Archaeofauna 16 (2007): 117-172

An ichthyoarchaeological survey of the ancient fisheries from the Northern Black Sea

ARTURO MORALES[1], EKATERINA ANTIPINA[2], ALUNA ANTIPINA[2] & EUFRASIA ROSELLÓ[1]

[1] Laboratorio Arqueozoologia. Depto. Biología. Universidad Autónoma de Madrid. Cantoblanco. 28049 Madrid. España.

[2] Institute of Archaeology. Russian Academy of Sciences. Moscow, Russia.

(Received *February 5, 2007*; Revised *May 9, 2007*; Accepted *June 4, 2007*)

ABSTRACT: In the present paper, an overview of the fish remains from archaeological sites of the Northern Black Sea region in the period from the VIIc. BC to the IVc. AD is undertaken. Although the original aim of the paper was to make the pertinent Russian literature available in English, finds of fishes that were reported in English and German were incorporated into the data set in order to provide as complete and coherent a picture of the fish samples as possible. Additionally, data on the biology and features of the species that have been mentioned by all these sources were incorporated in an attempt to get a better grasp of the cultural (economic) meaning of the fish assemblages. Finally, a comparative overview was carried out in order to find hints of spatial or diachronic patterning that would explain the reasons for the onset of the industrial fishing enterprises in the area that started with the Greeks as well as points of coincidence with the industrial fisheries that developed during this time in the waters of the Iberian peninsula. Although still at a very tentative level of analysis, the data indicate that one of the major targets of such industrial fishing, the marine taxa –in particular the clupeid fishes- is lacking in material evidence. Until this sector is systematically analyzed the impression is that what we are seeing in the archaeological record are the features of a local (i.e.,non-commercial) fishery that apparently focused on brackish and freshwater species and remained essentially stable for the period under consideration.

KEYWORDS: FISH, FISHING, CLASSICAL ANTIQUITY, NORTHERN BLACK SEA, RUSSIAN LITERATURE

RESUMEN: El trabajo revisa los hallazgos de peces en yacimientos arqueológicos de la zona septentrional del Mar Negro desde el siglo VII a.C. hasta el IV d.C. Aunque el propósito original fue el de traducir al inglés la bibliografía rusa sobre el tema, se han incorporado al corpus documental trabajos en inglés y alemán en un intento por proporcionar un cuadro lo más exhaustivo y coherente posible sobre el tema. El trabajo incorpora datos sobre la biología y rasgos de las especies mencionadas en las fuentes a fin de mejor captar las implicaciones culturales (económicas) de las asociaciones de peces. Por último, se llevó a cabo un somero análisis diacrónico con el fin de evidenciar patrones espaciales y taxonómicos que pudiesen ayudar a comprender las razones del establecimiento de pesquerías industriales en la zona, iniciadas por los griegos, así como posibles puntos de coincidencia con sus equivalentes en la Península Ibérica. Aunque aún estamos en una incipiente etapa de investigación, los datos indican la inexistencia, a efectos prácticos, de evidencias materiales referidas a un sector clave de estas pesquerías, el estrictamente marino, especialmente los clupeidos. En tanto no se disponga de información sistemática sobre el mismo, la impresión que proporciona la arqueozoología es la de unas pesquerías de tipo local, no comercial, que, centradas sobre especies de aguas dulces o salobres, se mantuvieron estables a lo largo del milenio considerado.

PALABRAS CLAVE: PECES, PESCA, ANTIGÜEDAD CLÁSICA, MAR NEGRO SEPTENTRIONAL, LITERATURA RUSA.

INTRODUCTION

The studies on the development of fishing in the Northern Black Sea coast have a long tradition in Russia that dates back to the seminal monograph of Köhler (1832). Traditionally, these studies have been based on tree kinds of sources, namely:

1. *Written sources* of the classical Greek and Latin authors that mention fish species, catching and processing methods and also export.

2. The wide variety of *archaeological evidence* that relates to commercial fishing and fish processing.

3. The material evidence provided by the *remains of the animals*, themselves an item in the larger context of archaeological evidence.

Of these three, the later to put it mildly and paraphrasing Lund & Gabrielsen (2005) *«…has apparently not been at the forefront of research»* (*Ibid*.: 163) and constitutes the basis of this contribution.

Written sources can be considered the elements that set the archaeological studies in motion more than 150 years away and, in a certain way, one gets the impression that a lot of the effort that has gone since that time on the part of the archaeologists has had the aim of corroborating what people like Athenaios, Aristophanes, Aristotle, Eupolis, Polybios, Strabon or Oppian, to mention but a few, had to say on the issues of fish processing and trade in this region (see comments below on the translated works of Tichy, 1917; Marti, 1941; Lebedev & Lapin, 1954; and Kruglikova, 1978). As an example of this influence of the classical authors on the modern archaeologists, one may mention Robert Étienne's theory suggesting that it was possible that the Phocaean Greeks first introduced fish processing to the Punic colonists of the Southern Iberian Peninsula after arriving in the region from Asia Minor, where they had practised fish-preservation techniques since the seventh century BC (Étienne, 1970: 298-299). Where did Étienne get the idea that the Greeks had been preserving fish since the Archaic period? Étienne & Mayet (2002) themselves tell us: «… *Strabon rapelle que les Turdetans ont developpé une importante industrie de salaisons qui soutinennent la comparaison avec celles du Pont; celles-ci servent donc de référence et semblent bien anteriéures à celles de Gades*» (*Ibid*.: 9). If these are the kinds of evidences that set researchers in motion no wonder that debates are still a long way from arriving at a consensus.

Written sources have been also confusing at the nomenclatural level of naming fishes. The ancient Greeks, as people with a long maritime tradition, were well acquainted with all the fishes of commercial importance. In many cases, they had different names for animals of the same species but different age or sex (Table 3). Sometimes different names were also given to fishes from the same species but of different habits (eg. migratory vs. sedentary). All this translated into a confusing terminology that the classical authors, themselves not fishermen, and their translators have additionally complicated (Strömberg, 1943; D'Arcy Thompson, 1947). When the readers of such names have no ichthyological background the results can be disastrous (eg. Ponsich, 1988: 38-39). In the case of the Black Sea, one of the more disturbing fish names comes from the written sources («khamsa») whereas the other was used by some Russian archaeologists (i.e., «herring»). Both names apply to clupeid fishes but since no specific identifications have been made of this family in the Black Sea sites, we remain uncertain about the species to which these names refer.

The archaeological evidence related to fishing in the Black sea, in addition to the animal remains, includes a lot of data on fishing equipment (in particular net weights and hooks), a lot of «descriptive sources» *sensu lato* (i.e., coins and epigraphy) and, of course, data on the processing installations (fish salting vats, in particular) at Chersonessos and four additional sites of the Bosporan Kingdom (Tyritake, Myrmekion, Zolotoe and Salatčick) (Marti, 1941; Gajdukevic, 1952 a, b). Ever since their discovery, the later data have remained as the main exponents of a large-scale and technologically advanced fishing and fish processing industry for the Russian-speaking world. For the remaining sites of the northern Black Sea coast, the evidence of fishing in terms of tackle and fish remains is clear from the period between the fourth century BC and the fourth century AD but installations are wanting or debatable (eg., the smoke-curing facility at Elizavetovka).

The one disturbing piece of information for which archaeologists have tried in vain to reconcile the written sources with a dearth of data in many *ad hoc* ways has to do with the evidences of transport. To this day, the only shipwreck with an amphora containing fishes, was found in 2003 and the evidence available suggests that the amphorae produced in the Black Sea region –not just its northern shores- during the Classical and Hellenistic periods were not primarily intended as containers of fish and fish products. For this reason it is concluded that *«…such a trade was either at a small scale or irregular»* (Lund & Gabrielsen, 2005: 166). Moreover, for the remaing of the Black sea *«…we have plenty of literary and epigraphic evidence for comemercial fishing and processing…… but hardly any archaeological evidence to match it»* (Munk Højte, 2005: 156). In fact, before the Roman period, there is no evidence of fish processing except for the previously mentioned finds at Elizavetovka and Varna.

With these data, Russian archaeologists have put up a lot of quantitative estimation and theories on fish productions forward that, in the light of the incomplete data sets –even for the fish salting installations-must necessarily remain at this point as nothing more than educated guesses (Munk Høtje, 2005: 157).

This brings us into the issue of the fish remains themselves, an often neglected part of these researches on ancient fishing yet critical for any future developments on the subject.

METHODS: SOME CURSORY COMMENTS

The data set on fishes gathered from the Russian literature evidences a heterogeneous approach to the analysis of these remains that has given rise to a series of shortcomings (Table 24). Among these one may mention:

1. A large fraction of the reports provide only qualitative data (i.e., lists of names with occasional comments). This shortcoming is worsened by nomenclatural problems such as a lack of equivalences between the vernacular and scientific names as well as by an inacessibility to the original collections and unpublished fish reports.

2. Another large portion of the sites have been analized quantitatively, with the identified number of remains (NISP) occasionally complemented by the minimum number of individuals (MNI) represented in the samples but these samples are small to the extent of rendering comparisons, statistics or any other quantitative treatment unreliable when not downright misleading.

3. Finally, for the minority of sites whose fish collections are large and have been thoroughly documented and quantified, a lot of important data that are key for a correct interpretation of the assemblages has been left out. Among these, one may mention the methods of recovery (ie., hand collection, dry or water sieving, flotation, mesh size, etc.) and the identification protocoles (i.e., whether pictorial information or reference collections were used, whether all or a selection of elements from each species were identified, etc). These two items are vital for a correct interpretation and overlooking them renders comparisons among samples unreliable. Similarly, lack of specification on how were the bones measured, the size estimations carried out or the condition of the elements recorded (i.e., whether the bones had been burned, eroded, crashed, digested, etc) precludes any thorough comparison among the samples. It is with these restraints in mind that one should read most of the elaboration of data that is presented in the Discussion section.

There are, for these thoroughly studied fish collections but also for the remaining ones another two reasons why samples are incomparable in many cases. As it so happens, these limitations do not exclusively refer to the literature in Russian. Thus:

a) In the case of the fishes retrieved at Olbia and Berezan Island, Ivanova (1994) undertook the methodologically questionable way of treating both data sets as a single sample. Although for its time her approach represented a major advance over previous scholarship, the specific diachronic patterning was obscured by that method as were the possibilities of extracting meaningful inferences from each sample (Tables 27 & 28).

b) On a wider scale, we are lacking a chronologically reliable framework to compare faunas in many instances. In this way, at some sites the Roman period samples were gathered in isolation but at some others the «colonial» (ie., Roman + Greek) deposits were clumped together and still at others, the subset corresponding to the colonial levels *sensu lato* and that corresponding to the local populations, whether Scythians or Maiotics, have been mixed (eg., some sites in Northwestern Crimea and others in the Asian side of the Kimmerian Bosporos).

Clearly, one needs to proceed with caution when trying to make inferences from much of the data that follow and the most one can say is that, in many ways, we are presently at the very begininnig of a systematic study of fish remains from the Black Sea. For such reason, if this document is to be of any future use, we propose that forthcoming analyses of fish remains be undertaken with the following provisos in mind:

1. Samples need to be thoroughly excavated, retrived and processed previous to identification and the methods used at each step clearly specified in the report. From this perspective, it is vital that contexts be culturally defined and the bones from each chrono-cultural deposit treated as independent units.

2. In the laboratory, it would be necessary to use a reliable reference collection for carrying out the identifications and that the procedures for quantifying, measuring and describing remains follow the conventional protocoles for which many publications exist (eg. Wheeler & Jones, 1989). Among these methods, importance should be laid on calibrating the ratio of fish bones to the remaining animal remains, that of freshwater to marine fishes and also to comment on problems of the representativity of taxa, such as sturgeons and certain sharks (eg. *Squalus acanthias*, the dogfish) that despite being abundant in the area may leave few or no traces in the archaeological deposits due to the lack of ossification of all or the majority of their skeletons. In these cases, certain procedures (eg. skinning, be-heading, etc) may contribute to eliminate any traces of these fishes in the archaeological deposits and one should be keen on trying to spot signals that would neutralize such distortions since absence of evidence by no means needs to be taken as evidence of absence.

3. Finally, from a more comprehensive level of interpretation, it would be important to instruct readers with the necessary environmental background (i.e., evolution of the Black Sea basin) that would help better frame the finds of fishes or aquatic organisms in general (Ryan & Whitman, 1998). To this end, the lines that follow will hopefully constitute a first step.

THE FISHES

An important aspect when studying the fishes from archaeological sites that is often overlooked by the archaeologists concerns the biology and characteristics of the various species. These features often determine which species are more important from the economic standpoint, which more accesible, when can the animals be captured and what are the properties of the meat that allow for a certain way of preparation and consumption. For such reasons, we have attempted to provide some basic data on the taxa that have been at one time or other mentioned in the archaeological literature in Russian. Although these data are far from exhaustive they at least provide a first *corpus* on which future analyses can elaborate and will, hopefully help better frame some of the non-biological issues related to fishes.

GUITARFISHES (RHINOBATIDAE): Guitarfishes are cartilaginous fishes whose closest relatives are the sawfishes (family Pristidae). Unlike the latter, Guitarfishes feature a normal rostrum, their appearance resembling that of elongated skates. Guitarfishes are bottom-dwelling carnivores that use their rostrum to probe the sand or mud in search of invertebrates, their plate-like teeth unable to deal with fishes. Of the two species recorded in the Mediterranean, the smaller *Rhinobatus rhinobatus* (up to 1 m) has a far wider distribution (i.e., Angola to the Gulf of Gascoigne) than *R. cemiculus* (up to 2 m) although both are presently recorded as rare in this sea (Bauchot & Pras, 1980). Such rarity undoubtedly is related to their biological needs for guitarfishes are characteristic of warm seas.

Although guitarfishes are presently recorded as occasional visitors to the Mediterranean, their restricted mobility and the fact that *R. cemi*culus appears to constitute an indigenous species for this sea hints at more sedentary habits and residential populations in the past. Perhaps the populations of guitarfishes fluctuated as sea temperatures went up and down, reaching a peak during the Neolithic climatic optimum (i.e., 8-6 ky BP) that coincided with the filling of the Black Sea basin. At any rate, none of the Mediterranean species reach into the Sea of Marmara and, if only for this reason, the presence of the genus in the west Crimean sites of Panskoe, Tarpanchi and Kulchuskoe might be taken as indicative of warmer water conditions in the Black Sea during this period (i.e., Vth BC-IIIrd AD, see below).

STURGEONS (ACIPENSERIDAE) are restricted to the cold temperate zones of the northern hemisphere, being particularly abundant in Russia, that features most of the 26 living species and whose Black Sea captures of wild specimens averaged 1,000t from 1976 to 1984. Nowadays, a large proportion of the commercial sturgeons derive from aquaculture installations.

Sturgeons are benthic or semi-pelagic fishes, often migrating between coastal marine waters and the rivers where they spawn, although many species became landlocked and only inhabit fresh water bodies (i.e., the Caspian and Aral seas). Fond of oxygenated waters and essentially solitary, sturgeon gather in small groups during their migrations but their capture nowadays never takes place on a large scale. Most species, in particular those living permanently in freshwater either hibernate or undergo a stage of torpor during the winter. Spawning takes place during the spring or the beginning of the summer and young animals spend one year before swimming downstream into the estuaries, taking another year before entering fully marine waters. Fond of soft bottoms, sturgeon feed mainly on benthic invertebrates (molluscs for the most part) but also take small fishes. One of the target taxa for the common sturgeon (*Acipenser sturio*) is the smelt or silverside (genus *Atherina*) that thrives in coastal waters but we have been unable to document whether this is also the case for the Black Sea sturgeons where the main prey fishes seem to be small clupeids (see below). After spawning specimens take several years before their gonads are ripe again.

The taxonomy of sturgeons is complicated by the fact that many species hybridise regularly. A more serious problem, over-fishing, has combined with pollution during this past century and now threatens most of the wild sturgeon populations of the Black Sea. From such standpoint, archaeozoological data could greatly help with the distributions of species since classical times thus provide data to better frame the study of over-fishing from a deeper perspective than that provided by the XIXth and XXth centuries' statistics and documentary records.

Sturgeons are among the most valuable commercial fishes. World-wide catches from 1976-1983 ranged from 27,582-31,800 tons. Over 90% of this catch was taken by the URSS and of it, 90% came from the Caspian Sea (the Sea of Azov yielded 3-5% of the soviet fishery catch during this period and the Black Sea at large less than 1%). Since then, captures in the wild collapsed further still. Nowadays most of the catch derives from fish farms.

The skeletons of sturgeon are only ossified in the case of the dermal plates (scutes) and most of the cranial elements. Traditionally, the identification of species has been restricted to the former, no study being available on the comparative osteology of their skulls. The scarce vertebral elements present are cartilaginous and for this reason the classical sources refered to sturgeon as «the fishes without spines», this being one of the reasons why we believe that the classical reference by Pliny («*In Borysthenes catfish are found of outstanding size without bones or cartilages and with very tasty meat*» Plin.*HN* 9.45) is probably refering to a sturgeon and not to the well ossified Sheat-fish (*Silurus glanis*) (another reason why the «catfish» name may still hold for a sturgeon has to to with the mouth barbels, resembling wiskers, that these fishes have hanging from their mouths).

Five species of sturgeon inhabit Black Sea waters at present. These include the Russian (*Acipenser gueldenstadtii*), the fringebarbel, ship or spiny sturgeon (*A. nudiventris*), the starry sturgeon or Sevryuga (*A. stellatus*), the common sturgeon (*A. sturio*) and the Beluga or great sturgeon (*Huso huso*). To these one should add the strictly freshwater Sterlet (*Acipenser ruthenus*) that ranges through the Danube basin, Caspian Sea and most of the Russian rivers. The first striking thing one notes when reviewing the archaeological fish remains is that, to date, no find of the widespread common sturgeon has ever been reported (see below). Our presentation of the main species here will therefore be restricted to the remaining aforementioned five.

The BELUGA is the largest of the living sturgeons reaching maximum lengths of 4-6 m (800-1,000 kg) depending on the area, with reports of 8 m long animals, with weights exceeding 3200 kg being exceptional at present. The species is known to hybridise in natural conditions with the Sterlet, Sevryuga, Ship and Russian sturgeon to mention only the ones reported in the Black Sea and this obviously is a problem when trying to achieve a positive identification of remains that do not quite fall within the morphology of the Beluga. Belugas live in the Mediterranean and Black Seas at depths of 30-170 m, adults at distances of 1-12 km from the coast. These require offshore fishing to be captured. Only juveniles remain in shallow, warmer waters during their first year of life. During both the seaward (dispersive) and spawning migrations, Belugas travel mostly in the deepest parts of the river bed though often ascend to the surface. The Black Sea spawning migration normally takes place from the end of January-beginning of February coming to a close at the end of November or early December. No seasonal data can be thus gathered from the archaeological materials. Two races have developed: the winter race spends the winter in freshwater and reproduces there in the spring of the following year whereas the spring race reproduces the same year it enters the river. Despite it, catches do exhibit a clear peak with 41-57% of the Belugas being caught from September-November and only 7-15% taken in the period from February to April. Regardless of the season they have entered the river, Belugas spawn during the high-water period in the spring. For the rivers that reach the Black and Azov seas, this happens between April and May, with the peak in the Don taking place in May. Spawning begins at water temperatures of 6-7ºC, the optima ranging between 9-17ºC. While still larvae the animals travel down to the sea.

Although the great sturgeon used to be one of the main catches in inland water bodies, its fishery in the Black and Azov seas traditionally lagged behind the freshwater catch. This marine fishery is nowadays anecdotic and essentially restricted to the northern part of the Black Sea. In the 1958-1981 year period catches fluctuated between values of more than one order of magnitude apart (i.e.,19.7-240.5t, for an average of 105t/year). Even those catches, that nowadays are far lower, constitute a pale reflection of the ones recorded during the early part of the twentieth century. In Romania, for example 1,042t of great sturgeon were landed in 1898 and 1899 from only one of the sectors of the Danube but by the 1930s the combined Romanian fishery averaged catches of only 600-700t/year. The Sea of Azov fishery of the Beluga, that authors such as Korobochkina (1964) date back to the 6th century BC, managed catches of 1,200t from 1937-1939 and the proportion of Belugas in the total yield of the sturgeon from this area during the period from 1928-1961 ranged from a low of 3.7% (1942) to a peak of 26.4% in 1958. At the present time, the local Beluga population is maintained by artificial restocking [the decline in the fisheries was far more marked in the inland catches. In 1771 Gmelin reported the capture of 500 Belugas (600-800 kg on the average but some in excess of 1,000 kg) in the Volga river within two hours of work. These animals had been trapped by an Astrakhan Zaboiki, specially designed for the capture of sturgeons and a kind of trap that has been used in estuaries and brackish water «bottlenecks» in general for centuries].

The flesh and eggs from the Beluga are quite similar in nutritional contents to those from other sturgeon but have a special bouquet that makes them the most highly esteemed of all.

The STERLET (*Acipenser ruthenus*) is the only sturgeon found in fresh waters and constitutes the smallest of the Black Sea sturgeons, rarely recorded beyond 80 cm (20 years; 35-40 cm at 5 years). It is also one of the few species that is systematically grown in hatcheries and farms. A devoted insect feeder (i.e., Mayflies and chironomid larvae in particular) it also takes worms and snails. During the winter hibernation it barely feeds. With the arrival of spring animals swim upstream in order to spawn. Spawning concentrates in the months of May and June. Females mature anywhere from 5-9 years (40-45 cm), males far earlier (i.e., 4-5 years; 35 cm).

The Sterlet has traditionally been an important commercial fish, caught with various kinds of nets, traps and hooks. On the average 50% of all the sturgeon catches in Russian rivers correspond to this species. In 1935, the world catch amounted to 750-800t of which 700t corresponded to the Soviet Union. Most of the Sterlets caught nowadays come from the Danube basin but these catches are far lower (i.e., 36t (1979)-117t (1963) in the period from 1969 to 1985, for an average of 65t/year). This catch concentrated on 3-year-old specimens (i.e., non adults) thus has essentially wiped out the species from this basin in recent years.

The fast growth under controlled conditions (within 2 years Sterlets reach marketable weights of 900-1600 g) and the plasticity that these animals exhibit in relation to various kinds of man-induced disturbances has proved decisive for the survival of this species.

The RUSSIAN STURGEON (*Acipenser gueldenstaedtii*) is a medium sized sturgeon (average adult 140cm; common 105-170 cm; maximum 220 cm) (Table 1) with a distribution very similar to the Sevryuga that nowadays covers the Caspian, Azov and Black Seas and the lower portions of their tributaries but that formerly included their total courses as well (during the 19th century the species still ascended the Don as far up as the town of Zadonsk). The species appears to be very rare on the southern shores of the Black Sea.

A solitary animal that forms small shoals on its reproductive migrations (early spring-late autumn; spawning peaks in May-June), the Russian sturgeon is an inhabitant of shallow, preferably brackish, waters where the concentrations of its prey abound (small fishes, anchovies in particular, presently constitute important items of its diet). Optimum salinities are set at 18‰ and the temperatures for the optimal development of the larvae run between 15-21ºC. The animals normally eat round the clock although with peaks during sunset and sunrise.

The fastest growth of this species occurs in the Azov sea but subfossil specimens from the Don river exhibited a far slower growth that might be taken to indicate lower fishing pressure (Table 1, Tsepkin & Sokolov, 1970). Since the resident form in the Volga Basin has a retarded growth rate by comparison to that of the migratory form, the pattern recorded in the subfossil Don specimens could also be taken to indicate that a larger fraction of the river populations were non-migratory, thus more susceptible to overfishing and extinction. At present, the species reaches maturity around 9-11 years (♀♀) and 7-9 years (♂♂) when size goes over the 100cm «threshold». After the Sterlet and the Sevryuga (see below), the Russian sturgeon comes third in terms of precocity of maturation, meaning that it can support a heavier fishing pressure than slower growing sturgeon species. The Azov Sea stocks mature especially early, one or two years before those of the Black Sea and freshwater populations.

The Russian sturgeon catch nowadays takes first place among the acipenserids but only a small fraction comes from the Black and Azov seas where the fishery is concentrated on the Northwest sector near the Danube delta. This is in part due to the very recent (i.e., post-1980s) crash in the Sea of Azov populations whose landings reached 1,080t in 1939 (in the 1928-1961 year period, Russians constituted anywhere from 13% (1938) to 47% (1961) of the total sturgeon captures in this sea). This fishery preferentially cropped immature animals, thus wreaked havoc on the sturgeon populations. Already by the early fifties the Russian sturgeon catches fluctuated heavily at far lower values (i.e., 9t in 1951 *vs.* 76t in 1952) between adjacent years. During the 1980s the combined sturgeon catch for all countries bordering the Black Sea never exceeded values of 150-160t.

The last of the common sturgeon species in the archaeological record is the SEVRYUGA (*Acipenser stellatus*), a slightly smaller species than the Russian (common size ranges: 110-140 cm; maximum: 190 cm; Table 1). Sevryugas are demersal (i.e., dwelling near the bottom) during the day surfacing at night to feed. They occupy shallower waters (10-40 m) during the spring and summer that during the cold part of the year (i.e., 40-100m). The species also undertakes long migrations in the sea, being one of the few recorded sturgeon in Mediterranean waters (i.e., Adriatic). April-June is the period during which most fishes swim upstream to reproduce, spawning peaking from May-July in the Black and Azov seas' tributaries. Fishes constitute an important part of the diet of Sevryugas (30-50%) in the Azov and Black Seas, anchovies being critical during the autumn and gobids during the spring. *Mellina* is another key item for adult fishes in the northern Black Sea.

AGE (YEARS)	Mean size (Russian)	subfossil size (Russian)	Size range (Sevryuga)	Weight (Sevryuga)
1	25-31	29.5	13-28	c.0.5
2	50	46	25-61	1
3	66	55	39-79	1.5
4	77	61	49-86	3.5
5	86	66	61-98	4.5
6	91	71	70-107	6
7	99	77	82-116	7.5
8	104	81	90-123	10
9	109	86	95-129	11
10	114	90	96-134	11.5
11	124	96	98-137	12
12	127	100	101-142	13
13	132	114	105-146	14
14	138	118	110-147	14.5
15	142	121	153(?)	15.5
16	146	126	156(?)	19
25	182	-	-	
27	187	-	-	

TABLE 1

Selected growth parameters for Russian sturgeon and Sevryuga (size in centimetres; weight in kg). (Taken from Holčik *et al.*, 1989).

The species grows faster than the Russian sturgeon but in the Sea of Azov and Black Seas specimens over 16 years are very uncommon nowadays (Table 1). Maturity is particulary fast for this precocious species in the Azov Sea, in particular for the the Kuban River, where already during their 4th year of life males mature (common ages at maturation are 5-6 years (♂♂) and 7-12 years (♀♀).

The commercial importance of the Sevryuga rests in inland waters (Caspian), with the Black Sea and Azov Sea catches being marginal. The intensification of the marine fishery at the begining of the twentieth century had a devastating effect on the catches of Sevryugas that declined drastically after 1915. Still, in 1935 Sevryuga accounted for 62% of the Sea of Azov combined sturgeon catch but this decreased to 55-60% already during 1941-1947. The mean annual catches in the Sea of Azov steadily declined from 2,200t (1929-1951) to 1,500t (1952-1955). The Black Sea catch ranged from 18t (1967) to 0.2t (1980) most of the fishes (22%) being taken in Bulgarian waters and Sevryuga accounted for less than 10% of the total sturgeon catch in this sea.

Although the low frequencies of the ship sturgeon (*Acipenser nudiventris*) in the archaeological sites can be explained in terms of its less precocious maturation, slower growth rate and more selective feeding habits that today make it the most infrequent of the sturgeon species, such is not the case with the common sturgeon (*Acipenser sturio*) whose total absence from the archaeozoological record of the area seems baffling. Tsepkin (1984) mentions 200-250 cm specimens of *Acipenser sturio* in neolithic settlements along the Southern coast of the Black Sea but none during more recent times.

The common has all the odds to be a common item of the ancient Black Sea fisheries: large size (up to 6m), sturdiness, great mobility, excellent quality of the meat, etc. Although it might have been infrequent in the past in the Black Sea region and the number of described fish remains is still low compared with other regions, two very different phenomena might be responsible for such lack of remains:

1. The species is a recent invader from the Mediterranean that was never able to establish itself in the northern Black Sea, perhaps due to competence with the other sturgeon species.

2. The remains of *Acipenser sturio* in the area have been systematically overlooked or missidentified.

None of these two explanations appear satisfactory yet the former can be defended, to some extent, on biogeographical grounds. The common sturgeon appears to have been a Northeastern Atlantic species that later entered the Mediterranean and its present day distribution confirms such hypothesis (eg., Holčik *et al*., 1989: fig. 59). These authors' data, indicating that it reaches only to the Southern Black Sea perfectly fits the absence of remains in the Northern Black Sea coast but stands in contrast with the distributions offered by Fisher *et al*. (1987) and many other authors, that record *Acipenser sturio* as present throughout the Black and Azov seas. If the later references all provide incorrect data, then the absence of *A. sturio* in the northern Black Sea coast might be taken as an indication that the common sturgen never reached the area during classical times.

PIKE (*Esox lucius*) is the geographically most widespread of all the freshwater fishes inhabiting the Black Sea region. As is often the case with most of the freshwater species recorded in archaeological sites of this area, Pike also inhabits brackish waters being particularly fond of shallow ones rich in vegetation. Pike is an adaptable species living over a wide range of temperatures and spawning in waters anywhere from 2-12ºC (March-May in the Black Sea region). A poor swimmer and a stalking hunter, Pike prefers clear and still waters, most of the animals being sedentary. Growth is highly variable but often fast: one year specimens range from 9-20+ cm; at 2-3 years (when males mature) most fishes range form 25-40 cm (0.5 kg). Females mature from 3-5 years (40-50 cm; 0.5-1 kg) and from 4-6 years onwards most fishes weight more than 1 kg. Only rarely do males reach to 90-100 cm (5-8 kg; 10-14 years), the maximum sizes corresponding to «giant» females, often beyond 30 years (1.5 m and up to 35 kg) but these individuals are nowadays exceptional.

Pikes are voracious feeders that take all sorts of pelagic invertebrates and small fishes when juveniles, then become predators of fishes, including their own kind. Since the species does not concentrate in large shoals, it does not support a commercial fishery. Still, it does make a good sport fish whose total European captures reached to 10,000t in 1970. Nets, hooks and, more seldom traps are used. The flesh is commercialised fresh for the most part.

CLUPEIDS (CLUPEIDAE): Clupeids presently constitute the main resource of the world fisheries in terms of biomass, the Black Sea being one of the areas where their exploitation excels (Figure 6). All these fishes are pelagic, mostly littoral, highly gregarious and migratory for the most part, their migrations involving movements up and down the water column, entering surface waters during the spring and summer months. Shads are amphidromous migrants that swim upstream in rivers. All clupeids are essentially filter feeders concentrating on planktonic organisms of one kind or another. Their meat, high in fat, makes them ideal subjects for preservation and during classical times, along with scombrids, clupeids were one of the main ingredients of the various fish sauces (Curtis, 2005; Ejstrud, 2005).

The ANCHOVY, *Engraulis encrasicolus* presently constitutes the major item of the northern Black Sea fishery (Figure 6). The size of this fish reaches to 16 cm in the northeastern Atlantic but only 12.5 cm in the Mediterranean and 10 cm in the Sea of Azov (Figure 1). At present its highest densities in the Northern Black Sea area are reached in the Strait of Kerch, the species being abundant there from the months of May to August (April-September for the Mediterranean). During this time, the shoals of this mostly zooplancktonic feeder move along the shores of the Black and Azov seas ocassionally penetrating into brackish waters. Their capture is made with various kinds of movable nets operated from vessels but in the past, shoals were also taken with land-based nets operated with the help of small boats. After the summer, shoals dive deep and spend the winter in a state of torpor, unreachable for the fishermen before the appearance of sophisticated gear during the mid-twentieth century. In 1983 the URSS captures amounted to 212,000 t in the Black Sea representing 30% of the combined catch for the whole of the Mediterranean Sea.

Whereas there exists little doubt that Anchovy went under the name *khamsa* in the ancient sources, we have found several nomenclatural inconsistencies in the reviewed literature concerning the clupeid fishes. The first one is that this name was apparently applied to two, not just one, species of clupeids. Since the genus *Engraulis* is monospecific in Black Sea waters, one wonders what the other species could be. A second inconsistency applies to the name «herring» that the literature appears to use as a synonym of clupeids at large since the true «herring» (*Clupea harengus*) is a NE Atlantic species that never entered the Mediterranean. Disturbing in particular is the fact that Marti refers to «herring» scales as present at Tyritake's salting vats corresponding to animals of *«… no less than 38-49*

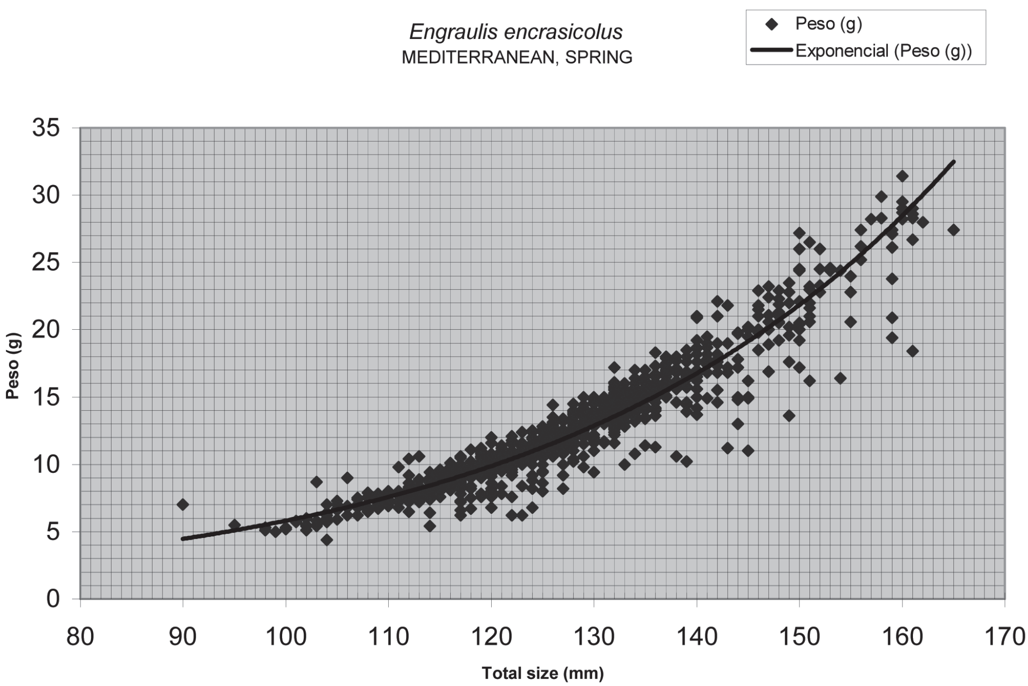

FIGURE 1

Weight (ordinate axis, in grams) vs. total length (abcissae, in millimetres) correspondences for the Mediterranean Anchovy (*Engraulis encrasicolus*).

cm...» (Marti, 1941: 95). The only clupeids that reach this size range are the shads, of which the species *Alosa fallax* presently reaches into the lower half of the Black Sea whereas both *Alosa caspica* and *Alosa pontica* are endemic to Black Sea and Caspian waters (Figure 2).

The TWAITE SHAD, *A. fallax* is, like all of the members from this genus an amphidromous species that lives in the sea but swims upstream in the late spring-early summer in order to reproduce. Nowadays these fishes rarely reach beyond 7 years of age although some specimens have been determined to reach up to 25. The maximum weights range from 1.5-2 kg and commercial sizes oscillate from 25-40 cm, occasionally reaching up to 55 cm. The finds at Tyritake appear to fall outside the species' present distribution in the Black Sea but it might well be that in the past large shoals of shads

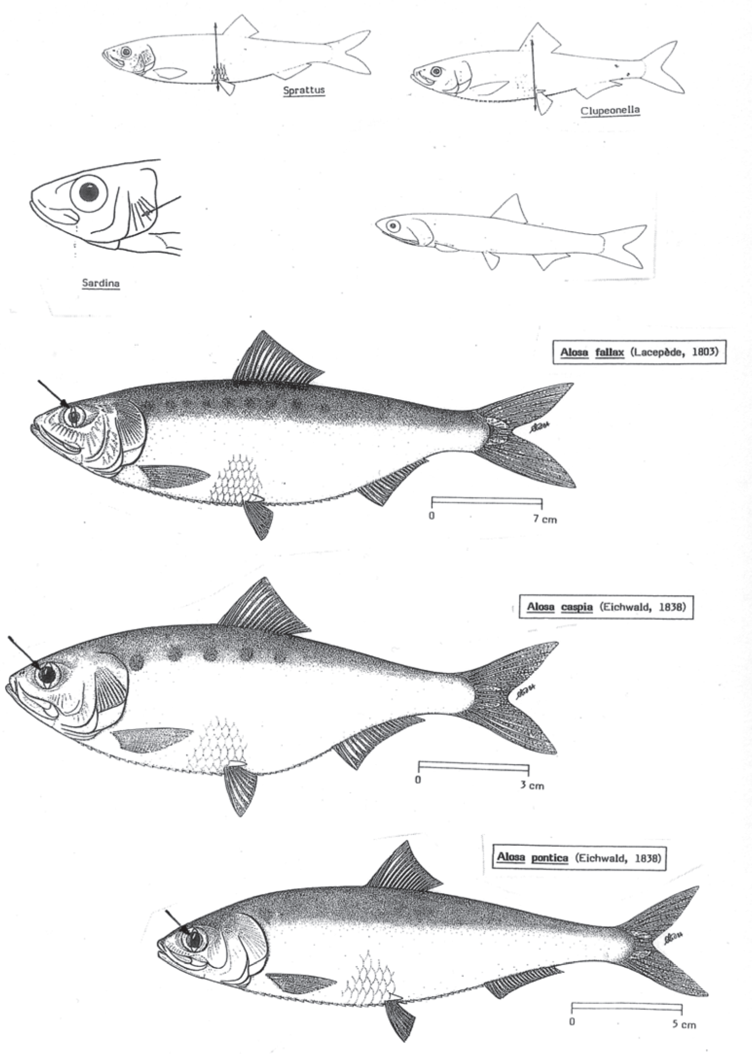

FIGURE 2

Selected species of Black Sea clupeiforms. Anchovy (*Engraulis encrasicolus*) differs from the remaining clupeids by its large mouth that reaches well behind the eye. Shads (*Alosa*) are the only genus featuring an adipose eyelid (arrows) whereas sardine (*Sardina*) features a series of grooves in the operculum that the Sprat (*Sprattus*) and Sardelle (*Clupeonella*) lack. The latter two species differ from the relative location of their pelvic fins in relation with the dorsal and the shads differ from each other by their general body shape and by the absence or number of dark spots on their back. (Taken from Fischer *et al.,* 1987).

concentrated in the Strait of Kerch to reach rivers draining into the Sea of Azov. If this was the case, the vulnerability of the species to intensive exploitation along the bottleneck of the Strait of Kerch could have placed it at a great risk of local extinction, a hypothesis that archaeoichthyological analyses might eventually corroborate.

An alternative shad at Tyritake might be one of the two endemic species: the CASPIAN SHAD (*Alosa caspica*) and the PONTIC SHAD (*A. pontica*). Both are smaller than the twaite shad. *A. caspia* has two subspecies of some economic importance. The Danube shad (*A. c. nordmanni*; maximum: 21 cm; common: 11-18 cm) covers the western half of the Black Sea whereas *A. c. tanaica* (maximum: 18 cm; common: 9-15 cm) is distributed in the Sea of Azov and eastern part of the Northern Black Sea shores. These migratory fishes are highly esteemed for the quality of their meat whose fat content in autumn trebles that of the spring and are fished, albeit in low quantities mostly when making their spawning migrations either at the mouths of the rivers or in bottlenecks such as that provided by the Strait of Kerch (April-June). The Pontic Shad is slightly larger (max. 30 cm; common: 20-25 cm) than the Caspian shad and a later spawner (i.e., May-August). Its distribution covers all the shores of the Black Sea, not only its northern half. Its commercial value is also far higher as catches reached to 2150t in 1982 (the range of catches for the 1956-1982 period was of 261-3800t (Y: 1470t) but these statistics are unreliable for they probably include young specimens of similar looking species, in particular *A. caspica*. At any rate, these two species are the most highly prized of the Black Sea clupeids. Presumably, this was also so in the past, so that a detailed analysis of the species implied in the archaeological record could eventually reveal the quality of the commercialised products and the species of large clupeids reported by Marti (1941) at Tyritake.

One of the most important commercial fishes in the Sea of Azov is the SARDELLE *Clupeonella cultiventris,* that ranges throughout the Black Sea shores. The catch of this animal in 1983 reached 120,000t but the commercial fishery of this 5-10 cm fish (maximum: 14.5 cm) began in earnest only during the 1930s. In 1938, only 3,400 of the 83,000t came from outside the Sea of Azov meaning that this could have been an important resource also for the Scythians and Maiotis tribes had they had the means to capture it. For such reason these euryhaline, spring spawners (April-June) flourishing in brackish waters and venturing into the lower courses of rivers, could have been one of the target species of the salting tanks of the classical fish factories.

In the case of the remaining species that could have been referred to as *khamsa* by the literary sources, two in the size range of the Anchovy are presently documented throughout the Black Sea: SARDINE (*Sardina pilchardus*) and SPRAT (*Sprattus sprattus*). Sardine is, after «herring», the most abundant clupeid in European waters and the number one in temperate waters but used to be rare in the Black Sea. This phytoplanktonic feeder is, like most marine clupeids, fished during the dark hours of the day during the spring and summer months and its commercial size in Atlantic waters ranges from 16-20 cm (maximum: 26 cm). The Black Sea sardines rarely reach beyond 15cm but this is 50% more than the maximum size for Anchovy. The feeding at a lower level in the trophic chain means that its biomass almost doubles that of the Anchovy and, if only for this reason one wonders if one of the clupeids that went under the name *khamsa* was also the sardine. Only future analyses of the bones and scales in the archaeological sites may help determine this. It must also be recalled that sardines were a major item in the fish sauces from the westernmost sector of the Roman Empire and that only they, not anchovies, have been known to be marketed as *salsamenta/ tarychos* in the later part of the Roman period (Wheeler & Locker, 1985).

The sprat is the smallest of the European clupeids although its present-day commercial size range (11-12 cm) is identical to that of the Anchovy. The use of this brackish water tolerant species in ancient fish sauces has only been documented in the shores of the North Sea during the II/III centuries AD (Van Neer & Lentacker, 1994) but it is also possible that its thriving in the colder waters of the Black Sea, where the species now represents the second item in importance of the commercial fishing fleets (Figure 6) may have determined it as an additional item of the Greek/Roman fish industry. In 1983, the captures of sprat in the Soviet Union waters of the Black Sea reached to 47,000t representing more than 60% of the sprat catch for the whole Mediterranean and Black Sea areas combined.

CARP-FISHES (CYPRINIDAE) constitute the most diverse group in European freshwaters, some of the species from the lower course of rivers venturing ocassionally into brackish waters. Most cyprinids have a diversified diet of invertebrates, insects and their larvae, but others have become more predatory, taking small fishes regularly whereas a few eat plants and organic debris. The tolerance ranges (i.e., temperature, pH, salinity) and environmental requirements vary greatly in such a speciose family being impossible to provide «averages» for the whole group. In many species there exist marked differences within populations that give rise to sedentary and migratory forms, turbid *vs.* clear water ecotypes, etc.

Only three species appear to be of economic importance in the Black Sea region nowadays. Not surprisingly, these species have been repeatedly found in the archaeological deposits:

1. The CARP (*Cyprinus carpio*) is by and large the most abundant cyprinid in archaeological sites, documented in four of the five «faunal regions» that we have created for analytical purposes (Table 24). This is a typical inhabitant of the lower course of rivers with slow or still waters, muddy bottoms and rich vegetation. Wild populations are shy and often more active at night. One of the limiting agents of its distribution is the temperature of the water during spawning (17-20ºC), so high that the wild form only occasionally reproduces in central and northern Europe. At temperatures below 8ºC the animal stops feeding and enters hibernation which it normally undertakes, as spawning, in very shallow waters. During its first year of life, the wild Carp reaches to 10 cm (100 g) then doubles those values during its second year (18 cm, 250 g). Between 3-4 years, wild Carps range from 20-40 cm (300-1000 g) this being the time when the fishes mature (males slightly earlier than females). Growth rates vary with water temperature (maximum voracity at 20ºC) and food availability, the populations grown in farms reaching 1 kg at 2-3 years of age. The largest Carps rarely exceed 1m but a rapid growth at this size produces a shorter, hunch-backed individual, the streamlined ones being indicative of a slower, smoother growth. Modern data for the mouth of the Don range from 33-100 cm (mean = 40 cm) being common at sizes between 33-42 cm.

Although today most of the world catch comes from fish farms, wild Carps have been an important commercial fish since ancient times. Its tolerance to low levels of oxygen allows the fish to survive out of the water for many hours, in particular during cold weather and when conveniently packed, and this has allowed for the introduction of animals in isolated water bodies.

2. The BREAM (*Abramis brama* but in the Black Sea area also its vicariants *A. sapa* and *A. ballerus* osteologically indistinguishable except for some very few bones such as the pharyngeals) is another inhabitant of the waters where the Carp thrives. As the latter, breams accommodate well to brackish waters, where some populations become sedentary, and constitute common items in estuaries under strong fluvial regimes (i.e., large rivers). Maximum activity takes place at night when the fishes reach to the shores of the river/estuary. Breams concentrate by the thousands in deep waters during their hibernation period.

Spawning in the Black Sea ranges from May to June, in very shallow waters with abundant vegetation and at lower temperatures than for the Carp (i.e., starting from 12ºC). In the rivers draining into the Black Sea, young fishes migrate to the sea during the month of July. More than anything else, growth depends on the amount of competence (i.e., density of siblings), the young being planktonic at first, then shifting to a diet of invertebrates. In the Sea of Azov breams mature anywhere from 3-4 years when they reach 20 cm (before this time, the animals are negligible as a fishing resource). Growth is far slower than for the Carp, breams with 18-20 years seldomly being more than 35 cm long. When 30-40 cm long, the weight oscillates from 0.5-2 kg and the species rarely reaches to 60 cm (3 kg; age?) although specimens of up to 80 cm (9 kg, age??) have been occasionally recorded. In the mouth of the Don the maximum recorded size has been 75 cm (range: 24-38 cm) and the mean size of the catches in the Sea of Azov were of 24 cm in 1923 and of 38 cm in 1924.

3. Two species of ROACH (genus *Rutilus*) constitute commercially important, albeit secondary, fish resources in the northern Black Sea area. These are the Common (*Rutilus rutilus*) and the Black Sea roach (*Rutilus frisii*) from which many subspecies have been described and which occasionally hybridise (a subspecies of the Common roach, *R. r. heckeli*, frequent in the area and far larger than the nominal subspecies receives the local name of Taran). For both species, growth is highly dependent on food availability and intraspecific densities being fastest for populations inhabiting non-isolated water bodies. The common roach, recorded at 40 cm (1 kg) in the Black Sea region, is a smaller species than the endemic species whose adults

commonly range from 40-60 cm (1-2 kg) and sometimes reach up to 70 cm (5 kg). Both the common and the Black Sea roach inhabit slow-flowing, fresh water but also lakes. In the Black Sea, both species regularly enter brackish waters and develop into local races that migrate into freshwater in order to hibernate and spawn. Spawning ends earlier for the Black Sea roach (April-May) than for the common roach (April-June) though both species require water temperatures of at least 10ºC in order to spawn.

Traditionally, roaches have constituted an item in the diet of the poor, the animals being sold fresh but also smoked or salted. Today, as it probably happened in the past, the main capture method is with either fixed or movable nets (seines) but the Black Sea roach is occasionally taken with hook as it is also appreciated as a sport fish.

4. The ASP (*Aspius aspius*) is a very rare find in archaeological Black Sea assemblages (Table 23) and also the most predatory of European cyprinids. In the Black Sea region this is a migratory fish that regularly penetrates brackish waters to feed. Spawning takes place in the lowermost course of the rivers in this area from March/April until May/June, in water temperatures that range from 4.5-14.5ºC. When migrating upstream the Asp congregates in small shoals although the species is essentially solitary. Fry immediately swim downstream and already at 2-3 months of age start eating fishes. We have been unable to gather data concerning the growth of this species. Animals apparently mature at around 4-5 years (50-55 cm; 2-3 kg) but the maximum size goes over one meter (120 cm; 9 kg; age??).

A good sport fish, most of the Asp captures are nevertheless still done with nets and, secondarily lines. The meat is very tasty in particular during the winter. Nowadays the fishing of the Asp in central Europe is regulated, minimum capture sizes oscillating between 28 cm (300 g) and 35 cm (500 g).

SHEAT-FISH (*Silurus glanis*) is a typical inhabitant of the lower course of large rivers where waters flow slowly and bottoms are muddy. In the Northern Black Sea the species ventures regularly into brackish waters. A nocturnal animal, this catfish spends the day hours hiding in rock crevices or buried in the mud. At night, it forages in shallow waters, often reaching the shore. A ferocious feeder, it preys mainly on other fishes –in the northern Black Sea region carpfishes and, secondarily, eels– but has an eclectic diet that includes crayfish, frogs and salamanders, water voles and young of various species of waterfowl. The year cycle includes a maximum activity during the spring. When autumn arrives, the feeding activity of the Sheat-fish declines and in both rivers and lakes the animal spends winter in a state of lethargy. This cycle is less marked for populations venturing into brackish waters although the densities of the fish decrease during the colder months of the year. For such reason, Sheat-fish could be taken as a seasonal activity indicator in the Black Sea.

Sheat-fishes require temperatures over 20ºC in order to spawn. Spawning in the Black Sea area takes place around the month of June, in shallow waters with abundant vegetation. The growth after the post-larval stage is very fast, animals of about a month ranging from 3-4 cm and those of about a year reaching to 20 cm. This size reaches 50 cm for animals of around 4 years (2 kg). Most of the animals of this size and weight are sexually mature but until recent times, most of the catches peaked at around 100 cm when the fishes were 9-10 years old and weighted around 10 kg. Nowadays the maximum sizes range from 2-3 m (i.e., weights of around 200 kg) and monsters like a specimen caught in the Dnieper in the early 1960s (5 m; 306 kg) are no longer seen. The common size range in the Sea of Azov is 78.5-97 cm and the maximum for the area c.250 cm. The meat of the Sheat-fish is very tasty and its caviar commercialised locally, often mixed with those of certain sturgeons, in particular the Sterlet and the common sturgeon.

PERCH (*Perca fluviatilis*) is an essentially sedentary fish that thrives in lakes, rivers and estuaries provided waters are well oxygenated (min. 3 ml O_2/l). Perches exhibit two ecotypes, the vividly coloured form that thrives in shallow waters with abundant submerged vegetation and the pale form that lives in deeper waters (i.e., down to 50 m) where some populations lead a fully pelagic existence. This solitary predator feeds mostly on small fishes, including its own fry and spawns in waters whose temperatures oscillate between 4-8ºC (for central Europe, this coincides roughly with the month of April but it can be as early as March in the Black Sea area). Young fishes of around 15-20 mm concentrate on the shores of lakes, rivers and estuaries in large numbers but are of no commercial value. At around a year, they range from 8-12 cm. Males mature from 2-3 years (females 1-3 years) anywhere from 15-25 cm but this depends also on environmental circumstances (i.e., in restricted areas where high densities are easily reached, males mature when only 7-8 cm long and females between 9-10 cm). At 8-10 years, the Perch measures around 25 cm (200 g). Nowadays it very rarely reaches 50 cm for a weight of some 3.5 kg. A good game fish, the Perch is commercially important in localized areas, the Black Sea region not being one of them at present. Its combined european captures in the seventies reached to 20,000-30,000t. The animals are commercialised fresh but also dried or salted, in particular in the Northern Black Sea.

PIKEPERCH (*Stizostedion lucioperca*) is a large version of the common Perch presently reaching maximum lengths of 120 cm (12 kg; c.20 years) although most catches today range between 35-55 cm (1 kg & 5-6 years). A far more exclusive fish than the common Perch, it requires large bodies of well oxygenated (i.e., min. 3.5 ml O_2/ l) yet warm waters. Many animals thrive in estuaries and other brackish water bodies (firths). The Pike-Perch is fond of turbid waters where it outcompetes the Pike (*Esox lucius*) since it stands higher chances of capturing the multiple kinds of small fish that constitute its main diet. It likewise avoids areas rich in submerged vegetation. Some populations of the Pikeperch, including those around the Black Sea, are sedentary whereas others are migratory. As this fish seldomly concentrates in shoals, its capture is carried out on an individual basis, often with traps or fixed nets, less often with baited hooks although the species at present constitutes a favourite game fish.

Pikeperch spawn when the water temperature reaches 12ºC (i.e., April-June, though earlier in the south-western shores of the Black Sea). Sandy bottoms are preferred as the eggs are placed within holes that have been digged in the substrate and both parents incubate until the larvae hatch. Within 6 months the young reach 6-10cm although large differences have been recorded depending on environmental conditions. Males mature anywhere from 2-4 years (33-37 cm; 300 g) and females between 3-5 years (40-44 cm; 600 g). European captures peaked during the 1960s at around 10,000t but these are mostly from freshwaters. No reliable statistics of its importance exist for the regions around the Black Sea.

GREY MULLETS (MUGILIDAE): This family features six species of pelagic littoral fishes with a preference for estuaries, coastal lagoons and firths that also thrive around harbours and other disturbed habitats created by man such as salt installations. In addition, several species regularly swim upstream during seasonal migrations reaching hundreds of kilometres inland. In this case, they return to the sea during autumn for reproducing, their large shoals being the target of the artisanal fisheries. Grey mullets are pelagic omnivores that sieve small organic items, both animal and vegetal but also detritus through their gill rakers. This filter feeding takes place passively in water or actively, with the help of their mandibles that ingest sediments or their preorbital bones that help detach the algal film covering hard substrates. It is this eclectic diet the one dictating the properties of their meat, highly esteemed in certain cases, disgusting and rejected in others. This phenomenon has been widely recorded in the documentary sources during classical times. It appears that, as happened in New Zealand with species such as the Greenbone (*Odax pullus*), for grey mullets that fed on algae the most appreciated tidbit was the stomach when the vegetal matter was still in a process of incipient fermentation (Leach, 2006). This seems to be the case when Galen states that *«For while some have plenty of weed and valuable roots and so are superior…»* (Galen, *On the properties of Foodstuffs* 3.24 = 6708-13 Kühn, trans. Powell, 2003). Diet also dictates to what an extent is the meat of grey mullets loaded with fat, something that makes it more apt for the various kinds of long term processing whether drying, salting or smoking.

Good swimmers and quite aggressive, grey mullets make good targets for sport anglers but are most often taken with various kinds of nets and traps, in particular in areas where tides are important elements of the coastal dynamics. Grey mullets are highly gregarious and this is one of the major reasons (the other one being diet) for presently growing them under controlled conditions. Although there is no hint that such a practice ever took place in the Black Sea, the rudimentary technology it requires (eg., wooden enclosures, etc.) makes it possible that under certain circumstances grey mullets could have been temporarily kept or raised in this way in the very productive waters of the large estuaries such as that of the Don or the Bug-Dnieper. Of the seven species recorded in European waters, only five are distributed in the Black Sea including the Sea of Azov (Figure 3). These are the thicklip (*Chelon labrosus*), Golden (*Liza aurata*), thinlip (*Liza ramada*), leaping (*Liza saliens*) and flathead (*Mugil cephalus*). Only three (i.e., Golden, thinlip and

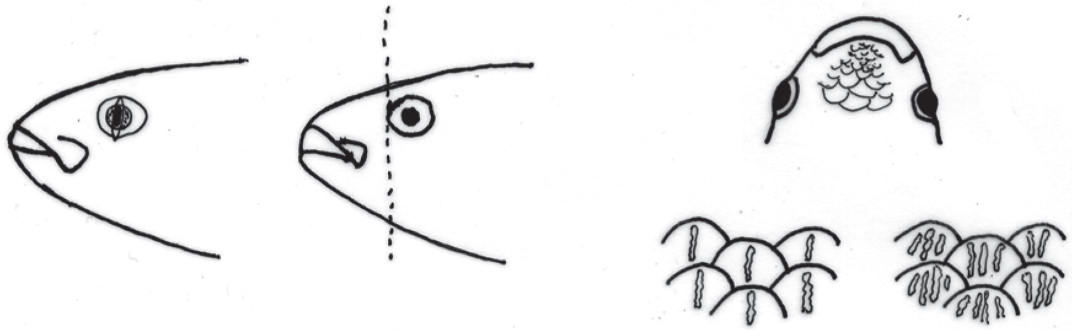

FIGURE 3

The three main species of Black Sea grey mullets: The flathead (*Mugil cephalus*) is the only species featuring adipose eye lids. Thinlip (*Liza ramada*) features predorsal scales with 2-8 grooves that reach to the tip of the snout and Golden (*Liza aurata*) predorsals with one groove that never proceed beyond the nostrils. (Taken with modifications from Fischer *et al*., 1987).

flathead) are mentioned in the classical literature or in the fish reports that follow (see below). The flathead, a cosmopolitan species is the largest of the three (maximum: 120 cm), the golden (max.: 55 cm) being the smallest whereas thinlips reach to 70 cm. Of all of the grey mullet species the flathead and thinlip happen to be the most tolerant to freshwater, their migrations reaching hundreds of kilometres inland. In contrast, the golden mullet only reaches upstream until the point where marine tides fail to exert their influence. The optimal temperatures for all these fishes range between 22-23ºC but thermic tolerance ranges from 7-37ºC although values shift from species to species.

The osteology of Grey mullets makes them easy to identify, both vertebrae and cranial elements, thus any future detailed study of the archaeological finds could come up with important environmental implications in addition to the cultural ones.

ANNULAR SEA BREAM (*Diplodus annularis*): This is a small sparid fish (maximum standard length: 24 cm; common between 8-18 cm) that inhabits all the littoral waters of the Mediterranean and Black Seas at depths that, for the later range from 0-30 m going down as deep as 90 m in the warmer waters bathing the Northern African and Levantine coasts. In winter, young fishes (i.e., those below 8-10 cm, when maturity is reached) concentrate in large schools in brackish waters. If such habit has always been so, then a size analysis of the archaeological specimens could provide hints on whether brackish water fishes where the bulk of the catch in the ancient Black Sea fisheries. The species is eclectic in habit, thriving over sands, rocks or substrates with vegetation. The Annular sea bream is a euryphagous species that both grazes and preys over a wide spectrum of small invertebrates, most often molluscs and crabs, but also sea urchins and corals.

Nowadays there exists a semi-industrial fishery of the species in Sicily and in the Adriatic, also artisanal and ocassionally sportive. In Turkey the combined catch of all *Diplodus* species peaked to 1,640t in the 1980s but never again were such figures reached. The catches of *D. annularis* in most areas of the Mediterranean are anecdotical. Spawning in the Black Sea takes place from July to September but depends on the temperature of the water, starting as early as February in the Levant and in the Southern Turkish shores.

Although RED MULLET (*Mullus barbatus*) is nowadays recorded as common between 12-20 cm (maximum 30 cm) the subspecies that inhabits the Black Sea (*Mullus barbatus ponticus*) is some 30% smaller (i.e., 8-12 cm). This is a gregarious demersal fish fond of sandy bottoms that, in the Mediterranean ranges from 10-500 m (10-100 m in the Black Sea). Red mullets in the later sea mature at around two years (7 cm for the females; 6 cm for the males) and spawn at the end of April and the beginning of May. Captures in 1983 for the combined Mediterranean went slightly over 29,000t of which 4,500 corresponded to Turkey but no data were specified for the Soviet Union and the share of Black Sea captures for Turkey we have been likewise unable to find.

The distribution of the BLUEFIN TUNA (*Thunnus thynnus*) in the Black Sea remains ambiguous to this day for even specialized works provide contradictory information on the subject. Most authors (e.g., Bauchot & Pras, 1980) consider the Bluefin to be evenly distributed in this sea whithout providing further specifications, yet Whitehead *et al*. (1984) report the species exclusively in its southern shores. Muus & Dählstrøm (1975) consider that Bluefins only occupy the western half of the Black Sea. The latter two distribution patterns appear to be consistent with the small yet regular catches of Bluefins reported by both Bulgaria and Turkey up until the mid-1980s (i.e., 3,000-5,000 specimens per year).

Vinogradov's ocassional finds of stranded tunas in the northern Black Sea shores at the beginning of the twentieth century convinced him of the importance of this species in the area during classical times, an idea that fitted the documentary data provided by some of the classical authors and set in motion a trend of thinking in Russian archaeology (Vinogradov, 1931; we have been unable to reach this paper, thus speak from what we have heard from informants). Indeed, although later Vodyanitskyi (1940) stressed that Vinogradov's casual finds could neither prove nor disprove the former importance of tunas in the Black Sea, many Russian archaeologists kept the idea of a Bluefin fishery rolling on their heads to the point of considering it as proven fact.

The issue has two complementary aspects to it, since one thing is the presence or abundance of the species in former times and a quite different one is whether the animals represented a major target of the fisheries during the classical period (i.e, Bluefins must have been common in the Strait of Gibraltar thousands of years before they appear in the archaeological record of southern Iberia; Morales & Roselló, in press). In fact, Bluefin is a cosmopolitan epi- and mesopelagic migratory species whose presence in any particular area is more dictated by prey availability than anything else. If, then as now, one major prey item in the NE Atlantic was the mackerel –until recent also abundant in the Black Sea- one sees no reason why Bluefins should have not entered this sea to spawn and feed as the classical authors refer.

Two additional lines of evidence derive from the nomenclatural and the technological data. In the case of the former, names such as *Cordyla* and *Auxides* apparently referred to animals born in the Black Sea that had not still reached the Mediterranean (Table 3). In the case of the later, the beam with multiple tridents that Thracian fishermen developed for impaling young bluefins, according to Oppian (Fajen, 1999) was obviously evidencing a specialized kind of fishing for large epipelagic fishes, although nothing prevented this gear from catching medium-sized scombrids such as the Bonito (*Sarda sarda*, see below).

If, as the evidence provided by several of the ancient authors indicates, watchtowers were used for spotting fishes in the Black Sea, these must have been meant for bluefin tunas rather than for any of the smaller gregarious fishes. This is so because it is these very big fishes the only ones able to change the aspect of the sea when swimming close to its surface at a large enough distance to grant fishermen stationed at the coast the time to set up their interceptor nets in the water before the schools actually arrive at the spot where the fishing will take place.

In light of this evidence, the scarcity of Bluefin tuna remains in the fish factories appears difficult to explain. In fact, it might not be so. Our own investigations in the Iberian fish factories evidence this same phenomenon and it has been only recently that we have found out why. A large butchery site, Punta Camarinal, has been recently discovered some 200 m away from the Roman fish factory of Baelo Claudia on the Strait of Gibraltar (Morales & Roselló, in press). In it, a «*golpe*» (i.e., a school) of bluefins had been butchered so that only the fins and vertebral columns piled up near a sand dune. Apparently, only those parts likely to be processed were transported to the factory and these, except for portions such as the branchial apparatus happened to be devoid of bones. Under such circumstances, the material evidence of fishing can dissappear from sight and the impression gained is that tunas were never an important resource. It remains to be seen whether such situation also took place in the northern Black Sea factories.

One way or the other, the biology of the Bluefin tuna in the Black Sea must be inferred from data on the western Mediterranean populations since, for all practical purposes, the species must now be considered extinct in the area. Even the data on the biology of the mediterranean tunas have changed dramatically over the last 50 years. Bluefins used to enter the Mediterranean when the superficial waters went beyond the 12ºC threshold, a temperature of 14ºC constituting their optimum for feeding. These temperatures are normally reached during the month of April, but the bulk of the fishery was carried out later although its peaks have changed drastically in less than 150 years. The tuna fishery of Sardinia took 74% of its catch in June and the rest in May for the period of 1829-1844 (Tyndale, 1849). In the period from 1950-1971, the captures of May had risen to 45% and some fishes were taken as early as late April but nowadays, more than 80% of the catch takes place in May and the rest throughout the month of April since by June no tunas are to be found (Dean *et al.*, 2005). Probably these shifts reflect the effects of an intensive exploitation but perhaps the environmental warming of the surface waters may also have something to do with them. One way or the other, given its distance to the Strait of Gibraltar, in the past a tuna fishery in the Black Sea must have been more of a summer event (i.e., June/July) than a late spring one.

Age (years)	Size (Fork length)	Weight
1	45-53	2-4 kg
1-2	68-85	4-12 kg
3	90-95	15-18 kg
3-4	85-125	12-27 kg
5	130-140	130-150 kg
14	240-250	240-300 kg
20?	+300	+500 kg?

TABLE 2

Size and weight ranges at specific ages for Bluefin tuna (*Thunnus thynnus*). Data taken from Quero (1984).

Bluefins in temperate waters live anywhere from 0-500 m and try to avoid waters below 12ºC but also those above 25ºC. The species tolerates brackish waters of 18-20‰ yet avoids waters above 38‰ (Quero, 1984). This means that it could have thrived in the low salinity waters of the former Sea of Azov, where it presumably spawned according to the writings of Aristotle, Appianus and Strabon but, by the same token, the increase in salinity that apparently occurred in areas of the Strait of Kerch such as the Gulf of Taman in the recent past could have spelled disaster for the Bluefin (Lebedev & Lapin, 1954: 213).

Size and weight data for Bluefins have not been systematically compiled or, if so, are not readily available for the «*common of the mortals*». Table 2 provides some very general data taken from a non-specialist volume (Quero, 1984). Bluefins are the largest of the bony fishes and animals in excess of 800 kg are mentioned from time to time although the only certified record at this point is an angling record of a 679 kg specimen that reached a fork length of 304 cm (Collette & Nauen, 1983). We have been informed of one specimen in excess of 900 kg (Gil de Sola, verb. com.).

Although several other tuna-like fishes regularly enter the Mediterranean, in the Black Sea, and in addition to the small-sized (i.e., up to 50 cm) mackerels (see below), only three middle-sized (i.e., up to 1 m) scombrids have been recorded: the BULLET TUNA (*Auxis rochei*), the LITTLE TUNNY (*Euthynnus alleteratus*) and the ATLANTIC BONITO (*Sarda sarda*). Of these, only the bonito, representing some 1% of the 2002 fish landings (i.e., 1,000t) is of any commercial importance in the Black Sea (Figure 6).

Bonito, like most middle-sized scombrids, is a tropical to temperate water, epipelagic, neritic schooling species that can adapt to gradual but not sudden changes in the environment and may occur in water temperatures between 12ºC and 27ºC and salinities between 14‰ and 39‰, ocassionally entering estuaries in colder waters such as the Black Sea (Collette & Nauen, 1983). In most parts of the Mediterranean spawning occurs between May and July but off Algeria it extends from March to May (*Ibid.*). Adults prey primarily on small schooling fishes, the choice in the Black Sea being Anchovy and Sprat.

Recorded at a maximum fork length of 85 cm (5 kg) in the Black Sea, the western Atlantic record stands at 91.5 cm for a weight of 5.4 kg yet weights do not correlate as much with size as they do with the condition of the fish, the all-tackle angling record standing at 7.6 kg for a 78 cm long bonito (Collette & Nauen, 1983). Minimum length at first maturity stood at 39.5 cm (♂♂) and 40,5 cm (♀♀) some twenty years ago (Collette & Nauen, 1983) but nowadays the animals mature at significantly smaller sizes although apparently no official data on this seem to be available (Gil de Sola, verb. com).

A side issue when dealing with scombrids, whether large or small has to do with the nomenclatural confusion that has existed both with the modern vernacular names, on the one hand, and with the names –or, rather, the translation of names- used by the ancient authors, on the other

(Table 3). This is a problem that plagues the inference on the kind of fish the references might be referring to, a matter made worse by idyosyncratic interpretations and by a deficient knowledge of the physical features of the animals at different ages.

NAME	COMMENTS
Tuna	Vernacular generally applied to any large (i.e.,+1m) species of scombrid fish, most often the Bluefin tuna (*Thunnus thynnus*), the only large scombrid entering the Black Sea, but also other species from the same genus of which only the albacore (*T.alalunga*) enters the Mediterranean
Tunny	A synonym of "Tuna". In the scientific literature this vernacular is also used as a common name for certain species of medium sized scombrids (i.e., up to 1m), most often of the genus *Euthynnus*
Bonito	A Spanish vernacular that in the scientific literature constitutes the common name of the species *Sarda sarda* and, by extension has been also given to other species of the genus *Sarda*
Cordyla	Greek term used for "newborn" bluefins (some authors specify 30-40 days old) that have not had the chance of leaving the Black Sea
Auxides	Greek localism (Byzantion). According to some authors a synonym of Cordyla although others specify that the vernacular applied to fishes 2-9 months old
Pêlamys	Greek generic for "young tuna"(i.e., presumably young Bluefin), a vernacular applied to animals 1-1.5 years old that had left the Black Sea and travelled into the Mediterranean
Limosa	A Greek synonym for Pêlamys
Thynnos	Greek vernacular apparently referring to Bluefins 1.5-2 years old (Latin equivalents: Thynnus and Tunnus)
Thuo	Greek synonym for Thynnos
Orcynos	Greek vernacular apparently referring to Bluefins 2-3 years old
Cetes	Greek vernacular apparently referring to Bluefins more than 3 years old that some of the classical authors considered as a kind of whale
Sarda	According to Galen, salted meat from an "adult" Bluefin
Saxitana	Greek vernacular referring to the Spanish mackerel (i.e.,from the town of Sexi, present day Almuñecar in the province of Granada)
Scombrus	Latin equivalent of Saxitana
Colias	A Latin synonym of Scombrus (i.e., Colias sexitanus; see Saxitana)
Lacertus	Latin vernacular referring to a mackerel with clear vermiculations on the back (could be either the Spanish or the Atlantic mackerel. See text)
Pelamyd	Modern word applied to small sized scombrids (i.e., up to 50 cm), essentially referring to the two species of mackerels

TABLE 3

A selection of recent names as well as others used by the ancient authors to refer to the main Black Sea scombrid fish species, with their scientific equivalents [taken from several sources, including Strömberg (1943), D'Arcy Thompson (1947), Ponsich (1988), Curtis (1991), López Linage & Arbex (1991) and Étienne & Mayet, (2002)].

The ATLANTIC MACKEREL (*Scomber scombrus*) is a pelagic migrant over the continental shelves of the northern Atlantic whose distribution closely matches that of its main prey, small clupeids for the most part (i.e., Anchovy, sprat, sardines and juvenile «herring») although mackerels are also feeders on the zooplankton when necessary. Given the local biomasses reached by both zooplankton and some of these clupeid fishes, anchovies in particular, the Black Sea should be a haven for mackerels whose present day scarcity probably reflects an overfishing of the species' stocks in mediterranean waters before the animals have a chance to reach the Bosporos. Indeed, the Atlantic Mackerel was apparently the most important catch of the artisanal fishery of the northern Black Sea at the beginning of the twentieth century (Andrusov & Zernov, 1914) and this has probably misled authors like Stolba (2005: fig. 6) into considering it to be still one of the main Black Sea species of commercial interest. Present day fishing statistics tell another story (see Figure 6).

The second species of mackerel, the SPANISH MACKEREL (*Scomber japonicus*) is a cosmopolitan species of subtropical, rather than cool-temperate waters. *S. japonicus* is a primarily coastal species and, to a lesser extent epipelagic or mesopelagic over the continental slope (surface-250/300 m) whereas *S. scombrus* is more of an epipelagic and mesodemersal species. The biology of both fishes features many coincidences. *S. scombrus* is a seasonal species that overwinters in a state of torpor in the deeper waters of the North Sea and the Northeast Atlantic (70-200 m) re-surfacing to coastal waters when the superficial temperatures rise to 9-13.5 ºC (11-14ºC in the Mediterranean and Black Seas, meaning anywhere from March to April). This is the time when both spawning and the largest agreggations of fishes occur thus the time when the former artisanal coastal fleets peaked in their activity. Once spawning comes to an end, the fishes undertake feeding migrations that last until the month of August/September in the Mediterranean and take them to offshore waters. At this time shoals are far smaller and looser although it is during the late spring and summer that most of the commercial fishing now takes place. The lack of a swimming bladder in *S. scombrus* and in some specimens of the Spanish mackerel (the presumed ancestral species of the Atlantic Mackerel) allows the fishes to travel fast and unrestrained in the water column. For such reason, artisanal fleets operated far better in shallow waters near the shore than in the deeper offshore waters (at present, most fishes are taken when wintering in very deep waters).The spawning optima for *S. japonicus* most often range from 15 ºC to 20 ºC. Schooling by size is well developed in both species.

AGE (Years)	Standard length (cm)
1	25.7
2	30.1
3	32.2
4	34
5	35
6	36.2
7	37.4
8	38.3
9	38.8
10	39
11	39.6

TABLE 4

Sizes of *Scomber scombrus* at ages 1-11 years for an average non-dominant year class in the North West Atlantic.

The early growth of both mackerel species is rapid. Fishes hatched in June or July reach a length of 16 cm in 90 days and grow to c.20 cm by November (a shorter period of growth at upper latitudes is compensated by faster growth rates). The sizes of *S. scombrus* at ages 1-11 years for an average non-dominant year class in the North West Atlantic appear in Table 4. Both mackerels normally grow to a maximum of 50 cm (c.1.3 kg), the Spanish (up to 1.5 kg) often slightly larger than the Atlantic and females larger than males of the same age. Nowadays specimens over 30 cm are rare catches. In general, for any given size, the Spanish is normally heavier than the Atlantic Mackerel but weights fluctuate depending on the condition of the fish (Table 5). Traditionally, the lengths at first maturity for *S. scombrus* were approximately 34 cm (♀♀) and 32 cm (♂♂) but overfishing is apparently forcing fishes to grow slowlier and to reach maturity at smaller sizes thus these figures are probably more useful for archaeological than for present day studies.

Scomber scombrus	*Scomber japonicus*
190 cm (77 g)	162 cm (50 g)
197 cm (64-74 g)	
290 cm (300 g)	270 cm (285 g)
345 cm (350 g)	
360 cm (580 g)	365 cm (790 g)

TABLE 5

Size (standard length) and weight from selected specimens of Atlantic and Spanish mackerels from our comparative collections.

Mackerels constituted one of the main items of the roman fishing installations in the iberian and northern african areas but almost all the finds belong to the Spanish mackerel that today is rare in this region. Mackerels were processed both as *salsamenta* and sauces and they apparently became the major target of the fishing industries in Iberia from the second half of the Ist century AD until the end of the IInd century AD (Morales & Roselló, in press). Various analyses reveal a targetting of specimens in the size range of 40-50 cm (estimated weights from 600 g to more than 1000 g according to Desse-Berset, 1993) thus significantly larger animals than those constituting the bulk of the catch today. This size decrease in the past two millennia has been interpreted to be the result of an overexploitation of the stocks but it is difficult to say when such a phenomenon started. The role of the mackerels (no species has been thus far positively identified) in the Black Sea ancient fishing enterprises remains unknown.

Pleuronectiforms (flatfishes) are refered to in the literature as «flounders», along with passing references to flukes (genera *Pleuronectes* and *Glyptocephalu*s) and windowpanes (*Lophopsetta*). Except for *Glyptocephalus*, fully marine, the other two genera are known to tolerate brackish waters and, in the case of *Pleuronectes*, to colonize the lower course of rivers. We will not provide data on any of them because they are referred to in terms of presences (Table 24) and we essentially remain uncertain on their identification. The most peculiar absence is that of the Turbot (*Psetta maxima*; «kalkan» in Russian), an important catch of the former Black Sea fisheries that has not even been found by Ivanova (1994). Only in Middle Age deposits from Chersonessos has this species been now identified (Van Neer, pers. com.).

RESULTS

A. SITES: AN OVERVIEW OF TAXA

[For location of number codes, see Figure 4. See Table 24 for a quantitative description of the remains].

0. OLBIA POLIS. Big town, initially connected with Greek colonists. The occupation ranges from the VII/VIth BC to the IVth AD. – The species list (19) includes various species of sturgeon *s.l.*, Sheat-fish, Pikeperch, Bream, roaches, Carp, Asp, Perch, Pike, etc. but no marine fishes [Fish data on Olbia from Ivanova (1994); in English].

1-13. CLASSICAL GREEK-SCYTHIAN SITES OF NW CRIMEA – ranging from the Vth BC to IIIrd AD and initially connected with Greek

FIGURE 4

Location of the sites mentioned in the text (number codes explained above). (Map from World Atlas Microsoft Encarta'97) colonists. Fish materials have not been dated. [Fish data taken from Scheglov (1978); in Russian]. (The s.l. in sturgeon means that several species may be included).

1. Vladimirovka (fort): sturgeon *s.l.*

2. Panskoe (fort): grey mullet, flounder, guitarfish and sturgeon *s.l.*

3. Kalos Limen (small town): grey mullet, flounder and sturgeon *s.l.*

4. Karadzshinskoe (village): grey mullet fishes and flounder

5. Dzshan-Baba (village): flounder

6. Tarpanchi (fort): grey mullet, Annular sea-bream, flounder, guitarfish and sturgeon *s.l.*

7. Lazurnoe (village): flounder

8. Kulchukskoe (village): flounder and guitarfish

9. Belyaus (fort-site): grey mullet

10. Uzshno-Donuzlavskoe (village): grey mullet, Annular sea-bream and flounder

11. Airchi (village): grey mullet and Annular sea-bream

12. Beregovoe (village): grey mullet

13. Kara-Tobe (small town): sturgeon *s.l.* and grey mullet

14. CHERSONESSOS. Big town initially connected with Greek colonists. Bones of flounder, Anchovy, Red mullet, Grey mullet, mackerel, sturgeon *s.l.*, Sevryuga, Sterlet, Beluga, Pikeperch, Carp, and Sheat-fish were found in layers ranging from the I-IVth AD. More than 90 fish salting vats were found in layers dated I-VIth AD. The ceramic evidence points to a construction date in the Ist to IInd centuries AD for most of the installations. Estimated total volume of salting vats was 2,000 m^3 for a total of 1,566 tons of estimated fishes processed simultaneously [Fish data on Chersonessos from VVAA. «Classical States in Northern Black Sea Coast» (1984); in Russian].

15. MICHAILOVKA SETTLEMENT. A fortified village on the European side of the Kimmerian Bosporos. Bones of Sevryuga, Carp and Pikeperch found in levels ranging from the II-IIIrd AD. [Fish data from Kruglikova (1975); in Russian].

16. TYRITAKE. Big town initially connected with Greek colonists. Mainly bones of «herring» and Anchovy, and smaller quantities of sturgeon *s.l.,* Sevryuga, Pikeperch and Taran were found in layers near fish salting vats ranging from the I-IIIrd AD. Some 57 salting vats were found in layers dated I-VIth AD [3-22 m^3 in capacity each for an estimated combined total of 457-466 m^3 (i.e., some 365 tons of fish processed simultaneously). Apparently all salting vats were constructed during the Ist AD but they could possibly have replaced previous processing installations (Gajdukevič, 1952a). Fish data from Marti (1941); in Russian].

17. MYRMEKION. Big town initially connected with Greek colonists. Mainly bones of Anchovy, followed by sturgeon s.l., Sevryuga, Pikeperch and Taran were found in layers near 8 fish salting vats dated IInd-IIIrd AD. Total processing capacity of 116m^3 (i.e., an estimated c.90 tons of fish processed simultaneously) (Gajdukevič, 1952b) [Fish data from Marti (1941); in Russian].

18. PANTIKAPAION. Big town initially connected with Greek colonists. Mainly bones of Pikeperch, Sheat-fish, sturgeon *s.l.*, and smaller amounts of Sevryuga, Sterlet, Roach, Carp, Bream, and rarely Ship sturgeon and tuna were found in layers ranging from the IIIrd BC-IVth AD. [Fish data from Lebedev & Lapin (1954); in Russian].

19. SEMJONOVKA. A fortified village on the European part of the Kimmerian Bosporos. Bones of sturgeon *s.l.*, Pikeperch, Carp, round goby, flukes and roach were found in layers ranging from the II-IIIrd AD. [Fish data from Kruglikova (1975); in Russian].

20. PHANAGORIA. Capital of the Asian part of the Kimmerian Bosporos. Mainly bones of Sevryuga, sturgeon *s.l.*, Carp, and smaller quantities of Pikeperch, Bream and Sheat-fish were found in deposits ranging from the III-IVth AD. [Fish data from Lebedev & Lapin (1954); in Russian].

21. ELIZAVETOVKA VILLAGE. Big village of the Maiotis tribes close to the town of Elizavetovka on the Asian part of the Kimmerian Bosporos. A dominance of Carp bones and smaller quantities of Pikeperch, Bream and Sheat-fish were found in deposits ranging from the VIth BC-III-IVth AD. [Fish data from Lebedev & Lapin (1954); in Russian from a previous reference by Nikolsky (1937) that we have not found].

22. SITE N3. Site of the Maiotis tribes near the village of Novo-Djereshevskaya. A dominance of Pikeperch bones and smaller quantities of Sevryuga and sturgeon *s.l.* were found in the surface associated with dates that range from the VIth BC – II/IIIrd AD. [Fish data from Lebedev & Lapin (1954); in Russian].

23. CHUMYANY REDANT. A fortified village of the Maiotis tribes in the Asian part of the Kimmerian Bosporos. A dominance of Pikeperch bones and smaller quantities of Sevryuga, Carp, and Pike were found in deposits from the IInd-IIIrd AD. [Fish data from Lebedev& Lapin (1954); in Russian].

24. ELIZAVETOVKA FORT. Large fortified town in the lower Don initially inhabited by Scythian populations. Large plots covered with up to 20 cm thick layers of fish bones plus refuse pits in the periphery filled with fish bones and scales. Few fishes prior to the IVth century BC, the fishing boom starting during the IVth-IIIrd centuries BC. Fish remains judged so large (36% of faunal remains) that export is inferred. Most common cyprinids, Carp in particular, followed by sturgeon *s.l.*, Sheat-fish and Pikeperch. No tanks or salting vats found. Smoke-curing installation inferred from archaeological data (Fish data from Marčenko *et al*. (2000); in German).

25. NIZSHNE-GNILIVSKOE SETTLEMENT IN DON. Mainly bones of Sheat-fish, Sterlet, Sevryuga and Carp, followed by those of sturgeon *s.l.*, Beluga, Pikeperch, bream and Taran were found in layers I-III centuries AD. [Fish data from Myagkova (2002), using data from an unpublished 1999 report by Vasilieva that we have not found; in Russian].

26. TANAIS. Big town in Don with an initial Scythian population. Mainly bones of Sheat-fish, Sterlet, Pikeperch, Carp, followed by sturgeon *s.l.*, Sevryuga, Pike, and rarely Beluga, Asp, Taran, Bream and Perch were found in layers ranging from the IIIrd BC-IIIrdAD. [Fish data from Tsepkin (1970); in Russian].

27. MERTVY REDANT. Village of the Maiotis tribes located in the city of Primosko-Achtarsk. Dates ranging from IInd c.BC to II/IIIrd c.AD. Bones of Russian sturgeon and Sevryuga.

28. BEREZAN. A settlement on the island with this name, located at the mouth of the Bug-Dnieper estuary whose occupation lasted from the VIIth BC- IIIrd AD. As in the nearby town of Olbia, the taxonomic list (13) includes various species of sturgeon *s.l.*, Sheat-fish, Pikeperch, Bream, roaches, Carp, Asp, Perch, Pike, etc. but no marine fishes [Fish data from Ivanova (1994); in English].

29. ZOLOTOE. Fish processing installation found in a small village with salting vats. One of the four thus far detected tanks is of 23.5 m^3 for a combined capacity of 83 m^3 and a simultaneous fish processing capacity of c.65 tons per filling (i.e., c.530 tons for a combined total). Fragments of «herring» bones plus unidentified shells mentioned in a *pithos* with a capacity of c.1,000 litres; fishbones and scales on the floor of the same storeroom. Amphorae from the IInd-IIIrd centuries AD (activity postulated to be posterior to that recorded at Chersonessos, Tyritake and Myrmekion) [Data on the fishes mentioned by Vinokurov (1994); in Russian].

30. SALATČIK. Processing unit from the IInd century AD with at least two very large tanks almost obliterated by houses of the IVth century AD. No fish bones mentioned.

31. VARNA. A shipwreck where remains (vertebrae?) of Sheat-fish have been retrieved in an amphora that was apparently manufactured in Sinop, Turkey (radiocarbon dates on the fishes indicated that they were between 2,490 and 2,280 years old (i.e., 487-277 BC) (http://news.nationalgeographic.com/news/2003/01/0110_030113_blacksea.html.)

B. THE REFERENCES TO FISH FINDS IN THE RUSSIAN LITERATURE

From the standpoint of the existing Russian literature, we have been unable to track down some key references (eg. Nikolskii, 1937) and also refrained from commenting the results of those consulted. In the ones that follow, all the portions of the text referring specifically to fishes and fishing have been translated into English. The value of these references is very variable. Some of them constitute first-hand data (i.e., bone reports) whereas others refer to unpublished reports or to data previously published by other authors.

The translations of the pertinent portions of the texts appear in italics.

B1 - Gajdukevič V.F., 1952a. Excavations in Tyritake.1935-1949 («Raskopki Tyritake v. 1935-1949 gg.», In Russian) *MIA*, 25: 15 – 134

p. 31 [About the construction of the fish salting vats]:

The outer parts of the four main salting vats were built from the levelling of slabs which had not *a well-defined slab form; these were stacked without any defined horizontality of the stacking row although the adjustment of the stones to each other had been done very thoroughly. The space between these slabs and the outer walls of the diggings in the clay subsoil trench where the fish salting vats had been built was filled up by rubble of clay. This was the element that gave the main walls their massive appearance. The thickness of these walls ranged from 0.90-1.20 m. The inside partitions, seen in the first of the four salting vats, were built on another principle. The thickness of these second order partitions ranged from 0.35-0.45 m. They represented a combination that included cuttings having the correct form, slabs and stone-work made from small rubble of a pink cement mortar. The walls and bottom of these salting vats were covered by multiple layers of a plaster that combined limestone mortar with grinded ceramics.*

The salting vats were filled up by soil, small stones, multiple animal bones and masses of ceramic fragments including fragments of tile, pithos, hand-made ceramics, kitchen pots, made in potter's wheel as well as red-glaze ware, fragments of glass vessel, coins and so on.

Large, well-cut blocks of limestone were found in the bottom of the salting vats, which probably were used as a «press»: they were the weights under which fish stayed during the pickle.

The large number of tile fragments in the salting vats testify to the presence in antiquity, of tile roofing over the fish-salting installations.

p. 48:

First of all, we will describe the complex of fish salting vats which was found in 1935 (plan in figures 48 and 49). It consisted of six salting vats, which were located in pairs in three lines from the south-east to the north-west (fig. 52). Salting vats walls are constructed from limestone slabs, which have a thickness from 0.15 up to 0.27 m. The two last ones of the south-east hall (N 5-6) were partially damaged during the digging works of 1933.

In ground plan, every vat has a nearly square form (1.70x1.80 m). The majority of the slabs, forming the salting vats' walls, were placed on their edge and only some were located in a flat position; there are visible cuttings made during the adjustment of placing the vertical slabs of the next line of stone-work.

The inner walls and bottom of the salting vats were covered by some layers of mortar, comprising a mixture of marine sand and pounded ceramics. Undoubtedly, the salting vats had a tile covering.

p. 59:

In the bottom of the salting vats the layer of sea sand was found. It was also seen in the cement plaster of angle salting vats parts a lot of scales.

Area A is located lower than area B. Apparently, both of these areas, or rather those small cisterns which formed the bottom of such areas, were built as auxiliary vats of the main complex. They were meant for any kind of operation related to the fishing installations. Probably, these included preliminary cleaning of the fishes, pickle preparation and so on.

p. 61:

In vat N 4, a bronze fishing hook was found and four bone needles with a side incision near the upper blunt edge (See below, p. 67) were found in vat N 5. In the bottom of this tank a lot of fish scales and bones, –mainly from «herring» secondarily of grey mullet– were retrieved.

As happened in complex B, the salting vats from complex G obviously were in exploitation later (ranging from the I–III centuries AD). The finds of early medieval ceramics in the bottom of the salting vats, at any rate, is the evidence that the salting vats of complex G were not filled up during the IVth century AD, as it was the case with other fish salting vats at Tyritake.

p. 113:

Some dozens of amphora's bottoms were found in the building. Some of the amphorae were storage for fish, something that is confirmed by the finds of fish bones and scales.

In the floor of one of the buildings there were a lot of stone weights of different sizes. There were cuttings in the oblong limestone bits like a gutter deepening in the middle part (fig. 141). The abundance of such plummets for large fishing nets is verified, for the inhabitants of this house were connected with fishing. Two pyramidal clay pendants for loom were also found in the building.

p. 114:

Speaking about the close connection of the economical activity of the house with fishing, it is nec-

essary to mention a bone object (drawing we can see in fig.143), found during the excavation of building IV. S.A. Semenov studied this object and concluded the following: «object, having a flat surface, made from the cylindrical bone of a large animal. The length is 13 cm; max width is 3 cm. The form of object is similar to a knife. The lower edge is blunt, the opposite edge features a groove. The handle is much glossed; the polishing of prominent parts of the concave surface, undoubtedly have been made from friction by hand…

p. 116:

………So one can propose that this bone knife was used for fish cleaning»

p. 133:

According to the number of salting cisterns excavated already by 1932, the scale of fishing trade in Tyritake must be depicted as gigantic: 200 tons of fish could be salted simultaneously in Tyritake's complex of 16 cisterns.

But a new discovery of fish salting vats in the southern area of Tyritake has now increased the total number to 50 cisterns

B2 - Gajdukevič V.F., 1952b. Excavations in Myrmekion in 1935-1938 («Raskopki Mirmekiya v 1935-1938 gg.», in Russian) *MIA*, 25: 135 –222

p. 198:

In the final period of the 1937 excavation during an exploration made in the south-west part of the main area of excavation, it was evidenced that the long wall N 27 was limited a big complex of fish salting vats (vat N II). One of them was excavated completely and it was determined, that the whole complex consisted of at least 8 such salting vats.

In addition to the fact that this was the first discovery of a fish salting economy from the I–III centuries AD in Myrmekion, the impressive scale of this complex could be compared with the largest Tyritake complex, excavated in 1931.

p. 207:

The presence of amphorae in the salting vats is explained by the fact that one of the manufacturing operations of the Myrmekion 'factory' was the transfer of fish from vats to clay vessels, which were packaged for storage and transport of the finished product. Fish were extracted from the vats through special clay vessels, one of which was found near vat N VII (south-east side) inside a large pithos (1), from which only lower part was found (fig. 125).

The species of salted fish were correctly identified from the lot of remains found in some of the salting vats. They show that the main target of fishing was khamsa. The layer of pressed khamsa remains in some of the salting vats amounted to 0.10 m.

Two clay vessels named pithos, lower parts of which were found near the salting vats, were used for fish salting.

p. 218:

In 1937-1938 a large complex of fish salting vats from the I–III c. AD was excavated in area 3. Its capacity may be compared to that of the well-known vat complex from Tyritake discovered in 1931, although the latter greatly exceeds the production capabilities of the Myrmekion «factory».[1]

With this discovery of Myrmekion salting vats it seems obvious that during the I –III centuries AD not only Tyritake, but other Bosporos settlements, located in the coast of The Strait of Kerch, were taking part in an intensive exploitation of fishing resourses. Of course, Tyritake with its unparalleled abundance of fish salting 'factories' constitutes the largest center of fishing in I–III centuries AD, but now we know that it was not the only such centre along the coast of the Kimmerian Bosporos.

B3 - Kruglikova, 1975. Agriculture in the Bosporos («Selskoe hozyaistvo Bosporosa» in Russian). D.B. Shelov. Moscow: Nauka.

p. 212 [On cites concerning the classical authors]:

«In IV century BC the Greek poet Archestratos assembled the book «The notes about the Bosporos salted fish» (Athen., VII, 21). Polybios writes about

[1] According to Marti, 1941, the maximum capacity of the Tyritake complex of fish salting vats was 204 m3 and that of Myrmekion complex didn't exceed 120 m3 (taking into account the whole depth of the vats).

the export of salted fish, which was considered one of the luxurious foods of antiquity (Polyb., IV, 38,4). Athenaios (Athen., IV, 109) transmitted Polybios' description of Cato, who was indignant at some Romans that lived in luxury «buying by 30 drachms the cask of Pontic Sea salted fish…». Strabon (VII, 4,6; XI, 2, 4) narrated the export of salted fish from the Maeotida region and the fishing for salting. He also informed about bonito (Sarda)- fishing, spawning in the Azov Sea then moving to the Black Sea. Moreover, he noted the big size of the sturgeons (Acipenser sp.) in the Strait of Kerch, which were similar to dolphins (Delphinidae)in size.

p. 212 [About fish finds in the Bosporos]:

Different species of sturgeon (Acipenser sp.), Carp (Cyprinidae), darters (Percidae) and other fishes were known in Antiquity in the Black Sea sites. Pressed remains of Anchovy (Engraulis sp.) were found in the bottom of some fish-salting tanks in Myrmekion and the same «herring» (Clupeidae) remains – in Tyritake. In this place sturgeon bones were also found near tanks. Remains of Russian sturgeon (Acipenser gueldenstaedtii), Sevryuga, bream (Abramis), Carp (Cyprinus carpio), Sheat-fish (Silurus), Pikeperch (Stizostedion) were found in Phanagoreia in deposits of the III-IV c. AD. Since Sheat-fish lives only in rivers, it may be postulated that the people from Phanagoreia fished not only in the Gulf of Taman, but also in the Kuban River.

p. 213:

Sturgeon (Acipenser gueldenstaedtii) remains were found among the fish bones in Semjonovka. The age of one of them was six years old. Scales and bones of Carp (Cyprinus carpio) were also found there. These fishes had different sizes – 40-85 cm although lengths of 50-70 cm were the most common. The age of one hundred and five years for a Carp was determined through vertebral analysis. Still, only Carps of 10-12 years predominated in the catch (p.212). There were bones of Pikeperch (Stizostedion lucioperca), round goby (Neogobius melanostomus), roach (Rutilus rutilus heckeli Nordm.) whose sizes ranged from 22 to 37,5 cm. Flukes (Pleuronectes flesus luscus Pall) bones were also found there. All these species occur in the Black Sea and Azov Sea today. (Fish remains were determined at the Ichthyology Department of Moscow State University by E.K.Sychevskaya and E.A.Tsepkin) (p. 213) Bones of Carp predominated and did not exceed their modern counterparts in their sizes. Large accumulations of Carp remains in one of the buildings, excavated in 1957, where a mass of fish remains, located in a layer 0,5 m thick, was found, indicates fishing with the help of fixed nets and seines. Bones of Sevryuga, Carp and Pikeperch are found in the settlement near modern village close to the Michailovka site.

Prevailing in the catch of clams were blue mussels (Mytilus). Their shells are abundant in refuse pits of settlements including those far away from the coast. Probably clams were one of the best foods of Bosporosians. Among the bone remains in the settlements of III-IV century AD there were repeated finds of dolphins (Delphinidae) (bones from Semjonovka were determined by V.I.Tsalkin). Apparently, they were fished and used as food, and perhaps even the dolphin's fat was used for lamps.

Comparison of the fish species found in sweep-net fishermen from the Bosporos with those from Northern-West Crimea region, allows to spot some differences in the fishing from these two areas. Investigations of bones remains, occurring from settlements of Northern-West Crimea region show that the catch of grey mullet fishes (Mugilidae s.l.) was the main element. A second place was taken by Annular seabream (Sparidae) and by flukes (Pleuronectiformes). The third place belonged to sturgeons (Acipenser) and guitarfishes (Rhinobatidae). Specialization of the Bosporos fishing was somewhat different and connected with the peculiarities of the Bosporos geographical situation and the proximity of the Sea of Azov (213).

p. 208-213 [About fishing-equipment in the Bosporos]:

Among the items found in the buildings there are a lot of fishing hooks of different sizes – from 2 to 10 cm; plummets, including clay, pyramidal and flattened; stone weights and little plummets made from amphora handles. Cork and wooden fishing floats were also found in some Semjonovka buildings as well as remains of fishing nets. ….Bone needles and bronze fishing hooks for net manufacture (p.208). There are bone knifes for fish cleaning (p.208-209).

Traces of large fishing trade are represented as complexes of fish salting cisterns (or vats) from the I-III centuries AD. There were a lot of cisterns especially in Tyritake and Myrmekion. Of the 59 *salting cisterns found in Tyritake most date from the I-III centuries AD, but some functioned up to the IV c. AD. 48 cisterns can simultaneously contain and salt 3600 centimeters of fish. Calculations show that the combined production of all vats found in Tyritake may exceed 28 thousand centimeters of fish per year. (p.209-210). Probably, in addition to salting, fish were dried and smoked (p.210).*

At the bottom of Tyritake's cistern is a foundation pit, usually extending down to a depth of 1,7-1,9 m, rarely-2,28 m while two samples had a depth of 3,27 m; the shape of the cistern is square or rectangular, rarely trapezoid (p.211-212).

Fish were transported in large spheric vessels named «pithos», or in big amphoras, having great capacity (p.213).

B4 - Lebedev V.D. & Lapin U.E., 1954. (On the issue of fishing in the Bosporos) K voprocu o rybalovstve v Bosporosskom tsarstve –in Russian) *MIA*, 33:197 – 214.

p. 197:

Among the slave-owning Greek towns settled in the VI-V century BC on the territory of the Northern Black Sea, particularly favorable conditions for the economic development occurred in Pantikapaion, Phanagoria, Myrmekion, Tyritake, etc. located in the coasts of the Kimmerian Bosporos.

United, they had organized the Bosporos Kingdom, that included East Crimea, Taman peninsula, the region near The Kuban River and the lowlands of the Don River. Living in these territories were tribes of Scythians, Sarmats, Sinds and Maiotis that became part of this Kingdom, which lasted from the V c. BC up to IV c. AD

Bosporos towns were not only trade intermediate points for the transmission of imported goods. Making use of the natural conditions, local resources and manpower, the Bosporos Kingdom developed its own manufactures and trade. The first place of these productions corresponded to agriculture. The main trade was wheat. Wine growing and winemaking had considerable significance also. Finally, the remains of animals revealed the importance of animal husbandry.

Hunting was apparently secondary, since the remains of bones from wild animals were not numerous. At Tyritake and Myrmekion, the bones of hare, fox, red deer and saiga antelope were rare.

Great economic importance for these populations from the Northern Black Sea region was given to fishing. Having a strategic location on the sea coast and the major rivers outfall, Greek colonists used these fine conditions for the development of fishing.

Numerous finds of fish remains, fishing tools, and large fish-processing constructions (for example, at Myrmekion and Tyritake, fig. N 1) have evidenced the development of fishing in the region. Fishing dishes, made of clay, were common in Bosporos towns and other Greek colonies.

A building inscription (presumably set up over the entrance door to the fish market) *which was studied by Semenov-Zuser S.A. (1947), testified to the importance of fish during the IInd c. AD in the northern Black Sea region. It refers to the fish market from Chersonesos.*

p. 198:

Fish was food for all levels of the population of the Bosporos Kingdom. Salted fish and «preserved» fish sauces were exported in large quantities to foreign markets.

Greek writer of IV c. BC Archestratos had written a special work on the Bosporos salted fish (but this report doesn't exist any longer and is mentioned only from references of other ancient authors).

Fishing was common trade in the peripheral regions of the Bosporos Kingdom: in the lower Don, the eastern coast of the Azov Sea and in settlements of the Kuban River region one finds remains of Acipenser, Cyprinus, Esox in almost all layers of the ancient sites, located in middle course of the Kuban River, «quite often their scales in the cultural strata of the Kuban River and, in particular the Sea of Azov region are found as thick layers» (Gajdukevich V.F., 1947).

Fishing tools were found during the excavations of the site near Elizavetovka village (Asian side of the Kimmerian Bosporos), including bronze hooks and big clay plummets, which are not found in the coastal regions' sites at that time.

The most important area was the Strait of Kerch. This is evidenced by the presence there of many fish-salting installations dating from the I-III c. AD.

Observation towers were built to aid with the fishing of some species, such as Engraulis and Clupeidae. From these towers people followed the fish schools (fish-herds) movement. In this way, Strabon (XI 2.4. from a translation in Russian by Mischenko, 1879) informed about extant observation towers (possibly for fish observation) in the east coast of the Maiotis lake.

p. 199:

Fish remains, found in sites and settlements of the northern Black Sea region were studied by several specialists (M.I. Tichy, 1917; V.Yu. Marti, 1941; G.V. Nikolsky, 1937; S.A. Semenov-Zuser, 1947). They reported that the main targets of the fishing in the ancient Greek colonies of the Bosporos were the Anchovy, «herring», Sevryuga, sturgeon, flukes, roach, scomber and Red mullet. Our studies of ichthyological materials from six sites have added more data.

1. Fish remains from Pantikapaion

The following species were identified:

– Acipenseridae – sturgeon family

17 fragments were found:

1. Acipenser nudiventris Lovetsky – barbel sturgeon

2. Acipenser ruthenus – Sterlet

From the latter one fragment of cleithrum, one fragment of vomer and one fragment of frontale were identified

These represented two fishes of 58 and 64 cm in length.

Nowadays Sterlet is very rarely found in the The Kuban River, but there are data that it was fished in the last quarter of the 19th century at the mouth of the The Kuban River. The sizes of the archaeological Sterlet are not larger than the sizes of modern fish.

3. Acipenser gueldenstaedtii Brandt – Russian sturgeon.

Four bone scales belong to this species (fig. I, 1).

It was not possible to estimate the length of this fish. Nowadays the Russian sturgeon is common in the area.

4. Acipenser stellatus Pall – Sevryuga

Remains of Sevryuga are represented by four spinal scales and a fragment of the praeoperculum from a fish having length close to 140 cm.

Nowadays Sevryuga is the most common member of the Acipenseridae in this region.

p. 200:

– Cyprinidae – Carp family

Carpfishes are the most common fishes in the rivers of the Azov Sea, Black Sea and Caspian Sea

1. Rutilus rutilus – Common roach

There were found the following remains from this species: pharyngeal teeth: 3 fragments (fig. I, 2), dentale:1 fragment. Fish lengths were of 23, 32, 35 and 42 cm, for an average of 34 cm. Probably the fish remains from Pantikapaion do not belong to the roach proper but to its larger subspecies, Rutilus rutilus heckeli (Nord.), which are now living in some places of the Azov and Black seas from where they are re-entering rivers including the Don (up to Manych), Kuban (up to its middle course), Rion (?), Dnieper (up to the rapids), and Dniester (Berg L.S., 1948). Kuban roach has sizes that range from 140 to 223 mm. Nowadays the roach is fished along the Azov Sea coast and directly in the Kuban River.

2. Abramis brama (L.) – bream

There is one fragment of a cleithrum from this fish, having a length of 23 cm. Bream appears in brackish waters of the Azov Sea; also, in small number in the Kuban River. The average sizes of the captures were of 24,2 cm in 1923 and of 37,9 cm in 1924.

3. Cyprinus carpio L. – Carpio/Carp

There are three kinds of Carp: the «resident Carp», that lives year-round in the river, the so-called (lit.) «walking Carp», travelling regulary from the river mouths to the estuaries and finally the «firth Carp», living permanently in the estuaries. There were 3 fragments of Carp remains – 2 fragments, and a pelvic bone (fig. I, 3) from fishes having estimated lengths of 61,5 cm, 70,5 cm and 75 cm. (Average length was of 69 cm).

Average size of carps from the site near Elizavetovka village (IVthBC – VIth AD) is recorded at 53,8 cm (materials studied by G.V. Nikolsky, 1937). Probably, it corresponded to smaller (river) fish. In modern times, in the lower reaches of the Kuban River and Azov Sea the average size of Carp ranges from 30-35 cm, but sometimes it can *reach up to 1 m and have weights of more than 16 kg. Thus, the average lengths from Pantikapaion and the site near Elizavetovka village were larger than the averages of the modern fish from the The Kuban River and Azov Sea although maximum sizes weren't more than the maximum sizes of the present day animals.*

– Siluridae – Sheat-fish family

Silurus glanis L. – Sheat-fish

2 spiny pectoral radials of thoracic (pectoral) fin (fig. II, 1) (estimated lengths (abs.) of 107 and 135 cm (average: 121 cm) plus 3 caudal vertebrae from fishes 9, 11 and 13 years old were found.

The remains of this species from the site near Elizavetovka village site (III c. BC – IV c. AD by Nikolsky, 1937) indicate that the Sheat-fish from the Kuban River had average lengths of 193,5 cm and average ages of 14,1 years.

In modern time this fish usually appears in the delta and firths of the Kuban River.

– Percidae – darter family

Lucioperca lucioperca (L.) – Pikeperch

Remains of Pikeperch are more numerous and common. 9 fragments of Pikeperch were found: dentale – 3, ceratohyale – 1, articulare – 2, praeoperculum – 1 plus 2 vertebrae.

p. 202:

The age of two of these fishes is estimated at 7 and 11 years.

Fish lengths are: 50,5; 54; 56,5; 60; 67,2 and 72 cm for an average of 60,3 cm.

Three fragments from the site near Elizavetovka village identified by G.V. Nikolsky (1937), had lengths of 34, 75 and 87 cm. (Average: 65,8 cm).

Size ranges of the Kuban River Pikeperches in the modern town of Temruk in 1929 were of 40-80 cm, and the Kuban Pikeperch from modern village of Achuevo had an average of 54,7 cm in 1923.

Thus, the average lengths of the Pikeperches from Pantikapaion are slightly larger than those from the modern Kuban River populations.

p. 203:

The modern [Pikeperch]has lengths 50-130 cm (Berg L.S., 1948) appearing in brackish and semi salty water. In the southern rivers, such as the Kuban, it is a «resident» animal, living in the river at all times; «walking Pikeperch», travels from the river mouth into the marine waters close to it.

In modern times, Pikeperch is a major target of the fishing of the Azov Sea basin.

– Thunnidae – tuna family

Maximum and average sizes of fishes of similar flesh texture to that of bonito, have great meaning for the Pacific and Atlantic ocean populations. Tuna fishing is common in the Mediterranean Sea.

1. Thunnus thynnus – Bluefin tuna

There were 2 vertebrae (fig. II, 3) and one fragment of an operculum (fig. II, 4) and probably, fragments of a dentale and a praeoperculum that corresponded to this species.

The first vertebra had a length of 54 mm and a maximum diameter (horizontal) – of 69 mm. The vertical diameter was not measured as it was damaged.

The second vertebra had a length of 48,5 mm and the diameters were as follows: horizontal: 61 mm; vertical: 51 mm. Age according to the annual rings: larger vertebra: 18 years; smaller vertebra: 16 years.

Because we haven't tuna fragments in the reference collections we estimated fish sizes by calculating the number vertebra from drawings by H.C.Godsil and B.D. Bayers. According to those pictures, there are 38 vertebras. The length of the body and the tail vertebra is the same. It may be assumed due to the presence of cartilage between the vertebrae, that tuna length is the equivalent of 51 vertebras. Thus, by this analogy, tuna lengths for the fragments at Pantikapaion are: for the fish, having 18 years: 275,4 cm and for the fish having 16 years: 227,4 cm.

Weights for tunas of sizes similar to these, probably are around 315 kg and 260 kg respectively.

Modern tunas reach lengths of up to 3 m for weights of c. 600 kg.

Finds of tuna in Pantikapaion are very important. There were indications of tuna fishing on the northern part of the Black Sea in the ancient sources. But there existed doubts in relation to the correctness of those translations of ancient authors due to the absence of tuna bones in archaeological excavations up until now.

M.I. Tichy (1917), thinking about the presence and fishing of tuna in the Black Sea in antiquity *and modern times, presented data from Roman and Greek naturalists. For example, Strabon wrote that tuna spawned in the «Maiotis swamps» whereas Aristotle and Appianus referred to bonito herds «the descendants from angry tuna females», that spawned among the thickets in Maeotida, corresponding to the Sea of Azov.*

M.I. Tichy (1917) likewise noted that ancient authors gave different names to fishes of the Scombridae family and derived one name from another.

Analyzing ancient authors and comparing their ideas with the modern data about bonito, tuna and scomber's migrations, Tichy concluded that «more often these fishes were not tuna, but bonitos (Sarda sarda), which were cut into slices as was also done with tunas».

p. 204:

Tuna remains from Pantikapaion indicate that tuna was fished in the Greek colonies of the northern Black Sea. As for bonito, which was named by ancient authors as tuna, it was similar to tuna for the majority of people in the Greek settlements of the northern Black Sea region who originally came from the Mediterranean region where tuna was a common and highly appreciated fish.

Apparently, in spite of not clearly knowing about the origin of the different fishes from the Scombridae family, people in ancient times knew well the differences for tuna, bonito and scomber (pers. idea of L.S. Berg after working the fish collection from Pantikapaion).

Nowadays (in 1954) a few tuna are fished annually in the Crimean coast. Thus M.I. Tichy also knows about some tuna fishing in the Black Sea coast.

Vinogradov K.A. in his recent work (1931) published data and facts about tuna appearance in the Black Sea, in particular the Crimean coast. For example, in November of 1949 in the coast near the town of Sudakh part of a tuna, having a length of not less than 3 m was found; also in November that same year, in Dvuhyakornaya bay another tuna, having the length about 2m was found. In September of 1950 in the city of Eupatoria a tuna of about 2,5 m and a weight of 250 kg was fished. In Tarchancut peninsula 3 tunas, having weights from 35 to 80 kg were fished. The conclusion of K.A.Vinogradov indicates that tunas appear in different parts of the Black Sea, except for the modern city of Odessa (ancient Olbia). These Black Sea tunas come from the Mediterranean Sea.

V.A.Vodyanitskiy (1940) demonstrated that tuna reproduced in the Black Sea and K.A.Vinogradov supposes that the Black Sea has a specific tuna population, isolated from the Mediterranean population that partly or completely winters in the Black Sea.

But the observations of M.I. Tichy (1917), indicate that tuna was not numerous in the northern coast of the Black Sea and fishing in Crimea was always in small numbers.

In modern times tuna fishing in the Black Sea region is known to occur in Bulgaria and Turkey; Each year these countries are fishing some 3,000-5,000 tunas. Tuna remains from Pantikapaion show that in antiquity such fishing also took place along the Crimean coast. Probably numerous indications by the ancient authors about tuna fishing in this area are true.

p. 205:

The number of fish bones from Pantikapaion is not large, so one cannot make too strong conclusions on the role played by each species in the fishing economy.

SPECIES	*NUMBER OF bone FRAGMENTS (specimens)*	
	Specimen	%
Ship sturgeon	1	2,6
Sterlet	3	7,7
Russian sturgeon	4	10,2
Sevryuga	5	12,8
Roach	3	7,7
Bream	1	2,6
Carp (Carp)	3	7,7
Sheat-fish	5	12,8
Pikeperch	9	23,1
Tuna	5	12,8
TOTAL	**39**	**100,0**

TABLE 6

Fish remains from Pantikapaion.

Table 6 shows that Acipenserid remains are dominant (about 30%) in Pantikapaion. Among them most are Sevryuga remains –this species being more numerous in the Kuban River today. This fact agrees with the information about Sevryuga predominance in the site near Elizavetovka village (III c. BC-IV c. AD)– (Nikolsky, 1937).

Interesting is the finding of bones of the Ship sturgeon and the Sterlet, because both species are very rare nowadays in the Kuban River.

It seems that there are no typical river species among the fish remains. All species identified appear both in fresh and salt water.

The species composition indicates that fishing was popular not only in the river delta and less saline parts of the sea, but also in a part of the sea with a high salt concentration.

2. Fish remains from Phanagoria

p. 206:

Ancient Phanagoria was occupied from the V c. BC to the IV c. AD.

Fish remains were found only in layers with dates III –IV cc. AD.

The following species were identified:

– Acipenseridae – sturgeon family

144 fragments belong to this family – 57,6% of total number of identified remains. 39 fragments were not determined to species due to bad preservation.

1. Acipenser gueldenstaedtii Brandt – Russian sturgeon

There are 44 bone fragments, in particular: praeoperculum – 6; frontale – 2; operculum – 2; parasphaenoideum – 2; spinal scales -2; skull fragments – 30.

The estimated lengths (absolute) of the fishes were 109, 120, 130, 133, 171cm. The average length was 132,6 cm.

The average size of the fish from the site near Elizavetovka village (IV c. BC) was of 75 cm according to the data of G.V. Nikolsky (1937). It is not clear why such differences in average sizes exist.

2. Acipenser stellatus Pall – Sevryuga

There were 61 remains of Sevryuga: parasphaenoideum – 1; operculum – 1; frontale – 2; spinal scales - 2; spiny radials of pectoral fin – 11 (see fig.2 on page 207); skull fragments and fragments of bone scales - 44. Probably, the length of fishes estimated from the scales ranged between 130-150 cm.

The length (absolute) of fishes from other bones were 127, 130, 133, 133, 136, 136, 138, 139, 141, 144, 152, 154, 156 and 168 cm. Average length was of 141,7 cm.

Average sizes of the fish from the site near Elizavetovka village (IV c. BC) was 107 cm. It is not clear why such differences in average sizes exist.

– Cyprinidae – Carp family

There are 67 bone fragments, representing 28,2% of the total number of remains.

p. 207:

1. Abramis brama (L.) – bream

Only one fragment from this species.

The size is unknown. In modern times bream has not great importance.

2. Cyprinus carpio L. – Carp

There were 66 Carp bones: cleithrum – 5; operculum – 4; basioccipitale – 2; pterigophorum – 2; praeoperculum – 2; dentale – 1; pelvic bones – 2; spiny radials of spinal fin – 10; bones of the Weber apparatus – 2; first vertebra-1; ribs – 5; vertebrae – 32.

The lengths of these fishes (excluding the tail fin) are of 50,7, 50,8, 55, 61,5, 63, 67,2, 69,5, 76, 77 and 78 cm. The average length of Carp from the site near Elizavetovka village (IV c. BC) is of 53,8 cm, and the ranges of this modern fish from the lower reaches of the Kuban River and Azov Sea are 30-35 cm. Probably in Phanagoria larger Carp were fished.

Table 7 shows that the age of Carp in Phanagoria ranged from 6-13 years, fishes of 7-11 years being most common. In modern fishery Carps of 3-5 years are the commonest ones (V.V. Petrov, 1931).

Age	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**NISP**
NISP	2	8	4	4	6	4	2	3	33
%	6,1	24,2	12,1	12,1	19,2	12,1	6,1	9,1	100

TABLE 7

Age structure of the Carps from Phanagoria.

The first vertebra provided the age and size of one specimen: this was a Carp 13 years old that had a length of 76,5 cm (V.V. Petrov, 1931).

p. 208:

3. Silurus glanis L.- Sheat-fish

There is only one processus transversalis of a Sheat-fish vertebra, representing an animal with an absolute length (absolute) of 101 cm. Nowadays Sheat-fish is common in the Kuban River, but in the Gulf of Taman near the ruins of Phanagoria this fish is presently absent.

– *Percidae* – darter family

Lucioperca lucioperca (L.) – Pikeperch

Remains of Pikeperch are numerous (25 fragments) accounting for 10,5% of the total number of finds.

The following bones were found: praeoperculum – 25, cleithrum-10, maxillare – 2, articulare – 2, pterigoideum – 1, dentale – 2, vomer – 1, ceratohyale – 1, vertebrae – 3 fragments. The estimated lengths (up to end of the scale surface) are: 44,7, 46, 49,2, 51,5, 53, 56,5, 57, 58, 59,5, 61,5, 61,5, 63,3, 64,5, 65, 69,5 and 77 cm. The average length is of 58,6 cm; in site near Elizavetovka village (IV c. BC – VI c. AD) – lengths ranged from 34 to 87 cm, with an average length of 65,3 cm.

Average length ranges of modern Pikeperches from the Avchuev Ravn region is of 51,7-55,8 cm.

Thus the average lengths of Pikeperch at both Phanagoria and the site near Elizavetovka village were larger than the lengths of the modern Pikeperch.

Table 8 shows the species composition from Phanagoria and the number of bones.

SPECIES	NUMBER OF FRAGMENTS (specimens)	
	NISP	%
Russian sturgeon	44	22,2
Sevryuga	61	30,8
Bream	1	0,5
Carp	66	33,4
Sheat-fish	1	0,5
Pikeperch	25	12,6
TOTAL	198	100

TABLE 8
Fish remains from Phanagoria.

The Phanagoria fishes (as those in Pantikapaion) may have lived in fresh water, as well as in brackish water and some of them (for example-sturgeons) in salt water also. There are no species living only in fresh water. Sevryuga and sturgeon spawn in rivers; bream, Carp, Pikeperch are living in estuaries. Sheat-fish is an essentially river fish.

Such species composition shows us that Phanagoria's fishing concentrated in one of the branches of the Kuban River and in the then brackish waters of the Gulf of Taman.

In modern time, due to an increase in the salinity of the Gulf of Taman, breams, Carp and Pikeperch no longer appear in this place. Instead of them, grey mullet (Mugil cephalus), which lives in salt water, has appeared. Grey mullet is not found in Phanagoria.

Fishing in Phanagoria was carried out with nets and hooks. Average sizes of Sevryuga and Carp were more than the sizes of their modern relatives.

p. 209:

3. Fish remains from Maiotis settlements

The eastern sea coast of the Azov Sea (Maiotis) was populated by the Maiotis tribes. Classical authors wrote about them already by the VI c. BC. For example, Strabon (Strab., XI, 2,4) (p.209) reported the following about Maiotis fishing: «…in small Rombit themselves Maeoths are fishing», Strabon (Strab. VII, 3, 18) and also: «for example, from Pantikapaion to Phanagoria carriages are moving over the ice way when channels turn into land; furthermore in this place fish, predominantly sturgeon which reach sizes such as dolphins, are extracted from under ice by gangama (small nets)».

Big clay trapezi, typical of Kuban ancient settlements, form plummets that testify to the importance of fishing in the area.

Fort-settlement «Chumyany redant»

The site is located at the south of the village of Novo-Nekrasovskyi near the Chumyany estuary, which is connected to the Azov Sea by a system of channels.

SITE	DATE	NISP (total)	NISP (species)
Chumyany redant	II/Ist BC- II/IIIrdAD	60	56
Mertvy redant	IIndBC- II/IIIrdAD	12	6
Site N.3	VIth BC- II/IIIrdAD	47	47
Site near Elizavetovka	IVthBC- IIIrdAD	4	4
TOTAL	-	123	113

TABLE 9

Fish remains from Maiotis settlements.

Excavated cultural deposits of «Chumyany redant» are dated by II-I cc. BC. but the collection of fish bones was dated between II-III cc. AD.

The following species were found:

– Acipenseridae – sturgeon family.

4 fragments of operculum and probably 4 fragments of spiny radials of pectoral fin have been found. The size of the fishes remains unknown.

– Esocidae – Pike family

Esox lucius L. - Pike

One fragment of a dentale from a fish having length of 67,5 cm has been found. Today the species is rare in the Kuban delta.

p. 210:

– Cyprinidae – Carp family

Cyprinus carpio L. – Carp

There were 5 bone fragments: pterigoideum – 1, operculum - 4. The length of fishes is 24, 57 and 58 cm. Average length is 49 cm.

– Percidae – darter family

Lucioperca lucioperca (L.) – Pikeperch

There are 42 fragments: maxillare - 2, articulare - 2, cleithrum – 3, ectopterigoideum – 1, interoperculum - 2, dentale – 6, palatinum – 2, operculum – 1, parasphaenoideum - 1, frontale – 2, vertebrae – 12, ectopterigoideum – 1, ceratohyale – 1, basioccipitale – 1, supraoccipitale – 1, intermaxillare – 2, praeoperculum – 1, pteroticum – 1. Furthermore, 120 scale fragments were found (fig. 3 page 210).

Table 10 shows that Pikeperch sizes ranged from 41 to 62 cm with fishes having lengths 49-54 cm being the most common. Nowadays the average size of Pikeperchs from the «Chumyany redant» area is of 49,8 cm while that average from the site near Elizavetovka village was of 63,5 cm. In the delta of the Kuban River (Achuev) the commercial sizes ranged from 51,7-55,8 cm during the 1924-1925 period.

Length Classes	41-42-43-44-45-46-47-48-49-50-51- 52-53-54- 55-56-57-58-59-60-61-62	TOTAL NISP	length (mean)
NISP	2 1 3 – 1 2 - - 4 1 3 2 2 - - - 3 - - 1 1	26	49,8

TABLE 10

Size of the Pikeperches from «Chumyany redant».

Annual rings on the articulare and basioccipitale allow one to identify the fish size and age: one articulare of a 6 year old fish corresponded to a size of 51 cm and on a basioccipitale average for fishes of 8 years was 56 cm. The age structure of the modern Kuban River Pikeperch fishery ranges from 3-9 years.

Annual rings of 61 Pikeperch scales (out of a total of 120) allow one to identify the age structure of the Pikeperch (tabl. 11, p. 211)

p. 211:

Data from Table 11 shows that the age of Pikeperch in «Chumyany redant» ranged from 4 –

8 years with fish of 5–6 years constituting the bulk of the samples (more than 80%).

«Mertvy redant» fort-settlement (fort-settlement 1)

This site is located in the southeastern part of the city of Primorsko-Achtarsk in the northern bank of the Achtar salt lakes, which were connected with the Azov Sea in antiquity. Fish finds from settlement are dated from II c. BC up to II-III cc. AD, but some vessels were as old as V-IV c. BC.

There were 14 fish fragments. All of them belong to Acipenserids. Six bones of branchial apparatus and 1 fragment of a skull scale were only identified to family level.

Acipenseridae

Acipenser gueldenstaedtii Brandt – Russian sturgeon

There were 2 fragments of cleithrum. Both fishes had sizes of about 120 cm.

Acipenser stellatus Pall. - Sevryuga

There were 4 fragments of opercula. Length unknown.

Estimated years	4	5	6	7	8	Total
Number of scales	5	25	25	5	1	61
Percentage	8,2	41,0	41,0	8,2	1,6	100

TABLE 11

Ages of the Pikeperch from «Chumyany redant».

«Settlement N 3» near Novo-Djereshevskaya stanitsa

This settlement is located in the southwest part of Novo- Djereshevskaya stanitsa, in the right bank of the Kirpill River, that connects through the liman system with the Azov Sea.

There were no excavations in the settlement. The material was collected in the surface and dates from VI c. BC up to II-III c. AD – there were fragments of sturgeon at large, Sevryuga and Pikeperch.

– Acipenseridae

There were 16 fragments:

Acipenser gueldenstaedtii Brandt –Russian sturgeon – 2 fragments of bony scutes. Fish size unknown.

Acipenser stellatus Pall. – Sevryuga –

There were 14 fragments including 7 fragments of spinal scales; lateral bone scales sinister and dexter– 2 fragments; cleithrum – 2 fragments; operculum – 3 fragments. Sevryuga sizes were estimated as of 83, 85, 104, 117, 126, 130, 136, 139 and 144 cm. Average size was 118,2 cm. Average size from site near Elizavetovka village was 107 cm, similar to modern Sevryuga sizes in this region.

– Percidae – darter family

Lucioperca lucioperca (L.) – Pikeperch.

Fragments of this species include 31 fragments:

Parasphaenoideum – 1, maxillare dex. – 2, frontale sin. – 1, dex. – 2, dentale – 2, praemaxillare – 1, supraoccipitale – 1, vomer – 1, hyomandibulare – 1, praeoperculum dex. – 3, sin. – 1, ectopterigoideum – 1, quadratum – 2,

p. 212:

interoperculum – 1, palatinum – 1, urohyale – 1, epihyale – 2, epihyale – 2, ceratohyale – 1, and unidentified Pikeperch bones – 3 fragments.

The reconstructed lengths of these fishes appears in Table 12.

The average size of Pikeperch was of 50,4 cm, smaller than the size of modern commercial Pikeperch from the Kuban River. In years 1924 and 1925 these averages were of 51,7 and 55,8 cm (Chugunova N.I., 1931).

Length classes	20-25-30-35-40-45-50-55-60-65	TOTAL	Length (mean)
NISP	- 1 - - 1 3 5 12 2 4	28	50,4

TABLE 12

Sizes of the Pikeperch from «Site N 3» near Novo-Djereshevskaya.

The site near Elizavetovka village (Asian portion of the Kimmerian Bosporos)

The settlement is located in the southeastern part of this village (15 km to the west of the modern city of Krasnodar), in the right bank of the Kuban River. Excavations were conducted in 1934-1936 under the direction of V.A.Gorodtsov. Bones of fish were identified by G.V.Nikolsky (1937, pp.121-125).

The site near Elizavetovka village probably was a Maiotid settlement and dated from IV c. BC up to III c. AD. 4 fish fragments (found on the surface of the site by scientist Anfimov) belong to Carp and Sheat-fish:

Cyprinus carpio L. – Carpio - Carp

There are 2 fragments of operculum from two fishes, both having lengths of 56 cm. Average size of modern Carp from site near Elizavetovka village is unknown.

Average sizes of modern commercially fished carps from the Kuban River and Azov Sea are of 30 and 35 cm respectively (Table 13).

Silurus glanis L. – Sheat-fish

The remains include 2 ceratohyale of Sheat-fish, having lengths of 112 and 124 cm. Table 14 shows the total data of Sheat-fish sizes from the site near Elizavetovka village (data from Nikolsky, 1937 + two identified fragments in this paper)

Length classes	30-35-40-45-50-55-60-65	Total NISP	length (mean)	+*m*	+σ
NISP	1 - 4 8 17 16 7 -	53	53,8	0,76	5,56

TABLE 13

Sizes of Carps from the site near Elizavetovka village (data from Nikolsky, 1937 plus two identified fragments from this paper).

p. 213:

Length classes	100-125-150-175-200-225-250-275-300	Total	length (mean)	+*m*	±σ
NISP	6 2 8 11 8 5 5 3 -	48	195,25	7,54	52,0

TABLE 14

Sizes of the Sheat-fish from the site near Elizavetovka village.

Table 15 shows the number of fragments of the fish species fished by the Maiotis people.

Taxon	"Chumyany redant"	"Mertvy redant"	Site N 3	Site near Elizavetovka
Sturgeon	-	2	2	-
Sevryuga	6	4	14	-
Pike	1	-	-	-
Carp (Carp)	5	-	-	2
Sheat-fish	-	-	-	2
Pikeperch	42 (+120 scales)	-	31	-
TOTAL	54 (+ 120 scales)	6	47	4

TABLE 15

Fish remains from Maiotis settlements.

The total amount of material studied here is not so representative so as to reach clear conclusions, but we can summarize some aspects:

1. The statements by classical authors (Strabon. VII, 3,18; 6,2; IX, 2,4) about significant development of fishing in the Maiotis settlements are confirmed by the archaeological data –finds of layers with fish remains: bones, scales, and finds of fishing instruments– hooks and plummets.

2. The first place among the fished taxa is taken by Pikeperch and the second by sturgeons at large, then Sevryuga. Carp takes third place the last one belonging to Sheat-fish. Pike was rarely fished.

Nowadays Pikeperch keeps its first place in fishing.

The fishing of sturgeons is restricted in modern time and amounted to a mere 1,4% of the total fish landings in 1927-1928.

Roach also has great value in modern fishing, though their bones aren't found in Maiotis settlements.

3. The average sizes of Pikeperch, Sevryuga and Carp were probably similar to those of modern fishes.

4. Fishing in Maiotis settlements was done with sweep-nets and hooks.

* * *

The research of fish bones found at Pantikapaion, Phanagoria and the Maiotis settlements of the eastern Azov Sea basin as well as the documentary data provide a common picture of fishing techniques and fish composition in antiquity and the possibility to show changes taking place from ancient to modern times.

The main object of Bosporos fishing was «herring», Anchovy, and Red mullet. Salting vats at Tyritake and Myrmekion evidence this (V.U. Marti, 1941, pp.93-95).

The second place in the fish captures is taken by fishes of the family Acipenseridae including Sevryuga, sturgeons at large, and possibly, Beluga. Within these, as happens today, most of the captures remained with Sevryuga. The species composition changed due to fishing conditions at some places: near brackish limans, located near Maeotis settlements, sturgeons, Pikeperch, Carp and bream were fished; in the site near Elizavetovka village sturgeons, Pikeperch and a lot of Sheat-fish were taken; besides these, tuna and windowpanes were found in Pantikapaion.

As for modern fishing – there is no radical difference with ancient times, except for the huge scale of modern fishing and its influence on fish quantity, reproduction and biological parameters of fishes. The main target today in The Strait of Kerch (as in antiquity) is «herring» and Anchovy; in the delta of the Kuban River it is Pikeperch. Great significance is also given to roach fishing, the remains from this species being found in Pantikapaion. The captures of sturgeons in the modern fishery, by comparison with ancient times have been drastically reduced. The explanation is that sturgeons are fish with a long life cycle. Maturity is reached only from the 12^{th}-15^{th} year of life. These fishes are slow to recover in the case of overfishing in contrast to short-lived species such as «herring», Anchovy or windowpanes.

Still, one judges that some changes in the distributions of certain species were the result of *changes of the hydro-geological conditions. Some fishes (such as breams, Carp, Sheat-fish, and Pikeperch) were numerous in the tributaries of the Kuban River near Phanagoria. Today these species have disappeared and been replaced by grey mullets. The main reason for this is the increasing levels of salinity in the Gulf of Taman that resulted from the changes of the hydro geological situation in the Kuban River basin.*

Tuna was a traded item in antiquity, but today it is very rare, almost an anecdotical fish. The finds of tunas in Pantikapaion prove the possibility that tuna fishing occurred in the Black Sea as postulated by K.A.Vinogradov.

B5 - Marti V.Yu., 1941. New data about fishing in the Kimmerian Bosporos («*Novye dannye o rybnom promysle v Bosporose Kimmeriiskom*» in Russian), *SovA,* 7: 94-105

p. 95 [On ancient authors]:

Strabon indicated that a lot of fish from Maeothida (modern Azov Sea) were prepared as salted fish – {Strabon, VII, IV, par.6; XI, II, par. 4 – Scythica et Caucasia, v.1, p. 126, p.131}.

One of the main fished items were the Acipenseridae which were described by ancient authors as the «fishes without a vertebral column». A great abundance of «red» fish (Acipenseridae) was mentionted for the Gulf of Taman. In modern times Sevryuga (Acipenser stellatus) dominates the catches from the The Kuban River. Nikolskii (1937)[2], based on the study of the bones from ancient sites located near the Kuban River, referred that sturgeon and Sevryuga were more common in the fish catch from ancient times than in the modern catches.

Strabon specifically referred to the fishing of sturgeon «in the ice» in the Strait of Kerch, which were nearly similar in sizes to dolphins {Strabon, VII, II, par. 18 – Scythica et Caucasica, v.1, p. 121}

Accorging to M.Koehler (1832, p. 358) the composition of fishes in ancient times were similar to modern time fish catches. In this way, the main species in the Strait of Kerch are: grey mullet fishes (Mugilidae s.l.), scomber,«herring», round goby, Anchovy and Red mullet. Aristotle's statement that bonito derived from «angry tuna females» that spawned in the Azov Sea, contradict the situation of modern times. As is well known, bonito, scomber and tuna are members of different species. Today, neither tuna nor bonito migrate regularly from the Black Sea to the Azov Sea. Tichyi (1917)[3] mentioned that the first place in Black Sea fishing in antiquity was taken by the mackerels, but ancient authors considered tuna, bonito and scomber to be all tunas with different ages.

Dolphins were well known for the ancient Greeks – as their depictions on ancient Greek ware testify.

The description of classical fishing technology and of its instruments of fishing is mentioned in M.Koehler's 1832 monograph «… ou recherches sur la histoire et les antiquites des pecheries de la Russie meridionale.» (Memoirs de l'Academie Imperiale St. Petersburg, VI series)

According to Koehler the simplest technology of fish preparation in ancient times was fish drying following gutting (without internal organs) –done, for example, with the Acipenseridae, tuna and bonito. Tuna, bonito, sturgeon, «herring», mullet, scomber were also salted. For such procedures there were specialized fishsalting vats and amphoras for transport in the ancient Greek colonies.

Both Greeks and Romans made sauces of various kinds of fishes. Most well known were muria and garum. The first one was not too expensive and it was prepared in small amphoras from internal organs, blood and tuna gills; less often – from scomber. The second sauce was more expensive and was prepared from scomber and Red mullet. The most expensive sauce, named alix, was prepared from Red mullet liver and sometimes from anchovies (Koehler, 1832).

p. 95 [About fish finds in the Bosporos]:

Ancient fish salting vats are similar to modern cement vats for salting fishes. The total capacity of the open fishsalting vats at Tyritake is 457 m3 and that from Myrmekion – 130 m3. All fishsalting vats

[2] Nikol'skii G. 1937.
(To study of The Kuban River ichthyofauna) K poznaniyu ihtiofauny reki Kuban – in Russian, Bulleten moskovskogo obschestva Estestvoispytatelei. T. XVI, Vol. 2, pp. 121-125.

[3] Tichii M. 1917.
(Anchovy from Chersonesos Taurikum) Anchous Chersonesa Tavricheskogo. Vestnik rybopromyshlennosti za 1917 god. N 1, p. 4.

could simultaneously contain some 4720 quintal of crude fish.

Both in the fishsalting vats and near them a lot of fish remains were found – bones, occasionally – whole skeletons, scales and so on. On the basis of fish remains investigations it can be said that fishes, prepared during the Roman period are similar to fishes prepared in modern time in The Strait of Kerch.

One of the first items of this fishing refers to «herring» and Anchovy. Sizes of some «herring» scales from fishsalting vats at Tyritake attest to the very big size of «herring» – not less than 38-40 cm. A similar situation (bigger sizes) has been mentioned by Nikolskiy (1937) for other fish species from the site near Elizavetovka village in the bank of The Kuban River[4].

Anchovy has also been found in many of the fishsalting vats from ancient Mirmekyon.

A lot of bones of Acipenserids were found, most often near the vats. Unspecified sturgeon bones dominated the samples followed by Sevryuga bones. Beluga is absent.

Bones and scales of Pikeperch and pharyngoepiglotic teeth of Roach (Rutilus sp.) were found near fishsalting vats both at Tyritake and Myrmekion.

Shells of mussels and oysters were found in large quantity – in garbage heaps near the fishsalting vats.

In spite of references in the literature about finds of flukes in the excavations, no remains of this fish have been found near the fish salting vats. Perhaps this fish was consumed fresh, as in modern times. Moreover, neither bones of Red mullet (despite the many references of the ancient authors to this species), nor those from bonito, scomber, tuna and grey mullet have been found either.

As a conclusion it may be noted, that results of the last archaeological excavations in Tyritake and Myrmekion testify to the importance of fishing in the area, making this activity a second after agriculture in the economy of the Bosporos settlements.

B6 - Myagkova U.YA., 2000. Analysis of osteological material from Tanais («Analis osteologicheskogo materiala iz Tanaisa» - in russian) In: «Donskaya archeologiya» N2, P. 64–70.

This report refers mainly data on the mammal bones at Tanais but includes the number of fish bones which are not to be found elsewhere, and references the last results about the identified fish bones in Tanais made by E.A.Tsepkin,1970 and Vasilieva A.V., 1999 (unpublished data that we have been unable to track down).

p. 64 [On the fishes]**:**

Tanais site - is a Greek site, located at the mouth of the Don (modern Myasnikovskiy region, Rostov-on-Don area).

Among the fish bones one finds evidence of the following species: Sheat-fish, Sterlet, Pikeperch, Carp, which are abundant; Russian sturgeon, Sevryuga, Pike which are rare; Beluga, bream, subspecies of roach, Asp and darters– are represented by a single specimen (these were determined by Tsepkin E.A., 1970 and Vasilieva A.V., 1999). It seems that fish bones amounted for close to 2 % of the total bone material in the ancient period, 10-11% in the Roman period until IV c. AD, and only 6% in V-VI c. AD, at that the Acipenseridae are the taxon that decreases most drastically with time.

[4] Two different sites – a site near Elizavetovka village on The Kuban River (Asian Bosporos) and Elizavetovka fort-settlement on the Don River.

SPECIES	HELLENIC PERIOD	ROMAN PERIOD STRATA		STRATA OF IV c. AD	STRATA OF V-VI c. AD
		II c. AD	III c. AD		
Fish	1044	59	797	3042	82
Pond tortoise	-	-	1	15	-
Mussels					
Unio sp.	12	-	5	36	3
Aves	11	15	15	75	2
Mammalian					
Indeterminate	1044	182	1873	8915	758
Domestic species	1716	335	3916	14982	522
Wild species	8	2	60	206	1
TOTAL	3835	593	6667	27271	1368

TABLE 16

Animal remains from Tanais arranged according to period.

p. 65:

Among the mussels, Unio clams (two species common in the river Don) are found. These amount to a mere of 0,07-03% of the animal remains. Such insignificant number of mussels allows one to assert that they probably were not eaten; most likely these shells got into the site with sand and algae. (p. 64)

Category	NISP (to class)	NISP (to species)
mussels	-	3
fishes	102	858
birds	10	-
mammals	366	1026
TOTAL	478	1887

TABLE 17

Animal remains from Nizshne-Gnilivskoe according to major taxonomic categories identified to class and species levels.

B7 - Myagkova U.YA., & Vasil'eva A.V., 2002. Animals from Nizshne-Gnilivskoe settlement («Zshivotnye Nizshne-Gnilivskogo gorodischa», in russian). In.: IV Donskie arheologicheskie chteniya. Ed. Kopylov V.P., Press by Ministerstvo kultury Rostovskoi oblasti. Rostov-na-Donu. PP.34-39.

p. 34:

This material comes from excavations on the I^st^ century AD Nizshne-Gnilivskoe settlement, located in the outskirts of the modern city of Rostov-on-Don, in the right bank of the Mertvy Donetz. The director of the excavations is Tomashevich-Buck (Sweden). Probably the main part of the fish bones was connected with layers dating from the II-III^rd^ cc. AD.

A total of 2365 animal remains were studied (Table 17).

The few mussels recovered belong to clams of the genus Unio. Fish bones belong to 9 species (Table 16). Most of these still exist in the modern ichthyofauna of the Don region. These are Carp, breams, roaches, Sheat-fish, and Pikeperch.

p. 35:

Sheat-fish is the most abundant species followed by Sterlet, Sevryuga and Carp. Sturgeons at large constitute the most abundant taxon.

FISH TAXA	BONE NUMBER	
	NISP	%
Acipenseridae indet.	328	38,23
Sterlet (*Acipenser ruthenus*)	199	23,19
Beluga (*Huso huso*)	1	0,12
Russian sturgeon (*A. gueldenstaedtii*)	14	1,63
Sevryuga (*Acipenser stellatus*)	138	16,08
Cyprinidae indet.	128	14,92
Carpio (*Cyprinus carpio*)	92	10,72
Bream (*Abramis brama*)	13	1,52
Roach (*Rutilus rutilus*)	3	0,35
Sheat-fish (*Silurus glanis*)	332	38,70
Pikeperch (*Stizostedion lucioperca*)	16	1,86
TOTAL	858	100%

TABLE 18

Fishes from Nizshne-Gnilivskoe.

For some species the age and length of the fishes were reconstructed. These species include Carp, breams, Sheat-fish, roach and Pikeperch.

pp. 35-36:

Age (years)	Bones number (specimen)		
	Carp	Bream	Sheat-fish
4	1	-	-
5	2	1	2
6	2	-	5
7	1	-	3
8	-	1	8
9	-	-	17
10	-	-	26
11			25
12			21
13	1	-	5
14	-	-	3
15	-	-	5
16	-	-	1
17	-	-	3
18	-	-	1
19	-	-	2
Sum:	7	2	127
Average age	-	-	10,6
Average age (modern)	6[5]	-	4 [7]

TABLE 19

Age composition of selected fishes from the Nizshne-Gnilivskoe settlement.

The lowermost lines in Table 19 show the average ages from Nizshne-Gnilivskoe settlement compared with modern fishes of the Azov Sea (Southern area of the Caspian Sea in the case of Sheat-fish). The references are given within brackets.

p. 36:

The average age of the archaeological Sheat-fish greatly exceed the average of the commercial catches in the Don river region today (Table 19).

pp. 36-37:

The data on the fishes of Nizshne-Gnilivskoe shows that Sheat-fish and Carp are larger, on the average than their modern counterparts but maximum sizes are more similar. Unfortunately, in the case of other species, samples are too small or data altogether absent (for example, for sturgeons). Nevertheless, bones of sturgeon-s.l. are fairly large. Sturgeons and Sheat-fish (Carp to a smaller degree) played the main role in the fishing economy, judged from the quantity of remains, but size-age data demonstrate that these fishes were not exploited to a damaging level of overexploitation.

SPECIES	Maximum and average fish sizes (cm)			
	N-G settlement		Modern fishes of Azov Sea basin	
	Maximum sizes	average sizes	Maximum sizes	average sizes
Carp	77	52,9; n=34	More than 100[1]	40[6] 33-42 [5]
Bream	63	48,7; n=6	75 [4]	24-38 [3]
Roach	29;31	-	More than 50 [4]	11,5[1]
Sheat-fish	201	138,2; n=104	250 [7]	78,5[2] 97[7]
Pikeperch	67	53,5; n=4	130[4]	40,6-47,6[8]

TABLE 20

Size distribution from selected fish species from the Nizshne-Gnilivskoe settlement (Numbers within brackets refer to the references given at the end of this work).

p. 39:

References (only author, year and title provided) (all references in Russian)

1. Berg L.S., 1948-1949. Freshwater fishes of the USSR.

2. Vescherezov B.I., 1934. Bream, Carp and Sheat-fish in the Azov-Don river region.

3. Dmitriev N.A., 1931. Bream in the Azov Sea (biology and fishing).

4. Lebedev L.D., 1960. Fresh-water Quaternary Ichthyofauna of the European part of the USSR.

5. Petrov V.V., 1931. Data on the growth and age of Azov Sea Carp.

6. Svetovidov A.N., 1948. A History of the Don river ichthyofauna.

7. Fortunatova K.R., 1936 Main movements in Sheat-fish biology in the Caspian Sea.

8. Chugunova N/I/, 1931. Biology of the Pikeperch in the Azov Sea.

B8 - Sheglov, A.N.,1978. Northern-West Crimea in classical times («Severo-zapadnyi Krym v ancienthnuyu epohu», in Russian). Brashinskii I.B. Leningrad. «Nauka» Press.

p. 114:

Classical sites of Northern-West Crimea were created in connection with a process of Greek colonization of the Black Sea Northern coast, in particular Crimea, during the V–II cc. BC. All of the discussed sites were included in the agricultural territory protected by Chersonessoss during the IV–II cc. BC period. Most of these sites were occupied by the Scythian tribes in II c. BC, and existed as Scythian forts up to the III^rd^ c. AD.

Fishing had great importance in the economy of Northern-West Crimea region.

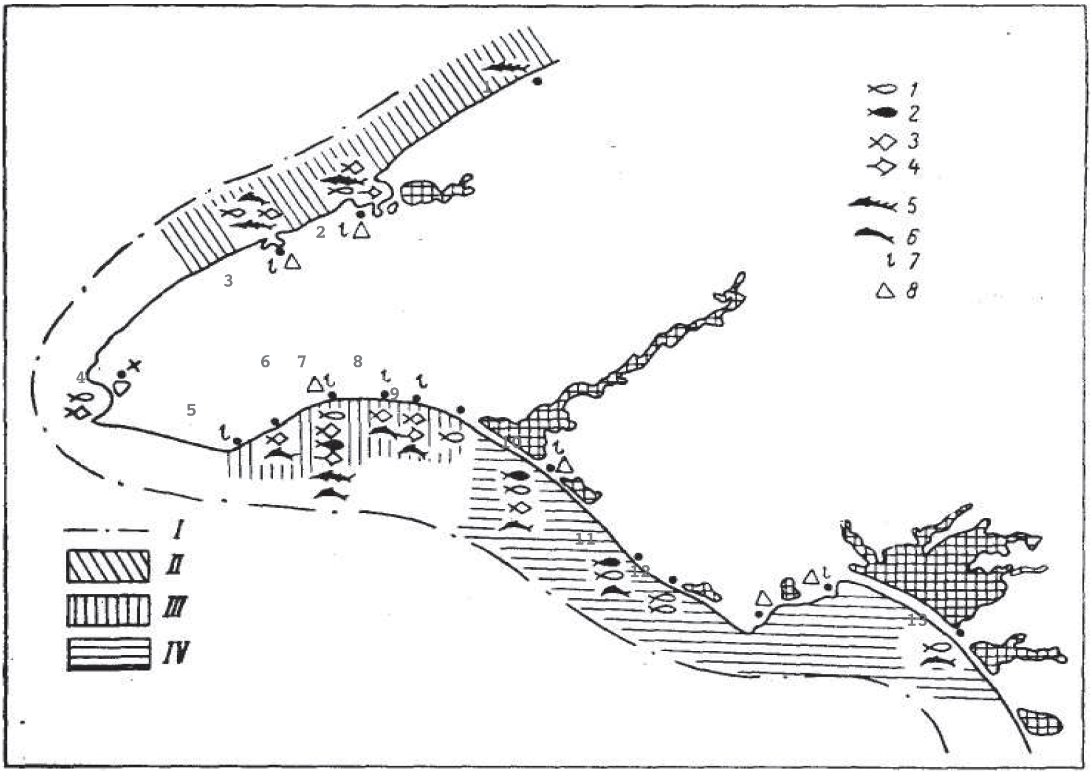

FIGURE 5

Scheme of ancient fishing according to the archaeological data (I: region of Mullet fishery; II: region with significant Sturgeon numbers fishery; III: region with significant Flounder fishery; IV: region of mainly Annular sea-bream fishery. Finds of fish bones and scales: 1. Mullets; 2. Annular sea-bream; 3. Flounder; 4. Guitarfish; 5. Sturgeon; 6. Dolphins; 7. Fishing hooks; 8. Net weights.). Site numbers as in Table 21. (Taken from Sheglov, 1978).

The main product was grey mullet. There were two common species: golden mullet –(Mugil auratus Risso) and common (black) mullet (M. saliens Risso); golden mullet was the most common of the two.

The second place was occupied by annular sea-bream and flounder.

In addition to fish, finds of mollusks –blue mussels and european oyster– along with a lot of claws and shells from crabs (Eriphia spinifrons), and a lot of dolphin bones were found.

p. 115:

Fish remains were found in all levels of the deposits (i.e., from Greek to Scythian periods) –in buildings and in pits.

SETTLEMENT	mullets	sea-bream	Flounder	Guitarfish	Sturgeon	Dolphin
1-Vladimirovka	-	-	-	-	+	-
2-Panskoe	+	-	+	+	+	-
3-Kalos Limen	+	-	+	-	+	+
4-Karadzshinskoe	+	-	+	-	-	-
5-Dzshan-Baba	-	-	+	-	-	+
6-Tarpanchi	+	+	+	+	+	+
7-Lazurnoe	-	-	+	-	-	+
8-Kulchukskoe	-	-	+	+	-	+
9-Belyaus	+	-	-	-	-	-
10-Uzshno-Donuzlavskoe	+	+	+	-	-	+
11-Airchi	+	+	-	-	-	+
12-Beregovoe	+	+	-	-	-	-
13-Kara-Tobe	-	+	-	-	-	+

TABLE 21

Fishes and dolphins from North-West Crimean Sites given on a presence:absence basis (mullets refer to grey mullets only and sea bream to Annular sea Bream).

Most fish scales belonged to three- four year old fishes. So perhaps fishing was very intensive and important both for the needs of the inhabitants and for trade (at Belyaus fragments of Chersonessos amphorae with fish scales were found). Fishing nets and fishing tackle of various kinds were used for fishing. Plummets, made from amphorae handles, stone and tile fragments were found there. Also, clay pyramidal plummets were produced in that place.

B9 - Tsepkin E.A., 1970. New materials for the History of fishing in Tanais («*Novye materially k istorii rybnogo promysla v Tanaise*» – in Russian). In: «Kratkie soobsheniya Instituta Archeologii», 124: 115-117.

p. 115:

The works of various researchers (Tichy, 1917; Marti,1941; Zshiteneva, 1967) have already addressed the study of the fisheries from the ancient cities of the Northern Black Sea Coast. These are based on materials from excavation from Chersonessos, Tyritake, Myrmekion, Pantikapaion and some other cities and settlements of the Bosporos Kingdom.

In this report, the data of the fish bones from the 1962-1966 excavations at Tanais are presented. The collection includes 715 bones. Their good condition has allowed to identify down to species level 676 of them (94,6 %).

Bones represent 11 fish species that belong to 5 families.

I. Acipenseridae – sturgeon family

1) 24 bones belong to Beluga (Huso huso). Reconstructed lengths fluctuated from 70 to 250 cm.

2) 103 bones are from Sterlet (Acipenser ruthenus). Reconstructed lengths fluctuated from 55 to 107 cm with most of them measuring between 70 – 85 cm.

3) 29 bones belong to Russian sturgeon (Acipenser gueldenstaedtii), whose lengths fluctuated from 90 to 180 cm.

4) 55 bones are from Sevryuga (Acipenser stellatus) – fish length from 120 to 150 cm.

II. Esocidae – Pike family

3 bones of Pike were found in Tanais for the first time. Fish lengths range from 97 to 105 cm.

p. 116:

III. Cyprinidae – Carp family

1) 6 bones of Roach (Rutilus rutilus heckeli). Fish sizes: 30,32,36,39,40 and 40 cm.

2) 4 bones of Asp (Aspius aspius) found for the first time in Tanais. Fish sizes are of 50, 55, 60 and 61cm.

3) 5 bones of Common Bream (Abramis brama). Fish lengths ranging from 38 to 50 cm.

4) 63 bones of Carp (Cyprinus carpio). Reconstructed lengths range from 36 to 85 cm with most specimens being of 50-70 cm.

IV. Siluridae – Sheat-fish family

332 bones belong to Sheat-fish (Silurus glanis). Reconstructed fish lengths fluctuated from 95 to 250 cm with most animals being from 150-190 cm.

V. Percidae – darter family

50 bones belong to Pikeperch (Lucioperca lucioperca). Fish sizes fluctuated from 48 to 105 cm with a dominance of individuals in the 55- 70 cm range.

Taxa	1959		1962-1966	
	NISP	%	NISP	%
Beluga			24	3,4
Sterlet	17	3,9	103	14,8
Russian sturgeon	48	10,0	29	4,2
Sevryuga	26	6,0	55	7,9
Acipenseridae			24	3,4
Pike			3	0,4
Roach			6	0,8
Rutilus frisii	3	0,7		
Asp			4	0,5
Bream	10	2,3	5	0,7
Carp	31	7,2	65	9,3
Sheat-fish	277	64,1	332	47,5
Pikeperch	25	5,8	50	7,1
TOTAL	434	100,0	700	100,0

TABLE 22

Species composition of fish from Tanais.

Sturgeons s.l. constituted the basis of the fishing economy at Tanais, followed by Sheat-fish and then Cyprinids. Carp is the most abundant taxon of all Cyprinids.

p. 117:

One needs to stress that mainly large fishes were taken at Tanais in ancient times. Their average sizes surpasses the average sizes of their modern counterparts for every species. This fact evidences that the fishing in Tanais was a specialized trade branch of husbandry.

The fishing in Tanais existed as an annual activity, but mainly from spring to autumn.

In the absence of salting vats, one may assume that drying constituted the main processing procedure followed for the long-term preservation of the fishes.

DISCUSSION: AN OVERVIEW OF THE FISHES FROM ARCHAEOLOGICAL SITES

The data set gathered on fishes from the Northern Black Sea area during classical times, despite its apparent large number of sites is misleading although it certainly hints at certain patterns (Table 24). Fully two third of the sites (i.e., 20) do not provide quantitative data on either NISP (remains) or MNI (individuals) and only mention taxa on a presence/absence basis. This same applies to one third of the 27 fish taxa considered in this report. It so happens that all of the presumably marine taxa (i.e., clupeids, mullets, sea breams, flatfishes and scombrids) fall into this category. For such reason, the comments that follow on diachronic and regional patterning essentially apply to the freshwater component of the fish faunas and, as such, not only can they be considered partial but heavily biased as well.

Sturgeon	100 cm / 10 kg
Sheat-fish	100 cm/ 10 kg
Carpfishes	50 cm (2 kg) & 60 cm (3 kg)
Pikeperch	35-55 cm (0.6-1 kg)
Pike	67 cm (2 kg)

TABLE 23

Size/weight equivalences for selected fish taxa.

Overall, sturgeons constitute the bulk of the remains (47% of the total NISP), followed by Sheat-fish (23.5% of the total NISP), cyprinids (17% of which close to 7% correspond to Carp), Pikeperch (11%), with a negligible 0.6% of the remains corresponding to Pike. The values do not reflect the contribution in terms of meat represented by each one of these groups. In order to do so, remains would need to be turned into weights. This is not an easy task for not all NISPs have an MNI to them and different fishes have different number of bones. Furthermore, we have no idea what where the criteria for identifying remains, (e.g., whether vertebrae were systematically counted or not) for this is nowhere stated in the various works. Finally, there is a quite substantial range of sizes for most of the recorded species so that it is not possible to provide an overall average weight for any particular taxon. Still, assuming that taphonomic loss has been extensive one can

FAUNAL PROVINCE	I		II														III						IV			V					VI	Total
TAXON/ SITE	**0**	**28**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26a**	**26b**	**26c**	**27**	**Σ**
Rhinobatidae				+				+		+																						(+)
Acipenseridae	226	44	+	+	+			+								+				17	+	39			2	+	328			24	8	688
A.gueldenstädti	469	210																		4		44		2			14	+	48	29	2	822
A. ruthenus	844	228														+				3							199	++	17	103	4	1394
A. stellatus	495	150														+	+			5		61		14	6		138	+	26	55	4	954
A. nudiventris	24																			1												25
Huso huso	310	171														+											1	(1)		24		507
Clupeidae																		+														(+)
Engraulis																+		+	+													(+)
Esox lucius	47	4																							1			+		3		55
Cyprinidae	289	124																								+	128					541
Cyprinus carpio	167	142														+	+			3	+	66	53		5	+	92	++	31	65		624
Abramis sp.	186	13																		1		1					13	(1)	10	5		230
Rutilus rutilus	86	14																+•	+•	3	+						3	(1)	3	6		116
Rutilus frisii	47	31																														78
Aspius aspius	15	1																										(1)		4		21
Silurus glanis	982	167														+				5		1	48			+	382	++	277	332		2194
Stizostedion	574	247														+	+	+	+	9	+	25		31	42	+	16	++	25	50		1019
Perca fluviatilis	8	1																														9
Mugilidae				+	+	+		+			+	+	+	+		+																(+)
Diplodus annularis								+				+	+	+	+																	(+)
Mullus barbatus																+																(+)
Neogobius																					+											(+)
Scomber scombrus																+																(+)
Thunnus thynnus																				5												5
Pleuronectiformes				+	+	+	+	+	+	+		+				+					+*											(+)
Delphinidae					+			+	+			+	+		+																	(+)
TOTAL	**4769**	**1547**	**(+)**	**(+)**	**(+)**	**(+)**	**(+)**	**(+)**	**(+)**	**(+)**	**(+)**	**(+)**	**(+)**	**(+)**	**(+)**	**(+)**	**(+)**	**(+)**	**(+)**	**56**	**(+)**	**237**	**101**	**47**	**56**	**(+)**	**1314**	**1044**	**437**	**700**	**14**	**10322**

TABLE 24

Overview of fish remains from archaeological sites from the Northern Black Sea region. Site code see pages 112-114. Explanations of faunal provinces appear in the text.

consider each fragment to represent an individual, an assumption that is, alas impossible to verify. Applying to these NISPs conservative values of weight estimates (Table 23) one can see that, for the samples under consideration, sturgeon would have represented 62% of the living tissue (i.e., 470,000 kg), Sheat-fish up to 30% (230,500 kg), Carpfishes a mere 5% (i.e., 34,000-51,000 kg for an average of 40,000 kg) and the contributions of Pikeperch (1.5%; 11,000 kg) and Pike (0.15%; 1,200 kg) could rightly qualify as anecdotic.

It would be of utmost necessity that the contribution of the marine taxa, clupeids in particular, could be incorporated into this «equation» to see to what an extent does the dominance of sturgeons hold and the contributions of the remaining groups further deflates. Thus far, marine fishes remain the *terra incognita* of the «fishing equation» and yet we believe that they were the basis of the commercial fishing operations that took place during the Hellenistic and Roman periods. No study of ancient fishing in the area will be adequate until the study of the marine taxa, clupeids in particular is incorporated into the data set.

A. DIACHRONIC CHANGES

Ever since Köhler (1832: 358) mentioned that the composition of the fish catches from ancient times was similar to those from modern times, several authors have repeated the idea without apparently bringing forth much evidence to back it up (eg., Marti, 1941: 95; Lebedev & Lapin, 1954: 213; Stolba, 2005: 132). The idea of a static Black Sea «fauna», though, was first formulated by Scheglov in the 1960's (Bekker-Nielsen, pers. comm). Although this is an interesting proposition, it is also a difficult one to explore for, among other things, we are here considering two intrinsically different data sets and one wonders whether meaningful conclusions derived from one could be adequately extrapolable to the other.

For one thing, as Lund-Jacobsen (2005) has so adequately stressed, data on modern day fisheries can not be taken as a reliable basis of inference since fishing statistics from this area, as in so many others, are highly questionable and often inaccurate. If we proceed beyond modern day data, for all we know, the most one can say is that the Black Sea fishery remained an artisanal one until the very end of WWII and data on numbers, species taken, etc., were gathered in a non-systematic way. The good news is that such a fishery would be carried out close to the shore, thus one could expect their data to be more similar to those from the ancient fisheries than those from the modern industrial fishery that developed after 1945 in the area.

TAXON	CATCH
Flathead mullet (*Mugil cephalus*)	18,000 specimens
Leaping mullet (*Liza saliens*)	300,000 specimens
Golden grey mullet (*Liza aurata*)	13,525,000 specimens
Atlantic mackerel (*Scomber scombrus*)	78,880,000 specimens
Sturgeon (Russian, Sevryuga, Beluga)	c.424,000 kg
Turbot (*Psetta maxima*)	c.512,000 kg
Pontic Shad (*Alosa pontica*)	c.120,000 kg
Red mullet (*Mullus barbatus*)	c.208,000 kg
Anchovy (*Engraulis encrasicolus*)	c.1,440,000 kg
Zostericola (?)	c.624,000 kg

TABLE 25

The landings of fishes in the Black Sea in 1910 according to Maximov. (Taken from Andrusov & Zernov, 1914).

The data provided by Maximov on catches along the northern shore of the Black Sea (i.e., from the Danube to the The Strait of Kerch) around 1910 may provide a starting point for our quest (Andrusov & Zernov, 1914) (Table 25). The main problem, in addition to not being sure to what animal (a shrimp?) does the name *Zostericola* apply, is that Maximov offered landings sometimes in terms of specimens and sometimes in terms of weights, thus his data set is inherently inconsistent. In order to reach a slightly larger degree of consistency, specimens need to be turned into weights. Again, this is not a straightforward task for both the grey mullets and the mackerel's commercial sizes vary greatly (i.e., 200-1000 g) thus require some sort of previous standarisation before the data can be homogeneously offered in terms of tons of fish, for example.

TAXON	CATCH
Grey mullets (combined)	4,100tons (1,300-26,000t)
Atlantic mackerel (*Scomber scombrus*)	23,000tons (7,880-38,000t)
Sturgeon (Russian, Sevryuga, Beluga)	c.424tons
Turbot (*Psetta maxima*)	c.512tons
Pontic Shad (*Alosa pontica*)	c.120tons
Red mullet (*Mullus barbatus*)	c.208tons
Anchovy (*Engraulis encrasicolus*)	c.1,440tons

TABLE 26

Maximov's 1910 data on the landings of fishes from the NW Black Sea converted into metric tons. Figures in brackets refer to estimations based on different mean values for the weights of the animals under consideration.

In Table 26 the data from Table 25 have been turned into tons. For the grey mullets and mackerel a «standard» weight of 300 g has been given as a conservative figure yet this provides only an average whose ranges appear within brackets (the lower value corresponding to weights of 100 g per specimen and the upper value being of 500 g. As some grey mullets and a few mackerels reach up to 1.2-1.5 kg even the upper values in this case could be considered underestimations).

No matter how distorted, this data set reveals striking differences with our previous archaeological samples. To start, the artisanal fishing of the early twentieth century featured a minor amount of sturgeon (i.e., 1.4%) in the catch. Even if all of the grey mullets (13.5%) were to be considered freshwater fishing, the fact that mackerels accounted for 75% of the biomass at this time reveals the importance of the marine component in the Northern Black Sea fishery one century ago and offers a great contrast with the data from the «classical fisheries».

Such results make one wonder to what an extent are our archaeological samples biased and marine taxa underestimated. Again, the need to study the samples recovered in the salting vats is evident.

Antoher important issue from the palaeoecological standpoint is that the 1910 artisanal fishery did not concentrate on the most abundant of the local resources, the clupeid fishes and instead targetted on their major predator. Indeed, at many places, anchovies constitute the main food item of the mackerel during the summer and without any doubt the large numbers of mackerels taken by the artisanal fleets at that time indirectly speak about a far larger number of clupeids in the area. The fact that the later only made up 5% of the catch (i.e., 4.6% anchovies + 0.4% Pontic Shad) reveal a fishery that was cropping resources at almost the top of the food chain at the beginning of the twentieth century (larger scombrids prey on mackerel but their abundances in the Black Sea at the time we can only speculate about) (Vinogradov, 1931; Vodyanitskyi, 1940). One conclusion is that this fishing reveals a rather local or restricted market where fishing goods could travel to and stresses the isolation of the northern Black Sea fishery at the turn of the twentieth century notwithstanding political or religious issues (i.e., the Turkish influence on the shores of the Black Sea before the First World War).

If the data from the archaeological and 1910 data sets were to be taken at face value another striking feature emerges. This corresponds to a more than one order of magnitude size change in the animals taken. Indeed, if the bulk of the «classical fisheries» is made up of specimens averaging a rather conservative figure of 10 kg per individual, by 1910 the major taxa taken did not even reach to 1 kg. It is interesting to note that in both cases the two major items (i.e., «sturgeon + catfish» *vs*. «mackerels + grey mullets») of each fishery represent some 90% of the total catch by weight (i.e., 92% in the case of the archaeological samples and 89% in 1910) and share equivalent weights.

Remarkably, both trends have some sort of continuity with the most recent fishery statistics, available for 2002 (Figure 6). In this case the two main

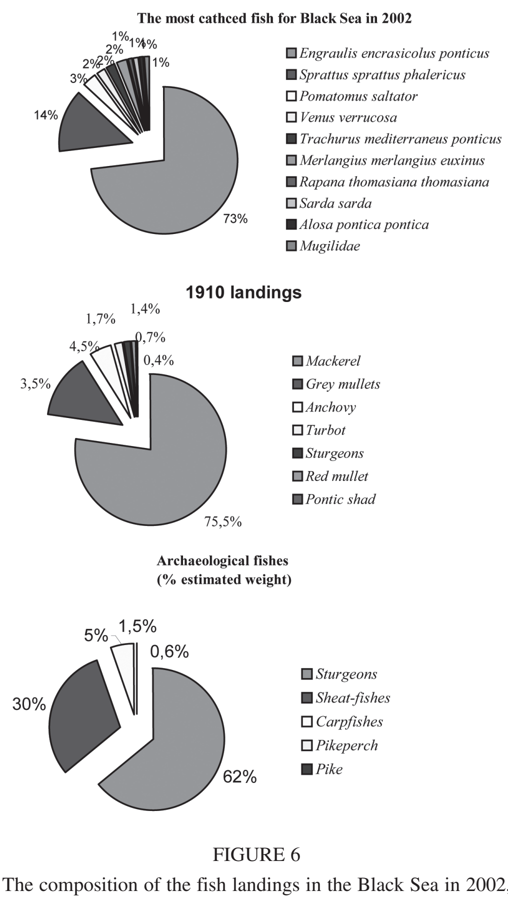

FIGURE 6

The composition of the fish landings in the Black Sea in 2002, the northwestern Black Sea around 1910 and the combined archaeological assemblages from the VIIth century BC to the IVth century AD of the northern Black Sea.

items of the fishery are clupeids of similar weight (i.e., Anchovy and sprat) and together they represent 87% of the total catch. Given that the commercial weights of both species oscillate between 5-35 g another order of magnitude reduction in the size of the animals has taken place, only this time within a century instead of a millennium. The modern fishery is now clearly targeting on the more productive resources of the Black Sea, were the potential catches of pelagic species (clupeids for the most part) range from 200,000-300,000t whereas demersal resources, where both sturgeons and sheatfishes are included, systematically fall below 25,000t (FAO 1981).

A meticulous analysis of these «trends» is clearly beyond the scope of this report. The robustness of the classical fishing strategy, though, is reinforced when one considers the diachronic changes revealed by the sieved fish samples at Olbia and Berezan Island reported by Ivanova (1994) that Tables 27 & 28 evidence.

TAXON	ARCHAIC	CLASSICAL	HELLENISTIC	ROMAN	TOTAL
Sturgeon	48%	53%	45%	67,5%	48,5%
Cyprinids	29,5%	4%	20%	12%	20%
Sheat-fish	7%	23,5%	17%	10%	15%
Percids	15%	13%	15%	8%	14.5%
Pike	-	-	1%	0,2%	1%

TABLE 27

The combined contributions of the main fish taxa al Olbia and Berezan island through time in terms of NISP percentages (taken from Ivanova, 1994).

Indeed, despite fluctuations, both sturgeon and Sheat-fish fishing increased during the Roman period whereas cyprinids decreased slightly through time. True, it can be said that this fishing has little to do with marine fishing thus we remain uncertain about the role played by the clupeids and other marine taxa at places where the influence of the fresh waters (i.e., the Bug-Dnieper estuary) was not so important. But the pervasiveness of the patterns throughout one full millennium in no way reveals the drastic taxonomic shifts one would expect took place with the onset of «industrial fishing operations» after the Vth century BC. In the Black Sea, with the fish remains data at hand one can not see, for example a replacement of sedentary or mildly migratory coastal taxa by epipelagic migratory species as was the case in the Strait of Gibraltar with the arrival of the Punic and Roman colonizers (Trakadas, 2005; Morales & Roselló, in press).

One way or the other, we see in these data no support for Vladimir Stolba's statement that «*… the last 2,000 to 2,500 years do not reveal any significant changes as to varieties* [of fish]*, their proportions…*» (2005: 132). Whether or not the changes described here are reliable or not is a different matter. In fact, the only instance where the fish data reveal the stability that Stolba mentions happen to be those sites, like Olbia and Berezan Island, with occupations lasting the millennium that runs from the VIIth century BC to the IVth century AD. Moreover, this stasis at the ichthyological level is reinforced with data on the technology since throughout the period under consideration the archaeological record shows no hints of any new developments in the fishing gear (Munk Højte, 2005: 138). To decide whether such was the case or only a biased picture gained from our incomplete knowledge of the fishes or the fact that technological changes could have taken place without leaving any traces in the archaeological record will no doubt require further analysis.

TAXON	ARCHAIC	CLASSICAL	HELLENISTIC	ROMAN	TOTAL
Sturgeon	55%	62%	36%	62,5%	45%
Cyprinids	21,5%	6%	37%	20%	29,5%
Sheat-fish	4%	18%	10,5%	5,5%	9%
Percids	19%	14%	12,5%	11%	14%
Pike	-	-	3,5%	1%	2%

TABLE 28

The combined contributions of the main fish taxa al Olbia and Berezan island through time in terms of percentages of the MNI (minimum number of individuals) (taken from Ivanova, 1994).

B. SPATIAL PATTERNING

Although restricted, the Northern Black Sea area features, in terms of fisheries, at least three major biotopes:

1. Large estuaries such as those of the Danube, Bug-Dnieper and Don Rivers are the domain of the taxa that seasonally migrate between marine and freshwaters, often in large numbers.

2. The Southern shores of the Crimean Peninsula, whose lack of major rivers creates a more conventional type of marine coast. These should be the domain of the more marine taxa.

3. The Sea of Azov and, to a lesser extent, the shores running from the Danube to the Bug-Dnieper estuaries constitute a sort of mixed habitat with smaller estuaries and a lower influence from rivers on an otherwise fully marine coast.

The area of the Strait of Kerch adds to the marine biotopes of the second category the bonus of seasonal fish concentrations, mostly of marine taxa that would turn it, as is the case of the Strait of Gibraltar, into an ideal zone for the cropping of migratory taxa such as the various kinds of clupeid and scombrid fishes.

The geographic patterning of the fish finds reflects these contingencies to a certain extent and allows one to define five «ichthyoarchaeological provinces» of sorts. These are (Table 24):

I. THE NORTHWEST SECTOR OF THE CRIMEAN PENINSULA**,** featuring the only sites where strict marine taxa such as the Red mullet and guitarfishes have been mentioned. Since no quantitative data are available the most one can say is that both flatfishes and grey mullets seem to be the most regular item at these sites. Sturgeons are reported on only a third of them. These Northwestern Crimean sites are also the only ones documenting the presence of dolphins, animals that regularly follow the schools of migratory fishes. One may speculate that the apparent lack of clupeids may be real or simply an artifact derived from the manual method of recovery.

II. THE STRAIT OF KERCH AREA is the only area where the remains of clupeids have been «systematically» mentioned. Unfortunately no positive identification of any particular taxa has been made and although one assumes that Anchovy was the major item at all times, the reference to large clupeids («herring») may well be an indication that species such as the Pontic Shad were also taken. As the shads are normally consumed fresh or salted, it is doubtful that they were used in the making of the fish sauces unless juveniles were also taken. In terms of groups represented, the scarce quantitative data available from Pantikapaion and Phanagoria evidence a dominance of sturgeon over the remainig taxa that is not as marked as in the areas close to large river mouths.

The fishes from Chersonessos located between these two «provinces», exhibit the same marine taxa that typify the former but also several species of sturgeon and anchovies that make them resemble the Kerch Stait sites (Table 24). As such, the fish assemblage from Chersonessos could go with either of the previous groups, a matter that only quantifiable remains of positively identified taxa could settle.

Except for the inland site of Elizavetovka village, where only Sheat-fish and Carp have been quantified (we have been unable to locate Nicholskii's 1937 paper), the three remaining ones on the eastern Azov lands exhibit a greater contribution of species such as Carp and Pikeperch than of sturgeon. If only for this reason these Maiotis sites, devoid of any marine fishes have been tentatively grouped into a third «ichtyoarchaeological province» (III).

The two remaining «provinces», located at the mouths of the major rivers of the Northern Black Sea feature a pervasive dominance of sturgeon but no single species of marine origin, including amphidromous taxa such as the grey mullets (Table 24). It is here that what can be properly labelled as «freshwater fishing» is best documented and here that Carpfishes reach their greatest contributions. The differences between these two regions are that one of them (i.e., nº I) links directly with the Black Sea whereas no. V sheds into the Sea of Azov, incorporating a large body of brackish water that isolates it from the fully marine environment. Ichthyologically speaking, though Sheat-fish is important in both regions, in the Bug-Dnieper estuary this catfish reaches far lower values through time (i.e., 7-23% of the NISP; Y = 15%) than the ones it reaches at places like Tanais or Nizshne-Gnilivskoe (i.e., 29-63%) (Table 24). Whether the reasons for these differences are cultural, ecological or other is open to debate at this point. Outside these two faunal groups, only cyprinids constitute a substantial portion of the assemblages, Carp always being the main species (Table 24).

As stated, these «ichthyarchaeological provinces» are to be taken as working hypotheses that future systematic work will help verify/refine or, alternatively, refute.

In connection with this, our preliminary studies of the Elizavetovka fort site (Roselló *et al.*, in preparation) are evidencing a dominance of cyprinids and a scarcity of sturgeon that neither correspond with the features highlighted above for province no.V nor coincide with the idea that sturgeon constituted one of the major groups there, something that Munk-Højte (2005) already mentioned. In fact, the data reported by Marčenko *et al.* (2000) reveal a dominance of cyprinids coincident with our own preliminary data.

C. SIZE CHANGES

Changes in the size of the fishes have been important tools for analysts trying to determine whether specific populations in the past may have been subjected to intensive fishing such as the one characterizing modern commercial fisheries.

As stated by Leach (2006) it is impossible to consider fish assemblages as time series due, among other things, to the long periods that most archaeological deposits represent. Still, archaeoichthyologists have been able to document drastic size changes in the average lengths of many species that probably indicate that in the past underexploited populations featured animals of sizes unheard of in the present day literature.

Although the data base on fish sizes from the Northern Black Sea sites is still quite restricted, it at least allows one to get a glimpse of the problem and put forward some very general ideas for future study (Tables 29 & 30).

If large size is taken as the trademark of non-intensive exploitation then the archaeological data indicate that fishing during this period can not properly qualify as «intensive». True, for most species, the archaeological specimens' size-ranges fall above the common size ranges that the species exhibit nowadays and this in itself could be taken to indicate that a decrease in size has taken place. But since we are talking here about a period some 2,000 years ago, such shifts could equally well be explained by alternative causes. Indeed, except for the Sterlet, the sizes of all of the archaeological remains fall below the maxima known today for each species so that we do not have archaeozoological evidence that animals in former times reached sizes for which we have no analogues today. Indeed, the most parsimonious explanation for this would be to assume that neither the artisanal nor the industrial fishing of ancient times was capable of catching the largest specimens that live in the deepest waters.

More important is the fact that, whenever we have sufficient data to see where most of the sizes fall, often the animals fall well below the maximum recorded sizes today. If fishing was ever carried out intensively at any time one would expect

SPECIES	TOTAL RANGE	MAXIMUM	COMMON RANGE	ARCHAEOLOGICAL SIZE DATA
Pike	9-150	150	25-50	97-105(Tanais), 29-64(Olbia/Berezan)
Asp		120	28-35	50-61(Tanais)
Bream		75	24-38	38-50(Tanais), 49(Y; NizhsneG), 23(Pantikapaion)
Common Roach		40	14-22	29-31(NizhsneG), (23-35 (Pantikapaion)
Black Sea Roach		70	40-60	22-37.5(Semjonovka), 30-40(Tanais), 15-55 (Olbia/Berezan)
Carp	20-100	100	30-45	40-85 (Semjonovka; common: 50-70), 36-85 (Tanais, common: 50-70), 53 (Y; NizhsneG), 61-75(Pantikapaion), 51-78 (Phanagoria), 24-58 (Chumyany Redant; Y=50), 30-65 (Elizavetovka village; Y=54)
Pikeperch	20-130	130	35-55	48-105 (Tanais; common: 55-70),), 35-60(Olbia/Berezan), 53.5 (Y; NizhsneG; maximum= 67), 45-77 (Phanagoria; Y=59), 41-62 (Chumyany Redant), 34-87 (Elizavetovka village; Y=50), 20-65 (Site no.3; Y=50)
Sheat-fish	20-300	300	80-100	95-250 (Tanais; common: 150-190), (Olbia/Berezan, see Table 30), 138 (Y; NizhsneG; maximum= 201), 107-135 (Pantikapaion), 101 (Phanagoria), 100-300 (Elizavetovka village; Y=193.5)
Sterlet		80	35-40	55-107 (Tanais; common: 70-85), (Olbia/Berezan, see Table 30)
Beluga		400-600?		70-250 (Tanais), (Olbia/Berezan, see Table 30)
Sevryuga			107	120-150 (Tanais), (Olbia/Berezan, see Table 30), 127 -168 (Phanagoria, Y=142), 107 (Y; Elizavetovka village), 83-144 (Site no.3; Y=118)
Russian sturgeon		220	105-170	90-180 (Tanais), (Olbia/ Berezan, see Table 30), 109-171 (Phanagoria, Y=132), 75 (Y;Elizavetovka village), 120 (Mertvy Redant)

TABLE 29

Size (standard lengths) values and statistics of modern and subfossil fishes from selected species of interest in the Black Sea region.

the largest specimens to fall first and the archaeological record to feature an unusual proportion of the largest animals.

In terms of trends, only the data from Olbia and Berezan Island provide evidence on size changes for the most important species of the assemblages. It is a pity that Ivanova plotted the data from both sites together as this leaves open the question of whether the patterns –or lack of them- is a statistical construction more than a reflection of the evolution of sizes for each species at each particular site (Table 30).

Overall, there seems to exist a pervasive diminution of size from the Archaic period (VII-VIth BC) to Roman times (I-Vth AD) but, except for the Sheat-fish, this trend is not marked and features quite a few exceptions. In this way Beluga's mean size rises dramatically at the end of the sequence whereas for Sevryuga the largest sizes are recorded during the intermediate classic period (V-VIth BC). Sizes remain constant for species such as the Russian sturgeon and the Pikeperch, the diminution though time being minimal in the case of the Sterlet.

Since Ivanova does not provide the basic statistics of these averages one is left wondering about the role of sample size, thus the meaningfulness of the values. If data were to be taken at face value, though, it seems that we are not confronting here any general trends but, instead a sort of idiosyncratic response that is difficult to reconcile with a general intensification of fishing through time. As the data set presently stands, the general impression is that at Olbia+Berezan, and in contrast to what Ivanova (1994: 280) concludes, there exists a quite stable situation for most of the commercially important fishes (the exception being Sheat-fish) during the millennium that witnessed tremendous changes in the other area were commercial fishing developed in antiquity: the Strait of Gibraltar.

SPECIES	ARCHAIC	CLASSICAL	HELLENISTIC	ROMAN
Beluga	128	125	100	140
Sterlet	82	79	78	70
Sevryuga	135	180	130	105
Russian sturgeon	90	90	95	89
Bream	60	-	30	45
Carp	62	-	40	50
Pikeperch	52	52	51	50
Sheat-fish	-	159	130	99

TABLE 30

The evolution of sizes, as expressed by the mean value of the estimated standard lengths trough time for selected species from the Olbia+Berezan island assemblages (taken from Ivanova, 1994).

D. BLACK SEA AND IBERIAN FISHERIES: A BRIEF COMPARATIVE SURVEY

Ancient Iberian fisheries have been studied for many years, yet the analysis of the fish remains is also here a relative late incorporation (Roselló, 1989; Morales & Roselló, in press). For such reason, we are still lacking many of the details of this industrial development and the general comments that follow might also be in need of further refinement in the future.

Factory	capacity (m^3)	fishes (metric tons)
Chersonesos	2,000	1,566
Tyritake	466	365
Myrmekion	116	91
Zolotoe	83	65
Salatčik	-	-
Total	2,665	2,087

TABLE 31

The estimated capacities of the fish salting installations from the Black Sea.

One coincident feature of the fish data from the Black Sea and the western centers of fish production of the Mediterranean concerns the temporal time frame. In the case of Iberia evidences of «fishing for export» start with the Phoenicians whose earliest involvement with fish commerce dates back to an amphora with tuna remains from the town of Acinipo (Cádiz; VIIth BC) (Morales & Roselló, in press). Whether the phoenicians became directly involved with fishing, exported fishing technology to the local turdetanian populations or were simply transporting goods from the West to the East remains open at this point. The earliest factories, such as the one discovered at Las Redes, are all restricted to the Bay of Cádiz and date from the time of the Punic colonization (i.e.,Vth century BC onwards). It appears that, in addition to tunas, other large fishes such as the meagre *Argyrosomus regius*, became the targets of this industry although the scarce evidence of fish transport from this period only reveals the presence of tuna bones. This is a T-11.2.1.3 type amphora, dating from the first half of the fifth century BC, retrieved in the site of Camposoto in the Bay of Cádiz (García *et al.*, in press).

In contrast with such finds, those evidencing a direct involvement of the Greeks with fishing, fish processing and transport in the Black Sea are far from clear due to a lack of fishing installations and transport vessels during the Classical and Hellenistic periods. In fact, it appears that no amphorae made in this region were apparently intended as a primary container of fish or fish products whereas for the Western Mediterranean no less than twenty two such kinds have been thus far described (Sciallano, 1997; Lund & Gabrielsen, 2005: 166).

Another difference between the Black Sea and the Strait of Gibraltar area refers to the numbers and sizes of the Roman fish factories.

In this way, although the figures vary from author to author, the number of roman fish installations in Iberia and northern Morocco is now well over one hundred (i.e., 120; Ponsich, 1988; Sciallano, 1997; Etienne & Mayet, 2002; Trakadas, 2005). Of these, some 40 are located on the Levantine façade of Iberia (Roman province of the Tarraconensis) and another 40 dot the Strait of Gibraltar shores (Baetica and Mauritania Tingitania provinces). Most of these were small, comparable to those found at Zolotoe or Salatčik, and none reached the size of Chersonesos. Still, when combined capacities are taken, the differences between the East and the West were not as large as the sheer differences in number would lead one into thinking (Tables 31 & 32). This seems to be revealing a basic difference in the distribution of the fish processing capacities in both areas, far more dispersed in the East, that is most probably explained on account of historical constraints rather than of environmental ones, whether biological or oceanographical.

Factory	capacity (m^3)	fishes (metric tons)
Troia (I/II)	+606	474.5
Troia (III)	103	80.5
El Majuelo	+500	391.5
Baelo Claudia	269	210.6
Quinta do Marim	55.7	43.6
Quinta do Lago	48	37.5
Setubal	47	36.8
Pessegueiro	78	61
Creiro	38.5	30
Sines	34.6	27
Almeria	12.8	10
Rosas	9.3	7.2
Cotta (1)	258	202
Lixus (10)	1,013	793
Total	3,073	2,405.3

TABLE 32
The estimated capacities of some of the major fish salting installations from the Western Mediterranean.

Another difference of the Roman factories on both areas concerns their chronology. Those from the Black Sea are exclusively of imperial times (i.e., I-IIIrd AD) whereas the Iberian ones start during the republican period (IInd BC) and some last until the VIth century AD. When one takes into account the fact that fish factories in Iberia started operating by the Vth century BC one can see that the time frame in the East is barely a fourth that documented for the West.

A last major difference is, in fact putative for we do not know whether it also holds in the Black Sea whose salting installations' fish assemblages remain undocumented to this day. We refer to the kinds of fishes and the shifts in the choice of species that the Iberian factories reflect with time. In this way:

1) Fishing on a commercial scale in the West always centered on marine, pelagic, migratory fishes and only very occasionally on the more sedentary taxa. No freshwater fishing has been ever documented as is the case of the assemblages from the Classical, Helenistic and Roman periods in the Black Sea.

2) The evolution of the products in the west is rather striking and evidences a rather dramatic taxonomic shift through time that roughly defines three stages (Morales & Roselló, in press):

2a) Tunas, from the IIth century BC until the middle of the Ist century AD.

2b) Mackerels, from the middle of the Ist century AD until the beginning of the IIIrd century AD.

2c) Clupeids, mostly fry and juveniles, from the begining of the IIIrd century AD onwards.

It appears that both *salsamenta* (i.e., *tarychos*) and sauces were produced during the first and second stages but that only sauces characterized the last one, clupeids being for the most part juvenile animals 4-6 cm long not worth consumption.

3) The sizes of the fishes diminished one order of magnitude with each period and contrast with the essentially stable scenario that the Black Sea species reveal during this period.

For these reasons we believe that from a biological standpoint, we are here confronted with two very different situations that may have had consequences at the economic level.

In this way, the character of the fishing in the West was heavily seasonal, concentrating in the late spring and summer when agricultural labor force was jobless. In the Northern Black Sea, although most or all of the documented species are migratory, except for the clupeids and scombrids all could be fished in the estuaries and along the shores throughout the year, their more restricted migrations not meaning a total disappearance of the stocks from a certain area. For such reason, an intensive fishery here must have been much more damaging in the long run, a phenomenon that would have left clear signatures on the archaeoichthyological assemblages (i.e., shifting abundances among taxa, local extinctions, drastic size reductions, etc.) that are, with the data at hand, scarcely evident (Sheat-fish?). It can be argued that commerce must have buffered fluctuations to a certain extent, blurring the effects of industrial fishing thus such hypothesis must remain an open issue at this point. One way or the other, if fishing could be carried out throughout the year in the Black Sea, the labour force there must have been of a more specialized kind than that existing in the West, another issue that would have had consequences at the socio-cultural level and presumably should have left signatures in the archaeological record.

A side issue that needs to be taken into account now is that only sturgeons among the documented Black Sea fishes are fatty fishes (i.e., with fat percentages ranging from 8-30% by dry weight; see Appendix 1) and, for all we know only fatty fishes were major items of the roman fish sauces and salting installations in the West. As the data stand at present, it appears that most of the fish productions from the northern Black Sea were for meat and that only detailed analyses of the fish remains from the salting vats could give us an indication about the nature of the sauces being produced there during Roman times.

CONCLUDING REMARKS

In this preliminary attempt to evaluate the fish assemblages from the northern Black Sea region during the period that runs from the VIIth century BC to the IIIrd century AD, far more questions have been raised than answers given. Both questions and answers, however, allow one to get a better glimpse of the material record provided by the fish remains. As such, both allow for the framing of future ichthyoarchaecological research on firmer ground and, from such a perspective both should be considered positive.

To summarize:

1. The fish assemblages that have thus far been studied with a minimum amount of rigour are essentially non-marine in character. It is true that almost all the species considered, sturgeons in particular live in brackish, estuarine or even fully marine waters but the fact remains that all of them are primarily freshwater fishes and their retrieval at the various places could be rightly argued as evidence of fishing in a non-strictly marine environment.

2. The strictly marine taxa, including some of those exhibiting amphidromous habits such as the shads and the grey mullets, have not been the target of any thorough analysis as of this writing. In fact, we are presently lacking any positive identifications on the species that have been retrieved in the excavations, most taxa being referred to in the literature by generic, often ambiguous, names such as khamsa, herring, grey mullets, etc.

3. Since we believe that fully-marine fishes- clupeids and scombrids in particular- hold the key to the development of large scale fishing (ie., fishing for export) in the northern Black Sea region during classical antiquity, no studies of these issues can proceed much further beyond the present level of knowledge until a thorough analysis of the remains found in the salting vats is accomplished. True, there are all sorts of problems for translating a list of identifications at the level of species into the kind of qualitative estimations like volume of processed or transported fishes that would give us an idea of the amount of production at specific places or particular times. Still, knowing what species were targetted will, at the very least, allow us to eliminate alternatives and focus on the biological constraints determining the distribution, availability and possibilities of processing of the relevant taxa helping us to better frame the cultural and historical questions that interest us most.

4. As things stand now, the most one can say is:

4a.The remains of fishes in sites with a long occupation exhibit a proportional increase in numbers in the Classical period, the Archaic period featuring few or no fishes. This increase is taken to represent the start of non-local consumption (ie., export) but, to date, such inference remains rooted on purely circumstantial grounds and could equally well be explained by alternative hypotheses (ie., population increase at the beginning of the Vth century BC).

4b. The available fish samples are intrinsically incomparable for comparisons require some sort of standardization and, at present, none on these samples has been undertaken. In this way, NISP is taken to reflect original abundances in most instances yet this estimator is inappropriate by virtue of design. The case of sturgeons is paradigmatic. Sturgeons constitute the bulk of the remains in most assemblages yet their NISPs are basically represented by scutes whereas for the remaining fishes their NISPs include vertebrae and a few cranial elements that sturgeons lack due to their cartilaginous nature. Since scutes are robust elements and one single animal may harbour dozens of them, chances are that a few sturgeons in a sample could provide the misleading impression that such animals were unusually abundant. Unless NISPs are turned into MNIs, chances are that sturgeons will be systematically overrepresented in the faunal collections conveying a false impression of abundance that will have a translation at the interpretive level.

4c.Without having a clear idea of how were the fishes processed, one furthermore remains uncertain on how to evaluate importance. To this end, one would need, for example, to have at least some hints on whether fishes were exported whole or butchered, and this not only requires checking butchering practices (ie., skinning, be-heading, etc.) but also what sort of skeletal representations one finds in the salting vats, fishing installations at large and transport vessels. One may, for example, have an overrepresentation of sturgeons (i.e., scutes) at the place where they were butchered in case they had been previously skinned yet no remains of them in the transport vessels if skinned chunks of meat were placed in them since the cartilaginous vertebrae would eventually dissolve. As things presently stand, no analysis of butchering practices has been reported and we lack information about the processing of fishes in the factories. Also, although no Black Sea amphorae was apparently meant for fishes, the Sheat-fish remains found in the amphora from the Varna shipwreck does not specifiy which bones were present (presumably most were vertebrae) or how were these processed.

4d. If the number of salting vats could serve as a proxy for the availability of marine fishes, it appears that the Bosporos Kingdom, with some 60 salting vats, was not as productive as the southernmost tip of the Crimean peninsula (ie., some 100 vats at Chersonessos). Given that straits feature regular concentrations of migratory fishes one is forced to think that the fish biomass crossing past the Strait of Kerch was less important than that travelling along the southern shores of Crimea. Obviously, without having an idea of what species were targetted or what sort of fishing tackle deployed, one has no way of putting forward a biological explanation for such an asymmetry of fish processing capacities. The lack of salting installation at other places of the northern Black Sea (in fact, of the Black Sea as a whole) may be taken as an indication that fish productivities in these areas were not worth developing industrial installations but such a conclusion would be defective in several ways. First of all, and most puzzling, the most productive waters in terms of plankton production are the western shores of the Black Sea yet no fishing on a commercial scale has ever been documented at places such as the Danube estuary. Could this be a reflection of an environmental constraint that has somehow passed unnoticed to scholars? (In connection with this, one should be reminded that malaria, prevalent in the area until half a century ago, may have severely restricted human settlement during classical antiquity). Secondly, migratory fluxes of most scombrids and clupeids tend to flow parallel to the coast, the southern one along Anatolia having been particulary rich according to the written sources. Also, there were historical and economic contrivances that may have been as decisive as the biological ones for deciding whether a fish salting installation was a worthy undertaking at a specific place or not. Finally, there exists always the recourse to *ad hoc* hypotheses like postulating that the installations for the processing of fish did not leave any traces on the archaeological record.

4e. From the data gathered thus far, we believe that the well documented fish assemblages of the northern Black Sea coast represent a fishing that one might most appropriately label «local» in the sense on non-commercial even though at a certain time, some of its elements (ie., sturgeons, red mullets) became items for export. This «background fishing», a sort of common denominator throughout the northern Black Sea for the period under consideration, centered on fishes that, despite restricted migrations up and down the rivers, could be considered resident in the area. The major shift, to incorporate fully migratory species, presumably only took place during Roman times but, contrary to what was the case for the Iberian peninsula, this did not mean a replacement of the «background fishing», that kept on during these centuries both in «local» (i.e., Tanais) and «colonial» sites like Olbia or Chesonessos. In fact, the persistence of only such «background fishing» at places like Olbia and the very restricted distribution of the salting installations, points to a coexistence of two different kinds of fishing strategies during the Roman period.

4f. Stasis, both at the level of taxonomic composition and, to a lesser extent, in the estimated sizes of the documented fishes might be taken to indicate a non-intensive fishing strategy set well below the carrying capacity of each of the targetted species. Given that resident populatons of littoral fishes and those occupying restricted freshwater bodies are far more vulnerable to intensive fishing, such taxonomical and size stability reinforces the idea of a local scale exploitation for the non-strictly-marine taxa and with it, the impression that trade of these taxa was probably never carried out on a large scale, meaning a scale comparable to that exhibited by the clupeid and scombrid fishes in the Iberian peninsula.

But the fact is that we do not know any of this for sure. In fact, one feels that we are lacking many essential elements of the equation, in particular those referring to the nature and kinds of the truly migratory marine fishes and the nature of the long distance transport of fish and fish products in the area.

Equally important would be the knowledge about several environmental features for which we can only speculate about at this moment. Among these, as has been mentioned, one should keep in mind that, up until the middle of the twentieth century malaria was a prevalent disease throughout the northwestern sector of the Black Sea, in particular in the biologically productive waters of the large deltas and estuaries. This disease could have been one of the main agents dictating a restricted demography at all times and no doubt constituted a serious handicap for the establishment of long-term and profitable fishing enterprises despite any potential bounties the sea could offer.

Until matters such as these are solved, most of the previous ideas will necessarily remain as working hypotheses, loose pieces of a huge puzzle that archaeologists will need to take into consideration should they ever seek to reach a more coherent, unitary picture about the nature of fishing and fish production in the northern Black Sea region during classical antiquity.

ACKNOWLEDGEMENTS

This report benefited from the support from a contract of *The History of Marine Animal Populations Centre* at the University of Southern Denmark (**HMAP-SDU**) entitled: «*Protohistoric fishing in the Black Sea: an Archaeoichthyological Approach*» to Arturo Morales Muñiz. The authors likewise want to thank Prof. Dr. Tonnes Bekker-Nielsen (Esbjerg), Prof. Dr. Wim Van Neer (Brussels), Dr. Luis Gil de Sola (Málaga) and three anonymous reviewers for critically commenting on the text and pointing out relevant information for this review.

REFERENCES

ANDRUSOV, N.I. & ZERNOV, S.A. 1914: âernoe more. In: *Krym. Putevoditel'. Simferopol*. (http://www.moscow-crimea.ru/atlas/more3.html).

BAUCHOT, M.-L. & PRAS, A. 1980: *Guide des Poissons Marins d'Europe*. Delachaux & Niestlé, Lausanne.

BEKKER-NIELSEN, T. 2005 (ed.): *Ancient Fishing and Fish Processing in the Black Sea Region.* Aarhus University Press, Aarhus.

BEKKER-NIELSEN, T. 2005: The Technology and productivity of Ancient Fishing. In: Bekker-Nielsen, T. (ed.): *Ancient Fishing and Fish Processing in the Black Sea Region.*: 83-95. Aarhus University Press, Aarhus.

BELOV, G.D. & STRZELECKIJ, S.F. 1953: Otãety (Raskopi 1937-1948 gg.) Kvartaly XV i XVI, MIA, 34: 32-236.

COLLETTE, B. & NAUEN, C.E. 1983: *Scombrids of the World*. FAO species Catalogue. Vol. 2. FAO. Roma.

CURTIS, R.I. 1991: *Garum and Salsamenta: Production and Commerce in Materia Medica*. E. J. Brill, Leiden.

CURTIS, R.I. 2005: Sources for Production and Trade of Greek and Roman processed Fish. In: Bekker-Nielsen, T. (ed.): *Ancient Fishing and Fish Processing in the Black Sea Region*: 31-46. Aarhus University Press, Aarhus.

D'ARCY THOMPSON, W. 1947: *A Glossary of Greek Fishes.* Oxford University Press, Geoffrey Cumberlege.

DEAN, J.M.; ADDIS, P. & CAU, A. 2005: *Mediterranean Bluefish Tuna: An ancient fishery copes with modern demands*.

http://www.mareblucamogii.com/mediterranean_fluefin_tuna.htm

DESSE-BERSET, N. 1993: Contenus d'amphores et surpêche: l'exemple de Sud-Perduto (Bouches de Bonifacio). In : Desse, J. & Audoin-Rouzeau, F. (eds.): *Explotation des Animaux à travers le temps*: 341-346. Editions APDCA, Juan-les-Pins.

DESSE-BERSET, N. & DESSE, J. 2000: Salsamenta, Garum et autres préparations de poissons. *MEFRA* 112: 73-97.

EJSTRUD, B. 2005: Size Matters: Estimating Trade of Wine, Oil and Fish Sauce from Amphorae in the First century A.D. In: Bekker-Nielsen, T. (ed.): *Ancient Fishing and Fish Processing in the Black Sea Region*: 171-181. Aarhus University Press, Aarhus.

ÉTIENNE, R. & MAYET, F. 2002: *Salaisons et Sauces de Poisson Hispaniques*. E. de Bocard, Paris.

FAJEN, F. 1999. *Oppianus Halieutica. Sammlung Wissenschaftlicher Commentare*. B.G. Teubner, Stuttgart.

FAO 1981: *Atlas of the Living Resources of the Seas*. F.A.O., Rome.

FISCHER, W.; BAUCHOT, M.L. & SCHNEIDER, M. (Rédacteurs) 1987: Fiches FAO d'identification des espèces pour les besoins de la pêche. Mediterranée et Mer Noire. Zone de pêche 37. Volume II. Vertebrēs. FAO. Roma.

GAJDUKEVIČ, V.F. 1952a: Excavations in Tyritake.1935-1949 (Raskopki Tyritake v. 1935-1949 gg.; in Russian). *MIA* 25: 15–134.

GAJDUKEVIČ, V.F. 1952b: Excavations in Myrmekion in 1935-1938 (Raskopki Mirmekiya v 1935-1938 gg.; in Russian). *MIA* 25: 135 –222.

GARCÍA, E.; ROSELLÓ, E.; BERNAL, D. & MORALES, A. in press: Un primer acercamiento a las Evidencias de Paleocontenidos y Depósitos Primarios en el ámbito Euro-mediterráneo.

GAVRILJUK, N.A. 2005: Fishery in the life of the nomadic population of the Northern Black Sea. In: Bekker-Nielsen, T. (ed.): *Ancient Fishing and Fish Processing in the Black Sea Region*: 105-114. Aarhus University Press, Aarhus.

HOLČIK, J. (ed.) 1989: *The Freshwater Fishes of Europe. Vol.1, Part II. General Introduction to Fishes. Acipenseriformes*. AULA-Verlag, Wiesbaden.

IVANOVA, N.V. 1994: Fish Remains from archaeological sites of the northern part of the Black Sea region (Olbia, Berezan). *Offa* 51: 278-283.

KADEEV, V.I. 1970: Essays on the History and Economy of Chersonesos Tauricus in the I-IVth centuries AD (Oãerki istorii economiki Chersonesa Tauriãeskogo v I-IV vekach n.e.). Charkov.

KÖHLER, H.K.E. 1832: *Tarychos ou recherches sur l'histoire et les antiquités des pêcheries de la Russie meridionale*. Mémoires de l'Academie Impériale de Sciences de St. Petersburg, 6^{e} série, t.1. St. Petersburg.

KOROBOCHKINA, Z.S. 1964: Razvitie i sovremennoe sostoyanie promysla v. Kaspiiskom basseine. *Trudy VNIRO* 54: 175-202.

KOSHELENKO, G.A.; KRUGLIKOVA, I.T. & DOLGORUKOV, V.S. (eds.): 1984 Classical States in Northern Black Sea Coast (Antichnie gosudarstva severnogo Prichernomor'ya; in Russian). Archaeology of the USSR monographs. Academy of Sciences of USSR. Nauka, Moscow.

KRUGLIKOVA, 1975: Agriculture in the Bosporos (Selskoe hozyaistvo Bosporosa; in Russian). D.B. Shelov. Nauka, Moscow.

LEACH, F. 2006: Fishing in Pre-European New Zealand. *Archaeofauna* 15: 9-266.

LEBEDEV, V.D. & LAPIN, U.E. 1954: On the issue of fishing in the Bosporos (K voprosu o rybalovstve v Bosporosskom tsarstve; in Russian). *MIA* 33: 197–214.

LÓPEZ LINAGE, J. & ARBEX, J.C. 1991: *Pesquerias Tradicionales y Conflictos Ecológicos*. Ministerio de Agricultura, Pesca y Alimentación, Madrid.

LUND-JACOBSEN, A.L. 2005: The Reliability of Fishing Statistics as a source of catches and Fish Stocks in Antiquity. In: Bekker-Nielsen, T. (ed.): *Ancient Fishing and Fish Processing in the Black Sea Region*: 97-104. Aarhus University Press, Aarhus.

LUND, J. & GABRIELSEN, V. 2005: A Fishy Business. Transport Amphorae of the Black Sea region as a source for the Trade in Fish and Fish Products in the Classical and Hellenistic periods. In: Bekker-Nielsen, T. (ed.): *Ancient Fishing and Fish Processing in the Black Sea Region*: 161-169. Aarhus University Press, Aarhus.

MARČENKO, K.K.; ZITNIKOV, V.G. & KOPYLOV, V.P. 2000: *Die Siedlung Elizavetovka am Don.* Moscow.

MARTI, V.YU. 1941: New data about fishing in the Kimmerian Bosporos (*Novye dannye o rybnom promysle v Bosporose Kimmeriiskom*; in Russian). *SovA* 7: 94-105.

MORALES, A. & ROSELLÓ, E. in press: Twenty thousand years of fishing in the Strait: The archaeological Marine Faunal Assemblages from Southern Iberia. In: Erlandson, J. & Rick, T. (eds.): *Human Impacts on Marine Environments*. University of California Press, Berkeley.

MUNK-HØJTE, J. 2005: The Archaeological Evidence for Fish Processing in the Black Sea Region. In: Bekker-Nielsen, T. (ed.): *Ancient Fishing and Fish Processing in the Black Sea Region*: 133-160. Aarhus University Press, Aarhus.

MUUS, B. & DÄHLSTRØM, P. 1975: *Havfisk og Fiskeri i Nordvesteuropa* G.E.C.GADS Forlag, Copenhaguen.

MYAGKOVA, U.YA. 2000: Analysis of osteological material from Tanais (Analis osteologicheskogo materiala iz Tanaisa; in Russian). *Donskaya archeologiya* N2: 64–70.

MYAGKOVA, U.YA. & VASIL'EVA, A.V. 2002: Animals from Nizshne-Gnilivskoe settlement (Zshivotnye Nizshne-Gnilivskogo gorodischa; in Russian). In: Kopylov, V.P. (ed.): *IV Donskie arheologicheskie chteniya*: 34-39. Ministerstvo kultury Rostovskoi oblasti. Rostov-na-Donu.

NIKOL'SKII, G. 1937: Contribution to the study of The Kuban River ichthyofauna (K poznaniyu ihtiofauny reki Kuban; in Russian). *Bulleten moskovskogo obschestva Estestvoispytatelei* T. XVI, Vol. 2: 121-125.

PONSICH, M. 1988: *Aceite de Oliva y Salazones de Pescado. Factores Geo-económicos de Bética y Tingitania*. Publicaciones Universidad Complutense, Madrid.

PONSICH, M. &. TARRADELL, M. 1965: *Garum et industries antiques de salaison dans la Meditérranée Occidentale.* Bibliothèque de L'Ecole des Hautes Etudes Hispaniques XXXVI, Paris.

POWELL, O. 2003: *Galen. On the properties of Foodstuffs*. Cambridge University Press, Cambridge.

QUERO, J.C. 1984: *Les poissons de mer des pêches Françaises*. Jacques Grancher, Paris.

ROSELLÓ, E. 1989: *Arqueoictiofaunas Ibéricas: Aproximación Metodológica y Bio-cultural*. Publicaciones Universidad Autónoma de Madrid, Madrid.

RYAN, M. & WHITMAN, M. 1998: *Noah's Flood*. Simon & Schuster, New York.

SCHEGLOV, A.N. 1978: *Northern-West Crimea in classical times* (Severo-zapadnyi Krym v antichnuyu epohu; in Russian). Brashinskii I.B. Leningrad. Nauka Press, Moscow.

SCIALLANO, M. 1997: *Poissons de l'Antiquité*. Catalogue de L'Exposition du Musée d'Istres, Istres.

SEMENOV-ZUSER, S.A. 1947: Rybnyj rynok v Chersonese. *VDI* 1947(2): 237-246.

STOLBA, V.F. 2005: Fish and Money: Numismatic Evidence for Black Sea Fishing. In: Bekker-Nielsen, T. (ed.): *Ancient Fishing and Fish Processing in the Black Sea Region*:115-132. Aarhus University Press, Aarhus.

STRÖMBERG, B. 1943: *Studien zur Etymologie und Bildung Griechisher Fischnamen*. Wettergren och Kerbers Förlag, Göteborg.

TICHII, M. 1917: Anchovies from Chersonesos Taurikum (Anchous Chersonesa Tavricheskogo; in Russian). *Vestnik rybopromyshlennosti za* 1917 god. N 1, P.4.

TRAKADAS, A. 2005: The Archaeological Evidence of Fish Processing in the Western Mediterranean. In: Bekker-Nielsen, T. (ed.): *Ancient Fishing and Fish Processing in the Black Sea Region*: 47-82. Aarhus University Press, Aarhus.

TSEPKIN, E.A. 1970: New materials for the History of fishing in Tanais (Novye materially k istorii rybnogo promysla v Tanaise; in Russian). *Kratkie soobsheniya Instituta Archeologii* 124: 115-117.

TSEPKIN, E.A.1984: Ostatki ryb iz drevnikh poselenii na poberezh'e Baltiiskogo morya. *Byull. MOIP*, otd. Boil 89: 50-58.¯

TSEPKIN, E.A. & SOKOLOV, L.I. 1970: Russkii osëtr *Acipenser* gueldenstaedti Brandt v srednem i pozdnem golotsene. *Vopr. ikhtiologii* 10: 24-36.

TYNDALE, J.W. 1849: *The Island of Sardinia*. R. Bentley, London.

VAN NEER, W. & LENTACKER, A. 1994: New Archaeozoological Evidence for the consumption of locally produced fish sauce in the Northern Provinces of the Roman Empire. *Archaeofauna* 3: 53-62.

VAN NEER, W. & ERVYNCK, A. 2004: Remains of Traded fish in Archaeological Sites: Indicators of Status, or Bulk Food? In: Jones O'Day, S.; Van Neer, W. & Ervynck, A. (eds.): *Behaviour Behind Bones: The Zooarchaeology of Ritual, Religion, Status and Identity*: 203-214. Oxbow Books, Oxford.

VINOGRADOV, A.K. 1931: O tunsakh v Chernom more. *Izvestiya Krymskogo otdela Geograf. Obschestva SSSR*. V.1: 77.

VINOKUROV, N.Y. 1994: Rybozasoloãnye kompleksy chory Evropejskogo Bosporosa. *RosA* 1994(4): 154-170.

VODYANITSKYI, V.A. 1940: K ekologii i istorii ryb Chernogo moray. *Trudy Novorossiiskoi biologicheskoi stansii.* T.2, v.3. Novorossiisk.

WHEELER, A. & LOCKER, A. 1985: The estimation of size in sardines (*Sardina pilchardus*) from amphorae in a wreck at Randello, Sicily. *Journal of Archaeological Science* 12: 97-100.

WHEELER, A. & JONES, A.K.G. 1989: *Fishes*. Cambridge University Press, Cambridge.

WHITEHEAD, P.J.P.; BAUCHOT, M.L.; HUREAU, J.C.; NIELSEN, J. & TORTONESE, E. (eds.) 1984: *Fishes of the North-Eastern Atlantic and the Mediterranean*. UNESCO, Paris.

WILKINS, J. 2005: Fish as a source of Food in Antiquity. In: Bekker-Nielsen, T. (ed.): *Ancient Fishing and Fish Processing in the Black Sea Region*: 21-30. Aarhus University Press, Aarhus.

ZAITSIEV, V.; KIZEVETTER, I.; LAGUNOV, L.; MAKAROVA, T.; MINDER, L. & PODSEVALOV, V. 1969: *Fish Curing and Processing*. MIR, Moscow.

ZSHITENEVA, L.D. 1967: Fish and fishery trade in Olbia (VI BC-IV AD). *Zoological Magazine* 45: 98-104.

APPENDIX 1

Bromatological features of selected fish species from the Black Sea.

SPECIES	TOTAL RANGE	MAXIMUM	COMMON RANGE	ARCHAEOLOGICAL SIZE DATA
Pike	9-150	150	25-50	97-105(Tanais), 29-64(Olbia/Berezan)
Asp		120	28-35	50-61(Tanais)
Bream		75	24-38	38-50(Tanais), 49(Y; NizhsneG), 23(Pantikapaion)
Common Roach		40	14-22	29-31(NizhsneG), (23-35 (Pantikapaion)
Black Sea Roach		70	40-60	22-37.5(Semjonovka), 30-40(Tanais), 15-55 (Olbia/Berezan)
Carp	20-100	100	30-45	40-85 (Semjonovka; common: 50-70), 36-85 (Tanais, common: 50-70), 53 (Y; NizhsneG), 61-75(Pantikapaion), 51-78 (Phanagoria), 24-58 (Chumyany Redant; Y=50), 30-65 (Elizavetovka village; Y=54)
Pikeperch	20-130	130	35-55	48-105 (Tanais; common: 55-70),), 35-60(Olbia/Berezan), 53.5 (Y; NizhsneG; maximum= 67), 45-77 (Phanagoria; Y=59), 41-62 (Chumyany Redant), 34-87 (Elizavetovka village; Y=50), 20-65 (Site no.3; Y=50)
Sheat-fish	20-300	300	80-100	95-250 (Tanais; common: 150-190), (Olbia/Berezan, see Table 30), 138 (Y; NizhsneG; maximum= 201), 107-135 (Pantikapaion), 101 (Phanagoria), 100-300 (Elizavetovka village; Y=193.5)
Sterlet		80	35-40	55-107 (Tanais; common: 70-85), (Olbia/Berezan, see Table 30)
Beluga		400-600?		70-250 (Tanais), (Olbia/Berezan, see Table 30)
Sevryuga			107	120-150 (Tanais), (Olbia/Berezan, see Table 30), 127-168 (Phanagoria, Y=142), 107 (Y; Elizavetovka village), 83-144 (Site no.3; Y=118)
Russian sturgeon		220	105-170	90-180 (Tanais), (Olbia/ Berezan, see Table 30), 109-171 (Phanagoria, Y=132), 75 (Y;Elizavetovka village), 120 (Mertvy Redant)

Codes as follows: G=Grey; R=Red; kcal=kilocalories; kjul=kilojules; Chol.=Cholesterol; MUFA=mono-unsaturated fatty acids; PUFA=Poly-unsaturated fatty acids; SFA=Saturated fatty acids. Macronutrient values are expressed as grams and refer to either mean values or ranges. Except for Anchovy, Sardine, Sheat-fish and Pikeperch, values refer to combined averages of several species although Bluefin tuna *Thunnus thynnus* and Atlantic mackerel, *Scomber scombrus* constitute the bulk of the samples that go under the headings «Tuna» and «Mackerel» respectively (Taken from several works, in particular Zaitsiev *et al*., 1969).