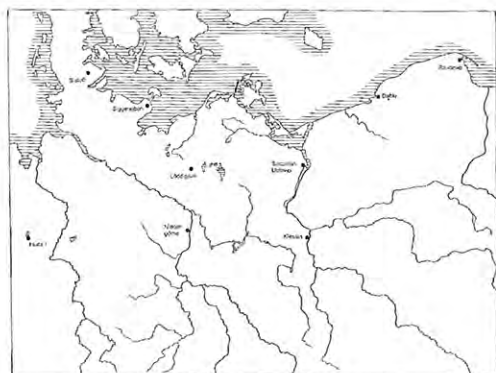


FIGURE 1

Location of Middle and Late Neolithic sites in the lowlands of Northern Central Europe from which large quantities of fish remains have been studied (references see text).

In the past few years I had the opportunity to study some faunal assemblages from newly excavated Middle and Late Neolithic sites in the north-eastern part of Germany. Three of those assemblages also comprise fish remains. These excavations are Niedergerne, Loddigsee and Klessin (Figure 1). The present paper gives some details about the results of the archaeoichthyological analyses.

FISH REMAINS FROM NIEDERGÖRNE

The site is situated north of the former village of Niedergerne at the very edge of the so-called Arneburg plateau on the left bank of the Elbe river (Stolle *et al.*, 1988; fig. 1). In 1985 rescue excavations at this site revealed two large pits belonging

to a settlement of the Middle Neolithic «Tiefstichkeramik» culture (Table 1). The strata of pit 1 were partly sieved (c. 0,1 m³ with a sieve of 1 mm mesh size), while pit 2 was not. The fill of the two pits consisted mainly of silty sand. During the excavation of pit 1 numerous nest-like concentrations of fish scales were encountered of which only a small sample has been collected (c. 250 specimens). These concentrations are probably the remains of skinning fishes. Another remarkable find is the large number of mussels in both pits. In pit 1 some of the shells were deposited as a continuous layer (Stolle *et al.*, 1988; fig. 2).

The faunal assemblage from both pits comprises 2590 remains (ommitting fish scales), 531 belonging to mammals, 699 to mussels and 1360 to various species of fish. Table 2 shows that 12 fish species could be identified in the material from Niedergerne: seven species of cyprinid [bream (*Abramis brama*), roach (*Rutilus rutilus*), rudd (*Scardinius erythrophthalmus*), chub (*Leuciscus cephalus*), orfe (*Leuciscus idus*), tench (*Tinca tinca*) and asp (*Aspius aspius*)], pike (*Esox lucius*), eel (*Anguilla anguilla*), perch (*Perca fluviatilis*), catfish (*Silurus glanis*) and sturgeon (*Acipenser sturio*). Fish scales are mainly of cyprinids and only some are of pike. With the exception of sturgeon, all identified species belong to the recent fish fauna in that part of the Elbe river (Bauch, 1958). From the zoogeographic point of view the presence of *Aspius aspius* is remarkable. Today this species is widely distributed in Eastern Europe and Western Asia with the Elbe river being regarded as its western limit (Ladiges & Vogt, 1979; fig. 73). As far as we know from the literature there is no subfossil evidence for *Aspius aspius* west of the Elbe river.

SITE	CULTURE	¹⁴ C-DATES (UNCAL. BP)
Niedergerne	Tiefstichkeramik	4550 ± 60 (Bln 3552)
Klessin	Britz	4459 ± 41 (Bln 4649)
Loddigsee	Single Grave	4130 ± 60 (Bln 3050)
		4290 ± 60 (Bln 3090)
		4200 ± 50 (Bln 3130)
		4080 ± 50 (Bln 3825)
		4290 ± 100 (Bln 3828)

TABLE 1

Radiocarbon-dates for Niedergerne, Klessin and Loddigsee (according to J. Görsdorf, Berlin, personal communication).

As can be seen from Table 2, cyprinids are the most numerous group in the ichthyological material from Niedergörne, followed by pike, eel and catfish. Within the cyprinids, bream, roach, rudd and chub are the most frequent species.

For some species, the size of the fishes was estimated by comparing the bones with skeletons of known length from our comparative collection. The size of the breams varies between 20 and 55 cm. Two pikes are larger than 100 cm, two c. 80 cm, six between 60 and 80 cm, two c. 50 cm and two c. 30 cm long. The catfish bones belong to small individuals with a total length between 50 and 70 cm. The bony plate of the sturgeon comes from a fish with an estimated length of about 100 cm.

Fishing gear is represented by a single fish hook made from bone. An interesting bone item is a knife-like object, which could have been used for removing the scales from the body (Stolle *et al.*, 1988; fig. 7.5).

SPECIES	NISP
Sturgeon (<i>Ancipenser sturio</i>)	1
Eel (<i>Anguilla anguilla</i>)	13
Pike (<i>Esox lucius</i>)	104
Bream (<i>Abramis brama</i>)	85
Roach (<i>Rutilus rutilus</i>)	38
Rudd (<i>Scardinius erythrophthalmus</i>)	32
Chub (<i>Leuciscus cephalus</i>)	21
Orfe (<i>Leuciscus idus</i>)	9
Tench (<i>Tinca tinca</i>)	6
Asp (<i>Aspius aspius</i>)	2
Carp (Cyprinidae indet.)	262
Catfish (<i>Silurus glanis</i>)	4
Perch (<i>Perca fluviatilis</i>)	4
Total identified	581
Total unidentified	779

TABLE 2

Niedergörne. List of fish species (Stolle *et al.*, 1988; Table 1). Frequencies are given in number of identified specimens (NISP).

SPECIES	NISP
Tench (<i>Tinca tinca</i>)	5
Roach (<i>Rutilus rutilus</i>)	2
Rudd (<i>Scardinius erythrophthalmus</i>)	1
Carp (Cyprinidae indet.)	28
Catfish (<i>Silurus glanis</i>)	1
Total identified	37

TABLE 3

Klessin. List of fish species (Benecke, in press; Table 1). Frequencies are given in number of identified specimens (NISP).

A second aquatic resource, mussels, was exploited by the inhabitants of the Niedergörne settlement. All shell remains encountered in the two pits belong to the species *Unio pictorum*. Most shells were complete, some still interlocking at the hinge. The state of preservation indicates that shells were not used as animal fodder.

FISH REMAINS FROM KLESSIN

A site similar to Niedergörne in terms of time period and location is Klessin, on the left bank of the Oder river, several kilometers north of Frankfurt (Figure 1). In 1994 test excavations revealed four pits of a settlement of the Middle Neolithic Britz culture (Table 1). The fill of the pits consisted of sand. The contents of these pits were collected by hand. Only pit S 189,3/O 335,9 was sampled for wet sieving and a small soil sample taken. It provided most of the fish remains from this site.

The faunal assemblage from the four pits from Klessin is quite small, comprising only 117 identifiable specimens. Mammal bones are most frequent in the sample, with 40 bones coming from domestic and 29 bones coming from wild animals. Fish are represented by 37 bones (33 specimens are from the soil sample of pit S 189,3/O 335,9). With the exception of one bone from catfish (*Silurus glanis*) all fish remains belong to cyprinids. Three species could be identified: tench (*Tinca tinca*), roach (*Rutilus rutilus*) and rudd (*Scardinius erythrophthalmus*). In relation to mammal bones,

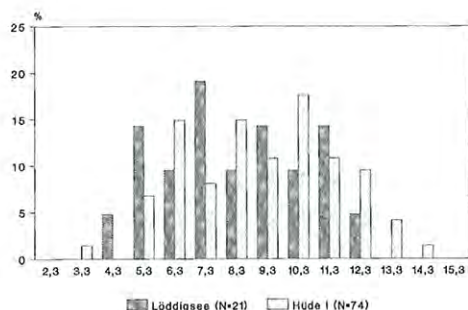


FIGURE 2

Pike. Osteometric comparison between Löddigsee and Hude I for the anterior height of the dentale (in mm). References: Löddigsee (Benecke, forthcoming), Hude I (Hüster, 1983; Table 3).

fish remains are not as frequent as at Niedergörne. Nevertheless fish seem to have been an important food resource at this site as well. Ten *Unio* shell fragments, which complete the faunal list of Klessin, demonstrate that a second aquatic food resource, was exploited by the inhabitants of this settlement.

FISH REMAINS FROM LÖDDIGSEE

The site Löddigsee several kilometers southeast of the town Parchim lies on a sandbank within the valley of the Elde river, which in the past formed a lake, the so-called Löddigsee, at that part of its course. Excavations between 1983 and 1989 led to a more or less complete exposure of a neolithic settlement which belongs to the Late Neolithic Single Grave culture (Table 1). In contrast to Niedergörne and Klessin, the Löddigsee site exhibits no permanent habitation. There are indications from the archaeological as well as from the zoological data that this site was only seasonally occupied, mainly during the spring and summer months. In the course of the excavations a large number of animal remains was found. As the cultural layer mainly consisted of peat, the process of sieving was very difficult yielding only few small animal remains. Most of the bones and fish remains were collected by hand.

The faunal assemblage, which comprises c. 15000 specimens, is dominated by bones from

mammals, mainly from wild species like red deer, aurochs, wild horse, roe deer, beaver and wild boar. Bones from domestic animals are represented by only 8% of the total NISP. A small number of animal remains belong to different bird species and to a terrapene (*Emys orbicularis*). Among the 207 identifiable fish bones, six species were identified (Table 4): pike (*Esox lucius*), perch (*Perca fluviatilis*), catfish (*Silurus glanis*), pike-perch (*Stizostedion lucioperca*), eel (*Anguilla anguilla*) and roach (*Rutilus rutilus*). Pike is the most numerous species followed by perch and catfish.

Table 5 provides some information about the size distribution of pike in the material from Löddigsee. For every bone, the size of the fish was estimated by comparing it with three skeletons in our reference collection. As can be seen from the table, most pike caught at this site varied between 60 to 90 cm in length. An osteometric comparison with pike bones from Hude I shows that the size distribution of pike is similar at both sites. In the Löddigsee sample the percentage of smaller individuals seems to be slightly higher.

The frequency distribution of pike skeletal elements exhibits an interesting pattern. In Table 6 the absolute numbers for the different elements and, for each of them, their frequency calculated on the basis of the MNI, are presented. It is remarkable that bones from the pelvic girdle (basipterygium)

SPECIES	NISP
Eel (<i>Anguilla anguilla</i>)	2
Pike (<i>Esox lucius</i>)	170
Roach (<i>Rutilus rutilus</i>)	2
Carps (Cyprinidae indet.)	4
Catfish (<i>Silurus glanis</i>)	11
Perch (<i>Perca fluviatilis</i>)	15
Pike-perch (<i>Stizostedion lucioperca</i>)	3
Total identified	207
Total unidentified	30

TABLE 4

Löddigsee. List of fish species. Frequencies are given in number of identified specimens (NISP).

SIZE GROUP	NUMBER	in %
< 30 cm	2	1,5
c. 30	1	0,7
> 30 cm	14	10,1
c. 60 cm	22	15,9
> 60 cm	37	26,8
c. 90 cm	38	27,5
> 90 cm	24	17,4

TABLE 5

Löddigsee. Size distribution of pike.

are missing, while those from the vertebral column only occur in very small numbers. A comparison of the relative frequency of elements of pike between Löddigsee and Hude I and Bistoft shows a similar pattern. Heinrich & Lepiksaar (1979) argued that the extremely low frequency of vertebrae at Bistoft was the result of some of the pike being butchered at the site by cutting off the head and the trunk/tail being consumed elsewhere. A similar scenario one can imagine for the Löddigsee site. Indirect evidence for this assumption one can obtain from the observation, that in at least five quadrants of the excavated area there are pike bones from originally complete heads, while vertebrae are missing altogether.

DISCUSSION AND CONCLUSIONS

The bone assemblages indicate that fish was an important food resource in the lowlands of Northern Central Europe during the Middle and Late Neolithic periods. At Niedergörne, where fish remains dominate the fauna (being two to three times as frequent as mammal bones), fishing seems to have been a common strategy in the food economy of this settlement. This also applies to collecting mussels as the abundant shells suggest. We can assume a similar situation existed at Klessin on the Oder river. The relative small number of fish remains in relation to mammal bones—in comparison to Niedergörne—is probably due to the lack of sieving at this site. A characteristic feature of both assemblages is the high percentage of bones from cyprinids. At Szczecin-Ustowo, a settle-

ment of the Funnel Beaker culture, species of Cyprinidae dominate the fish bone material as well (Figure 4). All three sites, Niedergörne, Klessin and Szczecin-Ustowo, have a similar topographic location. They lie on a high terrace of a large river (Elbe, Oder) overlooking its wide flood plain. The high percentage of cyprinids seems to indicate a fishery which exploited the seasonally flooded areas, probably at the time of spawning.

PART OF SKELETON/ELEMENT	NUMBER	VR (%)
Head		
Unpaired elements (NEB 22)		
Parasphenoideum	3	13,6
Basioccipitale	1	4,5
Paired elements (NEB 44)		
Dentale	36 (18:17:1)	81,8
Articulare	6 (3:3)	13,6
Keratohyale	6 (4:2)	13,6
Maxillare	4 (3:1)	9,1
Operculare	3 (1:2)	6,8
Quadratum	3 (0:3)	6,8
Frontale	2 (1:1)	4,5
Palatinum	2 (1:0:1)	4,5
Ectopterygoideum	2 (1:1)	4,5
Hyomandibulare	2 (2:0)	4,5
Praeoperculare	1 (0:1)	2,3
Suboperculare	1 (0:1)	2,3
Epihyale	1 (1:0)	2,3
Pteroticum	1 (1:0)	2,3
Nasale	1 (0:1)	2,3
Shoulder girdle		
Paired elements (NEB 44)		
Cleithrum	11 (6:5)	25,0
Trunk-Tail		
Serial elements		
Vertebrae praecaudales (NEB 41 x 22 = 902)	66	7,3
Vertebrae caudales (NEB 18 x 22 = 396)	18	4,5

TABLE 6

Löddigsee. Pike, frequency of elements. VR=value of representation, NEB = number of expected bones (for an MNI = 22).

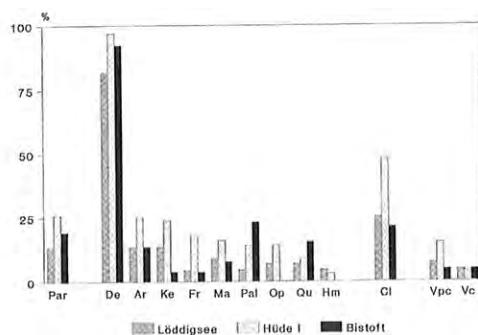


FIGURE 3

Pike. Value of representation for selected elements in the bone finds from Löddigsee, Hüde I and Bistoft. ABBREVIATIONS: Par: Parasphenoideum, De: Dentale, Ar: Articulare, Ke: Keratohyale, Fr: Frontale, Ma: Maxillare, Pal: Palatinum, Op: Operculare, Qu: Quadratum, Hm: Hyomandibulare, Cl: Cleithrum, Vpc: Vertebrae praecaudales, Vc: Vertebrae caudales. REFERENCES: Löddigsee (cf. Table 6), Hüde I (Hüster, 1983; Table 2), Bistoft (Heinrich & Lepiksaar, 1979; Table 2).

A different situation has been detected at sites like Löddigsee, Hüde I and Bistoft. The ichthyological materials from those sites comprise a large amount of pike bones, while cyprinids seem to have been only of marginal importance (Figure 4). In contrast to Niedergörne, Klessin and Szczecin-Ustowo, all three of these sites are located on a lake. Another common feature is that these sites were seasonal camps, where hunting and fishing activities took place mainly during the spring and summer months. The *annuli* of vertebrae from Löddigsee indicate that pike were mainly caught in spring. For Hüde I the late summer months appear to be the main season for fishing (Hüster, 1983). Obviously, only a portion of the catch was directly consumed at those sites while another portion was transported elsewhere for consumption. This seems to have been the case especially for pike as the frequency distribution of the skeletal elements for this species suggests (Figure 3). The processing of pikes meant for transportation included be-heading and probably drying of the flesh.

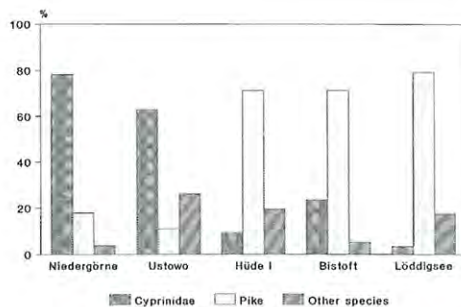


FIGURE 4

Percentages of Cyprinidae and pike in fish bone assemblages from different Middle and Late Neolithic sites. References: Niedergörne (Table 2), Szczecin-Ustowo (Chelkowski, 1960; Table 1), Hüde I (Hüster, 1983; Table 1), Bistoft (Heinrich & Lepiksaar, 1979; Table 1), Löddigsee (Table 4).

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Stone Age fishing strategies in Estonia. What did they depend on?

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(Received 10 October 1995; accepted 5 February 1996)

ABSTRACT: The paper combines zoogeographical and archaeological data in order to explore aspects of the development of Estonian fish faunas from Paleolithic times until the Neolithic. Although the main aim of this contribution is that of a regional survey, a wide variety of issues, from human paleodietary analysis to biology of the different fish groups under consideration, has been incorporated into the discussion in order to define the guidelines for a future systematic archaeoichthyological study in this particular area.

KEYWORDS: ESTONIA, THE BALTIC SEA, PALEOLITHIC, MESOLITHIC, NEOLITHIC, FISH, FISHING, C13 ANALYSIS

RESUMEN: En este trabajo se combinan datos zoogeográficos y arqueológicos al objeto de explorar aspectos referentes al desarrollo de las ictiofaunas estonas desde el Paleolítico hasta el Neolítico. Si bien el objeto primordial del estudio es el de proporcionar una perspectiva regional, una amplia gama de cuestiones, desde análisis de paleodietas humanas hasta consideraciones biológicas sobre los grupos de peces aparecidos, se integran en un intento por definir las futuras directrices de un programa sistemático de investigación arqueoictiológica en la zona.

PALABRAS CLAVE: ESTONIA, MAR BÁLTICO, PALEOLÍTICO, MESOLÍTICO, NEOLÍTICO, PECES, PESCA, ANÁLISIS C13

INTRODUCTION

The early history of Estonian fishes is poorly known. We have better knowledge about the Stone Age fishing implements, which have been found frequently in different parts of Estonia. The early history of Estonian fishes consists mainly of assumptions based on our knowledge of environmental changes during the Late Pleistocene and Holocene and the ecological requirements of different species.

A survey of the history of Estonian fish fauna is provided by Lepiksaar (1938, 1984), while comments on finds of different fish species are found in Tsepkin (1968, 1984), Jaanits (1991) and Lõugas (1995a, 1995b; Lõugas *et al.*, 1995a, 1995b).

This paper summarises finds of subfossil fish and the Stone Age fishing implements used to catch them. It describes the fishing strategies of the period and discusses the differences between the Mesolithic and Neolithic. The model relies on the

development of the fish fauna in Estonian waters and on the ecology of different fish species with special emphasis on their seasonal activities and the chances prehistoric people had of catching them. In addition, a C¹³ analysis, obtained during a project on Stone Age resource utilisation in coastal Estonia, was used in order to study the diet of prehistoric people (Lõugas *et al.*, 1995a).

THE PALAEOLITHIC-LATE PLEISTOCENE

No Palaeolithic sites have been discovered in Estonia and no subfossil fish finds from that period are known. Using geological and palaeoclimatological data, an attempt can be made to reconstruct the possible migration routes of different fish species at that time. This is important because the formation of the fish fauna was one of the requirements for the colonisation of that area by man.

There is reason to assume that the two sea basins, the Baltic and Sarmatian, were connected by a system of rivers and ice lakes during the Weichelian Ice Age (Kvasov, 1975, 1979) (Figure 1). The latter was fresh and partly brackish so that fish could move around freely (Lepiksaar, 1938, 1984).

During the formation of ice-dammed lakes, relict species from the Arctic Ocean could spread southwards. These species had to be both euryhaline and eurythermic, i.e. salt and cold tolerant (e.g., whitefish, *Coregonus lavaretus*; smelt, *Osmerus eperlanus*; and four-horned sculpin, *Triglopsis quadricornis*). One of the earliest immigrants from the Sarmatian basin could have been the catfish, *Silurus glanis* (Lepiksaar, 1938, 1984). The Baltic Ice Lake, corresponding to the first Baltic fresh water stage, was the region where fish species assembled and spread using the river system (Figure 2).

THE MESOLITHIC-EARLIEST PART OF THE MIDDLE HOLOCENE

The Mesolithic in Estonia spans the period from about 10000-6000 BP. and precedes the adoption of ceramic technology in the area. Climatically, the Mesolithic can be divided into three different periods: the Preboreal, which was cold and humid (10000-8500 BP.), the Boreal, which was warm and dry (8500-8000 BP.) and the Atlantic (first half), which was warm and humid. The history of the Baltic Sea during this period also went through three stages of development: a) the brackish (west part)/fresh water Yoldia Sea, b) the fresh water Ancylus Lake and c) the first part of the brackish Littorina Sea (Figures 3, 4, 5).

Figure 3 shows the location of the Baltic during the Yoldian Sea stage and the new route which fishes could have taken for migration into the Baltic basin. Immigration of the Atlantic forms into the Baltic at that time is quite doubtful because the influence of marine water in the Baltic was minimal and the analysis of invertebrates shows that Atlantic species (e.g., *Portlandia (Yoldia) arctica*) spread only as far as the east coast of modern Sweden and not into the Baltic. The brackish phase of the Yoldian Sea was short, 100-200 years, and more prominent in the west part of the Baltic (Björk, in press). The reasons for the short brackish water phase are not clear. The straits between

the Baltic and the west coast of Sweden had gradually become more shallow and narrow due to tectonic uplift. The outflow was probably also too large to allow a saline bottom current to enter (Björk, in press).

In its fauna, the Yoldian phase did not differ very much from the previous stage of the Baltic, but it was the next opportunity for euryhaline and cold tolerant species to immigrate into the Baltic (Lepiksaar, 1984). Several freshwater species probably used the large rivers of Europe (Oder, Vistula, Niemen, etc.) for immigration into this basin during the fresh water stage of this water body.

Only one site, Pulli (Figure 6), has been discovered near the estuary of the Pärnu river, Southwest Estonia; it was C¹⁴ dated to 9285 ± 120 (TA-284); 9600 ± 120 (TA-245) and 9575 ± 115 (TA-176) BP. Janis Sloka identified two species of fish, pikeperch, *Stizostedion lucioperca*, and bream, *Abramis brama* (Table 1) (Jaanimäe, 1991). These species derive from the ancient Sarmatian Sea and, together with other ecologically tolerant species, like pike, *Esox lucius*, perch, *Perca fluviatilis*, and some cyprinids, *Cyprinidae*, spread into the Baltic basin during the time of the Baltic Ice Lake or Yoldia Sea.

Because of rising temperatures, the ecological conditions for warm water fish improved during this phase. We therefore find the remains of more thermophilous fish species in the archaeological sites. Besides pike and perch, bones of tench, *Tinca tinca* (Table 1), which prefers lakes with muddy bottoms, standing water and rich vegetation, have been found at the Lammasmägi site in Kunda (Figure 6) (Lepiksaar, 1984). The Mesolithic layer of the site is dated to the Ancylus Lake stage: 8260 ± 90 (Ua-3000); 8485 ± 90 (Ua-3001) and 8515 ± 100 (Ua-3002) BP. (Åkerlund *et al.*, 1995).

At the time of the Ancylus regression a waterfall formed on the Narva river, which prevented entrance of the Baltic fish species into lake Peipsi (Figure 6). During that period smelt and whitefish inhabiting this lake split from their relatives in the sea and evolved into a new subspecies (Lepiksaar, 1938, 1984; Mikelsaar, 1984).

With the formation of the Danish Belts and the Öresund, an important route appeared for the distribution of marine species, allowing for the immigration of Atlantic species into the Baltic (Fi-



FIGURE 1

Ice margin during the Weichelian Ice Age at about 14000-13000 BP. (after Kvasov, 1975, 1979). → the possible directions (Arctic Ocean, Sarlatia basin and ice-dammed lakes) from which the first fish immigrants could have spread using the system of big rivers and ice-dammed lakes (Lepiksaar, 1984).



FIGURE 3

The Yoldia Sea about 10000-9900 BP. (after Björk, in press; Kvasov, 1975, 1979). → distribution possibility no. 2 for Arctic Ocean relicts (see also Figure 1; Lepiksaar, 1984). The immigration of Atlantic forms into the Baltic during this period is unproven. — the Yoldia Sea; - - - - - the Baltic Sea.



FIGURE 2

The Baltic Ice Lake about 11000-10300 BP. (after Björk, in press; Kvasov, 1975, 1979). → distribution possibilities through this large freshwater basin (Lepiksaar, 1984); — the Baltic Ice Lake; - - - - - the Baltic Sea.



FIGURE 4

The Ancylus Lake about 9300-8900 BP. (after Björk, in press; Kvasov, 1975, 1979). The situation is similar to the Baltic Ice Lake stage, but due to the warmer climate the fastidious fish species could have immigrated as well (Lepiksaar, 1984). — the Ancylus Lake; - - - - - the Baltic Sea.

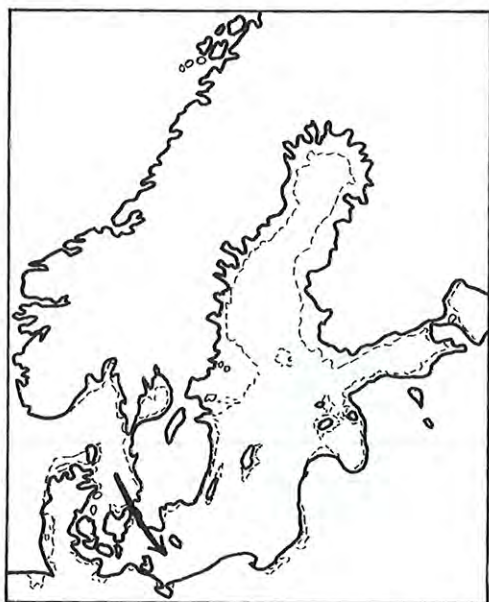


FIGURE 5

The Littorina Sea about 7000 BP. (by Kvasov, 1975, 1979) → the immigration route of salt favouring species through the Öresund (Lepiksaar, 1984); — the Littorina Sea; ----- the Baltic Sea.

gure 5). In the Baltic basin the limnic water of the Ancylus Lake was replaced by the saline waters of the Littorina Sea. This transgression, along with the rise of salinity, created hydrological conditions favourable for the production of plankton. The biomass of ichthyofauna, especially that of planktophagous herring, increased dramatically (Lepiksaar, 1986). Other species entering into the Baltic at that time were cod, *Gadus morhua*; tur-

bot, *Scophthalmus maximus*; flounder, *Platichthys flesus*; sturgeon, *Acipenser sturio*; sprat, *Sprattus sprattus* and eel, *Anguilla anguilla*, among others.

The Narva and Umbusi sites (Figure 6) date to the Late Mesolithic period and the archaeozoological material contains fish species which are typical for that period, (i.e. no Atlantic forms) (Table 1). Only the recovery of salmon (or trout) requires a comment since it is not clear whether *Salmo salar*/*S. trutta* appeared in the Baltic at the time of the freshwater stage or at the beginning of the brackish water, Littorina, stage. The latter possibility seems more plausible, because of the migratory cycle of the former species.

THE NEOLITHIC-SECOND PART OF THE MIDDLE HOLOCENE

At the beginning of the Neolithic the modern Estonian fish fauna was already defined, notwithstanding minor details. Climatically the Neolithic is characterised as a more continental state (Subboreal) with warm summers but cold winters; this probably caused a change in the choice of camp location. A comparison of the location of sites of Neolithic hunter-fishers with those of the Mesolithic period conveys the impression that the former preferred to establish their camp directly on the coast (not on the river banks or lake shores) and probably hunted species with fatty meat (i.e., seals and pigs) instead of leaner game (as happens at the Loona site). Physiologically this may reflect the

	PULLI	LAMMASMÄGI, KUNDA	NARVA	UMBUSI
<i>Esox lucius</i>		66	450	31
<i>Salmo sp.</i>			1	
<i>Perca fluviatilis</i>		2	1	
<i>Stizostedion lucioperca</i>	94		259	
<i>Abramis brama</i>	5			7
<i>Silurus glanis</i>			100	

TABLE 1

Number of fragments of fish bone from Mesolithic sites in Estonia (Lepiksaar, 1981; Tsepkin, 1984; Sloka (Jaanimäe 1991); Lõugas, 1995).



FIGURE 6
Locations of Stone Age sites in Estonia. • Mesolithic; ▲ Neolithic.

climatic conditions of the Subboreal period (Leppisaar, 1986). At the end of this phase there are initial signs of a deterioration of climate.

The coastal positioning of the Neolithic sites can also be explained as a result of the diversification of marine faunas in the Baltic (harp and grey seal, Atlantic fish). The island sites of Kõpu, Kõnnu, Loona and Naakamäe (Figure 6), are known as seal hunters' camps (Paaver, 1965; Lõugas *et al.*, 1995a, 1995b; Lõugas, in press) and the remains of cod, turbot and sturgeon indicate the existence and importance of Atlantic fish at that time (Table 2). The inland sites of Tamula and Kääpa (Figure 6), on the other hand, provide good examples of the freshwater fish species of the Neolithic (Table 2). Riigiküla and Kudruküla represent coastal sites which have yielded the remains of marine species as well.

FISHING AND FISHING EQUIPMENT

The absence of finds of marine fishes in the Mesolithic indicates that sea fishing was not important. Moreover, marine fishes were not available at the beginning of this period (i.e., prior to the Littorina stage). Fishing during the Mesolithic seems to have been connected mainly with the littoral zone; this does not exclude fishing from a boat

or on the ice farther offshore. The ecology of pike and perch is dependant on reeds in the water body and it is easy to catch them there with a fish spear or traps of wickerwork. A number of Stone Age fishing implements have been found in Estonia. The Stone Age fish spears (more than 300 fragments are known in Estonia) are made from tubular bones of big game (cervids, aurochs). About two thirds of these belong to the Kunda type (Figure 7: 1, 2), which occurs in different sizes (8-24 cm), with either triangular (Figure 7: 2) or quadrangular (Figure 7: 1) teeth. These are first found in the Boreal period. In the 1930s Indreko (1948) discovered a skeleton of a pike with a spear in the lake marl at Kunda.

The pikeperch and the catfish inhabit the deeper portions of lakes and rivers. The former species prefers clear waters, the latter muddy bottoms. These species were probably caught with spears, harpoons or hooks. The number of harpoons from archaeological sites is about 60. They were probably used to catch beavers and seals, but perhaps also large fishes like catfish (Figure 7: 3, 4).

Fish spears and harpoons occur throughout prehistoric times, as do hooks (Figure 8: 1-5) and hook weights (Figure 8: 6-9) (Jaanits, 1991). The first evidence for fishing nets derives from the Late Mesolithic or Early Neolithic. Stone weights and bone needles for fishing nets are known from both coastal and inland sites (Jaanits, 1991).

	A	B	C	D	E	F	G	H
<i>Acipenser sturio</i>							15	
<i>Esox lucius</i>	1	12	667	95	424	92	3	127
<i>Salmo sp.</i>						11		
<i>Gadus morhua</i>	4					4	11	5268
<i>Thymallus thymallus</i>						1		
<i>Perca fluviatilis</i>		5	4	4	449	18		6
<i>Stizostedion lucioperca</i>			593			16	3	
<i>Anguilla anguilla</i>								3
<i>Leuciscus idus</i>					23			
<i>Scardinius erythrophthalmus</i>					3			
<i>Abramis brama</i>			38	4	180	3		
<i>Abramis ballerus</i>					67			
<i>Tinca tinca</i>			1		29			
<i>Rutilus rutilus</i>		7			49	1		
<i>Silurus glanis</i>			13	41	159	1		
<i>Trigloporus quadricornis</i>								10
<i>Scophthalmus maximus</i>	1						14	25
<i>Platichthys flesus</i>								3

TABLE 2

Number of fragments of fish bone from Neolithic sites in Estonia (Tsepkin, 1968, 1984; Sloka(Jaanits 1991); Lõugas, 1995). A: Kõpu; B: Kõnnu; C: Riigiküla; D: Kääpa; E: Tamula; F: Kudruküla; G: Naakamäe; H: Loona.



FIGURE 7

Fishing implements: 1-2 spears; 3-4 harpoons; 5 ice pick. Lake marl (1); Lammasmägi site (2, 3, 5); Kunda and Tamula (4). Photo: E. Väljal. Size: 2:3.

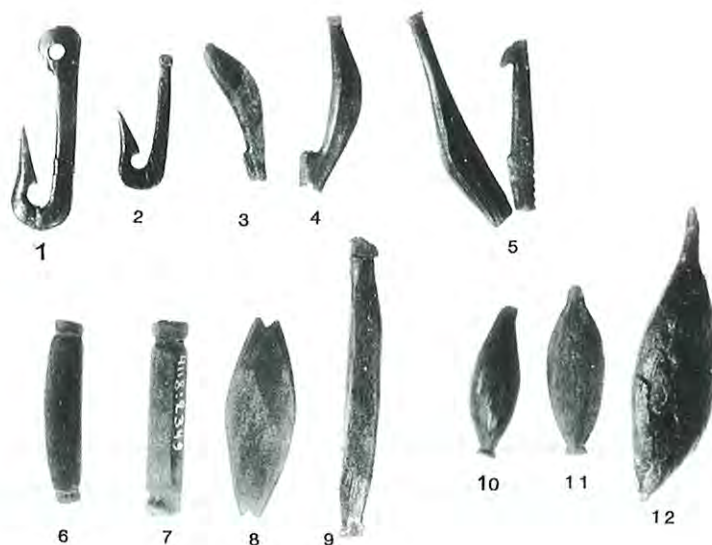


FIGURE 8

Neolithic fishing implements: 1-5 hooks; 6-9 hook weights; 10-12 trolls.
 Tamula (1, 2, 6, 7); Valma (3-5; 8-11); and Akali (12). Photo: E. Väljal. Size: 1:1.

Winter fishing took place on the ice. The naturally pointed tubular bones of big game which are often recovered at sites could have been used as ice picks (Figure 7: 5). This interpretation is based on the fact that seventy such implements were recovered from what appears to be a primary context at the bottom of lake Kunda, not far from the Lammasmägi site (Indreko, 1948; Jaanits *et al.*, 1982). To catch catfish and most cyprinids in winter is quite difficult due to their inactivity. However, if the prehistoric fishermen knew the wintering habits of these species they had the possibility of catching them. The winter shoals of bream make them easier to catch than most cyprinids.

One of the reasons why Mesolithic people did not use the Baltic Sea resources of their time was the small difference between the fauna of the freshwater Baltic Sea and inland lakes or rivers. Seal hunting did not have an important role in the economy of Mesolithic people at that time. Only the ringed seal was hunted, accounting for less than 1% of the total amount of mammal bones in the archaeozoological material of the Kunda-Lammasmägi and Narva sites (Paaver, 1965; Lõugas, 1995b; Lõugas *et al.*, 1995a). $\delta^{13}\text{C}$ analyses on human bones from Kunda and Narva produced $\delta^{13}\text{C}$

values of -21.1 (Lammasmägi at Kunda) and -21.9 (Narva), indicating that these individuals ate terrestrial food and/or freshwater fish species (Lidén, 1995; Lõugas *et al.*, 1995a). The zooarchaeological analyses reinforced this hypothesis. This result could have been anticipated because the Baltic Sea of that period was a freshwater body. Faunal and isotopic data from Neolithic sites on the Estonian islands indicate a dependence on marine resources. The sample from Naakamäe shows a typical marine value of -16.0; the Loona sample, however, has an intermediate value of -18.7. The samples from Kudruküla have terrestrial values (-21.7; -20.4; -23.0), which are to be expected by the location of the site, making terrestrial resources (game and freshwater fish) the sensible prey items (Lõugas *et al.*, 1995a).

CONCLUSION

The colonisation of the Estonian waters by fish began after the retreat of the ice during the Late Weichelian, with an invasion of species from the North and the South. The development of the post-

glacial fish fauna was gradual with no great changes in species composition at the beginning of the period. The first immigrants were species associated with cold water and euryhaline conditions. These were followed by fresh and/or brackish water species from the South. At the time of the invasion of Atlantic species into the Baltic during the Littorina Sea stage, the freshwater fish fauna in Estonian lakes and rivers had already reached its present day composition.

We can roughly divide the development of Estonian fish faunas into two stages: Pre-Littorina (fresh, brackish water) and Littorina (incl. Post-Littorina, brackish and/or salt water). The Mesolithic people caught fish of the first group from local lakes and rivers using primitive implements (spears, harpoons and hooks). During the Neolithic, species of the latter group became also available, since the implements, including nets and hooks, became clearly more sophisticated. The greatest change in fish exploitation in Estonia during the Neolithic was caused by an abundance of marine faunas in the Baltic which led people to colonize the coastline and islands.

Comparing the Mesolithic and Neolithic fish finds, we can see that the former derive from a limited number of species, while the latter comprise many species. The small number of fish species in the Mesolithic material is explained by the absence of marine fish in the eastern part of the Baltic Sea at that time. Also, the camps of Mesolithic hunter-fishers were probably used seasonally. A good example is the Pulli site on the bank of the Pärnu river, which was used during summer (perhaps also during autumn), but the area was evidently flooded in spring (pike spawns in spring in shallow water making them an easy prey at that time; the absence of their bones proves that the site was deserted during that particular season; T. Moora, pers. comm.). At the same time, pikeperch, which spawns on the sandy bottoms of river estuaries in late spring - early summer at water temperatures above 16°C (Mikelsaar, 1984) was intensively fished in Pulli. Lammasmägi at Kunda seems to have been inhabited in spring when the water level of the shallow ancient Kunda Lake rose enough for pike to spawn in the reeds. At this site the remains of pike dominate the fish finds (Lõugas, 1995b).

Finally, the results of fish bone analyses are, to a large extent, dependant on the state of preservation and the excavation technique employed. Päär (1965) and the author summarize the state of

preservation of the bone material from the different sites as follows: excellently preserved material was found at Tamula and Kääpa, good material at Kunda, Pulli, Naakamäe and Riigiküla (I and III layer), medium at Riigiküla (II), Loona, Kudruküla and Umbusi, and bad preservation at Narva, Kõpu and Kõnnu. Finally, it must be mentioned that sieves were used occasionally during archaeological excavations prior to the 1990s in Estonia and therefore a lot of small specimens were lost.

ACKNOWLEDGEMENTS

I would like to thank the organising committee of the 8th meeting of the I.C.A.Z. Fish Remains Working Group for their general support. My special thanks are due to Johannes Lepiksaar, Gothenburg, for supervision and discussions since 1991. I thank also Prof. Anto Raukas, Institute of Geology, Estonian Academy of Sciences, Prof. Toomas Saat, Institute of Zoology and Hydrobiology, Tartu University, and Dr. Vello Lõugas, Institute of History, Estonian Academy of Sciences for their useful comments; also Liis Soon (from the latter institution) for correcting the manuscript. My participation in the Madrid Meeting was funded by the PACT Paleoecological Research Group (Council of Europe) and the Estonian Scientific Foundation (grant no. 1022). Tartu University and the Estonian Scientific Foundation (grant no. 1022) covered the flight to Madrid and back.

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Fish remains from the Late Neolithic site of Rzucewo (Baltic Coast, Poland)

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(Received 10 January 1996; accepted 26 February 1996)

ABSTRACT: A description is given of the abundant fish remains found in a single pit dated back to the initial phase of the Rzucewo culture. The material is quantified and body size reconstructions are made. Interpretation focusses on the place and season of capture, as well as on the possible fishing techniques practised.

KEYWORDS: ARCHAEO-ICHTHYOLOGY, LATE NEOLITHIC, POLAND, FISHING, FISH SIZE

RESUMEN: Se describen los abundantes restos de peces recuperados en un hoyo datado en la fase inicial de la cultura Rzucewo. El material es cuantificado y se llevan a cabo reconstrucciones de talla. La interpretación se concentra sobre el momento y lugar de captura así como en los posibles tipos de técnicas de pesca practicados.

PALABRAS CLAVE: ARQUEOICTIOLOGÍA, NEOLÍTICO FINAL, POLONIA, PESCA, ESTIMACIÓN DE TALLA

INTRODUCTION

Archaeological research along the Baltic coast of Poland has revealed the existence of a number of sites attributed to the Rzucewo culture. It is believed to be a syncretic culture that combines elements of the Corded Ware culture complex, the Globular Amphorae culture and the Pit and Comb culture (Tetzlaff, 1970: 361, 364). The settlements of the Rzucewo culture cover the coastal area of the southeastern Baltic from the Bay of Puck in the west to the Sambia coast in the east, including the Bay of Gdańsk, the Vistula Bar and the Kursk Bar (Figure 1). Its chronology is determined by radiocarbon dates from two settlements, namely Rzucewo itself which represents the earliest phase of the Rzucewo culture (3320-2930 BC cal; 3260-2920 BC cal and 3310-2890 BC cal) and Osłonino which corresponds to the turn of phase II and phase III of the Rzucewo culture (oldest date: 3020-2510 BC cal; youngest date: 2200-1960 BC cal) (Machnik, 1979; Król, 1991).

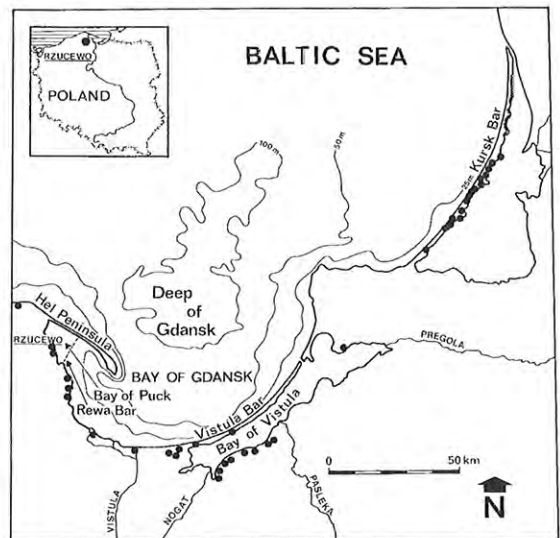


FIGURE 1
Location of settlements along the Baltic coast belonging to the Rzucewo Culture (dots).

Rzucewo is presently situated at the Bay of Puck which itself is part of the Bay of Gdańsk. However, during Late Neolithic times the area of the Bay of Puck was covered by pro-glacial stream valley deposits. Peat land and lakes extended eastward of the present-day shoreline as far as the Bar of Rewa (Rosa, 1984). This bar, which separated the Bay of Puck from the Bay of Gdańsk, was cut during the subatlantic transgression (Król, 1992).

Archaeological work at Rzucewo started at the end of the 19th century and lasted until the late 1920s (Żurek, 1954). Work was resumed in the 1980s by Król (1984). Faunal analysis on the old (Lubicz-Niezabitowski, 1929: 64-81) and new material (Lasota-Moskalewska, 1988, *in press*) has shown that the subsistence of these Neolithic people was not exclusively based on domestic animals and large terrestrial game as in contemporaneous inland sites. Hunting of seals and fishing played an important role as well. Until recently information about the captured fish was mainly limited to a list of species identified from the first excavations of Rzucewo. The present study deals in more detail with an assemblage of fish remains discovered during the 1989 excavation season (Król, 1993).

MATERIAL AND METHODS

About one hundred thousand fish bones were discovered in a single pit structure of about 1 x 1.5 m diameter and 20 cm deep (Figure 2). The pit was situated outside a hut at its northeastern wall (Król,

1993). A preliminary study of the pottery associated with the fish bones dates the deposit to phase I of the Rzucewo culture (Krol, *pers. comm.*). Retrieval of the fish bones was done by screening on very fine sieves used for flour. The remains being so abundant, it was decided to study only about one fourth of the material. Identifications were based on comparison with the reference material stored at the Royal Museum of Central Africa. Measurements were taken according to Morales & Rosenlund (1979). Size reconstructions were based on direct comparison with modern specimens of known length and on the regression formulas provided by Brinkhuizen (1989) for pike and perch, and by Enghoff (1983) for cod and Pleuronectidae.

RESULTS

Table 1 gives an overview of the fish taxa identified from Rzucewo. Only one small scute fragment indicates the presence of sturgeon. Perch is the predominant species among the freshwater fish, followed by pike, eel and cyprinids. Among the latter family, roach and bream have been identified in equal proportions. Marine fish comprise more than 60% of the total number of identified remains, with cod as the dominant species. The few remains of Pleuronectidae that were identifiable at species level all belong to flounder, whereas the Clupeidae comprise mainly herring. Only one vertebra could be assigned to shad.

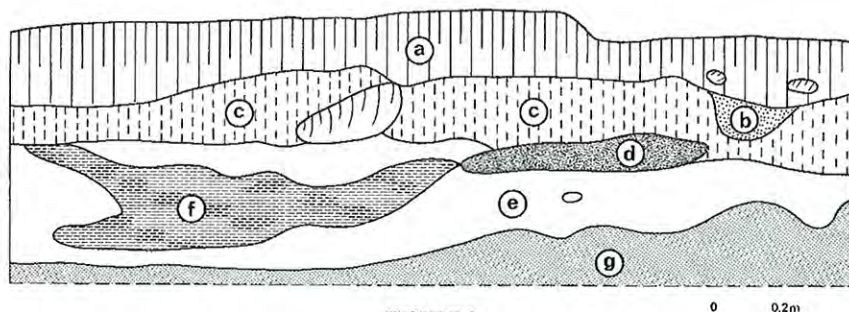


FIGURE 2

Stratigraphy of the central part of the western profile of the 19B excavation area from Rzucewo (by Danuta Krol, Archaeological Museum of Gdańsk). a, humus; b, mixed humus and sand; c, mixed brown and grey sand; d, brown sand with charcoal; e, cultural layer with charcoal; f, pit-like structure comprising abundant fish remains and some mammal bones; g, sterile layer of sand.

SPECIES	NISP	%
<i>Acipenser sturio</i> (sturgeon)	1	+
<i>Anguilla anguilla</i> (eel)	437	4.8
<i>Rutilus rutilus</i> (roach)	14	0.2
<i>Abramis brama</i> (bream)	14	0.2
Cyprinidae indet.	68	0.7
<i>Esox lucius</i> (pike)	621	6.8
<i>Perca fluviatilis</i> (perch)	2294	25.1
<i>Clupea harengus</i> (herring)	269	2.9
<i>Alosa</i> sp. (shad)	1	+
Clupeidae indet.	28	0.3
<i>Gadus morhua</i> (cod)	4952	54.2
<i>Platichthys flesus</i> (flounder)	13	0.2
Pleuronectidae indet.	431	4.6
Total identified	9143	100.0
Unidentified	13700	
Total	22843	

TABLE 1

List of fish species identified from a Late Neolithic pit at Rzucewo (NISP indicates number of identified specimens).

Direct comparison of the eel remains with modern specimens of known length shows that the individuals captured near Rzucewo measured between 40 and 90 cm total length (TL). The cyprinids yielded few remains for size reconstruction, but most of the bones seemed to be from medium-sized animals of 20 to 30 cm TL. Total lengths of perch were calculated using the regression formulas of Brinkhuizen (1989: 101) for the basioccipital, parasphenoid, preopercular, supracleithrum and first vertebra (Figure 3). These size reconstructions show that perch were between 24 and 36 cm long with the majority of the specimens between 27 and 31 cm TL. The predominant size class of perch presently found in the Bay of Gdańsk is 15-20 cm SL (Kosmaczewski, 1947: 48), although specimens of up to 31.5 cm SL have been reported (Terlecki, 1986: 374-378). This would correspond to specimens of up to 37 cm TL. Size reconstructions for pike were done with the regression formulas of Brinkhuizen (1989: 92-94) established for the basioccipital, parasphenoid, quadrate, dentary and articular. The total length of

pike varies between about 40 cm and 1 metre, individuals between 45 and 65 cm being most abundant (Figure 3).

Herring remains are mainly from individuals measuring between 20 and 25 cm TL according to direct comparison with modern specimens of known size. Some slightly smaller and larger individuals have been found as well. The cod remains being so numerous, it was possible to apply the regression formula for the first vertebra (Enghoff, 1983: 89) on a large number of specimens. The size distribution (Figure 4) indicates specimens between 25 and 72 cm TL, with the majority of the individuals between 40 and 60 cm. Cod can attain sizes of 1 metre and more; in the Baltic Sea the maximum size is reported to be 60 cm. The present-day catches of cod from the Bay of Gdańsk comprise mainly fishes between 30 and 60 cm (Żurekmudziński, 1990: 144). We should, therefore, not consider this small average size as an indication of inshore fishing. Such practices yield fish of much smaller size as is indicated by data from

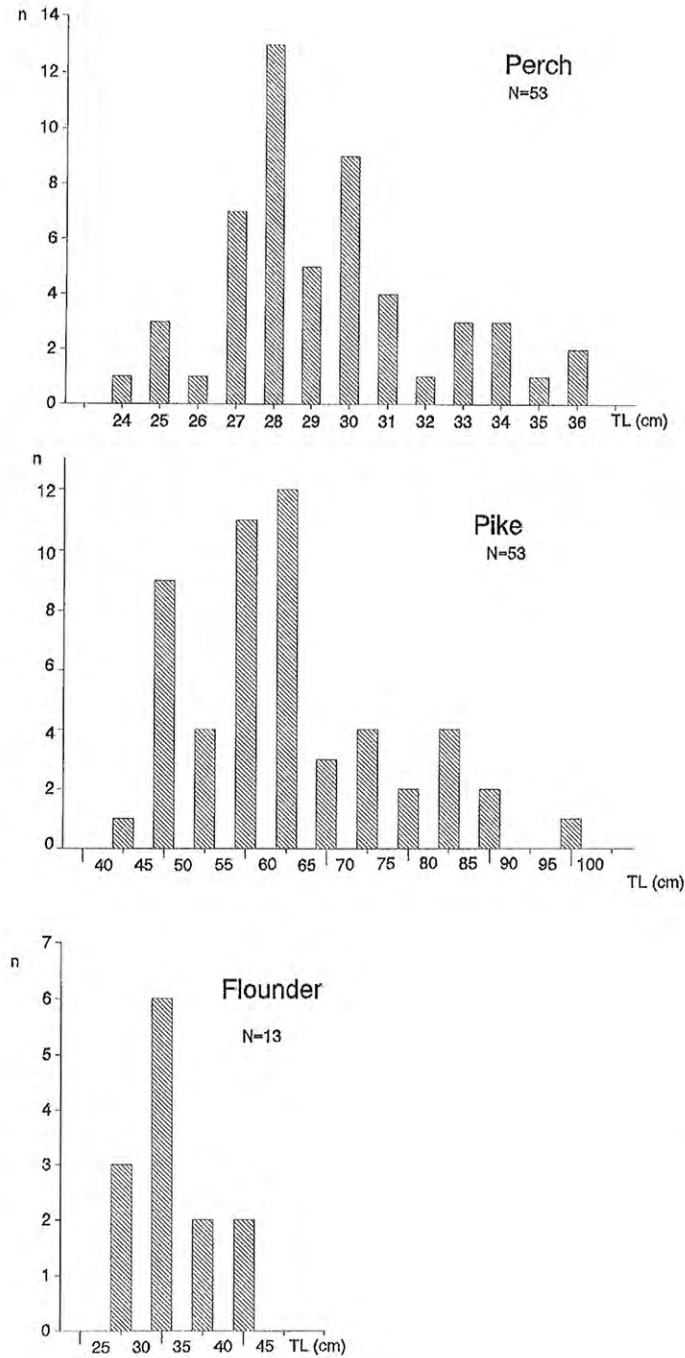


FIGURE 3
Size reconstructions for perch, pike and flounder based on individual specimens (TL = total length). The size classes for perch are only 1 cm, whereas they are 5 cm for pike and flounder.

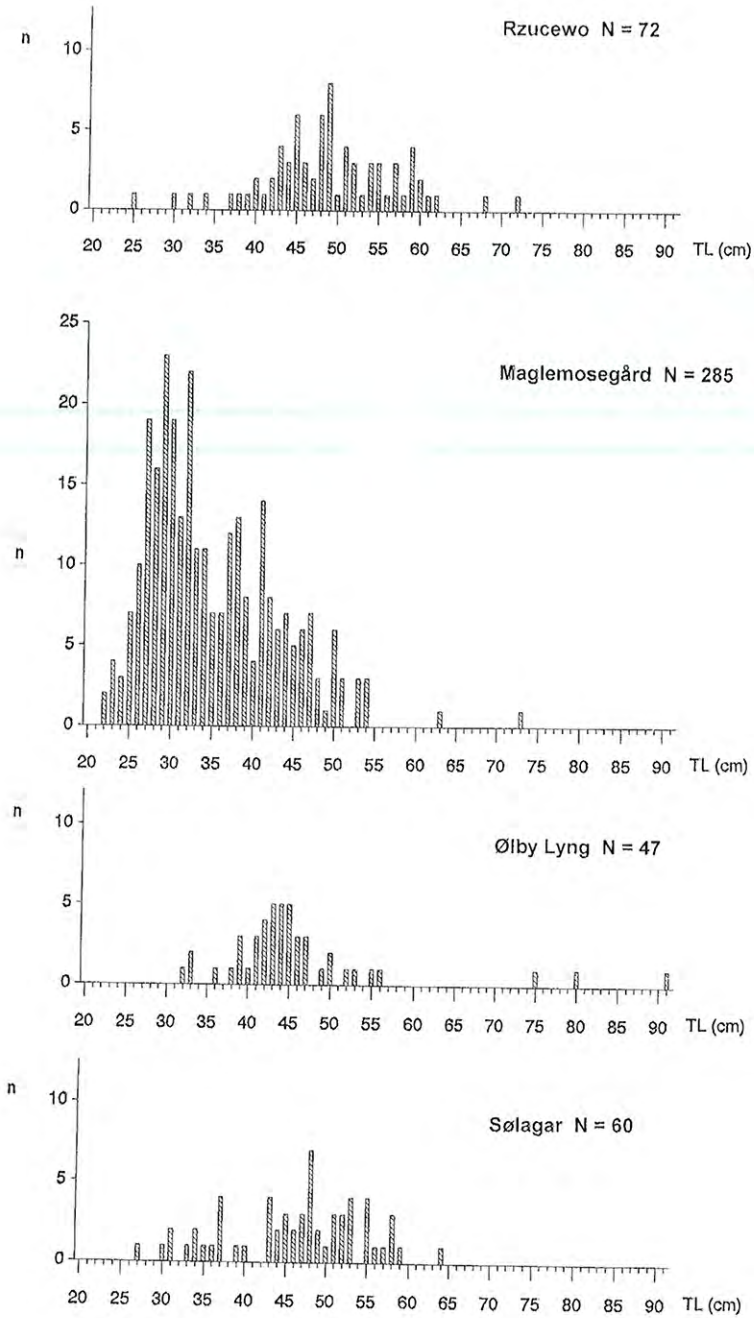


FIGURE 4

Size reconstructions for cod from Rzućewo, compared to data from Mesolithic Danish sites where coastal fishing of cod was practised. The material from Rzućewo and Maglemosegård was sieved, the two other assemblages were not.

Maglemosegård in Denmark (Enghoff, 1983). However, size distributions more or less comparable to the one seen at Rzućewo have also been found at some other Danish Mesolithic sites where coastal fishing is believed to have been practised. Those diagrams represent a distorted picture resulting from the fact that no sieving had been done. The Rzućewo material being carefully collected through sieves, it can be safely assumed that the size distribution observed at this Polish site is not typical of coastal fishing. Only four first vertebrae of *Pleuronectidae* were available that allowed the use of the regression formula of Enghoff (1994). Direct comparison of other skeletal elements with reference material of known size allowed an extension of the sample (Figure 3). The observed size range corresponds to the present-day catches of flounder in the region (Kosmaczewski, 1947: 47).

DISCUSSION

1. *Species diversity*

The number of species represented at Rzućewo is relatively low despite the large sample size and the application of fine sieving methods. Earlier work on fish remains (Lubicz-Niezabitowski, 1929: 64, 79), collected from different loci of the settlement, mentioned the presence of sturgeon, perch, pike, cyprinids and cod, which are species also found in the structure discussed here. Clupeids, flatfish and eel were not listed in that study although our data suggest that these fish were economically important. On the other hand, Lubicz-Niezabitowski (1929) also mentions the presence of pike perch (*Stizostedion lucioperca*), three-spined stickleback (*Gasterosteus aculeatus*) and stone loach (*Noemacheilus barbatulus*). Although it is impossible to verify these old identifications, we want to underline that, despite the abundance of Percidae material at Rzućewo and the existence of clear morphological criteria allowing the distinction of perch from pike perch, we could not attribute any bones to pike perch. The presence of three-spined stickleback and stone loach was not confirmed by our study but would indicate that, at least locally, sieve samples had been taken in the old excavations.

2. *Place and season of capture*

The reconstruction of the place of capture of the fish from Rzućewo has to take into account the dif-

ferent physical environment of the area during Late Neolithic times. It is likely that rivers and freshwater lakes were present in the peatland that extended over the present-day Bay of Puck as far as the Bar of Rewa. The freshwater species found in the Neolithic context may have been captured in such continental waterbodies. However, as a result of the low salinity of the Baltic Sea in this area, all the freshwater fish identified at Rzućewo presently also live in the Bay of Gdańsk. Salinity levels today are about 7‰ in the southern Baltic (Demel, 1947), an area which is, moreover, considered to be the most productive one for fisheries (Żmudziński, 1990: 7). The western coastline of the Bay of Gdańsk would also be the most nutrient rich of this part of the Baltic (Kosmaczewski, 1947: 26). These data on the present-day distribution of fishes cannot be simply transposed to the Late Neolithic. Salinity levels at that time were up to 3‰ higher than today, a situation which lasted until about 600 BC (Demel, 1947; Rosa, 1991). It is possible that the freshwater species migrated from the Baltic inshore region into estuaries and rivers when salinity levels approached or exceeded their physiological tolerance.

We have, thus far, not attempted any growth increment study in order to establish the season of capture. It is likely, however, that spring was the best fishing season for pike, perch and the cyprinids (Figure 5). That is when spawning takes place and fish occur in shallower waters. Today, eel is captured in the Bay of Gdańsk between March and November with the most successful catches from June to September (Kosmaczewski, 1947: 32-33).

Flounder is a very abundant marine species in the Bay of Gdańsk where it is caught in large quantities from May to October. The species then occurs inshore on shallow, sandy bottoms and prefers areas with low salinity (Kosmaczewski, 1947: 24). It is very likely that the flounders found at Rzućewo represent such specimens captured in shallow, inshore waters. Since this species also penetrates rivers, it cannot be excluded that some fishes were also captured in estuaries that may have existed near the site.

The herring also makes seasonal inshore movements. Spring herring is found today north of the Vistula Bar in April and May, whereas autumn herring spawns from September to mid-October near the Hel Peninsula in waters between 10 and 20 metres deep (Kosmaczewski, 1947: 20). Modern herring hence spawns in places with low salinity le-

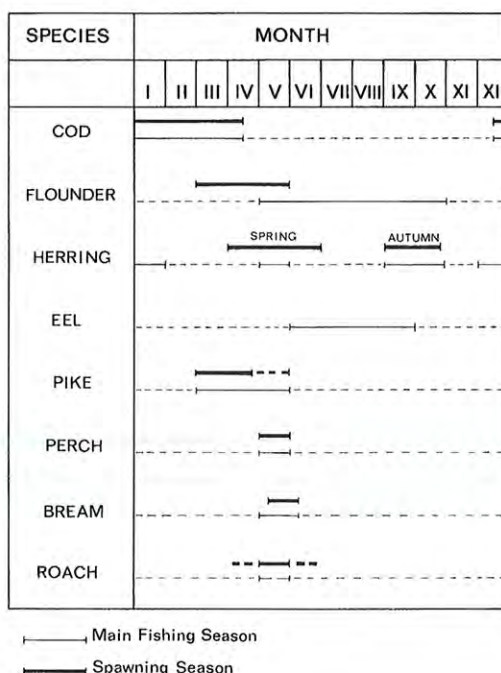


FIGURE 5

Present-day spawning seasons in the Baltic Sea of the species found at Rzućewo. Only cod and flounder spawn in offshore waters. The supposed major fishing season (cf. text for references) for each species is indicated as well.

vels (7‰). In Neolithic times comparable low salinity levels may have occurred near or in estuaries. It is therefore likely that Neolithic people were able to capture this species in inshore environments.

Cod was the most important fish species at Rzućewo both in number of identified specimens (NISP) and meat yield. Whereas flounder and herring may have been captured inshore, the presence of adult cod may indicate that fishing was also practised in a marine, offshore environment. This is shown by the size distribution which is atypical of coastal fishing (see above). Modern data on the distribution and spawning season of this marine species are available but, again, they have to be used with caution. Adult cod occur in great numbers in the Deep of Gdańsk where spawning takes place during spring (Kosmaczewski, 1947: 30, map 2). Fish from the Baltic Sea migrate to this area between January and April and are captured in large numbers throughout that period

(Żmudziński, 1990: 28, 144). The migration routes that are known today show that most cod from the southern Baltic Sea migrating towards the Deep of Gdańsk derive from the eastern part of the Bay of Gdańsk (area north of the Vistula Bar) (Żmudziński, 1990: 26, fig. 12). We can then accept that the inhabitants of Rzućewo went out in the open sea, at least for the larger cod. The preferential depth of cod is said to be below 20 metres, whereas spawning occurs below 10 metres (Poll, 1947: 196-197). Presently, the continental shelf reaches a depth of 10 m at a distance of 10-15 km from Rzućewo. Establishing where the fishing grounds of the adult cod were located precisely is impossible given the uncertainty about former distribution and migration patterns. It has recently been suggested that the modern distribution of gadids is affected by fishing pressure and that, in the past, cod and haddock may have occurred in more inshore waters (Beerenhout, 1994: 343). As we will demonstrate below, the inhabitants of Rzućewo, like the

Neolithic people elsewhere in the Baltic, were technically capable of seafaring. Offshore fishing need not be invoked, however, in the case of the smaller cod specimens, which may have been obtained by coastal fishing in waters less than 10 metres deep (Kowalska, 1973).

3. *Fishing techniques*

The archaeological material from Rzućewo comprises several artifacts that can be related to fishing. Some bone points are interpreted as fragments of fish gorges (Żurek, 1954, plate XI; Makowiecki, 1994), whereas two stone objects and a clay disc (Żurek, 1954: 22-23) probably represent net weights. It cannot be excluded, however, that these weights were used to keep fish traps in place. Moreover, some worked bone fragments are considered to be remnants of spears (Żurek, 1954: Plate IX; Makowiecki, 1994).

The larger cod found at Rzućewo were probably captured with hook and line in deeper, offshore waters. Tools used for hollowing wood represent indirect evidence for the possible availability of dug-out boats (Żurek, 1954: 19, 23) that would have been needed to reach the fishing grounds. The majority of the fish found at Rzućewo may, however, have been captured in the shallower inshore parts of the Bay of Gdańsk. In such places, nets may have been used as well as different kinds of stationary traps and fish fences. Evidence for the latter type of perishable fishing gear was not found at Rzućewo. This is not surprising given the limited chances of preservation of such material and the distance of the site to the coast. Nevertheless, Mesolithic and Neolithic finds outside Poland indicate that these techniques were already well established in the region (Enghoff, 1994: 84-85). This type of fishing gear would have allowed the capture of all major fish species found at the site, including the smaller cod. The spears that were found at Rzućewo may have been used for fishing in shallow, marginal waters. Spearing may have been a suitable method for the capture of spawning freshwater fish, especially pike. Large individuals of this species enter waters of 20-50 cm deep during spawning (Bryliński, 1986: 178).

CONCLUSIONS

The fish remains from the Late Neolithic site of Rzućewo comprise a relatively low number of species. Cod was the main food species both in number of specimens and in meat yield. Perch, pike and eel were the major freshwater species followed by the cyprinids, comprising roach and bream. Flounder and herring were also frequently captured, whereas sturgeon and shad were rarely fished. The determination of the place of capture is hampered by the changes in the coastal landscape and salinity that have taken place in the area since the Late Neolithic. The freshwater fishes may have been captured near the site in lakes and rivers of the peatland area that extended as far as the present-day Bar of Rewa. Alternatively, those species may as well have been taken from the coastal waters of the Bay of Gdańsk if the 5‰ increase in salinity did not cause a substantially different distribution of freshwater species from that observed today. Flounder and herring are likely to have been taken from those inshore waters of the Bay of Gdańsk or from the estuaries in the peatland. Smaller cod were probably also captured near the coast. For the larger cod, however, it seems necessary to invoke fishing further away from the coast if the present-day ecological preference of this species for waters deeper than 10 metres is accepted to hold also for the Late Neolithic. Fishing for large cod might have been practised from dug-out boats, using hook and line. There is also material evidence for the use of nets and spears which were probably used in shallower waters. Moreover, it is likely that other types of fishing gear such as stationary traps and weirs were available. This kind of equipment was not found at the site but is documented from older and contemporaneous sites around the Baltic.

ACKNOWLEDGEMENTS

This paper presents research results of the Belgian Programme on Interuniversity Poles of Attraction, initiated by the Belgian Office for Scientific, Technical and Cultural Affairs. The first author received a research fellowship from the same institution. We thank Alain Reygel (Tervuren) for the drawings.

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Archaeozoology of groupers (Epinephelinae) Identification, osteometry and keys to interpretation

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(Received 23 January 1996; accepted 5 March 1996)

ABSTRACT: A great number of species belonging to different genera of the family Serranidae, sub-family Epinephelinae (for instance, *Cephalopholis*, *Epinephelus* and *Variola*), are classified as «groupers». We find them in temperate and tropical waters, from small- or medium-sized fish to the largest of the Perciformes (*Epinephelus lanceolatus*). They all live under similar environmental conditions, practicing sedentary (and often solitary) carnivorous predation in rocky littorals. Under pre-overfishing conditions, they could be caught with rudimentary fishing gear. Many bones of their robust skeletons are found from the Neolithic onwards in Mediterranean and Indo-Pacific sites, but these remains are difficult to identify to species. The authors, making use of their large reference collection of skeletons from the Atlantic, the Mediterranean and the Indo-Pacific, present and discuss some traditional morphological criteria for specific identifications. They propose a model for the reconstruction of size and weight, calculated from the best preserved bones, which seems to work for the whole sub-family Epinephelinae and appears to be suitable for archaeological purposes.

KEYWORDS: EPINEPHELINAE, GROUPERS, OSTEOLOGY, SIZE/WEIGHT RECONSTRUCTION

RESUMEN: Una gran variedad de especies pertenecientes a diferentes géneros (por ejemplo, *Cephalopholis*, *Epinephelus* y *Variola*) de la subfamilia Epinephelinae, familia Serranidae, se conocen colectivamente como «meros». Se encuentran en aguas templadas y tropicales, desde tallas pequeñas hasta el mayor de los perciformes, *Epinephelus lanceolatus*. Todos viven bajo similares condiciones ambientales, practicando un régimen de vida depredador y, con frecuencia, solitario en litorales rocosos. En condiciones previas a la sobreexplotación pesquera pueden pescarse con artes muy rudimentarias. Muchos huesos de sus robustos esqueletos se recuperan a partir del Neolítico en yacimientos mediterráneos e indopacíficos. No obstante, la identificación a especie es difícil de llevar a cabo debido a la semejanza entre las distintas especies. Los autores, haciendo uso de su extensa colección comparativa de ejemplares procedentes del Atlántico, Mediterráneo e Indo-Pacífico, presentan y valoran algunos criterios morfológicos tradicionales referidos a identificaciones específicas. Asimismo, proponen un modelo de inferencia de talla y peso a partir de los huesos con mayores posibilidades de recuperación en sedimentos arqueológicos que se aplica a toda la subfamilia y que consideran lleno de potencialidades a efectos arqueozoológicos.

PALABRAS CLAVE: EPINEPHELINAE, MEROS, OSTEOLOGÍA, ESTIMACIÓN TALLA/PESO

INTRODUCTION

Groupers have a very wide geographic distribution. They are known as «mérous» in French, «meros» in Spanish, and are universally appreciated by consumers of fish from temperate and tro-

pical seas. Most groupers belong to the genus *Epinephelus*, which is part of the subfamily Epinephelinae, family Serranidae of the order Perciformes, the most numerous group of Osteichthyes (bony fishes).

The sub-family Epinephelinae includes 159 different species of marine fishes grouped in 15 ge-

nera (Heemstra & Randall, 1993)¹ (for Nelson, 1994: 165 species in 14 genera) in which we can find small fishes –some species grow no bigger than 10 cm– and very big taxa, such as one *Epinephelus coioides*² in our collection, from the Arabian Gulf, over 1 m in length, which weights 18 kg. The largest bony fish known is *Epinephelus lanceolatus*, which reaches close to 3 meters and about 400 kg (Smith & Heemstra, 1986).

Epinephelinae (groupers and rock-cods) are generally demersal fishes of temperate, tropical or sub-tropical seas, ranging from shallow coastal waters to moderate depths, rarely exceeding 200 meters; almost all of them live on coral reefs or rocky bottoms. Under natural living conditions, when protected from human predation, large groupers can be seen at the entrance of their rocky shelters in shallow waters. Under those conditions they can easily be captured with rudimentary fishing techniques. Consequently, groupers probably constituted one of the earliest groups of big fish caught by man and have played, at least from the Neolithic onwards, a very important economic role³. Their flesh is usually excellent and can be eaten without any danger, except for the oldest specimens from some tropical waters, where the poisonous disease cigatera is endemic.

The grouper skeleton is usually robust and its bones have a good chance of preservation in archaeological deposits. The big bones we generally use for archaeozoological analyses are easily retrieved during excavation, even without sieving. The wide distribution of groupers, their size, economic interest and strong skeletal elements confer them an extremely important role in the archaeo-ichthyology of warm and temperate coastal sites. But the great number of species seems to have been a handicap to serious attempts at species-level discrimination on the basis of their bones.

As is known by specialists, the keys to discriminate among Serranidae are established from the distinct number of dorsal and anal fin spines and soft rays, from the morphology of the caudal fin



FIGURE 1

These three groupers from the Arabian Gulf are distinguished by the morphology of their caudal fin: A emarginate (*Epinephelus areolatus*); B rounded (*Epinephelus coioides*); C truncate (*Epinephelus bleekeri*).

(Figure 1: emarginate, truncate or rounded), the differences in the cranial profile, the indexes between fish standard length and maximum height, the number of scales along the lateral line, and, obviously, colour differences. All this information is, as we all know, inaccessible to archaeozoologists.

The skeleton of the genus *Epinephelus* has very classical features for a Perciform Teleost. The number of its cranial components is constant, as is its vertebral number (24). One can always find 11 spines in the dorsal fin and 3 spines in the anal fin. But obtaining a species-level identification from archaeological bones, even well preserved ones, presents great difficulties. Only a few distinctive characteristics in bone morphology, such as the presence and number of canine-like teeth, or the number of ranks of the villiform teeth, seem to be of some help.

Interspecific morphological distinctions are not very numerous, are often variable on the archaeological bones, and appear to be useless on the vertebrae.

¹ Genera: *Aethaloperca*, *Alphestes*, *Anyperodon*, *Cephalopholis*, *Cromileptes*, *Dermatolepis*, *Epinephelus*, *Gonioplectrus*, *Gracila*, *Mycteroperca*, *Paranthias*, *Plectropomus*, *Saloptia*, *Triso*, *Variola*.

² The nomenclature of groupers has been reviewed several times. The latest review is that by Heemstra & Randall (1993). The names of frequent species, previously a) *E. guaza* and b) *E. tauvina*, were based on misidentifications of *E. marginatus* (Lowe, 1834) for the first one and *E. coioides* (Hamilton, 1822) for the second one.

³ We have determined it in many Neolithic Mediterranean sites published or under study; in Cyprus, at Khirokitia and Cape Andreas Kastros (Desse & Desse-Berset, 1994 a, b); in Corsica, at Monte Leone and Longone; in Italy, at Arena Candida; in the Arabian Gulf, at Qala'at al Bahrain (Desse-Berset, 1995) and Failaka (Desse & Desse-Berset, 1990); in Tunisia, at Zembra.

Osteometry applied to grouper bones is fortunately of much greater help. It allows us to directly reach the level of archaeological interpretation without a long and uncertain trial of species-level taxonomic diagnoses. The aim of this paper is to furnish a general method allowing grouper total or standard length reconstruction, relevant to any species of the sub-family Epinephelinae, from any place and any date. This results directly from application of the relationship existing between the most important isolated bones for archaeozoological purposes, on the one hand, and fish size and weight on the other.

For many years we have gathered osteometrical data from the numerous groupers caught during our archaeozoological expeditions on a wide geographical scale: the Eastern Atlantic, the Mediterranean, the Arabian Gulf, the Indian Ocean, and, recently, the South Pacific. In the spirit of the «Fiches d'Ostéologie Animale pour l'Archéologie», we have first tried to collect data and apply osteometrical analysis to one of the most common Mediterranean groupers: *Epinephelus marginatus*, wrongly called *guaza*².

MATERIAL, METHODS AND RESULTS

Our research is fundamentally pragmatic, and its sole purpose is an easy inference of fish size and weight, suitable for the numerous bones of groupers discovered at the Neolithic sites of the continental or insular Mediterranean, on the basis of bone measurements. The preliminary results, even when obtained on an infra-statistical number of modern specimens of *Epinephelus marginatus*, are excellent, and indicate a good correlation between the most important bones of the skeleton and the size of the fishes (Figure 2). Working in the Arabian Gulf, we tried to apply this classical osteometrical approach to the most common grouper, *Epinephelus coioides*⁴. This new species, as expected, has provided us with the same kind of good results (Figures 3, 4, 5). We then gathered the data obtained from these two species of groupers and observed good agreement, not only of the relationship between the standard and total lengths of the two

species, but also of the data obtained from the isolated bones of both *Epinephelus* (Figures 6, 7).

Later, we extended the comparison to all fishes belonging to the genus *Epinephelus* in our reference collection, whether from the Eastern Atlantic, the Arabian Gulf or French Polynesia; these re-

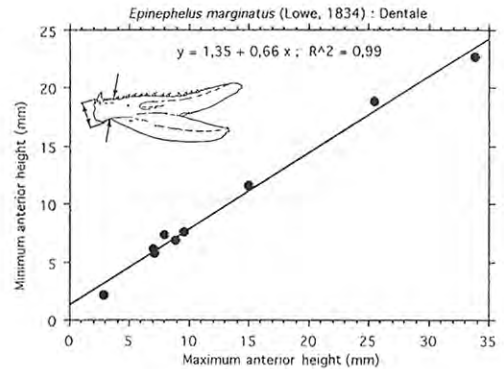


FIGURE 2

Correlation between 2 measurements on the dentale of the most common Mediterranean grouper, *Epinephelus marginatus*.

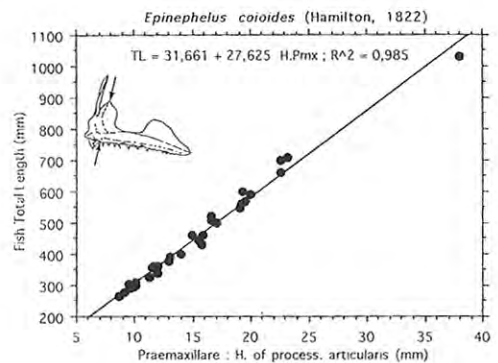


FIGURE 3

Correlation between praemaxillare and fish total length of the most common grouper from the Arabian Gulf, *Epinephelus coioides*.

⁴ Thirty-one specimens have been collected in the Gulf, and this species will be soon published in the «Fiches d'ostéologie animales pour l'archéologie»

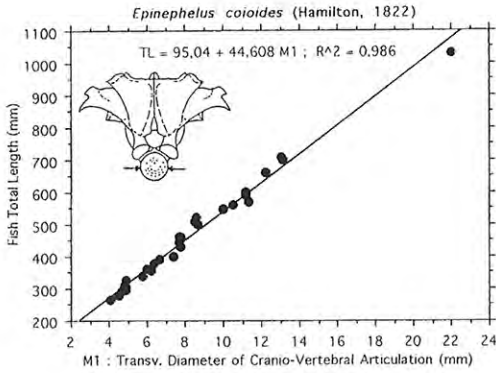


FIGURE 4

Correlation between cranio-vertebral articulation and fish total length of *Epinephelus coioides*.

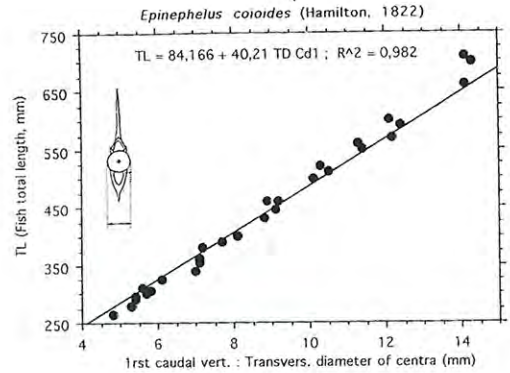


FIGURE 5

Correlation between the first caudal vertebra and fish total length in *Epinephelus*.

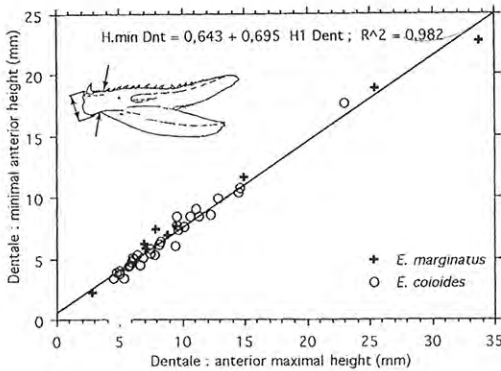


FIGURE 6

Relationship between two measurements on the dentale of two different species of groupers (*Epinephelus marginatus* and *E. coioides*): the regression lines for the two species are superimposed.

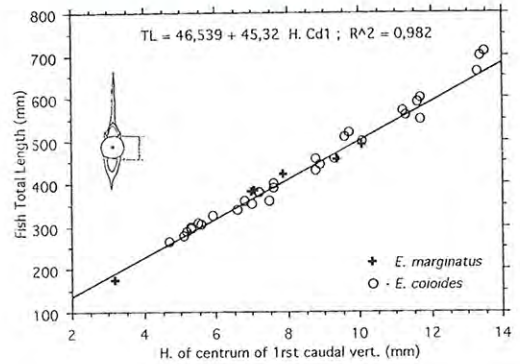


FIGURE 7

Relationship between the height of the first caudal vertebra and fish total length: the regression lines for *Epinephelus marginatus* and *E. coioides* are superimposed.

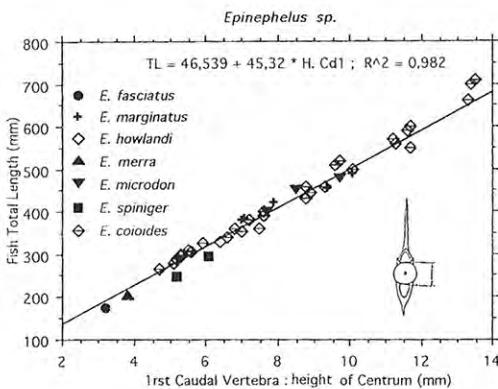


FIGURE 8

Correlation between first caudal vertebra and fish total length for several species of groupers from the Mediterranean Sea, the Arabian Gulf, the Indian Ocean and Polynesia.

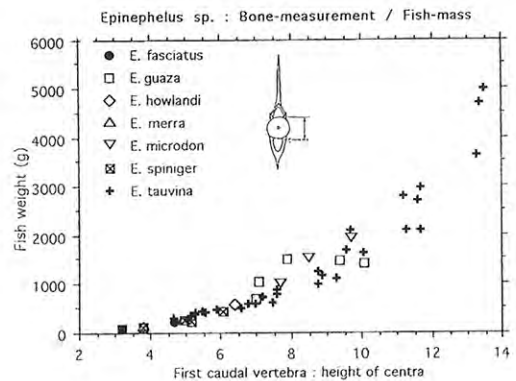


FIGURE 9

Correlation between first caudal vertebra and fish weight for several species of groupers from the Mediterranean Sea, the Arabian Gulf, the Indian Ocean and Polynesia

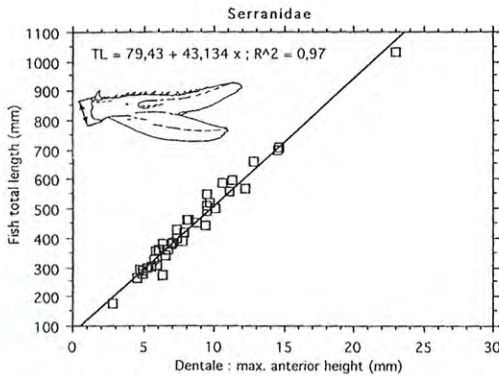


FIGURE 10

All groupers belonging to the genus *Epinephelus* exhibit the same correlation between total length and bone measurements (in this case the dentale).

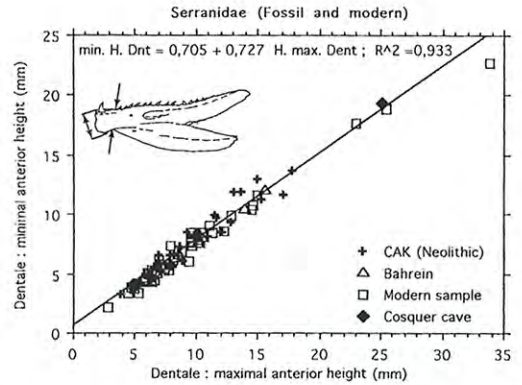


FIGURE 11

Archaeological and modern samples of dentale are positioned on the same curve in the scatter diagrams.

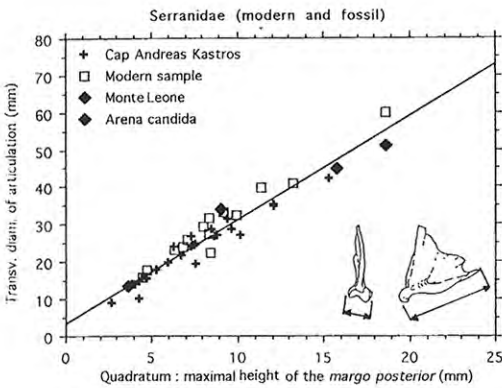


FIGURE 12

Quadratum: relationship between archaeological and modern bone measurement values.

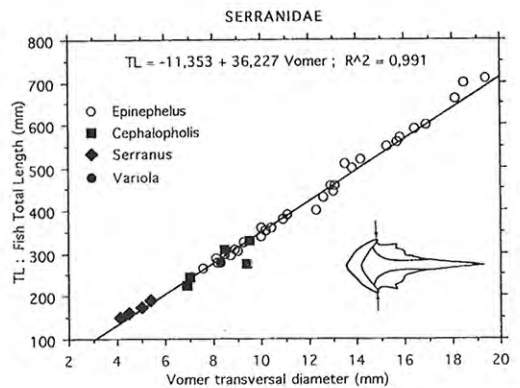


FIGURE 13

Extension to the sub-family level: correlation between vomer measurement and total length for the genera *Cephalopholis*, *Serranus* and *Variola*.

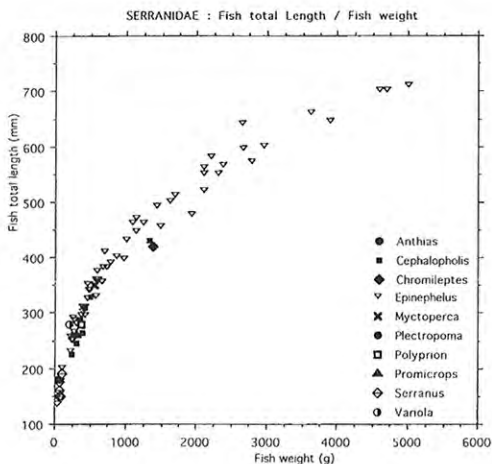


FIGURE 14

Fish weight/fish length relationship extended to all Serranidae in the reference collection of the Laboratoire d'Archéozoologie, Centre de Recherches Archéologiques, C.N.R.S.

present a sample of 128 fishes belonging to 25 species, which is, probably, at this stage, sufficient for statistical purposes.

The results obtained lead to interesting archaeozoological implications (archaeozoology is here used in the full meaning of the word, with some zoological and archaeological connotations). Whatever the specific identity or the geographic origin of each specimen, the relationship between its bone measurements and its body size (Figure 8) or weight (Figure 9) appears on the same curve in the scatter diagrams. For pragmatic purposes, we can consider that all groupers belonging to the genus *Epinephelus* have the same relationship between total length, standard length, weight and bone measurements of their skeletons. Consequently, for archaeological application, this clearly means that any bone belonging to a grouper found in an archaeological site, whatever its geographical origin and its age, is able to provide, through simple calculations, the size and weight of the original fish to which it belonged (Figure 10).

This relationship worked well for all 25 species of the genus *Epinephelus* which we have tested; it probably fits all species of this genus on coastal archaeological sites.

In addition to these results, we must add that the measurements we took on our fossil samples, when added to modern models, conformed to the scatter diagram curves drawn for modern samples (Figure 11, 12).

An extension to the sub-family level was later checked. Two species of the genus *Cephalopholis* (i.e., *Cephalopholis miniatus*, a small grouper of the Arabian Gulf and *Cephalopholis argus*, a Polynesian rock cod), both belonging to the subfamily Epinephelinae, were added to the diagrams. They also exhibited the same osteometric results as those established for *Epinephelus*. Later, we added two small-sized Mediterranean species of the genus *Serranus* (i.e., *Serranus scriba* and *Serranus cabrilla*), as well as specimens of the genus *Variola* (Figure 13). Finally, we extended this analysis to all the genera of the sub-family Epinephelinae in our reference collection. The results, again, appear to be helpful for archaeozoological purposes (Figure 14).

CONCLUSIONS

Our study indicates that all groupers, from the smallest species to the largest one, fit a similar set of regression equations. Furthermore, it also seems evident that all groupers represent a similar way of life. Fishing techniques depend, in fact, more on the animal's weight than on its taxonomic status. Even if they could be fished under the same environmental conditions, a 15 kg *Epinephelus marginatus* could not be captured with the fishing gear used for the small *Cephalopholis miniatus*. Nevertheless, this latter species could actually be caught with the same techniques as a juvenile specimen of some big *Epinephelus coioides*. The opportunities provided by osteometric applications to recalculate groupers' size or weight from isolated bones, even broken ones, seems a good answer to the archaeological problem of groupers' exploitation. And this answer, with all its implications for fishing strategies and palaeo-economy, can be supplied without detailed investigations into the species involved.

Let us end upon the image of a statue of Fatu Hiva, in the Marques Islands, kept in Tahiti's Museum of Islands. Ancient Polynesians, who recognised the morphological differences among groupers and gave them different names, nevertheless had a statue, named puna hapu, which means grouper fish. They would take it out of its sanctuary when setting out to fish, so that it might be propitious to them. The anecdote is metaphorically close to the work which has just been presented. Our results open a spectrum of promising applications for many genera of sea fishes, as will be seen in the near future⁵.

ACKNOWLEDGEMENTS

We are very grateful to Jacqueline Gaudy and Suzanne Needs-Howarth for their corrections of our English.

⁵ Desse & Desse-Berset, On the Boundaries of Osteometry applied to Fish, this same volume.

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Medieval fish weirs: the archaeological and historical evidence

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(Received 5 January 1996; accepted 18 March 1996)

ABSTRACT: In medieval times fish was of essential importance to the new towns as lenten food and protein supply. Archaeoichthyological research has shown that the demand for fish was satisfied by marine as well as inland fisheries. Although the marine fishing industry with its herring and stockfish trade was very important, the share of freshwater fish was consistently very high (about 50%). Despite this importance there is only very sparse archaeological evidence of fishing tackle. In Germany only some fish hooks, gorges and remains of netting tools, such as floats and sinkers, have been discovered. One has to consider other, more effective, means of catching fish, for instance fish weirs. These installations are only rarely excavated because of poor preservation conditions. Examples are only known from England and France. Their existence and their frequency in Germany, therefore, has to be determined with the help of charter evidence.

KEYWORDS: GERMANY, MEDIEVAL AGES, FRESHWATER FISH, FISHING TECHNIQUES, FISH WEIRS, ARCHAEOLOGY, HISTORY, CHARTERS

RESUMEN: Durante el Medioevo, el pescado resultó ser un alimento esencial en las nuevas ciudades como elemento esencial de las vigilias y como aporte proteico. La arqueoictiología evidencia que tal demanda fué cubierta tanto con pesquerías marinas como continentales. Si bien las industrias asociadas con las especies marinas, como el arenque y bacalao, siempre fueron importantes, los aportes de las pesquerías continentales no parecen haber bajado nunca de la cota del 50%. A pesar de tal importancia, la evidencia arqueológica sobre útiles de pesca es muy escasa. En Alemania tan solo algunos anzuelos, dobles puntas y restos de artes de red, como flotadores o plumadas, han sido descubiertos. Artes alternativas, más efectivas, caso de las presas artificiales deberían asimismo tenerse en cuenta. Estas instalaciones aparecen muy ocasionalmente sin duda como resultado de las pobres condiciones de conservación. Sólo conocemos ejemplos de éstas en Inglaterra y Francia. Su existencia y frecuencia en Alemania, por tanto, debe inferirse con ayuda de la cartografía.

PALABRAS CLAVE: ALEMANIA, MEDIOEVO, PECES DULCEACUÍCOLAS, TÉCNICAS DE PESCA, PRESAS PARA PESCA, ARQUEOLOGÍA, HISTORIA, CARTOGRAFÍA

INTRODUCTION

Unlike today, fish was of essential importance for medieval towns and monasteries. Although recent research still cites it as the main reason, the ban of meat, mentioned in chapter 39, 2 of the rule of St. Benedict (Benedicti Regula, 1969: 100), cannot be the sole explanation for the immense demand for fish.

Recent archaeological research at Ralswiek, Hitzacker, Menzlin, Mecklenburg, Alt-Lübeck, Scharstorf and other German sites has proven that fish, especially sturgeon and herring (Benecke,

1983), were vital suppliers of protein in the non-Christian settlements of the Slavonic area. In times of rapid population growth and the emergence of new centres the food supply was based on this valuable and easily accessible food.

Archaeozoological investigations have shown that the demand for fish was satisfied by coastal as well as by inland fishing industries. Until now, research has focused on coastal fisheries; the herring fishery at Rügen, in Pomerania and Scania, and the stockfish trade with Bergen have been the subject of many papers, usually in connection with research on the Hansa. However, the analysis of fish

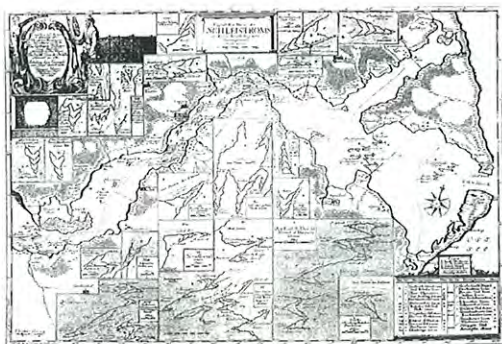


FIGURE 1

Herring fences in the Schlei, Drawing J. Mejer (after Radke, 1977).

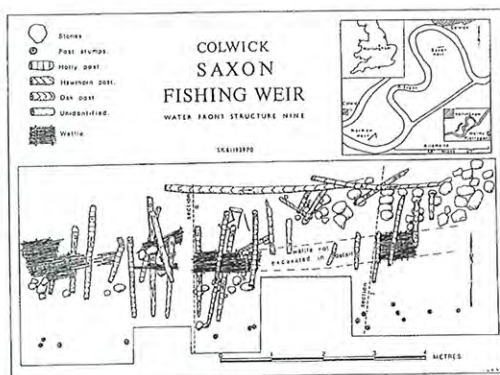


FIGURE 2

Anglo-Saxon fish weir: Plan of the main part of the excavation (after Losco-Bradley & Salisbury, 1988).

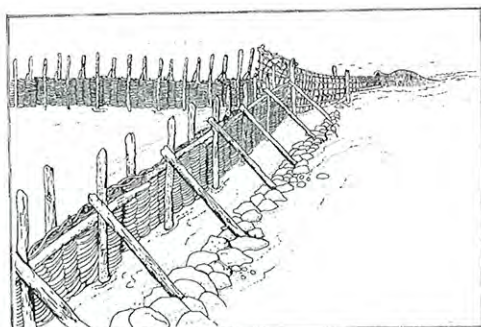


FIGURE 3

Reconstruction of the Anglo-Saxon fish weir (after Losco-Bradley & Salisbury, 1988).

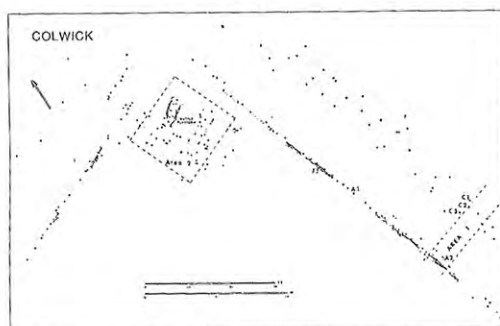


FIGURE 4

Plan of the Norman fish weir (after Losco-Bradley & Salisbury, 1988).

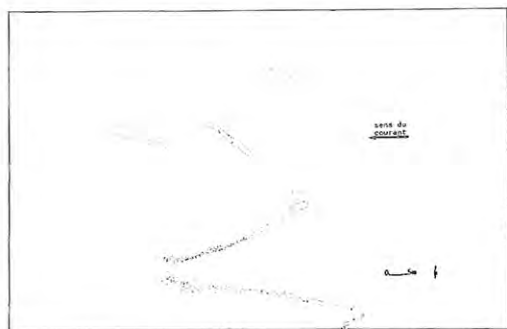


FIGURE 5

Plan of the fish weir «L'île», Beynac et Cazenac, Castelnau-la-Chapelle (after Nowacki-Breczewski, 1989).

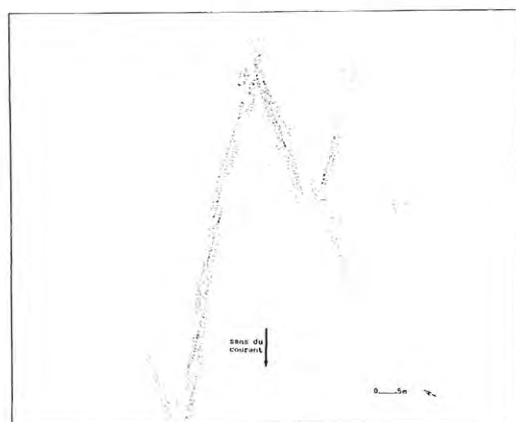


FIGURE 6

Plan of the fish weir «Sous les Milandes», Castelnau-la-Chapelle, St. Vincent de Cosse (after Nowacki-Breczewski, 1989).

remains has shown that even in trading places like Haithabu, Schleswig or Lübeck, the share of freshwater fish was consistently very high (about 50%). This freshwater fish was probably caught in local inland waters.

The examination of this inland fishing industry has been neglected until now, although the medieval charters show that fisheries existed almost everywhere and were systematically used as a source of revenue. We therefore have to examine how this inland fishery was organized.

On the one hand, fish was bred in ponds; in the Western Empire *vivarias* or *piscinas* are usually mentioned in connection with water mills. The waters which were dammed to run the mills were used simultaneously as fish reservoirs. In this context, one cannot speak of fish farming in the strict sense. The construction of fish ponds reached its climax in the late Middle Ages with the introduction of carp breeding (Currie, 1991; Hoffmann, 1995).

It follows that, especially in the early and high Middle Ages, an additional technique of inland fishing must have been used, but so far there is only very limited archaeological evidence of fishing tackle. In Germany only some fish hooks, gorges and remains of netting tools, such as floats and sinkers, have been discovered (Brinkhuizen, 1983; Szabó *et al.*, 1985; Steane & Foreman, 1989). The number of artifacts is surprisingly small, even if one takes into account loss through weathering and destruction. One has to consider other, more effective, means of catching fish, for instance fish weirs.

ARCHAEOLOGICAL EVIDENCE FOR FISH WEIRS

Christian Radke (1977) suggested that this fishing technique must have been in use at Haithabu; this cannot be verified for the early Middle Ages, but is known from early modern times in the Schlei (Figure 1). Such herring fences or fish weirs, have not been found in Germany but are known from England and France.

In England many rivers have been surveyed for fishing tackle and river fisheries in the last twenty years. Several fish weirs were found in the Trent (Salisbury, 1981), in the Witham and its tributaries (White, 1984), and in the Severn (Panett, 1988).

These fish weirs are structures with two wings and a small enclosure in the centre to trap the fish. The most thoroughly excavated and reconstructed weir, a fishery in the Trent (Figure 2), had a double row of posts that had collapsed towards the north (Losco-Bradley & Salisbury, 1988). Between the posts there was a series of wattle hurdles. The post alignment was examined over a length of 14 metres. The posts were made of oak and were 2.4 metres high. They had been set 1 meter deep into the ground. Towards the north the structure was secured by a stone wall. The weir can be dated into the 8th or 9th century by dendrochronology.

Although the archaeological evidence only uncovered one row of posts, this structure definitely is a preserved part of a fish weir. This was confirmed by the discovery of a second fish weir about 400 metres further west (Losco-Bradley & Salisbury, 1979, 1988). This second fish weir can be dated into the 12th century and is constructed in the same way as the Anglo-Saxon weir (Figure 3). In addition to the fences, a foundation was probably used as a working platform in the centre of the two wings.

In France, Nowacki-Breczewski (1987) analysed the economical importance of four fish weirs in the Dordogne and Charente (Figures 4 & 5). The four weirs discovered there were very large; the wings of the Milandes weir, for example, were 150 metres long and 7 metres wide (Figure 6). The fish weirs in the Dordogne and Charente were essentially all constructed in the same way but there were small differences due to local conditions: all structures consisted of 'V'-shaped fences with wicker baskets with nets or enclosures at their centre to catch the fish. The wings consisted of rows of posts or blocks of limestone with wattle walls.

The orientation of these weirs demonstrates that each device was specialized towards different species of fish. Usually they consisted of two wings which pointed in the direction of the current but there were also large structures which consisted of several pairs of wings. With these weirs one was able to catch fish moving both downstream and upstream.

EVIDENCE FROM CHARTERS

The archaeological evidence for the structure and function of fish weirs corresponds with the

evidence provided by historical sources. Although no medieval weirs have been excavated in Germany so far, it is thus nevertheless possible to prove the existence of fish weirs in this country. Like in England and France, weirs were sold, leased or given to someone and such legal transactions can be corroborated or confirmed with the help of written charters.

The terminology for «weir» changed during the Middle Ages and depends on the language. Apart from such general terms as the Latin *piscaria* or *piscatoria* or the Middle High German *vischenze*, which can also denote fish weirs, there are numerous terms which clearly can only mean fish weir: Merovingian charters usually use *venna* or *banna* (Pertz, 1872: 7, Nr. 5) while the late Carolingian and Ottonian diplomata go over to use different, more general terms, mainly *vadium ad piscandum*, which means ford. Other terms are *clusa* and *septa* (enclosure), *gurgustium* (weir) and *palum* (fence). Apart from these Latin terms there are also vernacular ones, for example *ghistellis* (stand/fence) or *wer*.

Fish weirs sometimes had a very long life; the fish weir in Lübeck, which belonged to the count, can be traced back in charters for a period of more than 50 years. A fish weir in the river Weser belonging to the monastery of Corvey, Lower Saxony, can be traced back even longer (Wilmans, 1867: 30f). It is first mentioned in a diploma of Louis the Pious from 832, where it is called *hocwar* by the locals. In the 12th century this fish weir reappears as the object of a lawsuit between the monastery and the Saxon earl. Again it is called *huqver*. In 1158 the weir is still mentioned in a list of gifts, presented to the monastery of Corvey (Hausmann, 1969: 24ff, Nr. 133; Diestelkamp & Rotter, 1988: 177, Nr. 239).

With the help of fish weirs one usually caught anadromous fish, which swim into the rivers during the spawning season. The previously mentioned example from the Dordogne indicates that weirs were constructed for special species of fish. Charters from Mecklenburg and Pomerania mention such special weirs: eel traps (*seran*) and salmon weirs (*Salmwege*) (Rödel, 1992: 177, Nr. 252).

The medieval charters show that fish weirs existed in coastal areas but they may have been more numerous in the interior. The construction and maintenance of these big fences must have requi-

red a huge expenditure in terms of both labour and finances from the owners.

In the various town charters for Lübeck the citizens were granted the right to fish by the local sovereigns, while the weirs belonging to the counts of Holstein are expressly exempted from that rule. In this case the sovereign (*Landesherr*) was the owner of the fish weirs. That was also the case in Mecklenburg and Pomerania and it was related to the fact that in the newly settled areas east of the river Elbe the *Landesherr* usually held the royal right for fishing.

Towns, monasteries or private individuals could also own fish weirs. Often the usufruct was split up into several single rights and sold; the knightly family Montevedule, for example, sold the right to fish with their weir in the river Bille at Hamburg for single nights (Archiv der Hansestadt Hamburg, 1911-39: 26f, Nr. 38; 40f, Nr. 56 & 101, Nr. 154). This is observed quite often and indicates that some weirs were primarily operated during night time.

Fish weirs were also leased out against a rent which was paid either in money or in kind - that is, fish. The example is taken again from the edition of the charters of Hamburg in which weirs play an important role. Here it was usually the town who owned the fish weirs or «fences». In the year 1309 the town leases out a weir to three persons for 60 Mark. After two years the lease is renewed, again for a period of two years but now not against the payment of a money rent but for half of the amount of fish caught (Archiv der Hansestadt Hamburg, 1911-39: 146f, Nr. 230). In this case the town acts as a procurer of fish. The payment in kind is preferred probably in order to improve the fish supply for the town. The lease holders are obliged to dismantle the wooden posts of the fence and return them to the city at the end of the two years. An exception is made when the fence should be too large and heavy to be dismantled by four men (*Sed aliquem palum, que, quatuor viri supratrahare non possent, stare facerent, ...*). At least in this case the timber of the weir was «recycled». Perhaps this explains the lack of archaeological evidence.

The fish weirs excavated in the Dordogne and in the river Trent and described in many charters were very large structures. Their «V»-shaped wings narrowed the rivers and sometimes even barred them. Sometimes there were several weirs constructed behind each other thus impeding the passage of

ships. The owners of fish weirs therefore inevitably came into conflict with ship owners. Legal disputes between fishermen and ship owners find their expression in charters. There are numerous examples for the high and late Middle Ages.

In a diploma from 979, emperor Otto II decided in a dispute between the abbots of Fulda and Hersfeld, two very important monasteries in Hessen (Sickel, 1888: 237, Nr. 209):

«[...] eo quod ipse iam dictus abbas Gozbertus in fluvio quodam Hursilla vocato qui fluit in Lupinzgove, a ripa ad ripam sine spatii intermissione gurgustium percutiendo hominibus sue ecclesie ac sibi navalis cursus transmeatum vetaret.»

The conflict was caused by the erection of a fish weir by abbot Gozbert of Hersfeld, which interfered with navigation in the river Hörstel. The abbot of Fulda, Werinhar, complained about the weir because his ships could not pass this point of the river. After sending legates to the locals who informed him about the situation, Otto decided in favour of Werinhar. He told abbot Gozbert of Hersfeld to open the weir in order to make space for the passage of two ships. The ships should touch neither each other nor the posts which were fixed at the banks of the river:

«[...] ac viam fluminis fractione gurgustii pandere iubentes, ut deinceps per illud navigantibus tantum spatii in itinere pateat quod due naves tripedalem mensuram in fundo habentes, ut neutra neutram tangat sibi invicem, sine palorum utrimque fixorum etiam tactu occurrere possint [...].»

Charters which verify conflicts between the fishing industry and ship owners are known throughout Germany. Usually in this context the weirs are called *obstaculum* or *offendicula* (obstacle or offence). Frequently the sovereign had to interfere in order to reconcile conflicting interests. The rulers tried to solve the problem by granting the right of fishing and the right of shipping to only one recipient. During the Middle Ages rivers were the most important traffic arteries of the empire. The link between grants of fishing rights and shipping tolls helped to control the rivers. The rivers stayed navigable, thus ensuring trouble-free transport of goods and persons.

CONCLUSIONS

Charters shows that during the Middle Ages fish weirs were commonly and intensively used to catch fish. This widespread use of fishing with the help of weirs explains why so few other kinds of fishing tackle are found. Unfortunately, these structures are only rarely preserved, therefore their existence and their frequency has to be determined primarily from charters.

On medieval estates weirs constituted a valuable possession. Many charters show that they had a long lifespan and that they were carefully maintained. When the towns began to flourish, more and more private persons and cities used them. The city council of Hamburg profited considerably from its weirs.

The construction of fish weirs got so out of control that even shipping was endangered. This is when the sovereigns interfered to ensure that rivers could continue to be used as traffic arteries; this could be one of the causes of a decline in weirs. Another reason was the increased mechanization and spread of coastal fishing since the 17th century which made inland fishing with weirs unprofitable.

Unfortunately, this very important fishing instrument has not yet been excavated in Germany. A more intensive look at medieval riverbeds is needed in order to obtain archaeological evidence for fish weirs.

ACKNOWLEDGEMENTS

I would like to thank the Cusanus-Werk, Bonn for providing me with a travel grant to attend the Madrid Meeting.

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Fishing at Minoan Pseira: Formation of a Bronze Age fish assemblage from Crete

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(Received 14 December 1995; accepted 29 March 1996)

ABSTRACT: Recent excavations at a Minoan (Late Bronze Age) trading settlement on Pseira, a small island off the eastern end of the north coast of Crete, yielded an assemblage of fish remains consisting primarily of sagittal otoliths from a single genus, *Spicara*, the picarels. Various factors that may have contributed to the formation of this assemblage are evaluated here.

KEYWORDS: CRETE, FISHING, LATE BRONZE AGE, MINOAN, OTOLITHS, PSEIRA, TAPHONOMY

RESUMEN: Las recientes excavaciones en el yacimiento minoico (Bronce tardío) de Pseira, enclave comercial situado en una pequeña isla en el extremo nororiental de la costa cretense, proporcionaron un peculiar acúmulo de restos de peces dominado por otolitos (sagitas) de chulas (género *Spicara*). Los varios agentes que pueden haber intervenido en la configuración de esta muestra ósea son evaluados en este trabajo.

PALABRAS CLAVE: Creta, Pesca, Bronce Tardío, Minoico, Otolitos, Pseira, Tafo-nomía

INTRODUCTION

First inhabited in the Final Neolithic, Pseira, a small island in the Gulf of Mirabello on the north coast of eastern Crete (Figure 1), was occupied continuously into the Late Bronze Age (Seager, 1910; Davaras & Betancourt, 1986, 1988, 1990, 1991, 1995; Davaras *et al.*, 1992; Betancourt, 1995). The Late Minoan I (1675-1500 B.C.) settlement consisted of ca. 60 structures, mostly situated around and above a sheltered harbour facing the coast of Crete, 2.5 km away. Destroyed near the end of Late Minoan IB (ca. 1500 B.C.), the settlement was briefly reoccupied after a hiatus of 50 years or more (in Late Minoan IIIA2), then abandoned. Some Late Minoan IIIC (1190-1125/1100 B.C.) activity at the site is attested by pottery, but there are no buildings from that period. A small Early Byzantine monastery built over the Minoan town in the sixth century A.D. was in ruins by the ninth century. The island is uninhabited today. Pseira was probably a trading center on the eastwest route along the north coast of Crete. The Minoan settlement of Mochlos is 3 km to the east and the Mi-

noan town and palace at Gournia are on the mainland, 13 km to the southwest. Building DA, from the LMIII Cretan reoccupation, has pottery from Cyprus, Syro-Palestine, and elsewhere on Crete. Other structures of note include BS/BV (the Plateia Building), which was possibly the residence of a local chieftain, and BY, which had an LMI obsidian workshop (Dierckx & Floyd, 1995).

The 1985-1991 excavations, directed by Philip Betancourt of Temple University and Costis Davaras of the University of Athens, produced fish bones, otoliths, and teeth from Bronze Age and Medieval contexts, most of which were water sieved (Rose, 1994, 1995b, in press). Remains from



FIGURE 1

Map of Crete showing sites mentioned in text.

37 Minoan contexts (414 bones and bone fragments, 426 otoliths and otolith fragments) are discussed here.

ASSEMBLAGE COMPOSITION

Most of the fish remains from Pseira are poorly preserved; few bones are intact, and identifiable cranial and facial elements are scarce (Table 1). Out of a total of 414 bones and bone fragments only 154 (37.2%) could be identified taxonomically. The salient feature of the Pseira assemblage is the abundance of otoliths, most of which derive from a single taxon (Centracanthidae: *Spicara*). Otoliths constitute 50.7% of all fish remains, and the 388 *Spicara* otoliths alone amount to 46.1%.

That *Spicara* remains are relatively abundant at Pseira is not surprising given that these fish make up 26.7% of the Cretan catch today (National Statistical Service of Greece 1967-69). There are three species of picarel in the Pseira region: golden picarel (*S. flexuosa*), blotched picarel (*S. maena*),

and picarel (*S. smaris*). *Spicara* are small schooling fish in littoral waters, whose maximum size is 25 cm in standard length (Whitehead *et al.*, 1986). The size frequency distribution of the 347 measurable *Spicara* otoliths from Pseira is presented in Figure 2. The mean height is 1.93 mm. For comparison, three modern reference specimens of picarel from the Argolic Gulf, Greece, with otolith heights of 2.4-2.5 mm were 11.3-12.5 cm in total length. *Spicara* are taken primarily in nets, including trawls (39.6%), purse seines (3.9%), and seines (46.5%). The balance of the catch (9.9%) is made with small ring nets and lines (National Statistical Service of Greece, 1967-69). Historically, Faber (1883) records the catch of *Spicara* using ground nets with diagonal meshes of 2.6-3.8 cm and cast nets, as well as hand lines with 3-10 small hooks. Guest-Papamanoli (1985: 186-187) observed them in catches from set net traps (italiani) along coast in the Pagassitikos Gulf. The small size of the *Spicara* represented by the otoliths and Sparidae/Centracanthidae vertebrae at Pseira suggests they were caught using fine-meshed nets. Stone and clay weights are common at the site, but

TAXON	Cranial/facial	Otoliths	Vertebrae	TOTAL
<i>Anguilla anguilla</i>			3	3
<i>Micromesistius poutassou</i>		1		1
SERRANIDAE			1	7
cf. Serranidae			1	[1]
<i>Epinephelus</i> sp.	2	1		[3]
cf. <i>Epinephelus</i>	1		1	[2]
SCIAENIDAE				3
<i>Sciaena umbra</i> /Umbrina cirrosa	2			[2]
<i>Sciaena umbra</i>		1		[1]
SPARIDAE/CENTRACANTHIDAE		28	135	163
SPARIDAE	1			7
cf. Sparidae	4			[4]
cf. <i>Pagellus erythrinus</i>		1		[1]
cf. <i>Pagrus pagrus</i>		1		[1]
<i>Spicara</i> sp.		388		388
LABRIDAE	1			1
MUGILIDAE			1	2
cf. Mugilidae	1			[1]

TABLE 1
NISP for taxa identified in Minoan contexts at Pseira.

the lead net weights known from many Late Bronze Age sites in the Aegean and eastern Mediterranean (Rose, 1994) have not been found. At Kahun, Egypt, 18th Dynasty (1570-1293 B.C.) nets have been found that have 0.5-1.5 cm meshes (Brewer & Friedman, 1989). A bronze fishhook (Betancourt & Davaras, 1995: AG 12) was found in a disturbed context at Pseira.

The skewed anatomical distribution of the Pseira assemblage can be seen by comparing the expected and actual counts of *Spicara* skeletal elements, assuming that 200 individuals were present, based on the number of right otoliths (200 of the *Spicara* otoliths were from the right side, 188 were from the left; 7 fragments of small otoliths, sparid or centrarchid, could not be determined to side). For each of the paired cranial and facial bones, represented here by the premaxillae and dentalia, 400 could be expected, but none are present. For the Sparidae/Centrarchidae vertebrae, at least 4800 might be expected (based on 24 per fish [Nelson, 1994: 362]), but only 135 are present. Thus the assemblage consists of otoliths, but no other elements from the head, and a scattering of vertebrae. The vertebrae are present in numbers not vastly out of line with what might be expected based on their normal anatomical proportions and a general tendency for caudal vertebrae to be underrepresented at Aegean sites (Rose, 1994, 1995a) (Table 2).

Among the undiagnostic bones, many of the fragments of cranial/facial bones (29), vertebrae (67), and other elements from the axial skeleton (164) may also be from *Spicara* or small sparids. Three unidentified otoliths, in poor condition, are

	PSEIRA		ANATOMICAL
	PRESENT	RATIO	PROPORTION
First	6	1	1
Thoracic	4	0.67	3
Precaudal	47	7.8	4
Precaudal/caudal	12		
Caudal	50	8.3	16
Thoracic-caudal	16		

TABLE 2

Anatomical distribution of Sparidae/Centrarchidae vertebrae at Pseira (n=135).

probably not *Spicara*, while 2 unidentified otolith fragments may be. Details of these are published in the descriptions of the bones from each context that appear in the final reports (Rose, 1995b, in press, and in preparation).

Certainly there is variation in the distribution of fish remains within the site. Not all contexts yielded fish remains, and in those that did, the remains vary in terms of quantity and skeletal elements represented. The recent work at Pseira, however, includes both cleaning of areas investigated early in this century and full excavation of other areas. So contexts at the site are not necessarily equivalent in either their excavation history or original function in the Late Bronze Age (e.g., roadway or fill within residential building). Calculation of the density of bone by context (the weight of bone per liter of deposit excavated) may facilitate comparison of contexts, but that is beyond the scope of this paper. Here, for the 37 contexts with fish remains, it can be pointed out that the majority (27) have 10 or fewer remains, while 8 contexts have between 11 and 50, and 2 contexts have substantially larger numbers. There is some variation in the skeletal representation among the smaller contexts (e.g., contexts with 6, 7, and 19 otoliths and no other remains), and the general impression is of a background scatter and small groups of remains that may represent individual depositional events. Of the two larger contexts, one has a total of 366 remains of which 288 are otoliths and otolith fragments, the other has 165 remains of which 104 are vertebrae and fragments. Undoubtedly there are real differences in the contexts that could relate to deposition events (from tipped over pot of fish

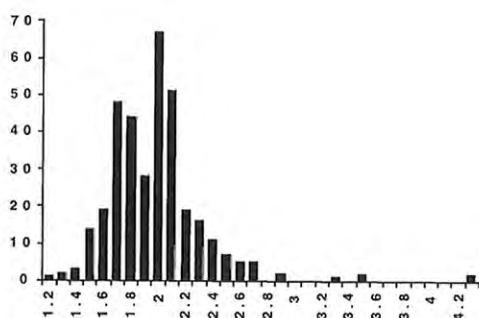


FIGURE 2

Frequency of *Spicara sagittae* at Pseira by height (MM)
(n=347)

There are few studies of Cretan archaeological fish remains assemblages from sites with adequate recovery to compare with Pseira. Excavations at Kommos, a Minoan harbour town on the south-central coast of Crete, produced an assemblage of about 1,100 bones, bone fragments, and otoliths of which 512 were identified taxonomically (Rose 1995a). Vertebrae were the most abundant skeletal element at Kommos, amounting to 64.6% (331) of the identified remains. Otoliths constituted 24.8% (127) and cranial and facial bones 10.5% (54) of the identified remains. In addition to this difference in anatomical representation between Kommos and Pseira, the majority of the otoliths (79 or 62.2%) were from sea bream, chiefly *Pagellus erythrinus*. Two assemblages from sites closer to Pseira, now under study, are apparently more similar to Pseira. Mochlos, a Minoan settlement on a small offshore island and the adjacent coast 3 km east of Pseira, also has abundant *Spicara* otoliths but not perhaps to the extreme seen at Pseira (Rose, unpublished data). Palaikastro, a large Minoan town and nearby peak sanctuary on the east coast of Crete some 40 km from Pseira, has numerous otoliths of small sparids or centrarchids (Dimitra Mylonas, pers. comm.). Perhaps there is a distinct east Crete fish assemblage in which otoliths of small sparids and centrarchids are abundant for whatever reason, e.g. a regional fishery or similar physical conditions at the sites.

ASSEMBLAGE FORMATION

The survival of only *Spicara* vertebrae and sagittae, and the categorical dominance of the latter element, invite comments about the taphonomic and cultural agents that might be responsible for this distribution. The distribution of remains, however, argues against butchery or discard: we have otoliths and some vertebrae, but no cranial or facial bones. Scavenging may have played a role in the assemblage formation, but the limited data on otolith survival in mammalian digestive tracts is ambiguous. Three of five otoliths ingested in experiments with dogs survived, but two were acid polished, one severely (Jones, 1984, 1986; Wheeler & Jones, 1989: 74). Species involved included snapper (*Lutjanus* sp.), haddock (*Melanogrammus aeglefinus*), plaice (*Pleuronectes platessa*), and herring (*Clupea harengus*). The one snapper otolith ingested and two haddock otoliths survived, alt-

hough they were diminished in size and exhibited an acid polish, which the Pseira otoliths do not. In another study most of the bones of ten herring heads fed to a dog were nearly completely destroyed (Jones, 1990). Otic bullae were the most abundant element to survive, but were scarcely identifiable; the report makes no mention of otolith survival.

Processing for consumption by humans may also have affected the composition of the assemblage at Pseira. *Spicara* are used for soup in traditional Mediterranean cuisine today; they are also fried or simply dried (Davidson, 1981: 90-91, 247, 373). Given their small size, the *Spicara* at Pseira could have been eaten whole. As with scavenging, experiments on human digestion of whole *Spicara* might elucidate the durability of otoliths compared to other skeletal elements.

Were the Pseira fish prepared by boiling? None of the remains has outward indications of burning but boiling would leave none. The bones have not been tested for collagen deformation indicative of heating (Richter, 1986). It may be worth recalling that Sir Arthur Evans found fish bones, otherwise unidentified, in a Middle Minoan III tripod vessel at Knossos (Evans, 1921: 554-556). A deep vessel suitable for use in boiling food, the tripod cooking pot is the most common cooking vessel at Pseira and elsewhere on Minoan Crete (Betancourt, 1980; Martlew, 1988). Perhaps boiling was a common method of preparing fish.

Nicholson's (1992a, 1992b, 1995) studies of the survival rates of fish remains are relevant here. Using a lapidary tumbler to simulate abrasion in archaeological deposits, Nicholson compared fragmentation of cooked and uncooked remains of haddock, plaice, and herring, and observed that boiled bones were destroyed more rapidly than uncooked bones (Table 3, adapted from Nicholson, 1992a: 82, table 2, and 83, fig. 1). For otoliths, Nicholson states that when tumbled with sand and gravel they became polished but that they broke when tumbled with pebbles or ballbearings. She does not report if there were differences between survival rates of boiled and uncooked otoliths. In another experiment, which may be significant for Pseira, Nicholson found that after two hours of constant trampling otoliths of boiled fish survived whole while the bones were mostly destroyed (Nicholson, 1992a: 88). More recent experiments by Nicholson (1995) confirm that cooking makes fish bones more fragile than otoliths.

	BOILED ONE HOUR		UNCOOKED	
	GRAVEL	SAND	GRAVEL	SAND
Haddock	23	69	95	98
Plaice	55	78	97	98
Herring	10	32	61	95

TABLE 3

Percentage survival of fish bones after 300 hours in lapidary tumber (otoliths excluded).

Conditions at the site affecting the preservation of fish remains must also be considered. Micro-morphology studies at the site indicate the sediments are considerably reworked rather than primary deposits (unpublished studies by Paul Goldberg, Boston University). Given the fragility of small *Spicara* cranial and facial bones, it is not surprising that none survived. The relative scarcity of vertebrae may be explained for the same reason. Otoliths, however, may be more durable than once believed (cf. Wheeler & Jones, 1989: 63; Lyman, 1994: 435-436). Perhaps their small size and shape, an elongate lentoid form, protected them from physical processes that destroyed the cranial and facial bones and most of the vertebrae. Favorable soil conditions at the site may have limited chemical destruction of the otoliths. The soils on the island are alkaline (pH 7.4 -8.2), medium-texture sandy silt loams (unpublished studies by Julie Clark, RADARSAT International, Inc., Richmond, British Columbia).

CONCLUSIONS

The assemblage from Pseira is marked by an abundance of otoliths of a single taxon and few other remains. This abundance may have several causes. *Spicara* may well have been more commonly caught than other fish to begin with. The *Spicara* present in the assemblage are quite small, and their cranial and facial bones would have been delicate, making them susceptible a combination of strong destructive mechanical forces (shifting and consolidation of deposits, trampling, etc.) and Minoan cooking practices (boiling). Cooking would have affected the *Spicara* otoliths less, and once deposited they survived because of their compact shape and favorable soil conditions. Domi-

nance of the assemblage by sagittae is as likely to be the result of these factors as other causes, whether human activities (e.g., butchery, discard, or consumption) or scavenging by dogs or other animals. Future experimental studies of the survivability of *Spicara* skeletal elements and comparisons with fish remains from nearby sites may help to clarify what taphonomic factors created the Pseira assemblage.

ACKNOWLEDGEMENTS

I thank Philip Betancourt and Costis Davaras for permission to study the Pseira fish remains and David Reese, Field Museum of Natural History, for his generous assistance. Support for the Pseira excavations has been provided by the Institute for Aegean Prehistory. Dimitra Mylonas kindly shared preliminary observations of the Palaikastro fish assemblage.

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Correlations between sample size and relative abundance of fish bones: examples from the excavations at Arbon/TG Bleiche 3, Switzerland

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(Received 18 December 1995; accepted 11 April 1996)

ABSTRACT: A method of on-site sample selection for both animal and plant remains from waterlogged deposits is discussed. On large sites, where it is not always possible to process all sediments, a program of random sampling is advised in order to collect representative data. Sample size is further discussed and some specific effects of differential selection on fish bones are shown.

KEYWORDS: RANDOM SAMPLING, ON-SITE SAMPLING, SAMPLE SIZES, WATERLOGGED SITES, NEOLITHIC, FISH BONES, PSYCHOLOGICAL EFFECTS

RESUMEN: El trabajo valora un método para la selección en el yacimiento de muestras, tanto faunísticas como botánicas, en depósitos saturados por agua. En yacimientos extensos, donde no siempre es posible procesar todo el sedimento, se aconseja llevar a cabo un programa de muestreo al azar a fin de recoger información representativa del conjunto total. El tamaño muestral es analizado en detalle mostrándose una serie de ejemplos específicos sobre la selección diferencial en huesos de peces.

PALABRAS CLAVE: MUESTREO AL AZAR, MUESTREO IN SITU, TAMAÑO MUESTRAL, SEDIMENTOS SATURADOS DE AGUA, NEOLÍTICO, HUESOS DE PECES, EFECTOS PSICOLÓGICOS

INTRODUCTION

One of the most difficult questions posed by analysis and interpretation of faunal remains is which method of collection from archaeological sites will provide representative samples. As various authorities have shown, too many small bones are overlooked by hand-picking during excavation (Payne, 1972; Clason & Prummel, 1977; Wheeler & Jones, 1989), so sieving is essential, particularly for representative sampling of taxa which have relatively small bones, notably fish. However, because of limitations on time and money, it is simply impractical to sieve all material from substantial excavations. Consequently, there is a problem in deciding upon a general sampling strategy.

Theoretical discussions (Mueller, 1975; Van der Veen, 1985) suggests that different strategies need to be adopted for different kinds of sites. In this

paper, we discuss the development of a sampling strategy for fish remains from waterlogged, lake-shore, sites of Neolithic age in Switzerland. These sites contain layers rich in organic debris, distributed quite uniformly. The method is worked out for the site of Arbon Bleiche 3 (Figure 1).

MATERIAL AND METHODS

The excavation of Arbon Bleiche 3 took place at Lake Constance from 1993 to 1995. The site is dated to 3.400 BC, which places it between the Pfyn and Horgen cultures, a key stage for understanding the ecological and economic developments in the alpine area. Dendrochronological studies indicated that the site was occupied for 17 years. Seven years after its establishment, the village was expanded by several houses. The settle-

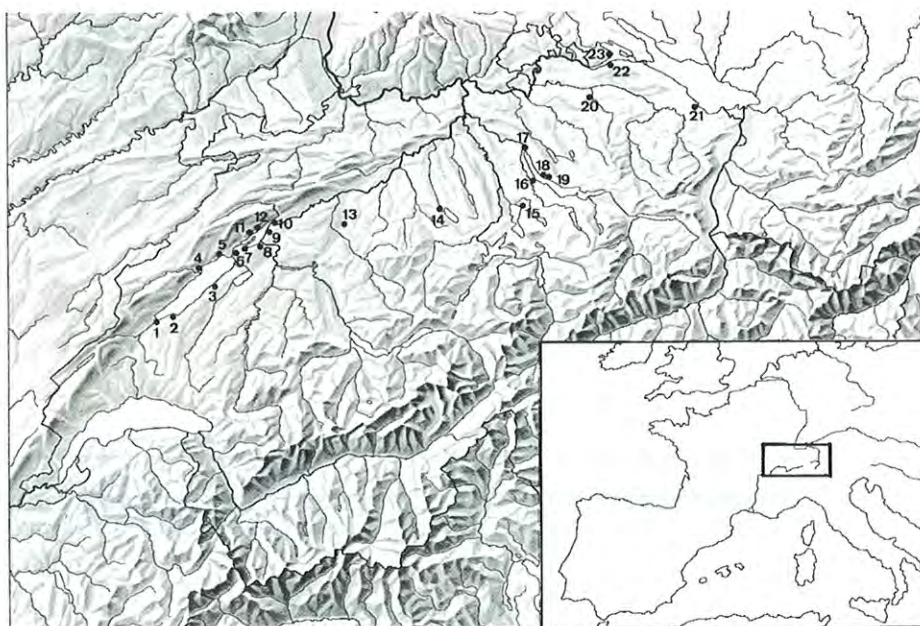


FIGURE 1

Neolithic lake shore sites in the alpine area. 1: Yverdon-Garage Martin; 2: Yvonand station III et IV; 3: Portalban-Les Grèves; 4: Auvernier-La Saunerie, Auvernier-Brise Lames, Auvernier-Port; 5: St. Blaise-Bains des Dames; 6: Thielle Wavre-Port de Thielle; 7: Vinelz-Strandboden, Vinelz-Grabung Strahm 1960, Vinelz-Hafeneinfahrt, Vinelz-Alte Station; 8: Lüscherz-Binggeli, Lüscher-Dorf-Äussere Station, Lüscherz-Fluhstation; 9: Latrigen VI, Sutz-Rüte; 10: Nidau-BKW 5, Nidau-BKW 3; 11: La Neuville-Chavannes; 12: Twann E1-9, Twann UH, Twann MH, Twann OH; 13: Seeberg-Burgäschisee SW, Seeberg-Burgäschisee Süd; 14: Egolzwil 3, Egolzwil 5; 15: Zug-Vorstadt; 16: Horgen-Dampfschiffsteg; 17: Zürich-Kleiner Hafner, Zürich-Mozarts-trasse, Zürich-Seefeld Kan.San., Zürich-Presssehaus, Zürich-AKAD/Presssehaus, Zürich-Mythenschloss; 18: Feldmeilen-Vorderfeld; 19: Meilen-Rohrenhaab; 20: Gachnang-Niederwil-Egelsee; 21: ARBON-BLEICHE 3; 22: Steckborn-Turgi, Steckborn-Schanz; 23: Hornstaad-Hörnle I (BRD).

ment was finally abandoned after a fire. There is one single cultural layer of 5 to 40 cm, containing organic material and large concentrations of charcoal and clay. The preservation of the material is truly extraordinary. In addition to thousands of hazelnut shells and bones, complete dog faeces containing fish bones, carbonized crusts of food in pots, and moss which was practically still green have been retrieved.

Working with archaeobotanical staff, a single sample was sieved in order to obtain material for both zoological and botanical analyses. The sample was divided into two fractions using a water-sieving-tower: one fraction contained material larger than 2 mm, the other material from 0.5 to 2 mm. The sieving and sorting was done in the field by students who had been introduced to the site some months earlier during a course in archaeobiological fieldwork. Specialists were responsible

for the identification of questionable pieces at the excavation and later in the laboratory. From material excavated during 14 days in 1994 and 21 days in 1995 a total of 65 samples (305 liters) were analysed. These came from an area approximately 75 m². Each sample was taken from a quarter of a square meter.

In the first year, 44 samples were used to address the question of the minimum number of fish bones which must be identified in order to have reasonably accurate results, and to determine the ideal volumes of the samples. The excavated area was at the edge of the prehistoric settlement. Since the locations of structures like houses, streets, stables etc., was unknown a random sample was drawn from the total number of square meters. Each soil sample was about 25 liters. From every soil sample we drew one subsample of 10 liters and another of 1 liter. In 1995, we used the same

basic procedure, except that we drew 3 liter samples from an area excavated at the center of the site. A random sample was also drawn, but in contrast to 1994, this time we knew about structures and could recover samples from inside and outside the houses, stables, streets and equivalent features. The samples were then sieved to fractions. Most fish bone was not found in the small fraction or the hand-collected material, but came instead from the 2 to 8 mm fraction. In the first sort, only vertebrae were identified. The results presented here are from this material.

RESULTS

Not all of the fish remains collected from Arbon Bleiche have been identified. Nevertheless, it is unlikely that the frequency distribution of species will change significantly with additional specimens. We can therefore assume that the amount of whitefish (*Coregonus sp.*) shown in Figure 2a is real. Since this is the first time that whitefish has been identified in Neolithic settlements in Switzerland, these have to be studied separately (Hüster-Plogmann, in preparation). Beyond that, the typical Neolithic ichthyofauna is represented by perch (*Perca fluviatilis*), pike (*Esox lucius*), and several species of Cyprinidae. Amazingly, the frequency distribution of recovered fish differs only slightly from the natural distribution recorded in 1935, when Lake Constance was less polluted and eutrophic than today (Hüster-Plogmann & Leuzinger, 1995).

It has become clear that there is no significant difference between the methods of random sampling used in 1994 and 1995. As a matter of fact, although the sampling procedure was different, the frequency distribution of species appears quite similar. There are also no major differences in the distributions of species among the various sample sizes: the 10 liter, 3 liter and 1 liter samples show very similar results (Figure 2b). Certainly the amount of bones varies among the samples. But since we have the same number of samples in each group and the main species are represented in almost every sample with the frequency distribution being basically repeated in every sample, we can assume that representative samples can be drawn, whether or not we are informed about the location of features. Surprisingly, it looks like the 1 liter, or at least the 3 liter samples, are large enough to get representative results.

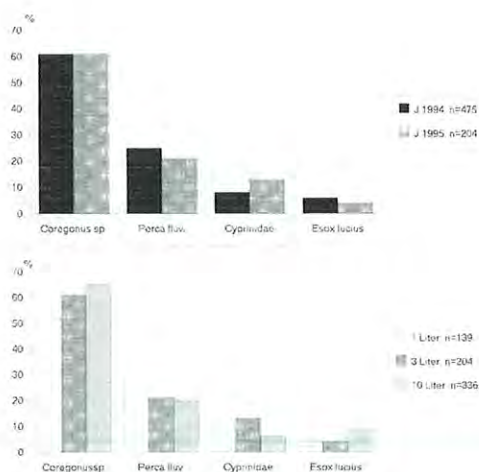


FIGURE 2

Fish bone. Arbon Bleiche 3. Overall frequency of species and the frequencies of species in different sized samples.

Another unexpected observation after a comparison of the 1 liter and 10 liter samples from 1994 was made. Assuming that the bones were randomly distributed within a sample (that is, that there are no systematic clusters of bone), the quotient of the 10 to 1 liter samples ought to be 10. In other words, we should expect 10 times more bones in 10 liters than in 1 liter. This does not seem to be the case (Figure 3). Five samples show about 10 times more bone, two show much more, but most of the samples are less than three times larger. So we actually missed bones in the 10 liter samples. We tried to analyze this loss although it is almost impossible to verify statistically. Figure 4 is a box plot showing the frequency of fish bones in the various samples (numbers per liter). Both the 10 liter and the 1 liter groups show equal or similar numbers of samples with few bones, but there are more samples with high numbers of bones in the 1 liter group.

If we were to split the perch and whitefish bones into crania and vertebrae, the frequency of headbones (Figure 5a) is similar to all bone combined: there are more samples with high numbers of bones in the 1 liter group. The head bones of small fish look quite similar to leaves, pieces of wood or stalks, so they could have been overlooked by the students. It is more likely that this happens in the 10 liter samples because it is a huge amount of material to process when one is under time pressure.

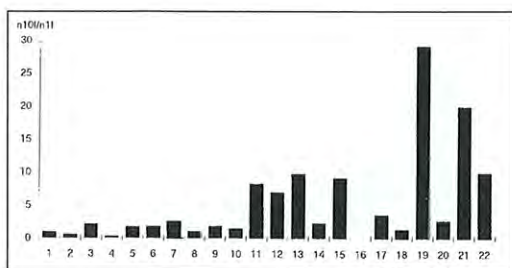


FIGURE 3

Fish bone. Arbon Bleiche 3. Ratio of fish bone in 10 liter and 1 liter samples (n10liter/n1liter).

The frequency of perch vertebrae (Figure 5b) appears to be quite similar (i.e., there are more samples with concentrations of perch in the 1 liter group). A contributing factor may be that different sized perch are represented in the material. Some bones are from individuals 30cm long, but most come from fishes smaller than 10 cm. It is possible that some of the small specimens were missed in the 10 liter samples in the same way we assume happened with the head bones.

Whitefish samples exhibit no differences between the 10 liter and 1 liter groups (Figure 5c). In my opinion, this is due to the fact that the vertebrae of *Coregonus* are very uniform in size and shape. If you have seen these vertebrae once, you will recognize them forever. Perhaps we should be much more aware of psychological effects on the sorting and identification of archaeological materials.

DISCUSSION

In this case study we tried to develop strategies for identifying optimal sample sizes and for random sampling on excavations. Our initial idea was to sample both seeds and bones with one single strategy. According to Van der Veen (1985) the required sample size depends on four variables. First of all, one has to deal with the amount of material in the target population (in her case total amount of plant refuse generated on a site), which can often be said to be infinitely large. Second is the proportion in which particular species occur. Two additional factors to take into account are the required degree of accuracy (in absolute terms), and the probability of achieving that accuracy. In Van der

Veen & Fieller (1982) a set of formulae is presented for calculating in advance the required sample sizes and confidence intervals for differing circumstances. In our case, we estimated that we needed about 550 specimens to fall within a 95% confidence interval for our sample populations. This turned out to be an easy target sample for the seeds, but not for the fish bones. In particular in the center of the site, the proportion of fish bones varied too much to systematically yield enough bone material. This is the reason why we went through the entire sample collecting bones, but stopped in the case of plant remains after arriving at 550 seeds. The frequency distributions for every sample were not statistically identical.

In general, we know about correlations between the number of collected bones and the number of identified species (Grayson, 1984). If we expect our target fish population to include no more than five common species and an additional 10 rare species at the most (which is a quite realistic estimation with lakeshore settlements in Switzerland), according to our calculations, most of these should be represented within 200 to 300 identified bones. This is what we found.

Random sampling yielded similar results for both botanical and zoological materials and, as mentioned above, the results with and without knowledge of structures are comparable. Nevertheless, there are differences to be discussed.

Organic remains in prehistoric sites cannot be assumed to be homogeneously distributed. There-

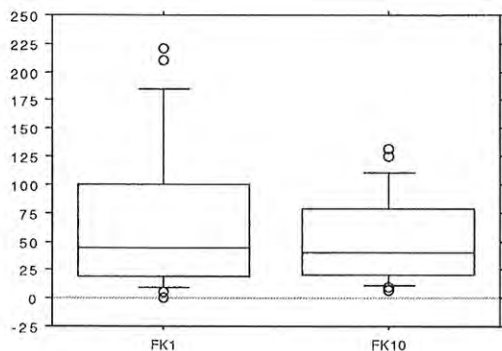


FIGURE 4

Fish bone. Arbon Bleiche 3. Frequency in 1 and 10 liter samples (n1). Box plot showing the 10th, 25th, 50th (median), 75th and 90th percentiles of the variable. Values above the 90th and below the 10th percentile are plotted as points.

fore, one has to find a way to establish a mean value. If no information is available about the site beforehand, it seems necessary to take samples in a very intensive and regular manner. In 1994, we took 22 samples from an area of 25 square meters, which means that a quarter of almost every square meter was sampled. This is a time- and money-consuming procedure that can be hardly carried out on large areas. One has to choose the «right» spots of the site.

Another situation occurs if one has knowledge about structures and features in the site. One suggestion then is that these structures or features be divided into archaeologically recognisable categories and that samples be taken out of each category. This procedure allows bones to be related to specific features at every stage of analysis. Another advantage of this kind of random sampling is that the dependence on one particular area is quite low. It allows samples to be taken from all areas and all stages of an excavation.

CONCLUSION

The case study of Arbon Bleiche allows us to make some recommendations concerning random sampling in excavations of waterlogged lake shore sites. In principle, it is possible to obtain representative results without knowledge of the structures in a site. In that case, however, sampling must be dense and regular. A better way is to focus on structures and/or features. The volume of each sample to be taken certainly depends on its density of bones, but something between 1 and 3 liters should work. As a matter of fact, it looks as if it is worth taking low volume samples not only to achieve a good representation of data; there might be good psychological arguments for doing so as well.

ACKNOWLEDGEMENTS

I would like to thank J. Schibler (Seminar für Ur- und Frühgeschichte, Basel) and S. Jacomet (Botanisches Institut, Basel) for providing the opportunity for the archaeobiological fieldwork at Arbon Bleiche, and for many discussions over the past two years. Additional thanks are due to colleagues and students at the excavation, who were ex-

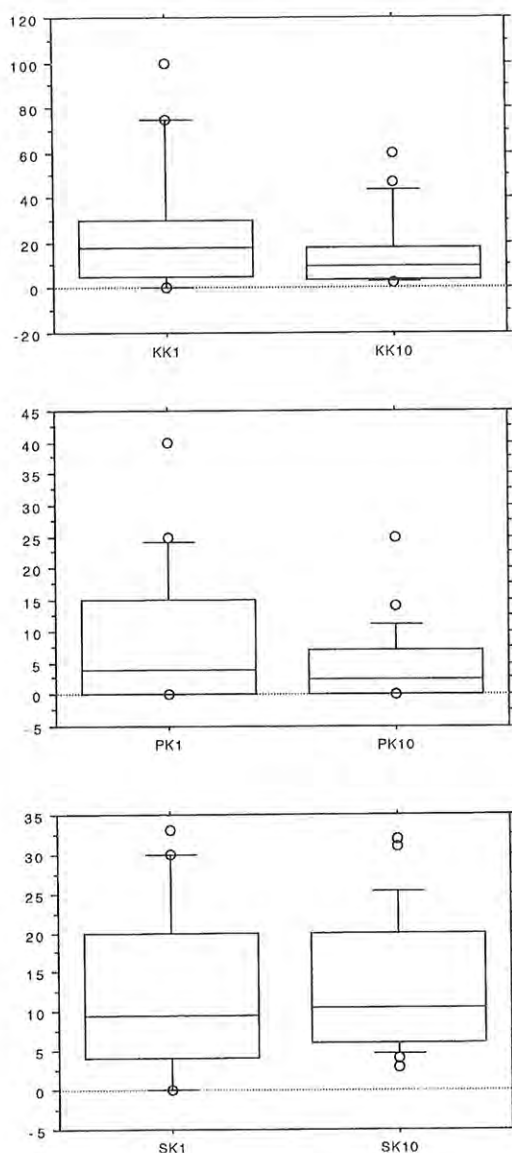


FIGURE 5

Fish bone. Arbon Bleiche 3. Frequency (n/l) of head bones (5a, KK1 liter and KK10 liter), vertebrae of *Perca fluviatilis* (5b, PK1 liter and PK10 liter) and vertebrae of *Coregonus* sp. (5c, SK1 liter and SK10 liter). Box Plots, showing the 10th, 25th, 50th (median), 75th and 90th percentiles of the variable. Values above the 90th and below the 10th percentile are plotted as points.

tremely patient with the fish bone and with me. I am also grateful to M. Glass, Tempe, Arizona, who corrected the text.

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Lake sturgeon fishing at Prehistoric Iroquoian sites near Lake Simcoe, Ontario

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(Received 13 December 1995; accepted 12 April 1996)

ABSTRACT: This paper is part of continuing research into fish subsistence strategies at several prehistoric Iroquoian sites near Kempenfelt Bay on Lake Simcoe. Lake sturgeon bones were found at each of these sites, although they are only present in significant numbers at the earliest one. A desire to establish how sturgeon fishing fit into the subsistence schedule of the site inhabitants prompted a survey of the relevant ethnohistoric and fisheries sources, as well as discussions with fisheries biologists. This paper discusses the range of fishing techniques and variety of locations that may have been used to catch sturgeon. It also suggests ways of determining time of capture. Analysis in progress of incremental growth in pectoral spines may to some extent narrow the range of possibilities. Lake sturgeon were most easily and reliably obtained during the spring spawn run at the headwaters of the Nottawasaga river. There are, however, several other possible scenarios; this paper details the various factors that complicate interpretation.

KEYWORDS: LAKE STURGEON (*Acipenser fulvescens*), IROQUOIAN, SEASONALITY, FISHING TECHNIQUES

RESUMEN: Esta ponencia forma parte de un análisis todavía en marcha sobre el uso en la dieta de los peces por parte de los Iroqueses en varios sitios prehistóricos situados cerca de la Bahía Kempenfelt del Lago Simcoe. Huesos de esturión (*Acipenser fulvescens*) aparecen en todos los depósitos aunque sólo se recuperan en número significativo en el yacimiento más temprano. El interés en establecer el papel de la pesca del esturión en el patrón dietético de los Iroqueses impulsó un estudio de las pertinentes fuentes etnohistóricas y de pesquerías, así como discusiones con biólogos marinos. Esta ponencia discute las diversas técnicas y lugares de captura. Concluye que es necesaria más investigación de tipo esqueleto cronológico para reducir el espectro de posibilidades. Al parecer los esturiones se pescaban de forma más sencilla y eficiente durante la migración gamética primaveral a la cabecera del río Nottawasaga. Existen, no obstante otras alternativas que nuestro estudio se encarga de valorar.

PALABRAS CLAVE: ESTURIÓN, IROQUES, ESTACIONALIDAD, PATRONES DIETÉTICOS, TÉCNICAS DE PESCA

INTRODUCTION

Lake sturgeon (*Acipenser fulvescens* Rafinesque) bones were identified at three late prehistoric Iroquoian sites in south-central Ontario, near Lake Simcoe. This paper, based on research in progress, explores ways of determining method, location and timing of capture in order to establish where and when the lake sturgeons at these sites were obtained.

The three sites were occupied between about A.D. 1290 and A.D. 1525 (Table 1) and are close to the headwaters of the Nottawasaga River and Kempenfelt Bay on Lake Simcoe (Figure 1). Settlement patterns and faunal assemblage composition indicate that these sites were permanently occupied, year-round villages rather than fishing camps (Archaeological Research Associates Ltd., 1989; Needs-Howarth & Sutton, 1993; Needs-Howarth, 1994, 1995; Needs-Howarth & Thomas, 1994, in press; Sutton, 1994; Thomas, 1995). The

people living in these villages were related to the Huron, who were living in the area when European missionaries settled there in the 17th century.

Prehistoric Ontario Iroquoian subsistence in general is based on corn horticulture, hunting, fishing and gathering (see Williamson, 1990; Dodd *et al.*, 1990 for overviews). Animal procurement at these three sites appears to be characterised to a large extent by opportunistic, small-unit exploitation, probably involving passive technology like snares, traps and nets (Needs-Howarth & Sutton, 1993; Needs-Howarth, 1994, 1995; Needs-Howarth & Thomas, 1994, in press).

Bone preservation at the sites was generally very good and diagnostic features were preserved on many of the fish bones. Lake sturgeon elements are easily identified because of their distinctive surface structure and robusticity, but many of the cranial bones are poorly ossified.

RESEARCH AIMS

A preliminary study of fish subsistence strategies at two of the three sites discussed here, Barrie and Dunsmore (Needs-Howarth & Thomas, in press), combined information on spawning behaviour and co-occurrences of fish species within archaeological features to establish location and timing of catch. The results suggest that there was considerable variability in timing, location and method of fishing, not only between taxa, but also within taxa disposed of in different features, and

therefore presumably representing different catch events. Although several taxa were probably infrequently or rarely caught during their spawning run, it was argued that the co-occurrence of many lake sturgeon and sucker (particularly longnose sucker, *Catostomus catostomus*) or larger yellow perch (*Perca flavescens*) bones in a single feature might indicate these taxa were caught together during a period of overlap in their spawning runs.

This paper examines in more detail various (mostly non-archaeological) sources of evidence pertaining to where and when the lake sturgeon represented at these sites were caught. Do the bones come from spawn run sturgeon going from a lake up one of the local rivers in spring, do they come from a year-round, resident population from the river, or do they come from resident populations in Lake Simcoe or Georgian Bay? A river-resident population is not completely stationary; although it lives in the same body of water year-round, it may have a range of up to 160 km (Bill Beamish, pers. comm.).

To find out where and when the sturgeon were caught, three further issues have to be addressed: the first is «how did the occupants of the sites catch sturgeon?» This may indicate likely fishing locations and season of capture. The second is «what was the condition of the local water sources at the time, and did they support sturgeon populations?» This may indicate where sturgeon could have been caught. The third involves determining population structure: «were the sturgeon from these sites of spawning age, and more specifically, were they caught around spawning time?» This

SITE	approx. TIME OF OCCUPATION	LAKE STURGEON*	STURGEON/FISH	FISH**	FISH/ALL TAXA	ALL TAXA
Barrie (BcGw-18)	AD 1290-1350	67 ¹	20%	344	50%	694
Dunsmore (BcGw-10)	AD 1350	4 ²	< 1%	634	70%	903
Carson (BcGw-9)	AD 1450-1525	3 ³	< 1%	423	65%	650

TABLE 1

Summary of lake sturgeon identifications, expressed as Number of Identified Specimens. (1) 5 ossified first pectoral fin ray sections (MNI=2); 2 incomplete pterygoids; 56 probable cranial fragments; 3 miscellaneous post-cranial fragments; 1 dermal scute fragment (ridge is angular, possibly indicating a younger individual than pectoral spines, which are relatively large) - recovered from 3 of 3 middens and 8 features in 2 of 2 houses, none from the 4 external non-midden contexts (all contexts from excavated portion of site were analysed). (2) 1 mid-line cranial fragment, 3 unidentified fragments - recovered from 1 of 3 completely analysed middens and 1 of 10 partly analysed houses (site partly excavated). (3) 3 probable cranial fragments - recovered from 2 features in 1 house of 2 completely and 2 incompletely analysed houses (site completely excavated). (*) elements in University of Toronto and Royal Ontario Museum Vertebrate Palaeontology reference collections only partly labeled. (**) fish identifications below family level; NISP does not include spines, rays, scales or vertebrae (except for sturgeon pectoral spines and ictalurid pectoral and dorsal spines).

could imply spring-time exploitation and would narrow the range of catch locations.

There is a lot of published information on the commercial lake sturgeon fisheries during the nineteenth and early twentieth centuries, but not much specific information is available on local non-commercial fishing or on this taxon's natural habits and spawning locations. The following discussion, therefore, relies on ethnohistoric and fisheries sources and on information gathered from several fisheries biologists during interviews.

CATCHING LAKE STURGEON WITH TRADITIONAL METHODS

Lake sturgeon are freshwater bottom-feeders that usually live in highly productive shallower areas of large lakes and large rivers (Harkness & Dymond, 1961: 17). They spawn in rivers at depths of about 0.5 m to 5 m in areas of swift water or rapids, or at the foot of low falls that prevent further migration (Harkness & Dymond, 1961: 38). In the lower Great Lakes there were also po-

pulations of lake spawning sturgeon (Bill Bea-mish, pers. comm) that spawned in shallow water over rocky ledges close to shore or around rocky islands (Harkness & Dymond, 1961: 40). The spawning date is precisely determined by water temperature, which has to be between 13.9 and 15.5° C (Harkness & Dymond, 1961: 36, 38). For the lower great lakes, this means sometime in May. Spawning temperatures will be reached earlier in rivers than in lakes (Harkness & Dymond, 1961: 40). Reports on other seasonal movements are conflicting (Harkness & Dymond, 1961: 19).

Several ethnohistoric sources provide useful information on techniques of capture. Early visitors to North America described uniform and widespread methods of taking sturgeon. On the east coast they were commonly netted or speared (Rostlund, 1952: 11). During the spawning season, sturgeon are more noticeable and more preoccupied. The fisheries biologists consulted for this paper suggested they can be caught individually with a spear from the shore, especially if they are in shallow water. In deeper water they can be speared from a canoe.

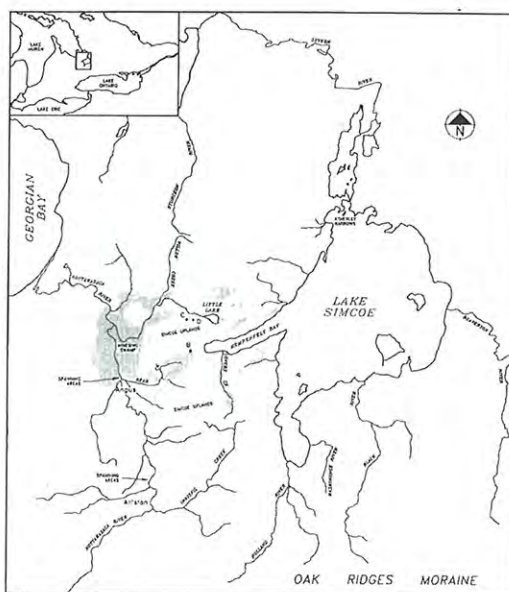


FIGURE 1

Location of sites and water sources. B = Barrie (BLGW-18); D = Dunsmore (BLGW-10); C = Carson (BLGW-9).

Map by Andrew Allan.

Spearing may also have been practiced on the lake. The French explorer Charlevoix (1923 [1761]: 236) described the following technique, relating to one of the Great Lakes (name not specified), during his visit to New France in 1720:

«Two men place themselves in the two extremities of a canoe; the [one] next [to] the stern steers, the other standing up holding a dart to which is tied a long cord, the other extremity whereof is fastened to one of the cross timbers of the canoe. The moment he sees the sturgeon within reach of him, he lances his dart at him and endeavours, as much as possible, to hit in the place that is without scales. If the fish happens to be wounded, he flies and draws the canoe after him with extreme velocity; but after he has swam the distance of an hundred and fifty paces or thereabouts, he dies, and then, they draw up the line and take him.»

Although sturgeon are not called biting fishes, they can be captured by means of set lines (Roslund, 1952: 11; Harkness & Dymond, 1961: 61). Iroquoian fishing nets were commonly made from Indian hemp (*Apocynum cannabinum*) (Sagard, 1939: 240) or nettle (*Urtica holosericea*) (Hennepin, 1903 [1698]: 522). Fishing line made from these fibres has about the same tensile strength as modern 12- to 20-pound (5.5-9 kg) utility test line (Salls, 1989: 186). The description of sturgeon fishing by Recollect Brother Gabriel Sagard, who lived among the Huron in 1623-24, may imply that sturgeon were caught with a hook and line. He states that hooks, made of wood with a bone bar tied with hemp cord, were often found in the stomachs of fish (Sagard, 1939: 189). In the same section he mentions that in Georgian Bay there were fish *«of such monstrous size that nowhere are they to be found bigger»* (Sagard, 1939: 189). This appears to indicate that the Huron used hemp fishing line to catch sturgeon, and that it was not always strong enough to hold the larger individuals.

Sturgeon are apparently easily entangled in gill nets because their pectoral spines get stuck, even in wide-meshed nets (von Brandt, 1964: 170). Father Louis Hennepin (1903 [1698]: 522) mentions that the Iroquois fished for whitefish and lake sturgeon with large gill nets that required two men at either end to draw them into shore. Sagard (1939: 185-186) recounts joining in a fishing expedition with the Huron. They went by canoe to an island in the «Fresh-Water Sea» [Georgian Bay of Lake Huron] and *«every evening they carried the nets*

about half a league or a league out into the lake, and ... at daybreak they went to draw them in, and always brought back many fine big fish such as As-sihendo [whitefish], trout, lake sturgeon, and others». Taking into consideration Sagard's comments about fish breaking the fishing line, it is likely that larger lake sturgeon would sometimes break these nets made from hemp or nettle. Nevertheless, netting probably was a highly effective manner of catching lake populations of sturgeon.

Other methods for catching sturgeon involve the use of impounding gear or a weir. There are native fish weirs on Lake Simcoe, which were described by explorer and missionary Samuel de Champlain in 1615 (Biggar, 1922-1936(3): 56-57).

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

The weir was investigated by archaeologists in the mid-1970s (Johnston & Cassavoy, 1978) and again in the early 1990s (Cassavoy, 1994). The orientation of the stake pattern indicates that the weir was, indeed, used to obstruct fish swimming with the current from Lake Simcoe toward warmer and shallower Lake Couchiching. However, another section of stakes was positioned to obstruct fish swimming upstream, towards Lake Simcoe. This part of the weir would entrap fish coming from Georgian Bay. Calibrated radiocarbon dates indicate that parts of the weir date back to around 2500 BC (Johnston & Cassavoy, 1978).

Although it would be interesting to link sturgeon fishing at the archaeological sites to a known prehistoric catch location, the weir was probably not designed to catch sturgeon. Excavator Kenneth Cassavoy (pers. comm.) suggests that the construction indicates that users of the weir were fishing for large quantities of smaller fish. The location itself was suggested as a possible catch location by several fisheries biologists (Bill Beamish, Lloyd Mohr, Tom Willans pers. comm.). It is likely that the resident Lake Simcoe and Lake Couchiching populations moved between their respective lakes, especially if they were part of the same genetic population (Bill Beamish, pers. comm.). It is not

known, however, whether they would have passed through the narrows to spawn. There may have been two Georgian Bay groups, one using the Nottawasaga river, the other the Severn river, to spawn. It appears likely, therefore, that sturgeon would get caught in the weir, but not necessarily in great numbers at a predictable time of year.

The modern Lake Simcoe population uses rivers on the eastern shore (Robin Craig, pers. comm.). The status of the Holland river, at the south end of Cook's Bay, is unclear. It appears too diffuse and calm for spawning (Bill Beamish, pers. comm.), but it is also unlikely that any of the tributaries of Lake Simcoe supported resident populations (David Noakes, pers. comm.). One article (Harkness & Dymond, 1961: 99) suggests the Holland river supported a commercial lake sturgeon fishery in the past, but does not specify whether this involved spawning fish, and does not cite a source.

Lake sturgeon can sometimes be caught from lake shoals; one biologist (Tom Willans, pers. comm.) reported seeing sturgeon off the shore of Lake Erie in areas so shallow that their backs were out of the water. Hennepin (1903 [1698]: 314) describes seeing sturgeon spawn on the shore of Lake Erie. However, there are several reasons why sturgeon would have been more accessible in a river than in a lake. They are fast water spawners, and even at other times of the year they prefer areas with a current. A river provides more opportunities for netting and somehow confining the fish. The inhabitants of these Iroquoian villages lacked the modern fishing gear and vessels required to safely access the local deep water Lake Simcoe population, and even the middle of Kempenfelt Bay may have been too deep to fish the resident sturgeon population with traditional methods (Robin Craig, Lloyd Mohr, pers. comm.), unless the sturgeon came close to shore.

STURGEON AVAILABILITY IN LOCAL WATERS

The annual commercial returns of lake sturgeon for Lake Simcoe peaked in the 1890s, but because of overfishing there was no significant population left by the beginning of this century (McCrimmon & Skobe, 1970: 30). It is likely that lake sturgeon were abundant in Lake Simcoe in prehistory. Nearby Lake Couchiching and the Holland and Se-

vern rivers also had a commercial lake sturgeon fishery (Harkness & Dymond, 1961: 99). Fisheries biologists (David Lostus, Bill Beamish, pers. comm.) confirm there was probably a year-round resident population in the Nottawasaga river in the past. There certainly is now, and was in the past, a resident population in Georgian Bay of Lake Huron, which spawned in the Nottawasaga river.

There are no significant barriers that form obvious spawning locations on the main part of the Nottawasaga river today (Dave Buritt, pers. comm.). There are ripples at Alliston (Fred Dobbs, Robin Craig, pers. comm.), but there were probably good spawning areas as well all around Angus (Fred Dobbs, pers. comm.), both up river (southward) from the sites.

Although lake sturgeon can travel great distances (Lloyd Mohr, Bill Beamish, pers. comm.; Harkness & Dymond, 1961: 19; Scott & Crossman, 1973: 87), they have a strong homing instinct (Harkness & Dymond, 1961: 19). Year classes of males spawn every 2 or 3 years, females every 4 to 6 years (Roussow, 1957; Magnin, 1962). A group of spawning sturgeon may, therefore, be composed of individuals of different states of maturity, and different ages and sizes (Roussow, 1957). It is likely, however, that members of the same population spawned in more or less the same locations, minimizing the year to year variation in which spawning sites were actually being used (Bill Beamish, pers. comm.).

There are ripples at the mouth of the river that may have provided a suitable spawning ground, especially at lower water levels (Robin Craig, pers. comm.). The mouth of the Nottawasaga would have been the most convenient and predictable place to obtain spawn run sturgeon. Travel to this location by water would have involved a canoe trip through the Minnising swamp (perhaps involving some portage) and down the Nottawasaga north-westward.

DO THE BONES ORIGINATE FROM SPAWNING FISH?

It may be possible to resolve which body of water the sturgeon came from and when they were caught by establishing whether the sturgeon from these sites were spawners. It has been argued (Neds-Howarth & Thomas, in press) that the co-occurrence of sturgeon and longnose sucker in the

same feature may mean they were caught during their spawning run. The literature confirms that «some late spawning suckers may have overlapped early spawning lake sturgeon» (Harkness & Dymond, 1961: 39). Suckers eat the roe of spawning walleye (*Stizostedion vitreum*) and it was suggested (Lloyd Mohr, pers. comm.) that they may do the same with lake sturgeon roe.

There may be more direct methods to address when the sturgeon were caught. The first step is to ascertain whether the sturgeon at these sites were sexually mature. Age at sexual maturity varies between bodies of water and by latitude (cf., Roussow, 1957; Harkness & Dymond, 1961). The first spawning takes place some years after maturity is reached (Roussow, 1957: 560). Nevertheless, it is probably safe to assume that if the sturgeon represented at the sites were older than 25 years, they were of spawning age (see Harkness & Dymond, 1961: 32, table II). This does not imply the fish were actually on their spawn run when caught, but it would allow for that possibility. There are some first (ossified) fin rays from the pectoral spine in the Barrie sample. Unfortunately their articular end is not complete enough to extrapolate fish size (cf., Desse-Berset, 1994), and thus obtain an indirect age estimate.

Age and growth interpretations on thin-sections of the spines are incomplete at the time of going to press. The following is a brief outline of the working hypotheses, based on preliminary research (Needs-Howarth & Casselman, 1996). Thin sections of sturgeon spines can be used to establish age and approximate time of capture (cf. Cuerrier, 1951; Cuerrier & Roussow, 1951; Roussow, 1957). It is likely that the archaeological spines from the Barrie site cannot be interpreted with as much confidence as the modern reference material. Because of their friable and partly mineralised condition, however, it might be possible to obtain a minimum age.

In theory, it is possible to establish season of death with even greater accuracy. Like many fish, sexually mature lake sturgeon form so-called spawning marks on certain bones, in this case on the pectoral spine (Roussow, 1957). If these marks were located on the two pectoral spines preserved from the Barrie site, it would indicate not only that the archaeological bone came from a sexually mature individual, but also when, in relative and to some extent absolute terms, it had most recently spawned.

However, even if the thin sections provide all the information that could possibly be hoped for, certain aspects of lake sturgeon physiology and behaviour will make it difficult to confirm or rule out spawn run exploitation. In older fish, the *annuli* are closer together, making age and season of death assessments more error-prone. An additional problem is that immature sturgeon (Harkness & Dymond, 1961: 17) and non-spawning mature sturgeon (David Noakes, pers. comm.) go up rivers in spring at the time mature fish of certain age classes are on their spawning migration. Finding fish without any spawning marks, therefore, does not preclude their having been caught from the river in spring. Conversely, finding mature fish together with spawn run fish also does not preclude their having been caught together from the river in spring. However, finding fish with a recently formed spawning mark would provide a good indication of timing of catch.

CONCLUSIONS

The aim of this paper is to investigate where and when the lake sturgeon at these three sites were caught. Do the bones represent spawning sturgeon caught from the Nottawasaga or Holland river, or a year-round, resident population from these rivers, or resident populations from Lake Simcoe or Georgian Bay? The paper addresses three further questions in an attempt to confirm or eliminate these three options.

The location and season of capture is investigated by establishing how the occupants of the sites caught sturgeon using available methods and implements. The fish from the river were most likely speared, those from the lake (gill) netted.

The location of catch is further elucidated by a survey of the condition of the local water sources at the time. There were almost certainly resident sturgeon populations in the Nottawasaga river, Georgian Bay and Lake Simcoe. There were also migratory populations that travelled from Georgian Bay up the Nottawasaga river and the Severn river to spawn. The mouth of the Nottawasaga is considerably closer, and there are several potential spawning locations close to the mouth.

The season and location of catch might be further narrowed down by establishing whether the sturgeon from these sites were of spawning age

and, more specifically, whether they were caught around spawning time. Based on preliminary research on age and growth, the paper concludes, however, that the quantity and condition of the archaeological material, together with certain aspects of sturgeon physiology and behaviour, would render population structure a somewhat inconclusive source of information on time of capture.

The fact that local sturgeon spawn in May does not mean they were exclusively caught during that time. Their movements vary within years and between years. The most predictable populations, the resident ones in Lake Simcoe or Georgian Bay, probably spent most of the year in less accessible, deep water. Even outside the spawning season in May, sturgeon would certainly be much more accessible in a river than in a lake. The zooarchaeological, archaeological, zoological and ethnohistoric data presented here, together with previous research on intrasite bone distributions (Needs-Howarth & Thomas, in press) indicate that it is likely that the site occupants were mostly exploiting semi-migratory spawning populations. If the pectoral spines prove to be from sexually mature individuals, age and growth analysis of pectoral fin rays may further support this argument.

The most productive and predictable place for a sturgeon fishing camp would probably be at, or close to, the mouth of the Nottawasaga during the spring spawn run. Nevertheless, it is evident that lake sturgeon were probably not an easily obtained resource. An obvious issue that is beyond the scope of the present paper is why there are so many lake sturgeon bones at one of these sites, when locating and catching sturgeon may have been a fairly labour- and time-intensive activity. Was lake sturgeon a special, perhaps mythically or religiously significant, fish for Iroquoian people? Was it considered more special by the occupants of the Barrie site, which has many sturgeon bones widely distributed across the site, than those of the Dunsmore and Carson sites, which produced only a few sturgeon bones? This clearly requires further investigation.

ACKNOWLEDGEMENTS

This research was sponsored in part by the Ontario Heritage Foundation. I thank the following people for the information and suggestions they

provided during informal interviews: Bill Beamish and David Noakes, Department of Zoology, University of Guelph; Dave Buritt, Nottawasaga River Conservation Authority; Kenneth Cassavoy, Department of Anthropology, Trent University; Robin Craig, Fred Dobbs, David Lostus and Lloyd Mohr, Ministry of Natural Resources, Owen Sound; Tom Willans, Department of Biology, Trent University.

This paper benefitted from discussions with Edwin Crossman, Department of Ichthyology and Herpetology, Royal Ontario Museum, Richard Hoffmann, Department of History, York University, Ed Kinnigh, Department of Anthropology, McMaster University and Stephen Cox Thomas of Bioarchaeological Research. I am indebted to the ARCHAEOFAUNA reviewer for her helpful and detailed comments and suggestions.

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Food rules and status: Patterns of fish consumption in a monastic community (Ename, Belgium)

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(Received 20 March 1996; accepted 22 April 1996)

ABSTRACT: Fish remains are reviewed in four contexts from the benedictine abbey of Ename. The abbey, which is located in a bend of the river Scheldt, was founded in the late 11th century and destroyed at the end of the 18th century. The assemblages presented date from the late 12th - early 13th centuries until about 1700 AD and are compared amongst each other. Attention is focussed on diachronic changes in the food rules in the monastery, the variety of species consumed, the proportion of marine versus freshwater fish, and on the introduction and breeding of carp. Relations between the status and the food of the different inhabitants of the abbey are explored.

KEYWORDS: MEDIEVAL AND POST-MEDIEVAL PERIOD, FLANDERS, MONASTERY, SEAFISH TRADE, FRESHWATER ECOLOGY

RESUMEN: Se estudian en este informe los restos de peces procedentes de cuatro contextos de la abadía benedictina de Ename. La abadía, situada en un recodo del río Scheldt, fué fundada en el siglo XI y destruída a finales del XVIII. Las colecciones presentadas proceden de finales del XII y principios del XIII hasta aproximadamente 1700 d.C. y se comparan entre sí. Especial atención se ha dedicado a los cambios diacrónicos ocurridos en las reglas monásticas referentes a la alimentación, la variedad de especies consumidas, la proporción entre peces marinos y dulceacuícolas así como a la introducción y cría de la carpa. Se investigan asimismo las conexiones entre el estatus social y el alimento de los diferentes habitantes de la abadía.

PALABRAS CLAVE: EPOCA MEDIEVAL Y POST-MEDIEVAL, FLANDES, MONASTERIO, COMERCIO DE PESCADO MARINO, ECOLOGÍA DE AGUAS DULCES

THE ABBEY OF ST. SALVATOR AT ENAME

The abbey of St. Salvator at Ename (town of Oudenaarde, East-Flanders, Belgium) was an important monastic site in Flanders (Milis, 1977). The abbey, belonging to the Benedictine order, was founded in the period 1063-1070 A.D. by Baldwin V, count of Flanders. It was erected near the right bank of the river Scheldt (Figure 1), on a location formerly occupied by a castle (*castrum*) and its dependent settlement. The latter is described in the written sources as a *portus*, a harbour with trading activities. From 974 until 1050 this site formed the centre of a margravate constructed to defend the frontier of the German Empire.

Around the middle of the 11th century, war and territorial conflicts destroyed the castle and village, and an abbey was founded to demilitarize the zone (Milis & Callebaut, 1990; Callebaut, 1991). The original 11th century complex was gradually enlarged by successive building campaigns until the site was greatly damaged during the turmoil of the 16th century religious wars. The reconstruction of the abbey took place only slowly during the 17th century. Political events following the French Revolution at the end of the 18th century caused the final abandonment of the site and its total demolition (Callebaut *et al.*, 1988; Berings, 1989). Buried remnants of the foundations now form the only surviving part of the former building complex.

cesspit, indicates that we are dealing here with an elite, high status part of the medieval abbey. Unfortunately, only a small bulk sample was taken from the fill of the cesspit and the sieved fish remains were mixed with the hand-collected material. The archaeozoological finds can be taphonomically (*sensu* Gautier, 1987) be identified as table refuse. The faunal analysis of this context has been published by Ervynck *et al.* (1994).

A second context belongs to a younger building phase of the abbey (Figure 2B) and consists of the filling of a refuse pit (Figure 2B, WW) situated in the centre of the west wing, in a part of the 14th - 15th centuries abbey that must have served as guest quarters. All fish remains from this context were collected from sieved bulk samples. Taphonomically, they presumably represent table leftovers (unpubl. data). Preservation conditions for bone were not as good in this context as in the other assemblages studied.

The third context analyzed previously was found in a kitchen and dates to around 1500 A.D. (Figure 2B: KF). In the kitchen, a loose sandy layer with a high density of fish remains was excavated and sieved in its entirety. Analysis of the stratigraphy, the nature of the sediment, the presence of tiny fish bones and some special finds lead to the conclusion that the material must have accumulated under a wooden floor (Ervynck & Van Neer, 1992). Clearly, we are dealing with an assemblage comprising kitchen refuse, with some possible admixture of table refuse.

The youngest context, dating to around 1700 A.D. (De Groote & Lemay, 1993), is the cesspit of the prior's residence (Figure 2B: CP). This priory was installed early in the 17th century in a former chapel that had been severely damaged during the 16th century religious wars. The conversion from chapel to priory included construction of a cesspit connected to the building. A later rebuilding and extension of the prior's residence meant this cesspit was abandoned in the early 18th century. The contents of the cesspit were completely sieved and, given that there was no kitchen in the prior's residence, have been taphonomically classified as table refuse (Cooremans *et al.*, 1993).

The four contexts described are the first of a long series that we hope will elucidate the food supply and consumption patterns within the abbey. The aim of the Ename research project is not only to reconstruct the way that cultural and economic factors influenced the food supply and consump-

tion. It will also investigate whether there are any diachronic trends in the consumption patterns and whether these can be linked to changes in the economy of the site or in the ecology of the surrounding landscape. Moreover, it will be possible to perform intra-site analyses within limited time periods. These could reveal differences between contemporaneous assemblages which may be explained in terms of taphonomy, social context or function of the feature investigated.

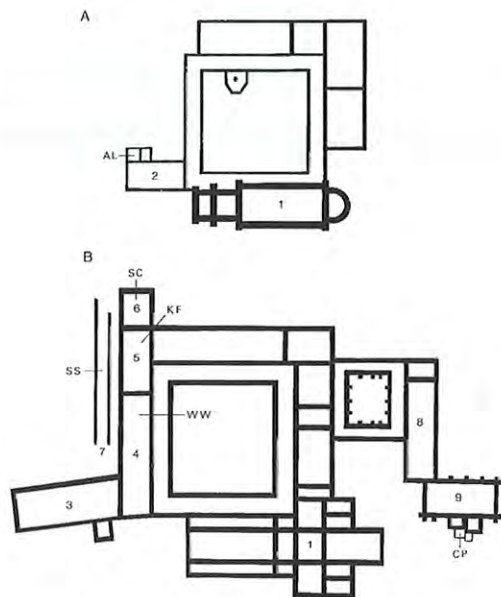


FIGURE 2

Plan of the abbey at Ename with main functional units of the 11th century building phase (A): St. Salvator's church (1), abbot's dwelling / guest quarters (2) and of the late and post-medieval building phase (B): abbot's house (3), guest quarters (4), kitchen (5), scullery (6), sewage system (7), infirmary (8) and prior's residence (9). Archaeozoological contexts mentioned in this study are a cesspit of the abbot's dwelling (AL), a rubbish pit in the west wing (WW), a kitchen floor (KF), the floor of the scullery (SC), the sewage system (SS) and the cesspit of the prior's residence (CP).

FOOD RULES IN A BENEDICTINE MONASTERY

Except for the cesspit of the abbot's dwelling, all contexts studied contained only small proportions of mammal bones; fish remains dominated the bone assemblages, comprising from 80% to

more than 90% of the NISP of vertebrate remains (Ervynck & Van Neer, 1992; Cooremans *et al.*, 1993; Ervynck *et al.*, 1994; unpubl. data). This pattern must be linked to the food rules that were followed within a Benedictine monastic community. The *Regula Sancti Benedicti* promoted a moderate way of life, including dietary habits, but was only a set of theoretical principles. These were translated into *consuetudines*, practical guidelines for daily life within each community (Callebaut *et al.*, 1988). Unfortunately, written evidence of these *consuetudines* is not preserved for the abbey of Ename, making it impossible to determine specific nutritional practices within that community. Generally, one can suppose that dietary rules were rather strict in the 11th century abbey, but that their application became more and more relaxed through time. It is possible that the monks originally followed a vegetarian diet (L. Milis, *pers. comm.*), but archaeological contexts from the earliest occupation phase, thus far unpublished, suggest that this diet was not strictly followed or that the rules were soon applied in a more flexible way. Perhaps the monks lived on a diet of fruits, vegetables and fish, which excluded the meat of quadrupeds and birds. In late medieval or post-medieval times, however, meat was gradually more and more included in the diet, although the consumption of animal products during special periods of the year such as Lent or the Advent remained restricted to fish.

This hypothesis about the evolution of the consumption pattern within the abbey will be further tested by the archaeozoological analysis of more contexts with consumption refuse but even now, it can be stated that the abundance of fish remains in most contexts accords with the food rules described. That the 12th - 13th centuries cesspit of the abbot's house had an exceptional high frequency of mammal remains can perhaps be explained by the fact that the high status guests who dined with the abbot did not have to follow the dietary rules. Later guests staying in the west wing of the 14th - 15th century abbey, who were perhaps of lower status than those residing in the abbot's house, seem to have observed the dietary rules. The kitchen floor context and the cesspit of the prior's residence also point to fish as the main animal (i.e. meat) product, although it is possible that the consumption of meat without bones attached left no traces in the latter context which consisted only of table refuse.

All contexts together show a spectrum of at least 25 fish species (Table 1). Ten of them are fresh-

water species, three are anadromous taxa and twelve are marine. This diversity is high for sites from northwestern Europe and, in fact, the Ename site has yielded more fish species than any other Belgian archaeological site (cf. Van Neer & Ervynck, 1994a). This suggests that the abbey had enough means to achieve a varied diet and also that, when food is limited by dietary rules, this need not necessarily result in a monotonous consumption pattern.

FISH OF THE SCHELDT BASIN

From the fauna that occurred naturally in the inland waters of Flanders, cyprinids (Cyprinidae), pike (*Esox lucius*) and eel (*Anguilla anguilla*) were the species most commonly eaten at Ename (Table 1). The domestic carp is excluded in this survey of freshwater fish, because it was introduced by man into our regions (see below). Many of the cyprinid remains from the three contexts that were completely sieved (WW, KF, CP) were not identified beyond family level but it is clear that they formed the greater part of the freshwater fishes consumed (Figure 3). The finds from the same three contexts suggest that eel was still important for the food supply around 1350-1450 A.D. diminishing in more recent periods. At present there is no clear explanation for this pattern; a link to changes in the ecology of the waters surrounding the site cannot be proven. Remains of pike reached the highest frequency in the cesspit of the prior's residence (CP) but whether this difference is meaningful or has any underlying cause remains to be investigated by comparison to more contexts.

Perch (*Perca fluviatilis*), ruffe (*Acerina cernua*) and burbot (*Lota lota*) were poorly represented among the freshwater species in the contexts studied (Table 1). The latter species is now extinct in the Scheldt basin (Bruylants *et al.*, 1989) but the finds from Ename prove that the species survived until the beginning of the 18th century in this part of the Scheldt basin. According to old fisheries literature, the burbot was still rather common in the Scheldt in the mid-19th century (De Selys-Longchamps, 1842).

Remains of fish that migrated from the sea into the river Scheldt to spawn, are found only in very small numbers in the context deposited around 1500 A.D. under a kitchen floor (KF) (Table 1).

Three species are present: sturgeon (*Acipenser sturio*), a whitefish species (*Coregonus* sp.) and a salmonid (*Salmo* sp.). The salmonid finds could represent the Atlantic salmon (*Salmo salar*) or the sea trout (*Salmo trutta*). The one *Coregonus* vertebra comes from an animal of 30 to 40 cm SL. It is supposed that three species –*Coregonus oxyrin-*

chus, *C. lavaretus* and *C. albula*– must be taken into account for the North Sea (Nijssen & de Groot, 1987: 103), but the diagnostic characters on the skeleton that distinguish them are not known.

None of the anadromous species found at Ename presently survive in the Scheldt basin. Ho-

	AL	WW	KF	CP
Thornback ray (<i>Raja clavata</i>)	-	1	13	4
Herring (<i>Clupea harengus</i>)	4	59	234	590
Cod (<i>Gadus morhua</i>)	2	-	8	76
Whiting (<i>Merlangius merlangus</i>)	-	-	10	31
Haddock (<i>Melanogrammus aeglefinus</i>)	-	4	14	13
Gadids (Gadidae sp.)	2	7	59	68
Gurnards (Triglidae sp.)	-	2	-	-
Turbot (<i>Scophthalmus maximus</i>)	-	-	1	2
Plaice (<i>Pleuronectes platessa</i>)	-	-	8	-
Flounder (<i>Platichthys flesus</i>)	-	-	1	-
Plaice / flounder / dab (Pleuronectidae sp.)	-	9	149	36
Sole (<i>Solea</i> sp.)	-	15	17	8
Sturgeon (<i>Acipenser sturio</i>)	-	-	1	-
Houting (<i>Coregonus</i> sp.)	-	-	1	-
Salmonid (<i>Salmo</i> sp.)	-	-	2	-
Eel (<i>Anguilla anguilla</i>)	5	39	175	50
Bream (<i>Abramis brama</i>)	-	1	-	16
Barbel (<i>Barbus barbus</i>)	-	-	-	2
Silver bream (<i>Blicca bjoerkna</i>)	-	1	-	-
Orfe (<i>Leuciscus idus</i>)	-	-	-	15
Roach (<i>Rutilus rutilus</i>)	-	2	11	14
Rudd (<i>Scardinius erythrophthalmus</i>)	-	1	2	3
Common carp (<i>Cyprinus carpio</i> f. domestica)	-	35	267	344
Cyprinids (Cyprinidae sp.)	7	27	379	535
Pike (<i>Esox lucius</i>)	-	4	20	86
Burbot (<i>Lota lota</i>)	-	1	2	2
Ruffe (<i>Gymnocephalus cernuus</i>)	-	-	5	2
Perch (<i>Perca fluviatilis</i>)	3	2	9	15
Percid (Percidae sp.)	-	-	-	7
Total identified	23	210	1388	1919
Total unidentified	96	566	2360	2180

TABLE 1

Fish remains from the Abbey of St. Salvator: AL, cesspit of the abbot's dwelling (late 12th-early 13th centuries); WW, refuse pit west wing (1350-1450 AD); KF, kitchen floor (ca. 1500 AD); CP, cesspit of the prior's residence (ca. 1700 AD).

wever, the limited numbers in which the remains of these species were found at the abbey site suggest that their presence in the region may already have been sporadic in medieval times. For sturgeon, this interpretation is in accord with the data from the historical records, in which captures of this species were often noted as remarkable events (G. Tack, *pers. comm.*). For the salmonids, interpretations on former abundance are more difficult due to the apparently poor likelihood of their skeleton being preserved. Throughout the archaeozoological record in Belgium we noted very few salmonid bones, even in sites dated to periods when the impact of man on the ichthyofauna must have been minor (Van Neer & Erynck, 1994b). The absence of migrating species in contexts AL and WW (Table 1) can be due to the small sample size in both contexts. Whether the complete absence of bones from anadromous fish in the large collection from the cesspit of the prior's residence is to be linked to a gradual extinction of these species in post-medieval times remains hypothetical.

IMPORT OF MARINE FISH

The abbey at Ename did not only rely on the capture of fish in freshwater for its supply of animal products. The importance of fish imported from the coast is illustrated by the three contexts with sufficiently large sample sizes (WW, KF, CP) in which marine fish formed almost half of the identified remains (Figure 4). The oldest context

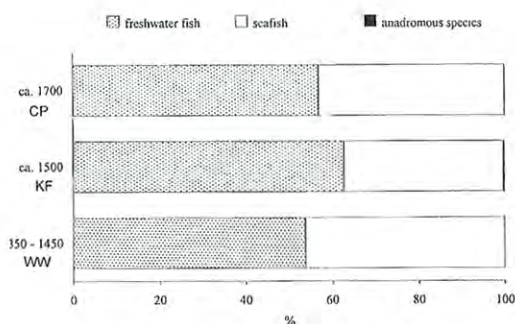


FIGURE 4

Relative frequency of freshwater fish, sea fish and anadromous species in contexts WW (1350-1450 A.D., $n = 210$), KF (ca. 1500 A.D., $n = 1388$) and CP (ca. 1700 A.D., $n = 1919$).

(AL) cannot be used in this comparison, because of its restricted sample size and the inadequate sampling strategy. Surprisingly, the analysis of the three younger contexts does not reveal any trend in the relative importance of marine fish for the food supply (Figure 4). As a working hypothesis, it was supposed that the import of marine fish into Flanders originated in medieval times as a response to a decrease in the availability of freshwater fish, due to damaging factors such as overfishing, water pollution and destruction of freshwater habitats (Van Neer & Erynck, 1993, 1994b). The effects of these factors must have been more pronounced in and around densely populated centres. The working hypothesis is corroborated by comparative archaeozoological research that reveals that along the river Scheldt the frequency of consumption of freshwater fishes in the late medieval towns of Antwerp and Ghent was significantly lower than the frequencies observed in contemporaneous sites located in the countryside, such as the abbey at Ename and the castle at Londerzeel (Van Neer & Erynck, 1993, 1994b). It was also hypothesized that the consumption of marine fish in medieval Flanders may have become more important through time, synchronous with the increasing deterioration of the riverine ecosystem. This hypothesized trend, however, is not yet illustrated by archaeozoological data from Flanders. The contexts from Ename studied thus far do not show any increase in marine fish consumption through time, nor do they throw light on the origin of the marine fish trade on the river Scheldt.

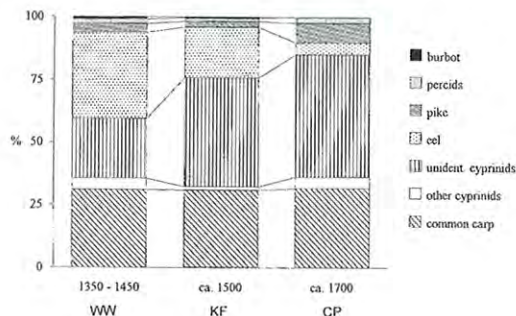


FIGURE 3

Relative frequency of freshwater species at Ename: data from contexts WW (1350-1450 A.D., $n = 113$), KF (ca. 1500 A.D., $n = 870$) and CP (ca. 1700 A.D., $n = 1084$). «Percids» include perch and ruffe, «other cyprinids» include bream, barbel, silver bream, orfe, roach and rudd.

Herring (*Clupea harengus*), gadids (Gadidae) and flatfish (Pleuronectidae) were the most important seafish for the food supply of the abbey (Table 1). The gadids comprise cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*). Within the flatfish, identification problems arise when trying to discriminate plaice (*Pleuronectes platessa*), flounder (*Platichthys flesus*) and dab (*Limanda limanda*), although the presence of the first two species could be proven conclusively by some finds. A soleid species is also present but it remains unclear whether we are dealing with sole (*Solea vulgaris*) or French sole (*Solea lascaris*). Given the rarity of this last species off the Belgian coast (Poll, 1947), an identification as *Solea vulgaris* seems most likely. A rarer find among the flatfish remains are some bones of turbot (*Scophthalmus maximus*), present in the two younger contexts (KF and CP). Other marine species that were more scarcely represented amongst the consumption remains comprise thornback ray (*Raja clavata*) and gurnards (Triglidae).

Traces on the bones and the intraskeletal distribution patterns indicate that a substantial portion of the marine fish arrived at the site in a processed form. The large collections of herring bones from contexts KF and CP indicate the import of animals mostly between 15 and 25 cm SL (standard length). Since bones of the shoulder girdle, i.e. supracleithrum, coracoid and cleithrum, are heavily underrepresented (Ervynck & Van Neer, 1992; Cooremans *et al.*, 1993), most of these herrings probably were not bought fresh but arrived as gutted specimens (see also Seeman, 1986). It is known from the historical sources that the consumption of gutted herring became very frequent in Flanders from the 14th century onwards (Degryse, 1938). Unfortunately, the small number of herring bones from the older contexts from the Ename abbey precludes the use of intra-skeletal distribution for inferences about processing.

Considering cod, again only the younger contexts from the abbey (KF and CP) yielded enough material to evaluate the condition in which the animals arrived at the site. Length reconstructions indicate animals from 60 up to 110 cm SL. No underrepresentation of cranial bones, which could have been an indication for stockfish (dried, beheaded cod, Heinrich, 1987), was noticed from these large contexts (Ervynck & Van Neer, 1992; Cooremans *et al.*, 1993). However, the underrepresentation of

precaudal vertebrae and the presence of characteristic longitudinal cutting traces on some cod bones from the cesspit of the prior's residence (Cooremans *et al.*, 1993) prove that some stockfish was consumed at the site (cf. Brinkhuizen, 1994). No archaeozoological evidence is available thus far for the import of processed flatfish or ray at the site, although 16th century historical sources describe the economic importance of this trade for the Low Countries (F. Egmond, *pers. comm.*).

THE INTRODUCTION OF DOMESTIC CARP

Historical and archaeozoological data reveal that carp spread from its original distribution area – the lower reaches of rivers running into the Black Sea – to northwestern Europe from the early Middle Ages onwards. Contrary to common belief, the earliest distribution wave, from east to west within Europe, may not be connected with the activities of early medieval monasteries (Hoffmann, 1994). However, in the absence of contradicting evidence, the apparent late arrival of carp in Flanders during the late medieval period must be linked to the activities of the abbeys in the region. Despite the presence of some late 13th–early 14th centuries finds in the castles at Laarne and Londerzeel, Ename is still the only late medieval site from Flanders where a significant number of carp remains have been found (Van Neer & Ervynck, 1994a). Fish ponds associated with the abbey indicate that carp was locally reared. It must also be underlined that the abbey at Ename is thus far the only monastic site from Flanders where excavations comprise the detailed sampling and recovery of fish remains (Van Neer & Ervynck, *ibid.*).

The oldest carp remains from the Ename excavations derive from context WW, dated between 1350 and 1450 A.D. The older context AL (late 12th–early 13th C.) does not contain domestic carp remains but it is also the only context in this survey that has not been adequately sampled. The present stage of research thus does not allow us to place the origins of carp breeding before the late medieval period. Surprisingly, the relative frequency of carp, which attains 31% of freshwater fish in context WW, does not change through time (Figure 3). A comparison of the standard lengths of the animals consumed shows that the carp eaten around 1700 A.D. in the prior's residence

were, on average, significantly larger than those from the older contexts WW and KF (Figure 5). However, whether this difference is due to an improved management of the carp ponds in post-medieval times, or whether the prior had access to the larger animals from the catch, remains to be investigated.

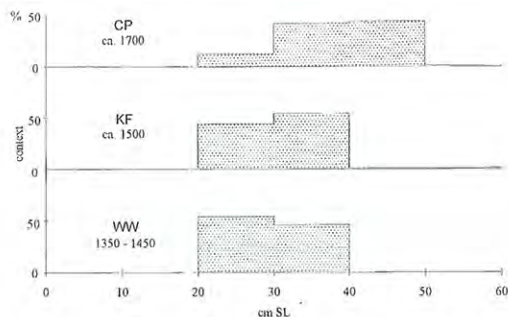


FIGURE 5

Comparison of the distributions of the standard lengths of domestic carp from contexts WW (1350-1450 A.D., $n = 26$), KF (ca. 1500 A.D., $n = 206$) and CP (ca. 1700 A.D., $n = 282$).

STATUS AND CONSUMPTION PATTERNS

The abbey at Ename was a rich community with extensive land ownership and most of its monks were recruited from the noble families of the time (L. Milis, *pers. comm.*). Hence it is no surprise that the food supply of the abbey, albeit originally limited by food rules, was varied and included expensive fishes such as turbot, sole and sturgeon. On a more detailed level, it is worth investigating whether possible differences in status within the abbey are illustrated by the archaeozoological dataset. It is not yet possible to compare different contexts within the same time period but one can investigate whether the consumption refuse found in the abbot's dwellings (context AL) and in the prior's residence (context CP) shows characteristics that indicate a higher status than the other material excavated within the abbey. It has already been demonstrated that the less stringent application of the food rules, which allowed the consumption of mammals in the abbot's house, can be seen as a sign of status. Restricting the analysis to the fish remains, the picture is less clear. It has been stated

that the size of domestic carp consumed could discriminate context CP from the other contexts with carp remains (Figure 5). On the other hand, no significant differences regarding the proportion of marine fish in the total fish consumption could be demonstrated between the contexts. For the freshwater species, the relative frequency of consumption of eel seems to decrease through time (contexts WW, KF and CP) (Figure 3), a trend that can hardly be linked to differences in status. Pike remains are more frequently found in the prior's residence than elsewhere in the abbey (Figure 3) but whether this suggests that the species could be used as an indicator of wealth remains to be investigated. Pike is absent from the cesspit of the abbot's house but, as has previously been stated, this context yielded only a small fish bone collection that was inadequately sampled.

It has been previously suggested that the relative frequency of cod versus haddock could serve as an indication of status for archaeozoological collections from medieval sites. Historical sources do indicate that cod was more expensive than haddock (Ervynck & Van Neer, 1994). Comparing the relative frequency of cod in the contexts from Ename, it becomes clear that the species is most abundant in the cesspits from the abbot's house and the prior's residence (Figure 6). However, the collections from contexts AL and WW are too small to draw any conclusions. The high proportion of cod bones in the post-medieval prior's residence, compared to the lower percentage of cod bones found under the kitchen floor, is perhaps the only real indicator in the fish remains of intra-site differences in status within the former abbey. This conclusion, however, remains entirely hypothetical because the contexts KF and CP were deposited in different chronological periods.

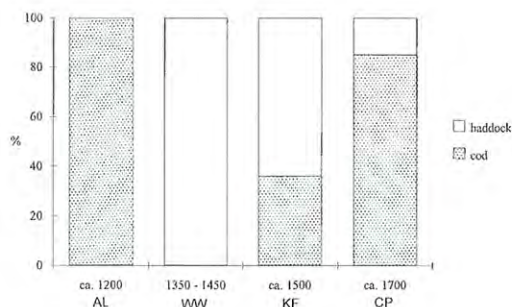


FIGURE 6

Relative frequency of cod and haddock in contexts AL (late 12th - early 13th century, $n = 2$), WW (1350-1450 A.D., $n = 4$), KF (ca. 1500 A.D., $n = 22$) and CP (ca. 1700 A.D., $n = 89$).

CONCLUSIONS AND FUTURE PROSPECTS

The fish supply of the Ename abbey was based partly on the purchase of marine fish on the inland market and partly on the exploitation of the local freshwaters. One third of the freshwater fish, i.e., domestic carp, was derived from specimens bred in ponds on the territory of the abbey. Except for the introduction of carp breeding in the late medieval period, it is not yet possible, in this preliminary stage of archaeozoological research on the site, to establish trends in the consumption pattern. Chronological differences, social stratification or the evolution of the environment around the abbey through time do not seem to have caused dramatic alterations in fish consumption at the site. However, the analysis of the material from Ename has just started and the majority of contexts is still unanalyzed. Moreover, the excavations are still under way. In the future it would be interesting to incorporate material from contexts that predate the presumed introduction date of the carp. Material from the earliest occupation phase of the abbey would not only allow a reconstruction of the consumption pattern of a community that did not benefit from fish breeding, it would also throw light on the original application of the food rules. The future analysis of more contemporaneous contexts will evaluate more profoundly possible intra-site differences. Finally, certain structures within the building complex show specific taphonomic characteristics. Examples are the recently excavated floor layers within the so-called scullery, a room adjacent to the kitchen (Figure 2B, SC), and the contents of the sewage system running along the guest quarters, the kitchen and the scullery (Figure 2B, SS). The analysis of these assemblages may illustrate how the monastic community dealt with consumption refuse and provide more detailed information on the food supply of the site.

ACKNOWLEDGEMENTS

The authors wish to thank D. Callebaut and K. De Groote (I.A.P.) for providing the archaeological framework of the contexts discussed, K. De Groote, J. Moens and S. De Smet (I.A.P.) for the care taken in sampling and recovering the fish remains from the site, L. Muylaert (I.A.P.) for sor-

ting out the sieved residues and R. Van Schoubroek (I.A.P.) for the preparation of the drawings. We also thank R. Hoffmann (York, Canada) for critically reading the manuscript and for the correction of the English spelling. W. Van Neer's contribution to this article represents research results of the Belgian Programme on Interuniversity Poles of Attraction, initiated by the Belgian Office for Scientific, Technical and Cultural Affairs.

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Conserves de poisson à partir de quatre amphores romaines

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(Received 25 January 1996; accepted 7 June 1996)

ABSTRACT: Fish remains retrieved from four Roman amphorae represent different products of fish processing activities. Two amphorae from Elba, recovered in wrecks, constitute Iberian products. Whereas one of them contained fragments of big fish, probably residue from a sauce, the other contained nearly complete mackerels. Two more ancient amphorae from Sardinia have been found in the excavations of the town of Olbia. The one contained whole fishes of different species, whereas the other contained a mixture of little fishes. The taxonomical and anatomical features of the various samples allow us to recognize in each of them a particular product of the Roman kitchen.

KEYWORDS: FISH, ITALY, ROMAN PERIOD, AMPHORAE, FISH PROCESSING

RESUMEN: Los restos de peces recuperados en cuatro ánforas romanas representan diferentes productos relacionados con las actividades de procesado del pescado en la antigüedad. Dos ánforas de Elba proceden de naufragios y constituyen productos de origen ibérico. Mientras que en una de ellas se recuperaron fragmentos de grandes peces, posiblemente residuos de una salsa, en la otra aparecieron caballas casi completas. Por otra parte, dos ánforas de Cerdeña anteriores a éstas proceden de las excavaciones urbanas de la villa de Olbia. Su contenido en uno de los casos consiste en una serie de especies de peces completos mientras que en la otra la característica principal es la diminuta talla de los ejemplares recuperados. La composición taxonómica y anatómica de estas muestras nos permite asimilar cada una de ellas a un determinado ingrediente de la cocina romana.

PALABRAS CLAVE: PECES, ITALIA, PERIODO ROMANO, ÁNFORA, PROCESADO DE PESCADO

INTRODUCTION

Le matériel objet de cette étude provient de quatre amphores d'âge romaine du I^{er} et II^{ème} siècle apr.J.C. Les restes recueillis dans deux amphores de l'île d'Elbe proviennent d'épaves. Il s'agit donc de produits qui étaient certainement commercialisés. La récupération non contrôlée et le séjour des échantillons dans un musée pendant une longue période ont causé la perte d'une partie des données concernant les caractéristiques des amphores, dont les échantillons ne représentent qu'une partie du contenu. Les deux amphores sont de provenance espagnole.

Les amphores de la Sardaigne ont été trouvées dans l'ancienne ville d'Olbia, colonie carthaginoise du IV^{ème} siècle avant J.C. et conquise par les Romains à la fin du III^{ème} siècle. Sur la petite

acropole, il y avait le sanctuaire principal, dédié au dieu Héraclès-Melqart. En 1994, on a fouillé une partie de l'espace de ce sanctuaire, où on a découvert un temple entre la fin de l'époque républicaine et le début de l'époque impériale. A l'intérieur, se trouvaient deux puits; un de ces puits a été rempli au II^{ème} siècle apr.J.C., et dans ce remplissage, on a découvert, avec beaucoup d'autres matériaux (céramiques, surtout africaines mais aussi espagnoles, verres, os, métaux, etc.) les deux amphores en question, encore en cours d'étude du point de vue céramologique et on les attribue une provenance africaine du II^{ème} siècle apr.J.C. En ce qui concerne l'amphore 2, il pourrait s'agir d'une Africaine I/Keay III, produite en Tunisie du début du II^{ème} siècle apr.J.C. jusqu'au IV^{ème}. On utilisait ce type d'amphore, en effet, pour transporter les produits de la pêche.

MATÉRIAUX ET MÉTHODES

Les matériaux étudiés proviennent des amphores suivantes:

Epave de Chiessi (Elbe), Vindonissa 583, 1er siècle apr.J.C. Le contenu, comprenant des restes osseux de poissons de grande taille, n'est pas complet.

Epave de l'île d'Elbe. Amphore imprécisée de la Bétique. 2nde moitié du 1er siècle apr.J.C./1ère moitié du IIème siècle-calfatée. Le contenu n'est pas complet et comprend des restes de poissons de taille moyenne, bien préservés. Les deux amphores de l'île d'Elbe sont restées dans un musée pendant plusieurs années, peut-être avec dommage du contenu, surtout dans le cas de l'amphore de Chiessi.

Olbia, Sardaigne. Amphore 1-non calfatée-IIème siècle apr.J.C. Le contenu (poissons entiers) n'est pas complet.

Olbia, Sardaigne. Amphore 2-non calfatée-IIème siècle apr.J.C. Récupérée avec la précédente dans la fouille de la ville. Une partie importante du contenu est conservée.

Pour la détermination spécifique a été utilisée la collection personnelle de l'auteur, dans le cas des maquereaux, en utilisant la radiographie.

Les amphores de Olbia ont été vidées en laboratoire ce qui a permis de connaître la disposition des poissons. L'estimation de la saison de capture par la lecture des lignes d'arrêt de croissance a été possible dans le cas de l'amphore de l'île d'Elba et de l'amphore 1 de Olbia.

RÉSULTATS

Les restes osseux provenant de l'amphore Vindonissa 583 de Chiessi sont rares, fragmentés et sont difficilement déterminables. Il s'agit d'une majorité de restes osseux de têtes de poissons de grandes dimensions, dont certains conservent des signes de dépeçage, ainsi que de deux vertèbres de maquereau (*Scomber sp.*) de taille moyenne. Parmi les restes de poissons de grande taille, nous avons pu identifier le thon (*Thunnus thynnus*) et la sérieole (*Seriola dumerilii*).

Le contenu de l'amphore de l'île d'Elbe était constitué de maquereaux (*Scomber japonicus*) de taille moyenne, de 30 cm à peu près (Figure 1). 9 individus presque entiers ont été comptés, mais

l'échantillon n'était pas complet. Une coupe de la partie antérieure des têtes, plus ou moins à la hauteur des orbites ou un peu en dessous à celle-ci, a été relevée (Figure 2). Les os concernés par les

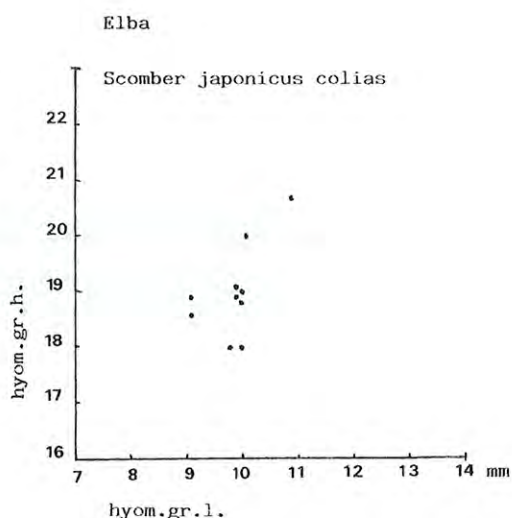


FIGURE 1

Amphore de l'île d'Elbe. *Scomber japonicus*: relation de deux mesures prises sur l'hyomandibulaire.



FIGURE 2

Amphore de l'île d'Elbe. *Scomber japonicus*: coupes sur un neurocrâne et un ceratohyale (1:1,5).

coupes sont un carré, deux ceratohyales et un neurocrâne.

Le contenu de l'amphore 1 de Olbia n'est pas complet. Les espèces suivantes ont été identifiées:

<i>Crenilabrus tinca</i> (L.)	26,44%
<i>Serranus scriba</i> (L.)	1,40%
<i>Spondylisoma cantharus</i> (L.)	12,51%
<i>Diplodus sargus</i> (L.)	33,95%
Sparidae	5,63%
<i>Maena</i> sp.	20,03%
NR ident.	639

Il s'agit de poissons entiers (Figures 3-4; Figure 6.1), couverts d'écaillles, conservés dans la partie inférieure d'une amphore de type non identifié. D'après l'examen des vertèbres, ces poissons ont dû être pêchés au printemps. Malgré le fait qu'il s'agisse d'espèces qui atteignent des tailles différentes, dans certains cas plutôt importants (le sargue et le labre), il s'agit d'individus ayant des tailles presque homogènes: autour de 15-20 cm (Figure 5).

Seulement une partie importante de la moitié inférieure de l'amphore 2 de Olbia est conservée. Le contenu, riche en substance organique, semble composé d'un mélange hétérogène de poissons de petite taille (d'environ 10 cm ou moins) qui ne se

trouvent pas en connexion anatomique ou qui le sont seulement en partie (Figure 6.2); dans ce mélange sont intégrés de nombreux petits poissons, entiers ou presque entiers.

L'identification est très difficile à cause de la fragilité des restes osseux les plus petits. Dans le mélange de base, les sars (*Diplodus vulgaris/sargus*), dont certaines parties de la tête et des groupes de vertèbres en connexion ont été conservés, ainsi que des éléments osseux isolés et des écailles semblent prévaloir. Il s'agit de petits individus, d'environ 10 cm. On a également identifié le pagot blanc (*Pagellus acarne*). L'identification des plus petits poissons (de quelques centimètres) est plus délicate à cause de la difficulté d'extraire les restes osseux de la masse sans les endommager et à cause de la petite taille des vertèbres et de l'absence d'os crâniens qui n'ont pas été conservés. On doit attribuer à ce groupe un maxillaire de clupéiforme.

DISCUSSION ET CONCLUSIONS

Dans le cas des restes osseux provenant de l'amphore Vindonissa 583 de Chiessi, il pourrait s'agir d'une muria ou d'un garum classique, peu raffiné, obtenu à partir de déchets de différents



FIGURE 3-4

Amphore 1 de Olbia: restes de poissons en connexion anatomique.

Olbia Amphore n°1

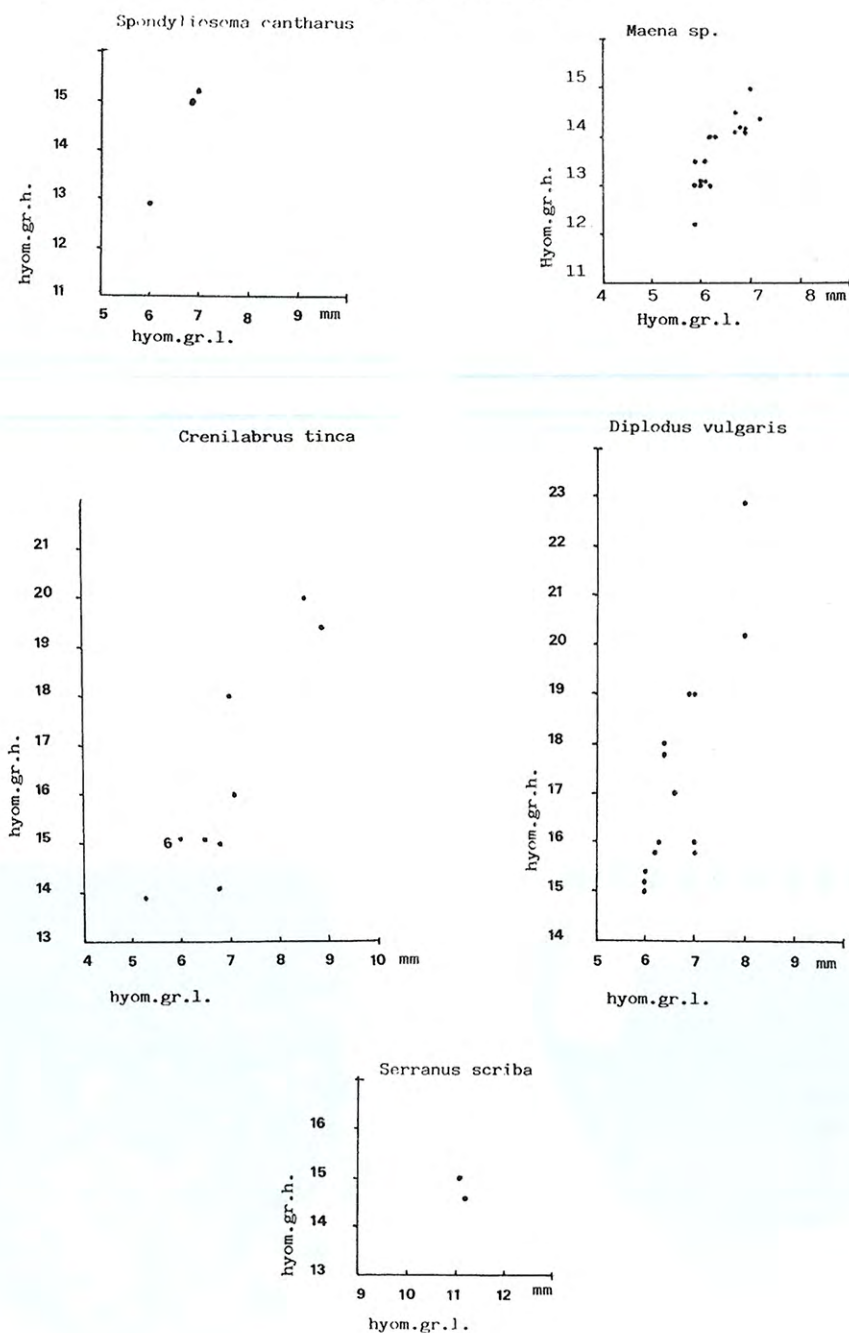


FIGURE 5

Amphore 1 de Olbia: relation de deux mesures prises sur l'hyomandibulaire de *Spondyllosoma cantharus*, *Crenilabrus tinca*, *Diplodus vulgaris*, *Maena sp.* et *Serranus scriba*.



FIGURE 6

1) Amphore 1 de Olbia: neurocrânes (1:1,5). 2) Contenu de l'amphore 2 de Olbia: mélange de poissons avec quelques fragments en connexion anatomique.

poissons. Comme dit Pline: «*Aliud etiam liquoris exquisiti genus, quod garum vocavere, intestini piscium ceterisque, quae abicienda essent sale maceratis...*» (il y a un autre type de liquide exquis appelé garum, obtenu en faisant macérer dans le sel les intestins des poissons et d'autres parties qui seraient à jeter....XXXI, 93).

La conserve de l'amphore 2 de Olbia pourrait être apparentée plutôt au *allec* de petits poissons dont parle Pline: «*Coepit tamen et privatim ex inutili pisciculo minimoque confici. Apuam nostri, aphyen Graeci vocant, quoniam id pisciculus e pluvia nascatur*» (on a commencé à le préparer avec un tout petit poisson insignifiant que nous appelons apua et que les Grecs appellent aphyen, car ce poisson naît de la pluie. XXXI, 95).

Dans les autres amphores il n'y a pas de sauce, mais le contenu consiste des poissons entiers.

La manière de traiter les maquereaux de l'amphore de l'île d'Elba a été également observée dans d'autres cas (Desse-Berset, 1993), alors que les maquereaux étaient très souvent entiers, comme dans le cas de l'épave de Grado (Wilkens, sous presse).

Le contenu de l'amphore 1 de Olbia se distingue aussi bien de ceux cités par les auteurs latins,

que de ceux qui sont très souvent retrouvés dans les fouilles terrestres ou sous-marines, par la variété des espèces présentes, appartenant toutes à des environnements côtiers, rocheux ou à posidonie, mal adaptées à une activité de pêche et de conservation du poisson sur une échelle industrielle. Il n'est pas exclu que dans le cas des deux amphores de Olbia, récupérées dans des fouilles terrestres, il puisse s'agir de conserves ayant un usage et une manufacture domestiques.

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On the boundaries of osteometry applied to fish

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ABSTRACT : The first major publication to consider fish remains from an archaeozoological standpoint, Casteel's 1976 book, already highlighted the remarkable correlation between fish size, weight and even age with bone measurements. Despite such potential it is shocking to note the under-utilization of fish osteometry by archaeoichthyologists. The first half of this paper discusses a few practical examples of automatic calculation of the size and weight of fishes of high economical importance. The validity of such calculations is then extended to archaeological samples. The second half discusses a simple model of calculation of fish size or weight extended to the level of genus and even of family, and its practical application to archaeo-ichthyology.

KEYWORDS: FISHES, ARCHAEO-ICHTHYOLOGY, OSTEOMETRY, SIZE/WEIGHT RECONSTRUCTION

RESUMEN: La primera síntesis en considerar los restos de peces desde una perspectiva arqueozoológica, el volumen de Casteel de 1976, destacaba la sorprendente correlación entre tamaño del pez, su peso e, incluso, su edad con los valores osteométricos individualizados. A pesar de este potencial resulta llamativa la infrautilización de la osteometría de peces por parte de los ictioarqueólogos. La primera parte del trabajo presenta una serie de casos prácticos de retrocálculo automático de la talla y peso de una serie de peces de importancia económica. La validez de estos cálculos se amplía a muestras arqueológicas. La segunda parte valora un modelo simple de retrocálculo de talla y peso ampliándolo a nivel de género, e, incluso, de familia así como sus posibilidades de aplicación en arqueoictiología.

PALABRAS CLAVE: PECES, ARQUEOICTIOLOGÍA, OSTEOMETRÍA, INFERENCIA DE TALLA/PESO

INTRODUCTION

Archaeo-ichthyology became a specialized branch of archaeozoology about 25 years ago. Examples of pioneering works are Georges Desse's 1970-1976 publications on fish vertebrae and Casteel's 1976 textbook. In this publication, among other things, the author noted the importance of osteometry applied to subfossil fish studies, something which has been subsequently corroborated by many other authors (Heinrich, 1987; Brinkhuizen, 1989; Van Neer, 1989).

The major difficulties which formerly prevented us from addressing high level investigations on archaeological fish material (such as excavations

without sieved samples or the lack of skeletal reference collections) either disappeared or became less of a problem. Since the eighties, fish bone studies have reached a high standard, as is reflected by the I.C.A.Z. Fish Remains Working Group conferences.

We are therefore surprised to note that osteometry has not been systematically applied (and is still under-employed!) to fish bones from archaeological sites. This may result mainly from difficulties in obtaining reliable taxonomic identifications for the numerous fish remains in sites. When dozens of different species occur in archaeological deposits, the majority of osteologists consider it useless or impossible to apply osteometry to bones which cannot be taxonomically identified.

The aim of the present paper is to demonstrate that osteometry, which is always able to give very interesting interpretations for our archaeological fish bone material, can be applied through simple osteometric models to a wide range of taxa. Osteometric studies can, in fact, be carried out without a (quasi) complete reference collection. The following is a brief overview of the results that can be obtained through osteometric techniques.

MATERIAL AND METHODS

The good correlation between fish length (whether standard, total or fork) and a particular fish bone measurement is now known to hold universally (Figure 1). In general, two measurements from the same fish bone correlate similarly well (Figure 2). It should be noted that measurements made on two different bones usually provide similarly high correlation values (Figure 3). The relationship between two bone measurements, or between a bone measurement and fish length, is described by a simple linear-regression curve. The relationship between fish length/fish weight or bone length/fish weight follows a logarithmic model. The use of this kind of simple formula provides archaeo-ichthyologists with a powerful tool for an archaeological interpretation of bones found on sites.

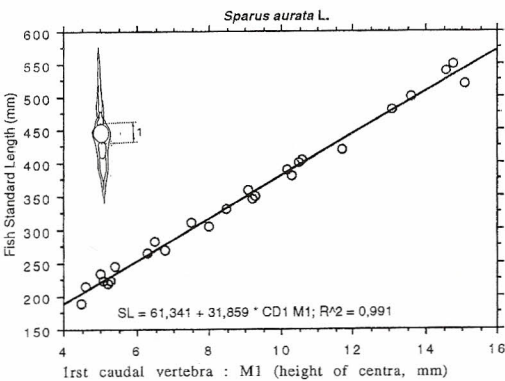


FIGURE 1

Correlation between fish standard length (SL) and fish bone measurement.

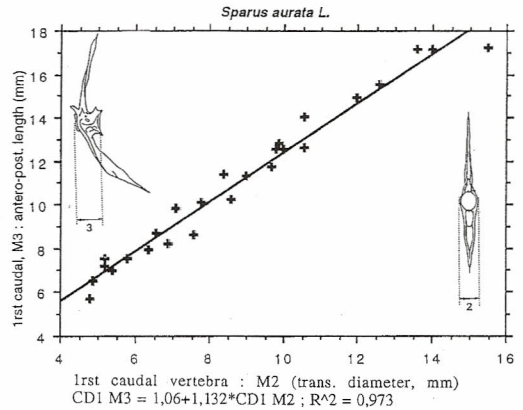


FIGURE 2

Correlation between two measurements on the same fish bone.

The correlation coefficients between bone lengths and fish lengths (or even fish weights), usually oscillate between 0.95 and 0.99. A simple example of these good correlation indexes can be appreciated from the results of three measurements taken on 31 praemaxillare of a common Mediterranean sea-bream species (gilthead, *Sparus aurata*) (Desse & Desse-Berset, 1996) that were correlated to a sample of selected bone measurements of the whole skeleton, and to the length and weight of selected specimens (Figure 4).

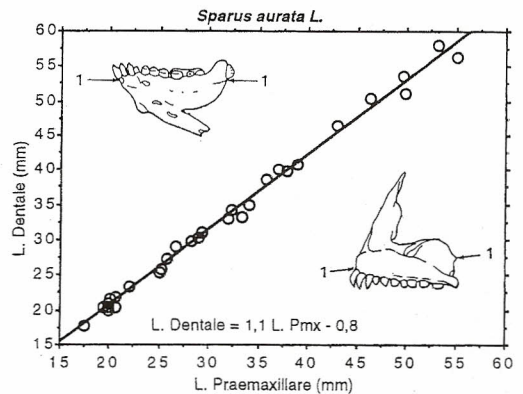


FIGURE 3

Correlation between two measurements on different fish bones of the same species.

A further, very practical, step is to calculate a simple formula which allows for an automatic reconstruction of many skeletal metrical data from a single measurement of a single bone (Figure 5). This calculation, which would have been a tre-

mendous job a few years ago, can now be easily done with the help of modern personal computers. An application of such calculations to a sample of 31 *Sparus aurata* shows their practical utility.

	Value of «r» between:		
	Pmx M1	Pmx M2	Pmx M3
and:			
Standard Length (SL)	0,99	0,99	0,99
Total Length (TL)	0,99	0,99	0,99
Neurocranium: M1	0,98	0,99	0,99
Neurocranium: M2	0,99	0,99	0,99
Neurocranium: M3	0,99	0,99	0,99
Neurocranium: M4	0,98	0,98	0,99
Neurocranium: M5	0,93	0,93	0,93
Neurocranium: M6	0,99	0,99	0,98
Neurocranium: M7	0,99	0,99	0,99
Neurocranium: M8	0,98	0,98	0,98
Neurocranium: M9	0,99	0,98	0,98
Neurocranium: M10	0,99	0,98	0,97
Praemaxillare: M1	XXX	0,99	0,99
Praemaxillare: M2	0,99	XXX	0,99
Praemaxillare: M3	0,99	0,99	XXX
Maxillare: M1	1,00	0,99	0,99
Maxillare: M2	0,98	0,98	0,97
Maxillare: M3	0,96	0,99	0,97
Dentale: M1	0,99	0,99	0,99
Dentale: M2	0,98	0,98	0,98
Dentale: M3	0,98	0,98	0,97
Articulare: M1	1,00	0,99	0,99
Articulare: M2	0,99	0,99	0,99
Articulare: M3	0,98	0,98	0,98
Quadratum: M1	0,99	0,99	0,99
Quadratum: M2	0,97	0,98	0,99
Hyomandibulare: M1	0,99	0,98	0,99
Hyomandibulare: M2	0,99	0,98	0,98
Hyomandibulare: M3	0,99	0,99	0,99
Praeoperculare: M1	1,00	0,99	0,99
Praeoperculare: M2	0,99	0,98	0,98
Operculare: M1	0,99	0,99	0,99
Operculare: M2	0,99	0,99	0,99
Operculare: M3	0,98	0,97	0,97
Post-temporale: M1	0,94	0,93	0,94
1st thoracic vert.: M1	0,99	0,98	0,97
8th thoracic vert.: M1	0,99	0,99	0,99
1st caudal vert.: M1	0,99	0,99	0,99
10th caudal vert.: M1	0,99	0,98	0,98
Otolith (sagitta): M1	0,97	0,97	0,96
Otolith (sagitta): M2	0,93	0,94	0,93
Weight (g)	0,98	0,98	0,98

FIGURE 4

Correlation-coefficient («r») between three measurements of the premaxillare (Pmx M1, Pmx M2, Pmx M3) and the main skeletal measurements of *Sparus aurata*.

y=	«r»=	Reconstitution:
Total Lenght (TL)	1,00	$y = 17,3211 + 1,7714 x$
Neurocranium: M1	0,99	$y = -37,3926 + 8,0072 x$
Neurocranium: M2	0,99	$y = -18,5152 + 4,3828 x$
Neurocranium: M3	0,97	$y = 151,6115 + 11,6939 x$
Neurocranium: M4	0,99	$y = 27,9853 + 25,3014 x$
Neurocranium: M5	0,94	$y = 82,0973 * x^{0,7801}$
Neurocranium: M6	0,98	$y = 39,6099 + 51,9345 x$
Neurocranium: M7	1,00	$y = 8,806 + 8,3643 x$
Neurocranium: M8	0,98	$y = 63,83 * x^{0,8109}$
Neurocranium: M9	0,99	$y = 68,8202 + 35,4943 x$
Neurocranium: M10	0,99	$y = 24,4574 + 31,1734 x$
Praemaxillare: M1	0,99	$y = 31,815 + 9,541 x$
Praemaxillare: M2	0,99	$y = 12,6993 * x^{0,8853}$
Praemaxillare: M3	0,99	$y = 45,4659 * x^{0,7901}$
Maxillare: M1	0,99	$y = 36,318 + 7,7112 x$
Maxillare: M2	0,98	$y = 45,1594 + 24,838 x$
Maxillare: M3	0,97	$y = 44,067 + 27,4795 x$
Dentale: M1	0,99	$y = 34,2352 + 8,9464 x$
Dentale: M2	0,98	$y = 27,3661 * x^{0,8926}$
Dentale: M3	0,98	$y = 50,4225 * x^{0,8254}$
Articulare: M1	0,99	$y = 24,6522 + 10,7319 x$
Articulare: M2	0,99	$y = 30,8836 + 12,1978 x$
Articulare: M3	0,99	$y = 72,6411 * x^{0,8601}$
Quadratum: M1	0,99	$y = 16,8152 + 19,3936 x$
Quadratum: M2	0,99	$y = 24,0702 * x^{0,9415}$
Hyomandibulare: M1	0,99	$y = 34,4368 + 16,4939 x$
Hyomandibulare: M2	0,99	$y = 35,7663 + 29,0515 x$
Hyomandibulare: M3	0,99	$y = 20,6692 + 7,3378 x$
Praeoperculare: M1	1,00	$y = 12,8828 + 5,3464 x$
Praeoperculare: M2	0,99	$y = 28,653 + 19,1089 x$
Operculare: M1	0,99	$y = 21,9259 + 6,9288 x$
Operculare: M2	0,99	$y = 45,2875 + 11,238 x$
Operculare: M3	0,97	$y = 39,9352 + 49,5095 x$
Post-temporale: M1	0,94	$y = 58,5151 * x^{0,906}$
1st thoracic vert.: M1	0,98	$y = 62,7561 * x^{0,8376}$
8th thoracic vert.: M1	0,99	$y = 36,3783 + 38,4039 x$
1st caudal vert.: M1	1,00	$y = 59,7994 + 31,9925 x$
10th caudal vert.: M1	0,99	$y = 43,6211 + 40,8131 x$
Otolith (sagitta): M1	0,97	$y = 10,9765 * x^{1,4658}$
Otolith (sagitta): M2	0,93	$y = 9,7122 * x^{2,032}$
Weight (g)	0,99	$y = 4,999 e-5 * x^{2,8934}$

FIGURE 5

Standard length reconstruction of *Sparus aurata* calculated from total length, main skeletal measurements and weight.

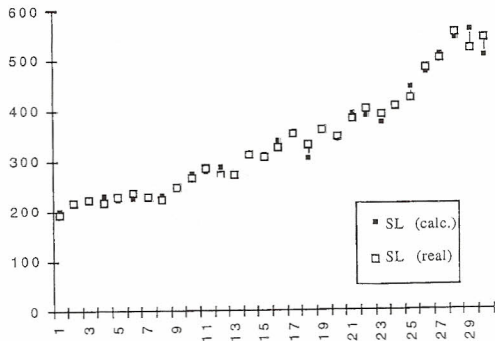


FIGURE 6

Standard length reconstruction (SL Calc.) of the sample of 31 *Sparus aurata* calculated from praemaxillare maximal antero-posterior length (Pmx M1). The error average between the real standard lengths (SL real) and the reconstructed data is worth less than 3% $SL\ Calc. = 9,541\ Pmx\ M1 + 31,815$.

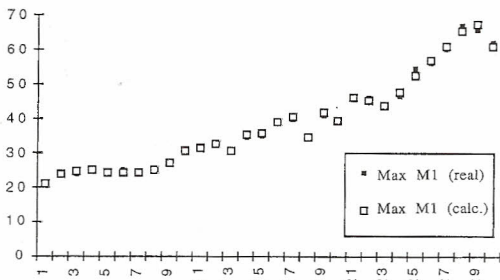


FIGURE 8

Calculation of the maxillare length (Max. M1) from the measurement of the praemaxillare antero-posterior length (Pmx M1). The error average is still very good; the highest errors concern, as always, older and bigger fish (Max. M1 $Calc. = 1,2366\ Pmx\ M1 - 0,5629$).

RESULTS

The first example is related to fish standard length reconstruction calculated from the length of the praemaxillare. The error average is less than 3%, and, as expected, the highest errors for «weight-bearing» bones refer to those from the oldest, thus biggest, fishes (Figure 6). Re-calculation of the praemaxillare height from the measurement of the praemaxillare length (Figure 7) provides an even better result than that for fish length estimation. Again the error average is less than 3%. Quite surprisingly, the results of the estimation of the maxillare length from the measurement of the pra-

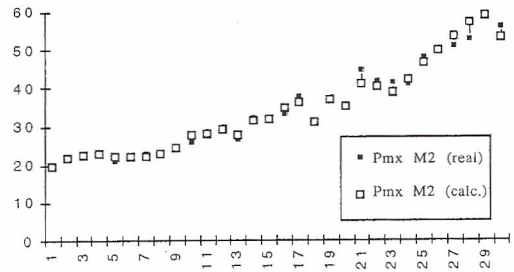


FIGURE 7

Recalculation of the praemaxillare height (Pmx M2 Calc.) from measurement of the praemaxillare maximum antero-posterior length (Pmx M1) on the same *Sparus aurata* sample. The error average, again, is less than 3%. (Pmx M2 $Calc. = 1,2909\ Pmx\ M1 + 1,0463$).

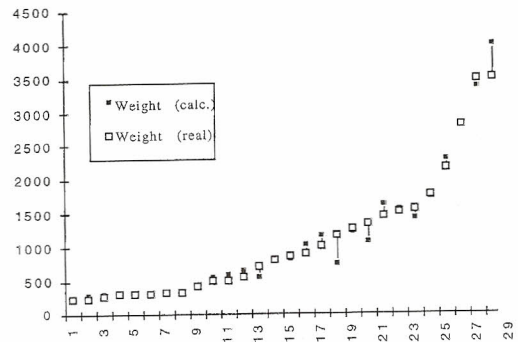


FIGURE 9

Direct calculation of the 31 *Sparus aurata* mass (weight calc.) from the praemaxillare length (Pmx M1). Weight $calc. = 0,1111 * Pmx\ M1^2 + 2,6394$.

maxillare length are as good as those from previous measurements (Figure 8).

Calculation of fish weight from a bone measurement can be achieved in different ways. The first one makes use of a double regression method, with a previous calculation of fish length from the bone measurement and with the use of the fish length/fish weight relationship; this method is the one generally employed and in our analysis it provided an error average of 10.32%.

The second method applies the direct relationship between a bone measurement and fish weight. Unexpectedly, when applied to our sample, both methods provide quite similar results; we note that

the direct method is not the worst! (Figure 9). The difference between the two methods is trivial (e.g., 63 g for a 2000 g fish).

Weight reconstructions are, obviously, less precise than fish length estimations, but weight estimation is much appreciated by archaeologists and useful in the case of palaeoeconomic analyses.

One could object that such good correlations depend on the choice of a particular fish species that provides exceptionally good results that cannot be obtained with other, more common, species. But our long experience demonstrates that *Sparus aurata* is not an atypical fish species, selected for the sole satisfaction of «hyper-scientific» archaeo-ichthyologists' modeling wishes.

This statement can be easily proved with a great number of cases obtained from very different fish species, published by Desse (1984), Heinrich (1987), Brinkhuizen (1989), Van Neer (1989), Rodríguez- Santana (1994) and Roselló & Sancho (1994) and others or those obtained by the authors on the Epinephelinae (Desse & Desse-Berset, this same issue; Desse *et al.*, 1996). In fact, so far, we have always observed good correlations in osteometric data for our modern and sub-fossil fish bones.

The «Global Rachidian Profiles» method, presented for the first time at the York I.C.A.Z. Fish Meeting in 1987, shows, in fact, a special case of such osteometric applications, most useful for fish size reconstructions and for the evaluation of minimum number of individuals in fishes calculated from isolated vertebrae (Desse *et al.*, 1989) (Figure 10).

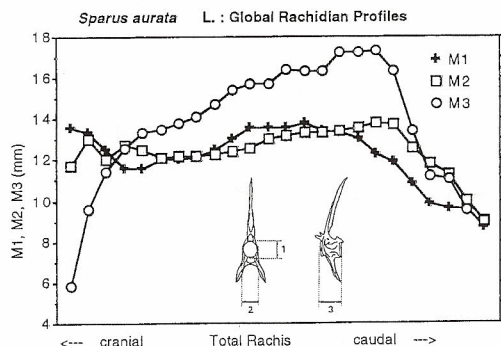


FIGURE 10

Global Rachidian Profiles for *Sparus aurata*.

CONCLUSIONS

To conclude, we shall propose a short, risky, synthesis with the «six rules» of osteometry as applied to fishes or, more precisely, to Teleosts. The first of these proposals seems to be at present universally accepted by the scientific community. If they were to be systematically tested, however, we believe that the remaining five «rules» could also be of great practical interest to fish bone analysts:

1. *Osteometric homogeneity* (Figure 11, a, b, c): «Bone measurements and fish lengths (total or standard) of the Teleosts are usually highly correlated. This observation holds, to a lesser degree, for bone measurements and fish weights».

2. *Taxonomic proximity* (Figure 12): «The relationship estimated between various bone measurements, or between bone measurements and fish length, is a general one for the species, often valid for the genus and, occasionally, for a whole family as well».

3. *Trophic individualization* (Figure 13): «Modifications in trophic conditions may change the position of the points in a regression curve but do not modify the regression curve itself».

4. *Diachronic homogeneity* (Figure 14): «The relationship between bone measurements, or between bone measurements and fish length, appears to be constant on an archaeological time scale. Measurements of sub-fossil bones fit the same regression curves as modern samples».

5. *Geographic homogeneity* (Figure 15): «Osteometric homogeneity is valid for a complete taxonomic sample, even for specimens with different geographic origins».

What can one say of this apparent and paradoxical «fixism»? We can propose an interpretation which, obviously, does not belong to the archaeological realm of interpretation, namely:

6. «Fly-away» rule?: «The apparent consistency shown by fish osteometric data, from the Palaeolithic to modern times, may result from a kind of stabilising selection, so that when a profound change in environmental conditions appears, specimens or taxa deviating from a particular standard are forced to either evolve or disappear».

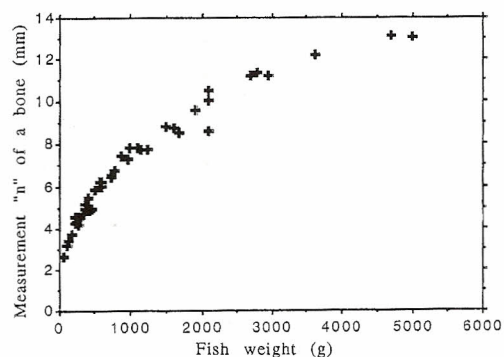
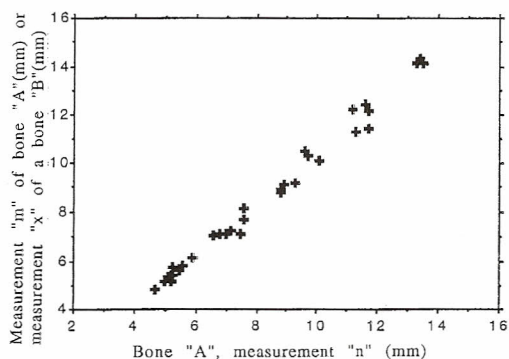
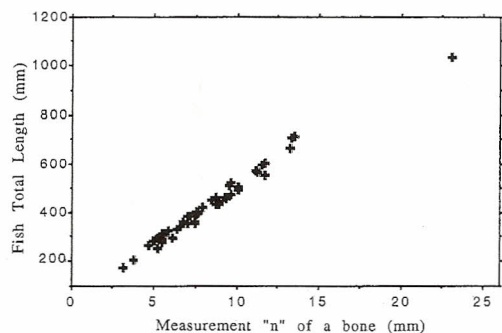


FIGURE 11

Osteometric homogeneity. a) General correlation between bone measurements and fish length. b) General correlation between bone measurements. c) General correlation between bone measurements and fish weight.

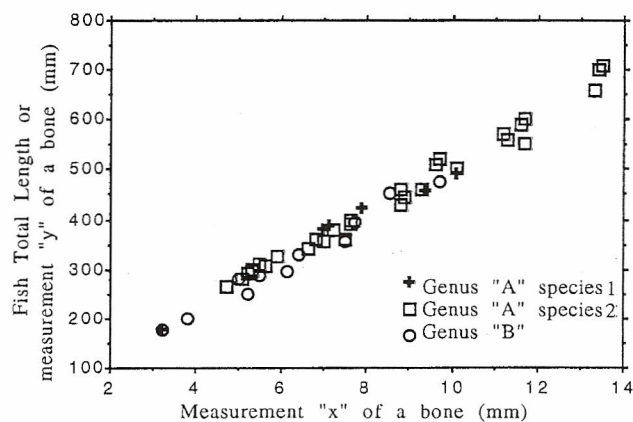


FIGURE 12

Taxonomic proximity.

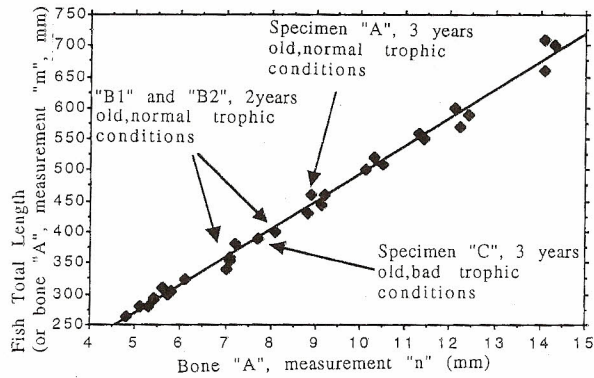


FIGURE 13
Trophic individualization.

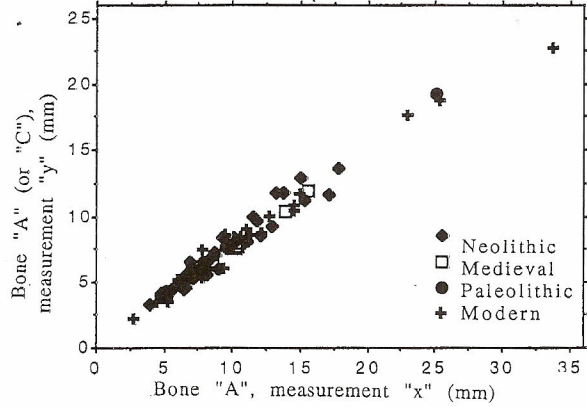


FIGURE 14
Diachronic homogeneity.

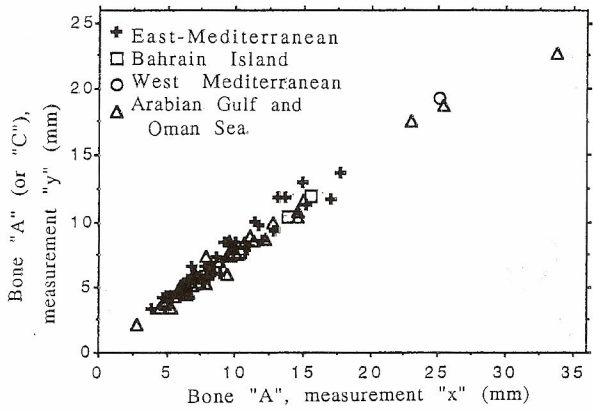


FIGURE 15
Geographic homogeneity.

ACKNOWLEDGEMENTS

We are very grateful to Jacqueline Gaudery for her corrections of our English.

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Book Reviews

Archaeofauna 5: 181-182

FAUNAL REMAINS: TAPHONOMICAL AND ZOOARCHAEOLOGICAL STUDIES OF THE ANIMAL REMAINS FROM TELL HESBAN AND VICINITY. Hesban 13. Andrews Univ. Press, Berrien Springs, Michigan. xxv + 236 pp., 114 fig., 186 plates, 135 tables, index, hard cover. ISBN 0-943872-29-4. LaBianca, Ø.S. & A. von den Driesch, 1995.

As the title implies, this volume deals with the faunal remains recovered at the site of Tell Hesban, located approximately 20 Km to the south of Amman, Jordan. The site was inhabited from ca. 1500-1200 BC to the end of the 15th century AD. Excavated between 1968 and 1976 by members of Andrews University, the site produced approximately 100,000 bone fragments. During the first campaigns, the faunal remains were sorted and identified on the spot by archaeologists and students of archaeology, and «*all unidentifiable fragments, and of disarticulated material, all ribs and long bone fragments that were not part of proximal and distal ends*» were discarded (p. 5). This «strategy» was abandoned only during the last excavation season, when professional archaeozoologists took over the faunal analysis. Some 20,000 animal remains could still be analysed properly, and Hesban 13 essentially focuses on the results of the analysis of this material.

The book has ten chapters, of which the first, by Ø.S. LaBianca, deals with the history and background of the archaeozoological work at Tell Hesban. Of more interest is the second chapter, in which the same author describes the results of ethnoarchaeological work in the modern village of Tell Hesban. These data contribute to our understanding on how pre- and postdepositional processes can influence the species and skeletal part composition of an archaeozoological assemblage. For anyone dealing professionally with the analysis of animal remains from Tells and other sites in the Near East, chapters 3 «*The Nature of the Zooarchaeological Record at Tell Hesban*» and 4 «*The Effect of Post-depositional Contexts on the Preservation and Interpretation of Bone Samples*», both written by Ø.S. LaBianca, are of limited interest, because the interpretations and conclusions are not new.

The results of the faunal studies are presented in chapters 5 to 9. Especially chapters 5 «*Final Re-*

port on the Zooarchaeological Investigation of Animal Bone Finds» by J. Boessneck & A. von den Driesch, 8 «*Birds, Reptiles, and Amphibians*» by J. Boessneck, and 9 «*Fish Remains from Tell Hesban, Jordan*» by J. Lepiksaar, provide a wealth of information about the 13 domestic and at least 95 wild species found at the site. The finds of deer and weasel are discussed in more detail in two separate smaller chapters (6 and 7). Whilst the finds of the wild species are presented in a very detailed way, including individual measurements, one would have wished a similar approach for the archaeozoological data obtained for the domestic species. The latter account for over 95% of the material, but unfortunately only a few measurements appear in the text. For those archaeozoologists who want to compare the osteometrical data of the mammalian bones in their material with those obtained at Tell Hesban, the work by Weiler (1981) will, therefore, remain the only source of information.

If in the final chapter the reader expects to find an elaborate discussion of the results of the faunal analysis and how these fit in the overall picture, based for example on the results of archaeological, paleobotanical, geological, etc., research, he or she will be extremely disappointed by Ø.S. LaBianca's dull four pages of «*Interpretive Conclusions*». This volume simply deserved better, especially if one is aware of the fact that the manuscripts on the fauna were submitted to the senior editor between 1979 and 1981, i.e. some 15 years ago. Agreed, circumstances can be invoked to explain the delay (see preface by Ø.S. LaBianca p. xxiv), but 15 years is definitely too much. J. Boessneck (1985) once criticised in another book review:

«*Die Osteoarchäologie ist ein naturwissenschaftliches Fach, das im Rahmen der Archäologie im weiteren Sinne ausgeübt wird. Sie ist deshalb in ihren Veröffentlichungen weitgehend von den Archäologen abhängig. Die Archäologen übernehmen als Ausgräber und Leiter archäologischer Projekte, für die sie naturwissenschaftliche Hilfe in Anspruch nehmen, die Verantwortung für den Abdruck der naturwissenschaftlichen Beiträge ... Bedauerlicherweise nehmen die schwarzen Schafe unter den Archäologen - von den weißen ist nicht die Rede - diese Verantwortung aber offenbar nicht wahr oder versuchen, ihr zu entgehen. Sollten*

doch Gewissenszweifel aufkommen, beruhigt die Auffassung: Wird das Knochenfundgut eines Grabungsunternehmens osteoarchäologisch untersucht, bringt das Ergebnis als Materialvorlage eine zeitlose Dokumentation, die kaum veraltet. Man darf die Befunde zunächst einmal ablegen, selbst verwenden, und, wenn die archäologischen Belange abgedeckt sind, wird man sie -möglichst im Rahmen anderer naturwissenschaftlicher Hilfsuntersuchungen -schließlich auch veröffentlichen. Dieses hier einmal als *conditio sine qua non* unterstellte Flämmchen einer guten Absicht ist allerdings stark windgefährdet und erlischt nur allzu leicht ... Die Jahre vergehen. Der Osteoarchäologe erlahmt seinerseits in seinen Mahnungen, er fügt sich in sein Schicksal und gerade als er aufgegeben hat, trifft ihn der Überraschung: Er wird aufgefordert, seinen Beitrag zu überarbeiten ... Nur der geduldigste Osteoarchäologe ... ist bereit, diese Überarbeitung so umfassend durchzuführen, daß kein Flickwerk entsteht. Aber auch er ist selbstverständlich verärgert über diese Einstellung seinem Fach und seiner Mitarbeit gegenüber. Die Überraschung kann natürlich auch anderer Art sein: Der Beitrag wird nach 10-20 Jahren doch noch gedruckt! Dem Autor bleibt ein Pyrrhus-Sieg. Er hat sein Ziel erreicht, aber die Informationen sind weitgehend wertlos geworden. Niemand braucht die Befunde mehr. So makaber es klingen mag, die Probleme können sich auch einfacher lösen: Der Verfasser stirbt ...»

Irony of fate, the founder of the Munich school of archaeozoology passed away in 1991, four years before the publication of the volume on the animal remains of Tell Hesban.

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Archaeofauna 5: 182-183

EXPLOITATION DES ANIMAUX SAUVAGES À TRAVERS LE TEMPS. Actes du IV^e Colloque de la Société interdisciplinaire «L'Homme et l'animal», Juan-les-Pins, 15-17 octobre 1992. Ed. APDCA, Juan-les-Pins, 539 p. Desse, J. et F. Audoin-Rouzeau (eds.), 1993.

La publication de ce riche ouvrage est la concrétisation d'une volonté de relier entre elles des disciplines souvent fort éloignées comme par exemple l'archéozoologie et l'histoire des religions ou l'ichtyologie et la parfumerie. Ce colloque, consacré à l'exploitation des animaux sauvages, en fut une brillante illustration. Elargissant la vision diachronique annoncée dans le titre par une ouverture à des zones géographiques aussi éloignées que les Alpes du Nord et les Aléoutiennes ou la Syrie et l'Argentine, les diverses communications abordèrent des sujets aussi différents que les activités de subsistance au Paléolithique inférieur ou l'emploi des sécrétions animales pour la fabrication des parfums.

L'exploitation des animaux dans un but alimentaire, allant du charognage à la chasse aléatoire, puis sélective, fut abordée dans plusieurs communications traitant aussi bien du Paléolithique inférieur et moyen, du Magdalénien, du Néolithique et du Moyen-Age, dans des zones géographiques variées. Les aspects complexes des activités cynégétiques sont mises en évidence dans plusieurs présentations. Ainsi, on peut citer la nette liaison existant entre les taux de chasse au cerf et l'évolution de l'élevage dans le Néolithique européen, ou le rôle symbolique que joue cet animal dans de nombreuses cultures préhistoriques européennes.

L'étude fine des âges de certains gibiers, le bison par exemple, permet d'aborder le problème des chasses saisonnières et de montrer, dès le Paléolithique moyen, une exploitation cyclique du monde animal.

Les autres catégories, mammifères marins, oiseaux, batraciens et poissons ne sont pas oubliées. Leur rôle dans l'alimentation humaine n'est pas à négliger et parfois, les techniques modernes de fouille permettent de montrer qu'en termes de ressources en protéines, les poissons ont été largement sous-estimés. L'étude détaillée de leurs restes osseux permet aussi de montrer des phénomènes de surpêche en Méditerranée, cela dès le Néolithique. Mais l'exploitation de l'animal ne se limite pas à la consommation de sa chair. Il livre bien des produits dits «secondaires» mais dont l'absence eut entravé

considérablement le développement de l'espèce humaine dans un milieu relativement hostile.

Plusieurs communications présentent ces aspects: outillage en os néolithique du midi de la France ou exploitation des plumes d'oiseaux en Argentine, mais aussi recherche de l'ambre gris, calcul intestinal des cachalots, fort prisé des fabricants de parfums ou sur divers produits animaux utilisés comme fixateurs en chimie. A propos des produits secondaires, on peut regretter qu'aucune présentation n'ait été consacrée aux activités de pelletterie et de tannage dont la préhistoire nous livre tant de vestiges probants. L'animal sauvage fut aussi utilisé comme auxiliaire de la chasse. La fauconnerie médiévale donna ainsi lieu à une présentation. Enfin, plusieurs communications insistèrent sur les aspects non économiques de l'exploitation des animaux sauvages. Nous citerons ici les bucrânes d'aurochs de Syrie, le culte des trophées en Europe occidentale, la morale de la chasse dans la Grèce antique ou encore l'ichtyologie d'une religieuse bénédictine du 12^e siècle.

Comme on peut le voir, au simple énoncé des quelques approches glanées parmi les 42 communications publiées dans cet ouvrage, la matière est fort riche et le sujet, loin d'être épuisé.

Nous avons là, avec ce livre, une somme considérable d'informations sur les relations ayant pu exister entre l'homme et les animaux sauvages. Le rôle alimentaire de ces derniers est certes prépondérant, mais une vision par trop économique cache trop souvent d'autres aspects, moins évidents peut-être mais essentiels au développement de l'humanité.

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Archaeofauna 5: 183-184

TOWARDS A HOLISTIC ARCHAEOZOOLOGY? ANIMALS IN THE URBAN LANDSCAPE IN THE WAKE OF THE MIDDLE AGES: A CASE STUDY FROM VÁC, HUNGARY. B.A.R. (International Series) 609. Tempus Reparatum, Oxford. (Price: £35). *Bartosiewicz, L. with contributions by Miklós, Z. & F. Gyulai, 1995.*

Because of their data content combined with usually limited heuristic scope, faunal reports constitute both the cornerstones and the cinderellas of archaeozoological research. In the financial heydays of this discipline, some 25-30 years ago,

partly forced by the hectic pace at which developments were taking place, partly due to the pride which exposing a hitherto unknown portion of the national cultural heritage implied, we learned, through voluminous monographs, about places like Burgasische-Süd, Eketorp and Manching (Boessneck *et al.*, 1963; Boessneck *et al.*, 1971; Boessneck & Driesch, 1979). Since those «good old days», funding shortages, shifts in focus from data to methods and theoretical studies, together with the rising costs of publications, have precluded for the most part those types of monographs, and have condensed information in faunal reports to the strict minimum (i.e. through descriptive statistics and the like) a matter of much concern and debate at present. One of the very few ways an author has of circumventing this state of affairs is to turn the faunal report into something of larger scope than a mere «list of bones».

This is essentially the approach taken by Bartosiewicz with apparent success. Blessed with a culturally diversified series of urban sites (i.e. Germanic, Slav and Turkish) and an expanded diachronic sequence from a historically relevant city, Bartosiewicz states that: «*Conclusions ... from the archaeological record ... reflect an inseparable mix of biological facts, past human behavior and current knowledge*» (p. 1). He incorporates a historian and a paleobotanist in the team of co-authors in an effort to insure an adequate evaluation of the faunal remains themselves.

Documentary sources, as a matter of fact, turn out to be exceedingly scarce in Vác, something which one should expect due to the often turbulent history of this city, so that the development of trade, guilds, taxes, etc., had to be partly inferred from those of neighbouring urban centers, in particular the ones of the future capital, Buda-Pest.

The urban context, ripe in terms of intra-site comparative analyses, poses the problem of short-lived excavations carried out at a frantic pace. In the case of Vác a side-effect was the hand collecting of zooarchaeological remains. Thus, no mites, no microvertebrates and little information to address paleoenvironmental or archaeological issues. This has been the case with fishing and fish trade which, despite the city's location on the banks of the Danube river, has been impossible to infer (a mere of 40 bones out of a total of 12.000 remains!). Partial recovery can also be inferred from the unexpectedly large amount of identified remains (95%) but, from the author's standpoint, it

seems as though its main effect would have been to bias the age profiles, leading to underestimations of non-adult cohorts of domestic stocks. Numerous papers since the now classic contribution of Payne (1972) evidence a whole series of withdrawals from the strictly methodological domain to the conceptual one, which make us feel that the issue is more complex and merited a more thorough discussion at some stage (Gautier, 1984; Grayson, 1984).

Even though the interaction between culturally heterogeneous stockbreeding strategies was typical for the Hungarian Middle and Modern Ages, it seems that cattle provided most of the meat consumed at Vác and that this dominance of beef was boosted by large scale cattle drives that crossed the Danube at this point (p. 112). Temporal «lows» (i.e., pigs during turkish times) and «highs» (i.e., mutton in the early medieval deposit from site XI) in the general pattern have been interpreted as a combination of factors, including ethnic traditions and socioeconomic status. At this point, Bartosiewicz carries out a very interesting analysis comparing meat quality, carcass parts, retail prices and bone fracturing patterns in 21 countries, in addition to those in published sources and his own samples, which might prove of great value as an inferential tool for faunal analysts (p. 35-42). The author postulates that: «*the degree of culturally determined variability, rather than absolute prices, may be useful in ranking cuts by the range of values they potentially represent beyond their biochemical composition*» (p. 38), a statement with obvious archaeozoological repercussions due to the correspondence between butchering patterns and bone fracturing patterns (Morales, 1988).

Many more issues are discussed at length in this monograph. Sometimes, as in the case of intraspecific variability of cattle, the discussion focuses on the osteological evidence. In other cases, as in the status assessment of dogs in Vác, non-biological data, historical or otherwise, are incorporated. The result is a highly instructive, at times overwhelming and occasionally disconnected treatise on medieval crafts, symbols, stockbreeding practices and landscape evolution around the city. The author evidences a command of English language and a prose rarely seen in the scientific literature.

This same story-telling structure is apparent in the chapters on paleobotany and history. The exhaustive documentation is well integrated in the discussions of «ecofacts» conveying the impression not only of the authors' thorough knowledge

of their subject, but also of the cooperative teamwork throughout the volume.

Although every work is prone to criticism (i.e. why so many inconsistencies between bibliographical citations in the text and the references section?) and although the partial recovery of remains at Vác casts some doubts on the validity of a series of conclusions, Bartosiewicz, Miklós and Gyulai should, nevertheless, be congratulated for producing such a readable book and for trying to overcome that bias which plagues a lot of publications, namely (in the authors' words): «*... the feeling that members of one's own group deserve special consideration ...*» (p. 114) ¡Bravo!

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ARCHAEOZOOLOGY OF THE NEAR EAST II: PROCEEDINGS OF THE SECOND INTERNATIONAL SYMPOSIUM ON THE ARCHAEOZOOLOGY OF SOUTHWESTERN ASIA AND ADJACENT AREAS. Leiden: Backhuys Publishers. 155 pp. NLG 76,00. *Buitenhuis, H. & H.-P. Uerpmann (eds.), 1995.*

At a cost of more than 30 US cents per page, this is an expensive book, paperbound as it is and not identified as having been printed on acid-free or archival quality paper. One continues to be amazed and always appalled at the price of books published in northwestern Europe (particularly Germany and the Netherlands, but also Britain), and as a result personal libraries contain fewer and fewer new works produced in this part of the world. The same is true for institutional libraries around the world which, due to budget constraints, are being forced to reduce their orders for new items, with the first books to go being the expensive European ones. Thus even as the English (or American) language is becoming the scientific *lingua franca* (and twelve out of fourteen articles in the volume under review are in some form of English and none by a native speaker), a divide between European and American but especially between «first» and «third world» scholarship continues to be perpetuated. This is particularly unfortunate in Archaeozoology where practitioners around the world can benefit greatly from reading each other's work.

Another way that researchers take advantage of each other's experiences, of course, is at international conferences, large and small, with the latter being the more effective forum for real communication. Some of the «working groups» recognized by the International Council for Archaeozoology (I.C.A.Z.) have actively sponsored such smaller conferences, among the most active and successful being the Fish Working Group, the Bird Working Group, and the one that produced the volume here under review: the I.C.A.Z. Working Group on the Archaeozoology of South-Western Asia (and Adjacent Areas). The ASWA(AA) group was formed at the VIth International Congress of the International Council for Archaeozoology (I.C.A.Z.) held in Washington DC in 1990. Its first meeting was in Groningen in early June of 1992 with the proceedings published in 1993 under the same title and by the same publisher as the proceedings here under review. These latter stem from the second

ASWA(AA) meeting held in Tübingen in late September 1994 prior to the VIIth ICAZ Congress.

In reviewing my notes and the program of the Tübingen meeting, I notice some omissions in the List of Participants printed on Page 4 of the present volume. Included among these are Chiara Cavallo (Amsterdam) and François Poplin (Paris) both of whom have papers in these proceedings (!) as well as Ajita Patel (Dept. of Archaeology, M.S. University of Baroda, India) who does not. In all, individuals from twelve countries attended this small two-day affair coming from as far as Japan, India, Israel, and USA as well as from around Europe, although British scholars are notable by their absence. In spite of this wide representation at the conference, however, the proceedings contain contributions only by European and Israeli researchers. Even so, they reflect well the wide range of concerns being addressed by archaeozoologists working on materials from Southwest Asia.

The longest of the 14 contributions, its 40 pages making up more than one quarter of the volume, is an important article by Rivka Rabinovich and Eitan Tchernov. In it they present a detailed paleoecological and taphonomic overview of the fauna from the Paleolithic site of Qafzeh in northern Israel within the framework of a discussion of the dating, archaeology, and hominid remains from that site. As the authors emphasize, the assemblages of micro- and especially macro-fauna from the various strata are small, with the total being 1594 identified rodent and insectivore specimens from 11 «Mousterian» levels (XV-XXV) and 2254 identified specimens of larger animals from 61 «layers» of the Middle and Upper Paleolithic. These small numbers, of course, affect the results of the analysis. Even so, in this first relatively complete modern study of a Middle Paleolithic cave fauna from the Levant, the authors raise a number of important issues, including scavenging versus hunting, seasonality of site occupation, and the behavior of particular rodent species. In the next three paragraphs I provide short takes on each.

Tchernov and Rabinovich (p. 38) note: «*Maybe today after so much research has been undertaken on this controversial topic, we have to admit that hunting and scavenging are not necessarily mutually exclusive in Hominid history, but rather a much more general behavior related, as previously mentioned, to the food - meat - fat acquisition and to social interaction of the group members ...*» I agree! And what about the other half of what some

have learned, namely, that we just cannot tell from the remains at hand and should begin asking other questions?

On seasonality, the authors take issue with the results of a study of incremental structures in a very small sample of gazelle teeth sectioned by Lieberman that indicates a changing pattern of seasonal occupation different from that suggested to them by the rodent remains, especially «*commensal animals like *Mus musculus**» (p. 33; but see the discussion in the next paragraph). Regretfully they do not point out that seasonality in gazelle procurement is just that. Evidence for year-round use of gazelle may well indicate year-round occupation or reuse of the site at different seasons of the year. But the inverse is not true - seasonal exploitation of gazelle means only that and need not have any direct implication for seasonality of settlement except that the site may have been in use at that time of year.

On rodent behavior, I would question the characterization of *Mus musculus* and *Mastomys batei* as commensal in the Mousterian. Certainly *Mus musculus* became commensal later, in part, but the ancestral form as well? And *Mastomys*? This needs some justification. I think what should be emphasized more is the great adaptability of these rodent forms. And if segregation is said to take place between domestic and wild forms, one needs to support that assertion. In addition, what is not addressed here is the means by which the rodent and insectivore remains got into Qafzeh in the first place. Did they live there or were their remains dropped by owls, and if they were resident, did their remains actually come from layers that were uppermost when they were alive or from younger burrows into older sediments? In this paper, taphonomic analysis is for larger mammals only, which may reflect the different interests of the two authors which, in turn, may explain why the paper seems really to be two papers put together as one.

The remaining 13 contributions in this volume are much shorter, ranging between 4 and 16 pages each. Eight are concise preliminary reports of the analyses of fauna from sites dating between the Neolithic and Medieval periods. Chiara Cavallo (Amsterdam) reports on an assemblage of 3127 specimens from sixth millennium BC levels of Tell Sabi Abyad in northern Syria. The presentation includes one useful technique of data analysis that is absent in the other contributions to this volume. This approach involves documenting the relative

proportion of sheep and goat in the collection element by element for selected skeletal parts instead of overall. This provides some idea of the degree of confidence the analyst can have in an overall ratio. Thus, in the Tell Sabi Abyad collection, the percentage of sheep (versus goat) is 84.1, 80.1, and 85.7 percent according to the humerus, radius, and talus, respectively. An improvement, of course, would be to tabulate the proximal and distal ends of the long bones separately and to list all skeletal parts. Nevertheless Cavallo's effort is to be noted and applauded.

Elisabeth Stephan (Tübingen) presents a useful if very preliminary report on a collection of 41,546 specimens from Tell Abraq in the United Arab Emirates. This is an important body of material for understanding animal exploitation patterns from the late third millennium onward along the southern shore of the Persian/Arabian Gulf. The author notes the relatively high proportion of terrestrial species represented compared with what has been found at most other coastal sites of the Gulf. Her identification of zebu cattle is also interesting, although use of the flat orbital rim as diagnostic of zebu is not really reliable in my experience (also in the experience of Caroline Grigson, pers. com.). In addition the author herself notes that the pots with zebras painted on them are probably imported, and I do not think that climatic considerations are particularly useful given the adaptability of bovine forms. The differentiation of zebu and taurine cattle remains to be worked out osteologically in a systematic fashion, and until that is done we who work in the «Adjacent Areas» to the east of Southwest Asia need to be careful about making too many assumptions.

The report of Birgit Dechert (Tübingen) presents the first analysis of 13,079 bone remains from the Early Bronze Age site of Hirbet ez Zeraqon in northern Jordan. Of particular interest is the identification of horse (*Equus caballus*) and donkey (*Equus asinus*) remains, and it would be important to know from when in the EB they come, as the author notes. This is the only article to deal with sex ratios in sheep and goat, which are apparently quite different in the two species - much more even in sheep than in goat. Unfortunately, it is difficult to evaluate this finding in the absence of a statement of how sex was determined.

Also in Jordan, but much later, is the interesting sugar manufacturing site of Tell Abu Sarbut. Lambertus van Es (Groningen) reports on 6,759 bones

from the Ummayyad-Mamluk Period among which are a particularly high proportion of *Bos* sp., *Equus* sp., and *Camelus* sp. This is unusual in a site in Western Asia and perhaps can be connected to the use of animals for draft purposes in an industrial setting. Rather complete data are presented on the numbers of specimens found for each taxon, on epiphyseal union patterns for *Bos*, *Ovis/Capra*, and *Camelus*, and on evidence for carnivore gnawing (which had quite a high incidence at this site).

The next report is by A.T. Clason (Groningen) in which she reworks and adds to an earlier report on the faunal remains from the first millennium AD site of Ta'as in northern Syria. The ca. 400 specimens were recovered from four small trenches widely spaced across the site. This is the only general bone report that gives measurements and probably can be considered to be the final statement on this small collection.

The famous west Anatolian site of Hissarlik (Troy), where Hans-Peter Uerpmann is leading a team of bioarchaeologists as part of the new excavations, is represented by two reports. Marian Fabis (Nitra, Slovakia) briefly summarizes (using bar graphs) some of the data collected on Hellenistic and Roman remains as well as noting single finds of particular interest. These include parts of the skeleton of a domestic cat, the ulna of a small dachshund-like dog, the first phalanx of a hybrid camel, and the tibiotarsal of a domestic chicken with osteopetrosis, probably reflecting avian leucosis. The first, third, and fourth are illustrated with excellent photographs.

Petra Krönneck (Tübingen) reports on 663 bird remains dating from the Early Bronze Age through the Roman Period at Troy. The assemblage is dealt with as a whole with no break-down according to period or skeletal part. Instead the goal is to look at the distribution of species by biotope and likely season of presence in the Troy region. The author emphasizes particularly the presence of 8 bones from the great bustard (*Otis tarda*). Since these animals do not inhabit areas with any significant amount of high vegetation, their presence would seem to indicate large expanses of open ground somewhere in the area of the site (unless the birds were imported from elsewhere in Turkey). It would be interesting to know whether the great bustard bones are confined to a particular segment of the long sequence at Troy or are found throughout.

The final general bone report is one by Jaco Weinstock (Tübingen) on 2062 bones from nine Punic and one Roman layer excavated during the 1991 season at Carthage. Presentation of summary graphs for each layer shows change through time from dominance by *Bos* in the earliest Punic layer to mostly *Ovis/Capra* in the late Punic and Roman layers. There is also an increase through time in the remains of pig. These trends are linked to the political and economic history of the site and its relationship to its hinterland. In addition, by comparing measurements of the *Bos* and *Ovis* remains from Carthage with those from contemporary sites in other parts of the Mediterranean, Weinstock makes a good case that the cattle represent a single population of large animals as do also the sheep, arguing that it is likely that both forms were imported, possibly from the Punic homeland (Lebanon). This is an elegant paper, containing a good deal of information and some interesting discussion in its six pages.

In concluding these brief reviews of the general bone reports, I would like to make two general comments without singling out any particular contribution. First, I think it is preferable to present faunal counts and weights in the form of tables or, if that is not possible, in flat bar graphs or flat pie charts rather than in the form of three dimensional bar graphs or pie charts like those so commonly used by authors in this volume. The three-dimensional ones, while they look elegant, are very hard to actually read and are even harder to reconstruct the original statistics from. Indeed, I sense that, in at least one or two instances, even the author(s) who published three dimensional diagrams in this volume had difficulties in reading patterns from them. Second, I think it would be worthwhile for the younger generation in particular to carefully read what J.P.N. Watson (1978) wrote nearly two decades ago about «*The interpretation of epiphyseal union data*». Even though one might not agree completely with Watson's pessimistic conclusions, many of the observations he makes - and particularly those about what epiphyseal union data represent - are very important.

The remaining five contributions in this volume include two dealing primarily with a single genus, one that is methodological, and two that are in French. Margarethe Uerpmann (Tübingen) presents data on some second or early first millennium BC mongooses from Bahrain in the context of a more general discussion of mongoose distri-

bution. The Bahrain specimens are identified as *Herpestes edwardsi* on the basis of metrical comparisons with both modern and other ancient material. The specimens come from at least ten individuals, and while clearly larger than any known *H. auropunctatus*, are ten percent or more smaller than published modern material of *H. edwardsi*. On this basis, the author feels «justified, therefore, to consider the present population of gray mongoose in the Gulf area as a group of feral domesticates rather than as an introduced wild species» (p. 67). Uerpmann does not define what she means by this distinction, which on the face of it seems rather artificial given that she herself talks about the mongoose as a «semi-domesticated» animal in the first paragraph of her article.

The second article dealing primarily with a single species is on the camel in Hungary by Lazlo Bartosiewicz (Budapest). The principal focus is on the Ottoman period site of Szekszárd-Palánk where a total of 14 *Camelus* specimens were identified among a corpus of 6621 fragments. These are considered to be from the dromedary given their relatively small size and gracile dimensions as demonstrated by measurements and scatter plots. This article adds to the growing body of information on the historical distribution of this important secondary domesticate.

Next is the methodological article by Hylke Buitenhuis (Groningen), who deals with the differentiation of sheep and goat scapulae using principal components analysis of six different attributes. Each attribute was deemed to have four states, with a score-value of 1 being most sheep-like and 4 being most goat-like as per the classic study of Boessneck, Müller, and Teichert (1964). The modern specimens examined included a maximum of 64 from domestic sheep, 30 from wild sheep (4 species), 20 from domestic goat, and 22 from wild goat (5 species). Plotting the scores for Factor 2 (nature of pecten on *collum*, shape of the *fovea articularis*) against those of Factor 1 (shape of *processus coronoides*, nature of *fossa synovialis* in *fovea articularis*, nature of the *fossa subscapularis* in *collum*, and curvature of the *margo cervicales*) led to almost perfect discrimination between the two genera in the case of the modern specimens. Application of the same procedure to archaeological specimens produced excellent discrimination for previously identified early Neolithic material (from Bouqras and Asikli) but a somewhat less good fit for Late Neolithic/Early Chalcolithic Ilipi-

nar. Attempts to discriminate the genera using canonical discriminant analysis and size indices based on bone measurements were less successful, and efforts to identify breeds using any of these techniques were failures.

Buitenhuis finds the value of his efforts to lie in the «advantage that the species determination is much more objectively reached and that fragments that show ambiguous characterisation can still be identified as to species with a high degree of certainty» (p. 154). He urges that other researchers try his method, and I would echo that call. Unfortunately, however, he does not discuss the problem of fragmentary specimens and the resulting missing values nor the benefits or drawbacks of including different species of the same genus (especially of wild forms). In addition, he does not give scores for each specimen nor does he say whether he includes right and left sides (or only one side) for each animal and what effect, if any, statistical non-independence might have on the technique. Indeed, it is necessary that in any such presentation, the requirements and limitations of the statistical techniques used be clearly outlined. I hope that in the final publication of this important study the author will attend to these details, because most faunal analysts are not sophisticated enough with numerical methods to be able to use even such a simple technique as principal components analysis in an informed fashion.

Finally, I turn to the contributions of our two French colleagues. Being in French, I fear that they will not be read by as many colleagues as might read those in English. This is unfortunate because they are the best written, most literate, and among the most informative of all the articles in this volume. The contribution of Jean Desse (Valbonne) provides an overview of the state of archaeo-ichthyological studies in the Persian/Arabian Gulf and the northern Indian Ocean. He emphasizes the need for good comparative collections and notes the locations of some of those that do exist. He provides information on work that has been done and that is in progress, discusses techniques of analysis, including osteometry, and in the end calls for the formation of a special working group dedicated to the ichthyofauna of the Indian Ocean and its particular problems.

To fill out Desse's article a bit from my own perspective, I should like to note that an important collection of Indian Ocean fish was made by Camm Swift of the Los Angeles County Museum

of Natural History in the late 1970s for the specific purpose of identifying the fish remains from the excavations at Balakot (Harappan Period, c. 2600-2000 BC). After he made the collection, however, Swift never carried out the archaeo-ichthyological study that he had intended to do (or at least oversee), and the Balakot material remained unstudied until the middle of this decade. Over the past three years, William Belcher (Madison, Wisconsin) - using the LACM(NH) collection as well as additional modern specimens that he collected - has analyzed most of the fish remains from Balakot, together with those from the site of Allahdino, nearer to Karachi. The results of this work should be available shortly.

Like Desse's contribution, that of François Poplin (Paris) is a progress report of sorts. In an instructive and entertaining piece, Poplin narrates his efforts to follow the trail of ostrich egg shells through collections from the circum-Mediterranean region. He shares with us the results of his search (including photographs), the important differences between South and North African ostrich egg shells (heavily versus weakly pitted - which he found out relatively late in his intellectual journey), and the reason why he thinks that South African shells were polished (to permit their being more effectively painted). In conclusion, he passes to the question of the working of pig canines, points out the relation of boar and elephant tusks to ostrich eggs, and ponders the connection of all three with coconuts. It is always rewarding to make one's way through Poplin's writing; his illumination of features on the margins of Archaeozoology makes them central to our field of enquiry.

In conclusion, in spite of its price this volume is a must buy for anyone working on material from Western Asia with some of the articles having a

more general appeal as well. The one thing the book would benefit from is an erratum compiled by the editors on the basis of a careful rereading of their articles by each contributor. There are myriad mistakes in figures and text and references throughout the volume. Whether these are due to poor editing or lack of care on the part of the contributors, future readers would be assisted by their correction. One has the feeling that providing proofs to the authors was sacrificed for speed of production. This is a trade-off that sometimes has to be made, but my firm belief is that authors should take more responsibility for the quality of their original manuscripts, leaving less for the editor(s) to have to worry about. In this day and age, even though we are all terribly busy, care in manuscript production can still pay major dividends, particularly in the speedy publication of high quality reports.

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