The Archaeological Evidence for Fish Processing in the Black Sea Region

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The archaeological evidence for fish processing in the Black Sea region in the Greek and Roman period is a vast topic covering finds at a large number of sites (Fig. 1) and with interconnections to several other related issues. The literature is extensive, scattered, and inaccessible, if indeed it is available from libraries in Europe.[1] This study, therefore, in no way professes to be an encompassing treatment of all the archaeological evidence for fish processing. This would indeed be far beyond the scope of one paper. Instead I will try to give an overview of the available evidence and present a selection of the most interesting finds and studies. Some of these, like the processing facilities at Tyritake and Myrmekion, are well-known, while others may give a broader perspective on the variety of uses of the fish resources. The aim will be to give an idea of what the archaeological material can reveal about the scale and organisation of the fish processing industry. Throughout I will try to point out some of the shortcomings of the evidence, which I think have not been emphasized enough in the literature, and also point to some areas, where I think scholars have jumped too readily to conclusions.

1. *Types of archaeological evidence*

There exists a wide variety of archaeological evidence that relates to commercial fishing and fish processing. It can be grouped comprehensively in the following manner:

- *Fishing equipment* (net weights, floaters, sinkers, hooks, wrecked fishing vessels, tools for making and repairing nets, and the nets and fish traps themselves)
- *Watchtowers* (σκοπιά)
- *Fish remains* (bones, scales)
- *Processing facilities* (for pickling, salting, smoking and drying. Salt works)
- *Transportation equipment* (shipwrecks, amphorae)
- *Descriptive sources* (epigraphy, coins)
- *Pictorial representations* (sculpture, terracotta, coins etc.)

Fig. 1 a-b. Maps of the Black Sea and the Kimmerian Bosporos with indication of the places mentioned in the text.

Not all these types of archaeological evidence will be discussed in the following. Coins with representations of fish have been discussed by Vladimir Stolba in the preceding chapter, and the constributions of Ejstrud, Lund and Gabrielsen below touch upon the vast topic of transport amphorae. As shown by the recent find of a shipwreck off the coast of Bulgaria, to be discussed briefly in the following, this is perhaps one of the most promising fields for advancing our knowledge of the production and distribution of fish products in antiquity. Likewise the sparse – although informative – epigraphic record and the pictorial representations will only be mentioned in passing.[2]

2. *Fishing equipment*

At practically all sites along the northern coast of the Black Sea and around the Sea of Azov, fishing equipment has been reported dating from throughout their entire existence. Particularly frequent are net weights, both lighter ones of clay or lead for throwing nets, heavier ones of regularly shaped stones for dragging nets (Fig. 2),[3] and sinkers of larger stones or even amphora handles used for the same purpose.[4]

Less common are hooks (Fig. 3a),[5] harpoons,[6] and equipment for making and repairing nets: for example bone and bronze needles (Fig. 4).[7] The nets, fish traps, and floaters for keeping the nets afloat have normally not survived, due to poor preservation conditions. An exception to this rule is a small part of a net found in Nikonion.[8] We do, however, have a few sculptural representations of these types of fishing equipment. One example from the Black Sea Region, a terracotta from Kepoi, represents a resting fisherman, with a basket for fishing at his feet (Fig. 3b).[9]

The problem with using fishing equipment to calculate the scale of the activity is of course the need to determine what type and what amount of

Fig. 2. Net weights from Elizavetovka. Left stone weights, right clay weights (after Marčenko, Žitnikov & Kopylov 2000, figs. 75-76).

equipment needs to be present for us to conclude that the fishing carried out did not merely supply a local market for immediate consumption, but was geared to large scale production and export. In many of the storerooms or work areas accompanying identified processing facilities,[10] fishing equipment has been discovered, but it seems virtually impossible to distinguish this equipment from that employed by fishermen catering for a local market for fresh fish. At Porthmion at the entrance of the Kimmerian Bosporos for example, hooks and net weights of the third to the first century BC are found in great numbers,[11] and Gajdukevič takes this as proof of large scale fishing activity.[12] But is this alone sufficient evidence? He draws similar conclusions for the fortified farming and fishing settlements established along the Sea of Azov in the first to third century AD, for example Semjonovka, where hooks, needles, net weights, and fish remains are very common.[13] At Elizavetovka on the Don, fishing equipment is known from as far back as the 4th century BC but for some odd reason no hooks have turned up, although these are known from nearby Tanais in the same period.[14] In this last instance we have reason to believe that processing and export actually took place during this period. This could, however, not have been deduced from the recovered equipment alone.

Fig. 3a. Bronze hook from Panskoye I/U7 in Čornomors'ke Museum (photo: Jacob Munk Højte).

Fig. 3b. Terracotta figure of a resting fisherman found at Kepoi. Now in Taman' Museum (photo: Jacob Munk Højte).

A further factor to be considered is the strategy adopted by the fishers.[15] Ordinarily most fishers in smaller villages may have had fishing as a part time occupation to supply the local market, but in the event of an exceptionally good catch, or in periods of migrating schools of fish, they might have delivered the catch at the nearest salting facility for processing and export. The transition between subsidiary and commercial fishing may therefore have been very subtle, and would not be traceable archaeologically. Nearer to the larger centres, where the demand for fresh fish was greater and where fish processing on a larger scale took place, fishing probably often constituted a full-time occupation, and the investment in equipment was consequently greater. Boats in particular would require a substantial turnover to give a return on the investment. So far no wrecked fishing vessels have been found to compare with the well-preserved boat recovered at Portus which, as evidenced by a built-in well box, clearly fulfilled a demand for fresh fish.[16] It is not entirely impossible, though, that the anaerobic conditions in the Black Sea at depths greater than 200 m will one day reveal an excellently preserved example, but most probably we will not be able to determine the type of fishing for which the vessel was used. Thus, fishing equipment in general can be a good indication of whether fishing took place at all, as for example at the

Fig. 4. Bone needles for repairing nets from Elizavetovka (after Marčenko, Žitnikov & Kopylov 2000, fig. 77).

Scythian sites along the Dnieper (Borysthenes) and Don (Tanais) where, to some degree, fishing seems to be linked to a shift from a nomadic to a semi-settled population.[17] On the other hand, it does not allow us to determine whether the fish actually caught with the equipment was consumed fresh or processed.

A point worth noting is that there does not seem to be any development in fishing technology throughout the period under consideration, judging from the available archaeological evidence. For example pyramidal shaped net weights remain unchanged from the Archaic to the late Roman period and are the most commonly occurring fishing equipment[18] throughout this time. Changes could, however, have taken place without leaving any traces. Firstly, the same equipment could be employed in different ways with a significant effect on efficiency. Multiple hooks could be attached to the same line or net weights could be applied to nets of different sizes. Secondly, there is all the equipment made of organic material that has not been preserved. The degree of use and the size of fishing vessels and the construction of fishing nets are of great importance for the productivity of fishing. In these matters we possess very little knowledge.

3. *Watchtowers*

Watchtowers or lookout posts (σκοπιά) known from literary sources belong to the category of potential evidence, since none have as yet been identified. They evidently served to give advance warning when schools of migratory fish were approaching. A simple shed may have served the purpose, but sometimes they seem to have been of a more permanent nature. Strabon informs us that even in his day the Klazomenians had a watchtower on the sea of Azov.[19] As for the southern shore of the Black Sea we hear about certain places where shoals of fish, particularly tunny, were caught on a regular basis. Strabon mentions Trapezous, Pharnakeia, and Sinope as the main fishing grounds (πηλαμυδεῖον),[20] and Athenaios cites Euthydemos for calling Byzantion "the mother of tunny".[21] At these places it would seem likely that some sort of lookout post existed with a device for signalling the nearest harbour about the approaching schools of fish.[22] The amount of fish caught during migration would clearly exceed the quantity that could be consumed locally in a fresh condition, thus some form of preservation would be required.

4. *Osseous remains and scales*

Osseous remains and scales constitute a very large and interesting group of archaeological evidence. When studied meticulously it offers important information about the ichthyofauna in a given area at a given time. By determining the size and age of the fish it is furthermore possible to obtain valuable data about the intensity of exploitation of the resource and possibly the

mode of fishing. As far as the actual quantity of fish caught is concerned, the evidence is much more problematic. One can quite easily calculate the weight of the live fish from an assemblage of fish remains.[23] A rough estimate can be arrived at from the observation that the weight of dry fish bones constitutes approximately 5% of the original weight of the fish,[24] and other much more precise methods based on the number and size of bones and scales have been developed. The problem is, however, to determine the amount of unrecovered osseous material from any given processing site. Bones could be removed for a variety of reasons. First of all they could be collected and disposed of elsewhere – possibly as fertiliser, or they could be removed by animals. Far more importantly, however, the bones could be exported along with processed fish. A good example of this is the wreck recently discovered off Varna in Bulgaria, from which a Sinopean amphora was recovered.[25] This had held large chunks of salted catfish, of which only the bones now remain. Since only one amphora was retrieved from the wreck it should be stressed that we do not know yet whether it is representative of the whole cargo. The mode of production employed here, whether the fish were dried or salted and then transferred to the amphora or salted directly in the amphora, caused the fish, archaeologically speaking, to disappear completely from the processing site. The osseous remains found at the site will to a large extent have derived from fish consumed locally. In other instances certain parts of the fish – head, tail or scales – may have been removed before processing, in which case far more reliable data about volume can be obtained. One such example comes from Tarpachi on the Tarkankhut peninsula.[26] In a stratum probably dating from the third to second century BC, a 1 cm thick layer of grey mullet scales was recovered. Probably several catches were brought here for cleaning and further processing.

The osseous remains found in connection with permanent fish processing facilities raise a number of questions. First of all, the amount of bones in the vicinity in no way accounts for the volume of fish we must assume was being processed in order to render the installations profitable. Again we must assume that, to a large extent, the bones were exported along with the fish. Secondly, there is the question of how the bones that were recovered relate to the production in general. In a number of salting vats a layer of fish bones has been identified at the bottom.[27] This regularly passes as evidence for the type of fish being processed, but in fact it need not be representative of anything but the content of the very last batch before production was discontinued, as we must assume that the vats, at least to some extent, were cleaned between batches. The evidence in all instances points to rather small fish such as anchovy, khamsa, herring, and mullet, but these could feasibly have been characteristic only of the later period of the existence of the processing facilities.

One of the most comprehensive studies of the ichthyofauna in the Black Sea area in antiquity concerns the fish bones of Olbia and Berezan in the

Dnieper (Borysthenes) and Bug (Hypanis) estuary.[28] That these waters were important fishing grounds from early times is hinted at by Herodotos, who praised the sturgeon of the Borysthenes, which he says was salted.[29] It has even been suggested that fishing was indeed one of the principal reasons for settling in this area in the 7th century BC.[30] N.V. Ivanova has examined nearly 6,500 bones from these two locations, 4,867 from Olbia and 1,602 from Berezan. The period under consideration stretches from the seventh century BC to the fourth century AD, with the Hellenistic period giving the largest yield. In all, 19 species of five families were identified, with the evidence from Olbia showing the greatest variety. At Berezan 13 species were represented, all of them present at Olbia also. The most striking fact the data reveals seems to be the clear dominance of very large fish: sturgeon, pike and catfish, while smaller fish are under-represented throughout the period. Carp and roach do occur in some quantity, but their importance is definitely secondary. We seem to be dealing with a very specific preference for fish that live in the slow currents of large rivers: not entirely surprising given the position of the two places. It contradicts, however, the evidence of the locations where fish processing facilities of the Roman period have been identified such as Tyritake and Chersonesos. Here, as seen above, migratory saltwater fish dominate. This trade seems to have bypassed Olbia entirely. Instead the most commonly occurring bones in Olbia and Berezan' were those of catfish. The content of the amphora from the recently found shipwreck off the coast of Bulgaria has been identified as catfish, and since catfish are relatively rare among the osseous remains in other areas of the Black Sea except for sites on the Don,[31] it therefore seems likely that the salted fish in the amphora had its origin here.[32] Next in terms of the quantity of bones are the different types of sturgeon: sterlet, beluga, sevriuga, Russian sturgeon and finally pikeperch, all rather large species.

Another interesting feature revealed by the study is the general decrease in the size of the fish throughout the period from the Archaic to the late Roman period, particularly for catfish, which falls from an average size of 1.59 m in the Classical period to under 1 m in the Roman period. Ivanova attributes this to excessive fishing of certain species, and it seems to indicate that fish were not an inexhaustible resource, at least with regard to the larger fish living in the estuaries of the great rivers. Today these species are largely extinct due to modern industrialized fishing techniques.

Another study by Tsepkin and Sokolov[33] concerns the sizes of the four major species of sturgeon: Beluga (*Huso huso*), Russian sturgeon (*Acipenser güldenstädti* Brandt), sevriuga (*Acipenser stellatus* Pallas), and sterlet (*Acipenser ruthenus* Linnaeus) found in archaeological material from sites in the lower Don region from the fourth century BC to the third century AD. Here it is characteristic that the specimens were extremely large. For example, 16 of the beluga found had lengths in excess of 4 m. In the middle ages the average sizes of sturgeon increases, denoting either that fishers went specifically for the larger specimens or that the intensity of fishing was lower, whereby the

fish generally lived to a greater age. Again modern comparison shows that industrial fishing methods have reduced the average size considerably and sturgeon now appear on the endangered species list.

In a sample of osseous material from Pantikapaion, Phanagoreia and settlements in the eastern part of the Sea of Azov published by Lapin and Lebedev, the most common fish was pikeperch closely followed by different types of sturgeon. Unfortunately the data are not directly comparable since they belong to different chronological periods. The rather small 2nd century BC sample from Pantikapeion corresponds well with the finds from Olbia. In the 3rd and 4th century AD in Phanagoreia, carp has taken first place at the expense of larger species.[34] However, the samples are too small and from too few contexts for us to determine whether they are coincidental or whether they represent a general tendency towards catching smaller types of fish in the Roman period. Such a shift could very well have been caused by a shift in production methods from salting chunks of large species, as in the shipwreck near Varna, to production of other salted fish products which could be made from smaller fish.

5. *Fish processing facilities*

Lastly we turn to the most prominent of the archaeological evidence, namely the remains of the processing facilities for salted fish products.[35] These consist normally of a series of vats built up or hollowed into the rock, lined with walls and finally waterproofed with *opus signinum* containing a high content of crushed ceramic material giving them a reddish colour. Storage and work facilities are usually found in connection with these vats also. Before introducing the five locations with such salting vats, it is worth considering what, to my knowledge, is the only identified pre-Roman installation for preserving fish in the Black Sea area. It was not intended for salting fish, but instead for smoke-curing fish.

5.1 *Elizavetovka*

The Elizavetovka Settlement southeast of Tanais has been excavated by Russian archaeologists since the 1940s but has only recently undergone proper publication.[36] The excavation shows that fishing played an important role in the economy of the settlement. In some areas of the site large plots were covered with up to 20 cm thick layers of compressed fish bones, and in the periphery of the settlement refuse pits filled with scales and bones have been uncovered.[37] As mentioned above, fishing equipment is found in abundance. Characteristically, fishing in the area only seems to have begun with the establishment of the settlement. During the nomadic or semi-nomadic periods of Scythian culture fishing played a minor role, although there is no doubt that it was practised, cf. Gavriljuk's contribution to this volume. At Kamenka on the

Dnieper, for example, there are traces of fishing activity during the Scythian period.[38] In the fifth century BC, few remains of fish are found at Elizavetovka Settlement, nothing to denote export. In the fourth and third century BC with the growing Hellenization, however, there is a fishing boom. The excavators believe that the amount of fish caught as early as in the first half of the fourth century BC already exceeded local consumption, and from that point onwards, fish must have been one of the foremost export goods. The excavators stress that the fish remains do not primarily derive from refuse deposits in households but rather from semi-industrial (*handwerklich*) production.[39] In the settlement, 36% of all osseous material derives from fish, most commonly sturgeon and carp, but also small amounts of perch and catfish. As seen above, the specimens are quite large, with a catfish – measuring about 2.40 m – as the largest.[40] No tanks for salting fish have been found either at Elizavetovka Settlement or in nearby Tanais,[41] but instead the excavators have uncovered what may have been a smoke-curing installation. It was situated in the northern section of the settlement in an area with a large amount of fish bones. It consists of two chronologically consecutive pits about 1.3 m in diameter with heavily burned sides and bottoms. In the younger, a pile of charcoal was found along with fish bones. What the installation once looked like and what its capacity for preserving fish may have been is impossible to determine. This unique example should remind us that fish preservation on a large scale could take place without leaving significant archaeological traces. This is especially true of the most basic method of preserving fish, namely by drying, since the fish screens made of wood would not survive at all. Thus the amount of archaeological evidence does not necessarily reflect the level of production but rather the prevalent production method.

5.2 Tyritake

The most thoroughly studied fish processing installations are those at Tyritake 11 km south of Pantikapaion, excavated by Gajdukevič from the 1930s to the 1950s.[42] A total of 57 salting vats were uncovered in the southern and eastern part of the city. Surprisingly, all the installations lay within the city wall (Fig. 5). The vats are of rectangular shape and partly hewn out of the rock. Typically the sizes range between 2.00×1.40 and 2.50×1.50. Inside and above the rock surface they are built up and covered inside with waterproof mortar (*opus signinum*). Depths range between 1.50 and 2.00 m with a few up to a depth of 3 m. The smallest vat has a capacity of only 3 m^3, while the largest, an irregularly shaped vat in unit B, measures approximately 22.12 m^3. The vats are all grouped in small production units. Three to six vats seem to be the common size. Typically the vats are in a single row or in two rows of two or three. The largest processing complex in Tyritake, situated by itself in the area just inside the southern wall, had 16 vats, four by four, of regular size (3.20×1.70×1.80) giving a total capacity of more than 155 m^3 (Fig. 6). Found

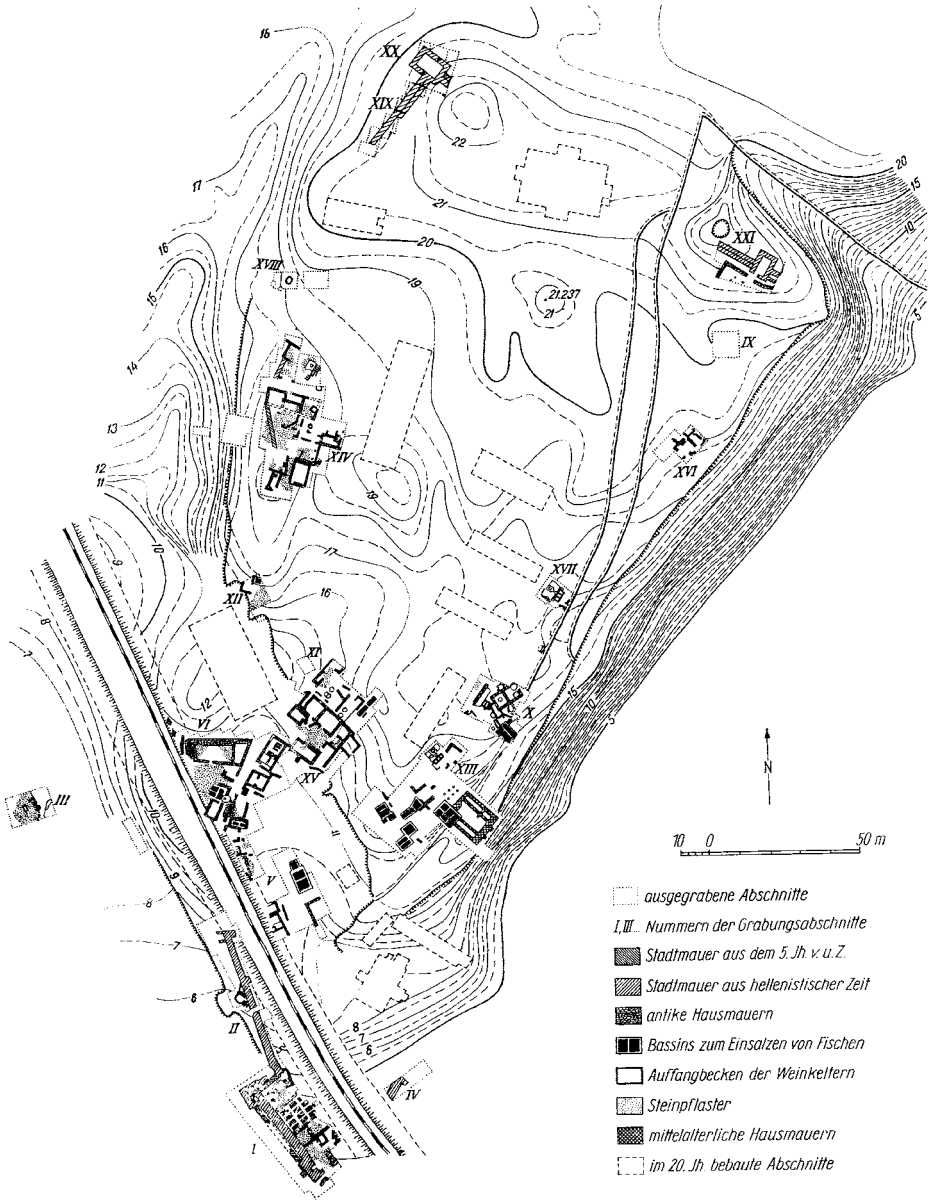

Fig. 5. Plan of Tyritake showing the location of the salting vats (after Gajdukevič 1952, 16).

Fig. 6. The largest salting installation with originally 16 vats located just inside the southern wall. The vats had a capacity of 155 m^3 (courtesy of the Photo Archives of IIMK RAN).

at the bottom of these vats were remains of herring. Vats have turned up in several of the excavated sectors, but it is particularly in sector XIII in the eastern part of the city that a high concentration was observed. Here no less than six individual installations were situated, and fish processing seems to have been the only activity in this sector during the first three centuries of our era (Fig. 7-8).[43] The lack of overall planning in the layout indicates that each unit was run separately. Gajdukevič has suggested that all the processing facilities were owned by the Bosporan king and operated by slave labour,[44] but the only evidence to substantiate this claim is the lack of luxurious houses in Tyritake, which in itself does not indicate slave occupants. In the vicinity of the installations, storerooms with *pithoi* are regularly found, and here net weights, fish bones and amphorae abound. To judge from the many tiles found near the salting vats these seem to have been covered by a tiled roof for protection from the weather. According to Gajdukevič's analysis of the finds, all the vats were constructed in the first century AD,[45] but they could possibly have replaced previous processing installations of some sort.[46] Production continues after the third century AD, but the number of vats is reduced and at some point in the fifth century a basilica obliterated at least one of the installations.[47] Whether the rest continued to function remains unknown.

That fish processing was not merely restricted to larger specialized installations is shown by a house of the 3rd to 4th century AD uncovered in sector XV (Fig. 9).[48] Room 1 contained a large *pithoi* with wheat. Other finds include

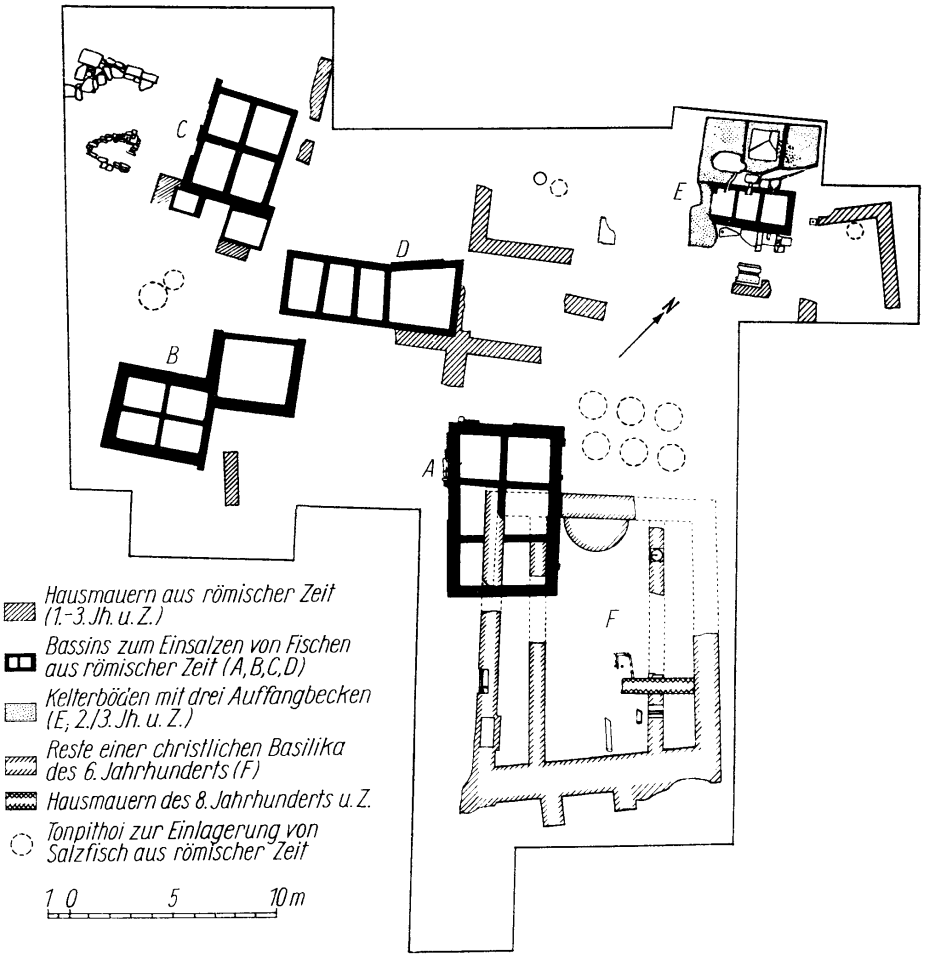

Fig. 7. Plan of sector XIII in Tyritake where a high concentration of salting vats was found (after Gajdukevič 1971, fig. 97).

amphorae, oil lamps and sturgeon scales. Rooms 2 and 3 contained mills and Room 4 seems to have been a storeroom with amphorae. Room 5 may have been a women's room to judge from the spindle whorls and an ivory *pyxis* with red dye. What is interesting is that in almost every room net weights and bone needles were found. Furthermore, outside to the southeast a vat had been built against the wall, which had been used for salting or otherwise processing fish. The house seems to have belonged to a fisherman and his family, who also processed the fish on a very small scale in the household.

The total capacity of the known installations in Tyritake has been calculated to 457 m^3 and they could process up to 365 metric tons of fish simultaneously.[49]

Fig. 8 a-c.
a) Salting unit B in sector XIII in Tyritake.
b) Salting unit D in Sector XIII.
c) Net weights found in the vicinity of salting vats in Sector XIII (courtesy of the Photo Archives of IIMK RAN).

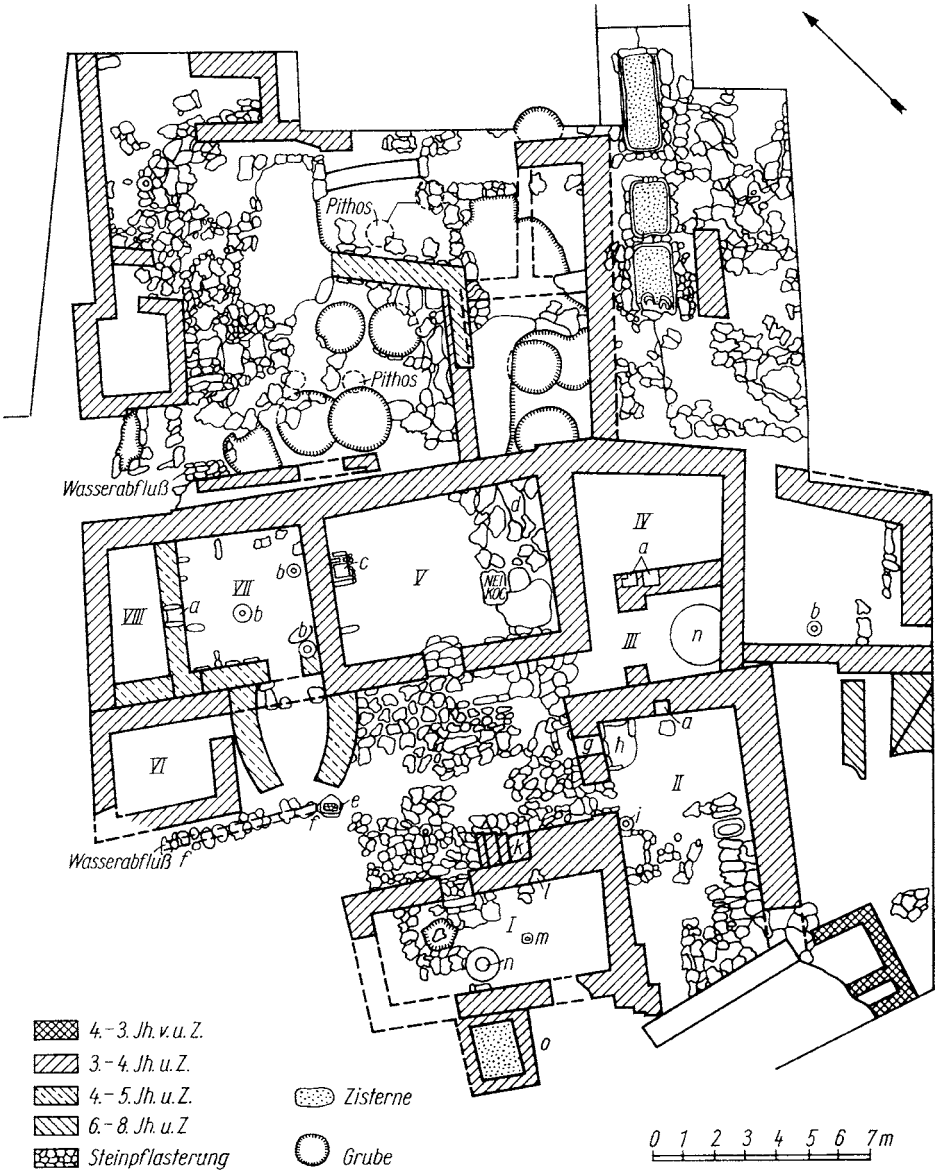

Fig. 9. Plan of house of the 3rd-4th century AD with small salting vat built onto the south-western wall (after Gajdukevič 1971, fig. 108).

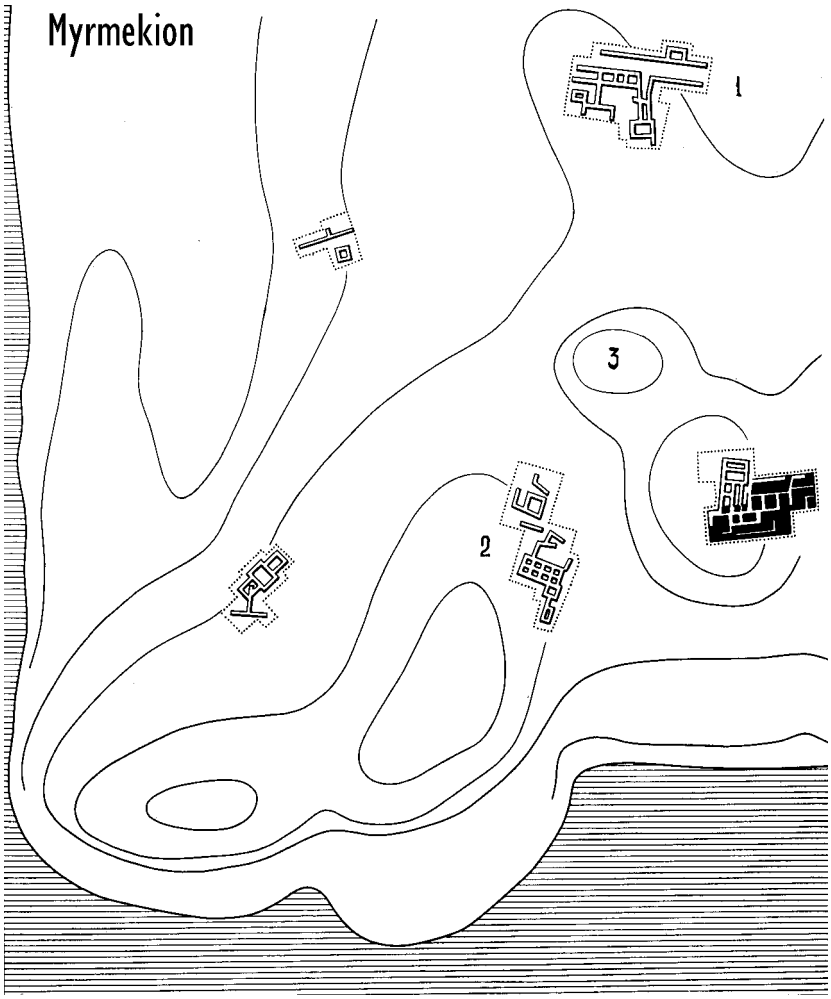

Fig. 10. Plan of Myrmekion. The single salting unit with eight vats in two rows is located in area 2 (after Gajdukevič 1952, 136).

5.3 Myrmekion

In Myrmekion a short distance to the east of Pantikapaion another single fish processing installation dating to the 2nd-3rd century AD was excavated by Gajdukevič (Fig. 10).[50] It consists of eight vats in two rows of four, each 3.00×2.70×1.80 m with a total capacity of about 116 m^3, accompanied by a storage room with a number of large *pithoi* (Fig. 11). To judge from the thick layer of bones at the bottom of some of the vats the last catch, at least, was anchovy. Other bones in the area include those of sturgeon. The construction of the vats is similar to those at Tyritake, but finds in the vicinity help to

Fig. 11. Salting unit in Myrmekion with a capacity of 116 m³ (courtesy of the Photo Archives of IIMK RAN).

shed further light on the production process. The large flat limestone slabs recovered may have been used to press down the fish into the salt solution (Fig. 12). A slightly conical ceramic vessel interpreted as a sieve for extracting the fish from the brine in the vats, or possibly used in the production of *garum*, was also recovered in one of the *pithoi* (Fig. 13).[51] To my mind, however, the holes in the side of the vessel are just ordinary repair holes rather than holes for drainage or for attaching a rope. What purpose this unusual vessel served remains unclear. Only a relatively small area of the town has been excavated, so it is quite possible that further excavation would reveal more installations.

5.4 Chersonesos

The city with the largest known capacity for fish processing was Chersonesos.[52] The installations have not, however, received quite the same thorough attention as those in Tyritake. An exception is a house in block XV-XVI in the northern central part of the town where a Hellenistic house in the first century AD was turned into a small fish processing facility.[53] According to Kadeev there are about 90 salting vats of all periods, predominantly in the harbour area, with a total volume of some 2000 cubic metres.[54] A recent publication

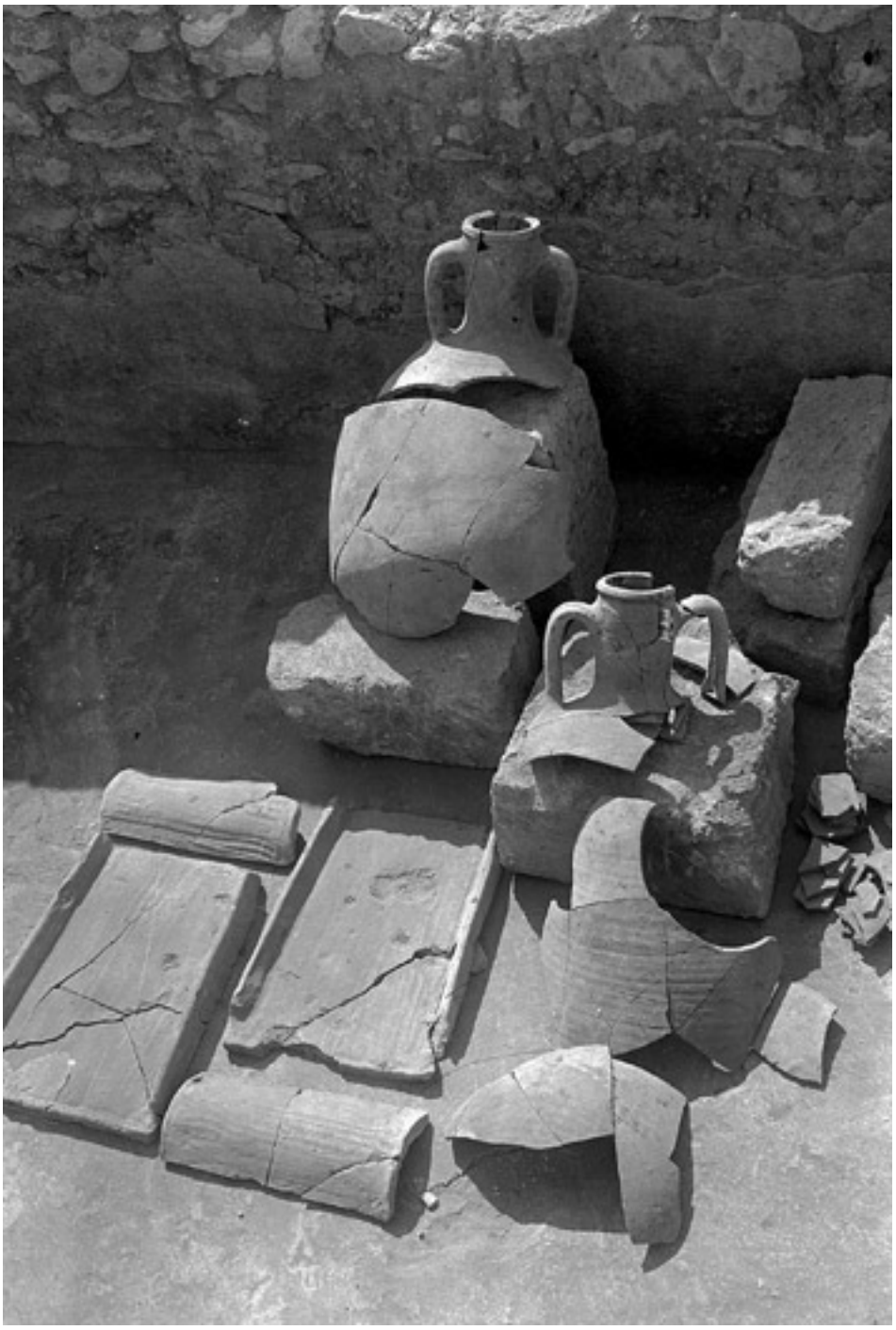

Fig. 12. Finds from the vicinity of the vats in Myrmekion. Note the tiles that may have belonged to a protective roof, and the limestone blocks that were used to press down the fish during processing (courtesy of the Photo Archives of IIMK RAN).

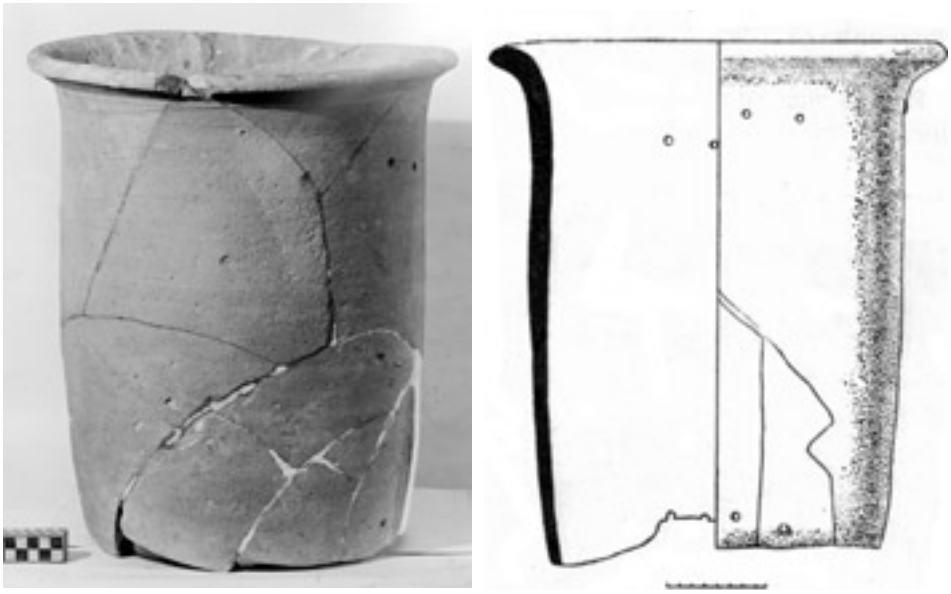

Fig. 13. Ceramic vessel thought to have functioned as a sieve (courtesy of the Photo Archives of IIMK RAN).

raises the figure to more than 100 vats.[55] To judge from the osseous remains found in the salting vats, anchovy (khamsa) seems to have been the primary catch.[56] Herring have also been identified.[57] The facilities in Chersonesos show a number of peculiarities. First of all they tend not be organized in larger units, but rather appear solitary or in groups of two or three at the most in what seem to be private houses. The individual vats also tend to be larger than those of Tyritake, particularly as regards their depth: 3 m or more does not seem to be unusual. Many of the vats are hewn out of the rock, lined with stones and finally waterproofed with *opus signinum* as at Tyritake (Fig. 14). In contrast to the situation in Tyritake, there is no evidence to show that the vats were covered by roofing. One scholar mentions pear-shaped vats, but there is every reason to doubt that these had the same function. This shape would have been quite impractical for the purpose. Rather they were probably water cisterns.[58] Beside the vats there are nearly always storerooms containing several *pithoi* (Fig. 15). The ceramic evidence points to a construction date in the first to second century AD for most of the installations, and production probably continued throughout antiquity.

Kadeev has calculated the yearly capacity to at least 3000 to 3500 metric tons,[59] but compared to the estimates for Tyritake and Myrmekion this figure is very conservative.

Fig. 14. Cistern A in a house in block XV-XVI in Chersonesos from the first to second century AD (after Belov & Strželeckij 1953, 80, fig. 44).

Fig. 15. Pithoi in a storeroom in the house in block XV-XVI in Chersonesos (after Belov & Strželeckij 1953, 79, fig. 43).

5.5 Zolotoe and Salatčik

More recently two further fish processing installations at Zolotoe and Salatčik on the Maeotis side of the Kerch peninsula have been identified.[60] These show many of the characteristics of the installations in Tyritake with regard to organisation and construction. The better preserved installation at Zolotoe probably consisted of four large tanks, two of which are fully preserved, the other two having been partially washed away by the sea (Fig. 16). The larger vat measures about 23.5 m^3 making it the largest known example in the Kimmerian Bosporos. If we assume that the two vats which did not survive were of similar size, the complex had a capacity of over 83 m^3. According to the estimates given for production in Tyritake, the complex could process approximately 65 metric tons of raw fish per filling. Vinokurov proposes eight annual productions and arrives at a capacity of 530 metric tons of fish. For this process 125 tons of salt would have been required.[61] Operating this facility (catching the fish, acquiring salt, filling vats, loading amphorae etc.) would have required considerable labour and would certainly have contributed significantly to the economy of this small community.[62] As at Tyritake, a storeroom was connected to the complex. Found within were pits for *pithoi*, one of which was still in situ. This *pithos* with a capacity of about 1000 litres contained fragments of herring bones. Found on the floor and in the pits were shells, fish bones and scales (unfortunately not specified), and fishing equipment – including net sinkers made from amphora handles. The amphorae, which constitute over 90% of the diagnostic profiles, and the *sigillata* found in the complex, date from the second and third centuries AD. This means activity here started somewhat later than at the installations in the larger cities of Tyritake, Myrmekion and Chersonesos.

The processing unit in Salatčik is far less well-preserved (Fig. 17). It consists of at least two – seemingly – very large tanks, but neither their size nor depth can be determined precisely, as they have been almost obliterated by houses of the fourth century AD.

The importance of these two new processing installations consists primarily in the fact that they show that fish processing within the Bosporan Kingdom may have been far more dispersed than the previous finds at Tyritake and Myrmekion would suggest.[63]

One last aspect of the preservation of fish needs to be mentioned, namely the amount of salt required for salting fish. Vinokurov, as mentioned above, suggests that the annual amount of salt needed at Zolotoe was over 125 metric tons. The amount of salt needed in Chersonesos, Tyritake, and Myrmekion would have been far greater. Kadeev has calculated that the salting vats in Chersonesos required around 800 metric tons and possibly more during peak years.[64] So far, very little work has been done concerning salt production in the Black Sea region. There are plenty of references to salt extraction taking place around the Black Sea. Herodotos (4.53) and

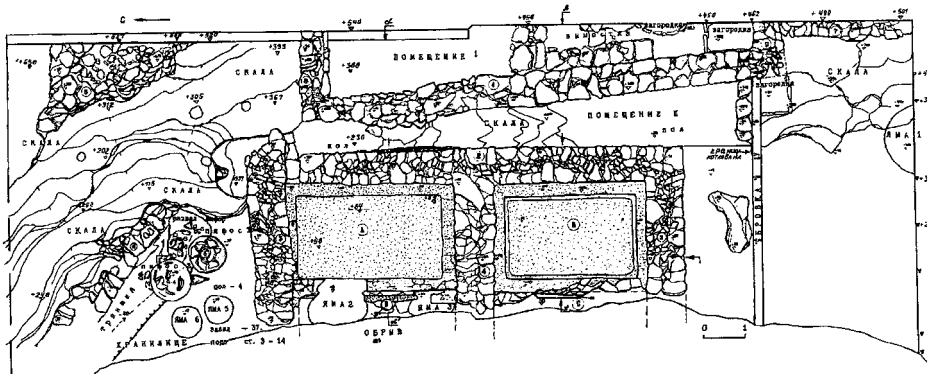

Fig. 16. Plan of the salting installation at Zolotoe (after Vinokurov 1994, 158-159, fig. 2).

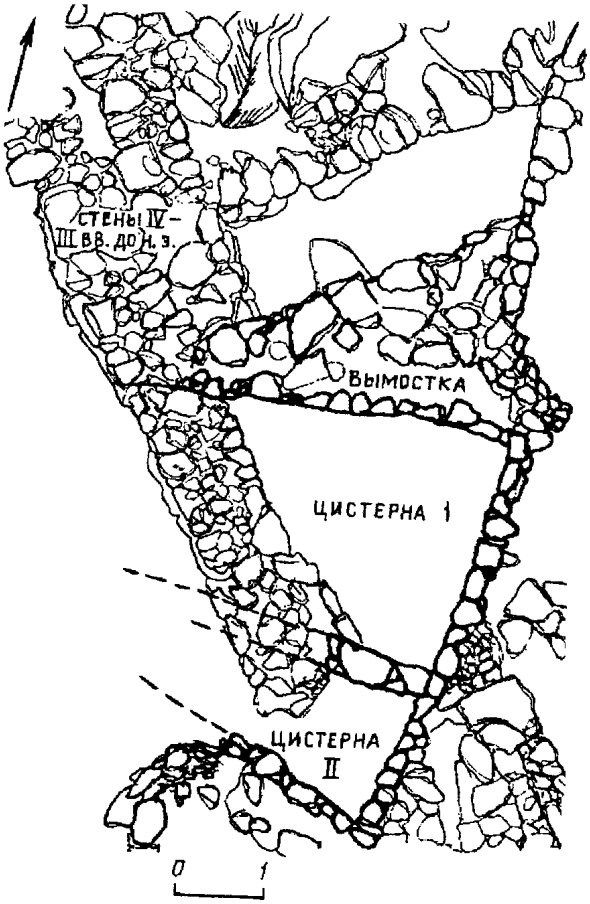

Fig. 17. Plan of the salting installation at Salatčik. (after Vinokurov 1994, 168, fig. 10.2).

Dion Chrysostomos (36.3) mention salt beds near Olbia in the Bug-Dnieper Estuary, which apparently also served the Crimea. Strabon (7.4.7) refers to salt works south of Chersonesos, and according to him salt was bought by local tribes in Dioskourias (11.5.6). He further relates (12.3.12; 12.3.39) that the river Halys took its name from the salt mines it flowed past in Ximene. To my knowledge none of these production sites have ever been identified. Only around Chersonesos have possible sites for salt extraction in antiquity been identified, primarily on the basis of the existence of later activities.[65] The changing landscape may of course have eradicated most of the evidence, but some traces of the infrastructure such as earthen dams, roads, and possibly jetties are likely to have survived. Near Pomorie in Bulgaria, salt is still being produced and the history of the saltworks can be traced back to at least medieval times. Whether Apollonia and Mesembria exploited the salt beds commercially in antiquity remains unclear.[66]

6. Conclusion

Practically everything discussed above concerns the northern part of the Black Sea. What about the other areas of the Black Sea? Here the situation is altogether more disappointing. We have plenty of literary and epigraphic evidence for commercial fishing and processing all around the Black Sea, but hardly any archaeological evidence to match it.[67] The western coast is fairly well explored, but no processing facilities have yet been identified. Along the southern coast of the Black Sea, disappointingly few excavations and surveys have been carried out. One of the most promising sites is at Sinope, where an intensive survey has been carried out over the past years. However, the only evidence for fish processing is a single tank near the port of Armene, which could easily be later than the Roman period.[68] Further research in Northern Turkey may change this situation significantly. Thus, necessarily, the conclusions drawn from the presented material only concern the northern coast.

As shown, plenty of evidence exists for fishing in the form of fishing equipment throughout the period under consideration, both at the Greek and Scythian settlements. The early literary sources also repeatedly describe the different fish being caught and fish products being turned out at different places around the Black Sea. Before the Roman period, however, we have very little archaeological evidence for fish processing. This can be explained in several ways. Firstly, it may not have taken place at all: the fish caught were all consumed fresh. Secondly, the Roman salting installations could have obliterated earlier Greek ones at the same locations. Thirdly, the production methods employed during the Greek period simply left very few traces. The first option hardly seems credible in the light of the literary evidence. Just to mention a few examples, Demosthenes refers to salted fish in transit from Pantikapaion to Theodosia (35.34; cf. Gabrielsen and Lund, in this volume), Polybios speaks of salted fish being exported to Rome (31.25.5), and Strabon

seems to think that the export of salted fish from the Kimmerian Bosporos during the Roman period was merely a continuation of an old practice (7.4.6). Neither is the second hypothesis adequate, as vats of an earlier period are unlikely to have been completely obliterated by later buildings. The second century AD installation at Salatčik, for example, was still clearly discernible under the fourth century AD house. The last option seems the most feasible. Drying, smoke curing or salting, for that matter, could be practised on a large scale without leaving significant traces. In this context the smoke-curing pit at Elizavetovka Settlement is very important, as it documents this practice for the first time. The scantiness of the evidence makes it next to impossible to estimate the volume of the production, but in such situations it is very easy to adopt a much too pessimistic view. Further research into shipwrecks may show how common the transport of fish products was before the Roman period compared to other commodities.

The emergence of the salting installations in the first century AD in the Bosporan Kingdom and in Chersonesos certainly signifies an important change. But the question remains whether it was only a change of production mode or whether it actually changed the quantity of processed fish. I would be sceptical of Gajdukevič's interpretation, that in the Greek period the export of fish was restricted to finer fish as luxury commodities, while in the Roman period cheaper pickled fish such as herring and anchovies were exported to meet the demands of a broader consumer market, and perhaps to the Roman army stationed on the Danube and in Asia Minor.[69] To my mind the one need not exclude the other.

During the Roman period, fish processing seems to have been big business, but can we estimate the volume of the production more precisely? For the installation at Zolotoe, Vinokurov estimated that 560 metric tons of raw fish could be processed annually, and suggestions for the total production from the northern Black Sea area exceed 20,000 tons. Such calculations are fraught with uncertainties. First of all we do not know how large a percentage of the salting installations once in existence have actually been found. As for the individual installation we can calculate the maximum capacity of each vat, but we do not know whether they were always filled to the top. Neither does our limited knowledge of the actual process leave us any clues as to the length of the process. Furthermore we have no reliable estimates for the availability of fish throughout the year. Production could have been seasonal. The suggestion of eight fillings a year is therefore nothing but an educated guess. Despite these reservations, I think it can still be concluded that fish processing accounted for a significant portion of the economy of Chersonesos and the Bosporan Kingdom. The prominence of the salting vats in the urban architecture, particularly in Tyritake, testifies to the importance of this trade.

Notes

1 I wish to thank Vladimir Stolba for helping me achieve the correct interpretation of a number of articles in Russian.
2 For representations of fish in Scythian art, see Gavriljuk (in this volume).
3 For the net weights at Elizavetovka, see Marčenko, Žitnikov & Kopylov 2000, figs. 75-76. Of particular interest among the many publications that include net weights is a study of the net weights of Phanagoreia from the 6th century BC to the 4th century AD carried out by Onajko (1956, 154-163).
4 Vinokurov 1994, 163.
5 Tichij (1917, figs. 4-5) and Carter (2003, 86) show a selection of hooks from Chersonesos. Čornomors'ke Museum displays a few fishing hooks from Panskoye I, building complex U7.
6 A small harpoon for fishing from Panskoe I/U7 can be seen in the museum in Čornomors'ke.
7 Marčenko, Žitnikov & Kopylov (2000, Fig. 77) has a fine selection of bone needles. Mack (2003, 86) shows bronze needles in Chersonesos Museum. Kruglikova 1963, 43-51.
8 Brujako 1999, 52-53 & fig. 17.
9 Sokol'skij 1968, figs 5 & 5a.
10 Gajdukevič 1952, 59; Vinokurov 1994, 154-170.
11 Kastanajan 1959, 203-207.
12 Gajdukevič 1971, 184.
13 Gajdukevič 1971, 201, 411-412. For Semjonovka, see Kruglikova 1963, 43-51.
14 Marčenko, Žitnikov & Kopylov 2000, 179. For Tanais, see Šelov 1970, 186.
15 Bekker-Nielsen 2002a.
16 Testaguzzi 1970, 143-44.
17 Marčenko, Žitnikov & Kopylov 2000, 175-176 examples with references. See also Gavriljuk in this volume.
18 Onajko 1956, 154-163.
19 Strabon 11.2.4. For a thorough survey of the literary sources for fishing and fish processing in the Black Sea region, see Curtis 1991, 118-129.
20 Trapezous: Strabon 7.6.2; Pharnakeia: Strabon 12.3.19; Sinope: Strabon 7.6.2, 12.3.11.
21 Athenaios 3.116b. See also Dumont 1976-1977, 96-117.
22 For similar installations in Italy at Cosa and Populonia that certainly functioned as lookout posts (*thynnoskopeia*), see Strabon 5.2.8 and 5.2.6.
23 Casteel (1976, 93-122) investigates four methods of estimating fish size and weight from bones.
24 Casteel 1976, 119-122.
25 Reported with photographic documentation at the National Geographic home page at: http://news.nationalgeographic.com/news/2003/01/0110_030113_blacksea.html
26 Ščeglov 1969, 128-130.
27 Chersonesos (anchovies, khamsa): Belov & Strželeckij 1953, 80; Kadeev 1970, 14. Tyritake (herring, mullet): Gajdukevič 1952, 59. Myrmekion (khamsa): Gajdukevič 1952, 207.
28 Ivanova 1994, 278-283.
29 Herodotos 4.53.

30 Domanskij & Marčenko 2003, 29.
31 Tserkin & Sokolov 1971; Casteel 1976, 130-132; Marčenko, Žitnikov & Kopylov 2000, 179. According to Lapin and Lebedev (1954, 197-214) catfish occurs at Pantikapaion but is very rare at Phanagoreia and at sites in the eastern part of the Sea of Azov.
32 Andrei Opait has kindly informed me that the amphora in question is a type Zeest 85 similis of the 2nd to 3rd century AD and not as stated in *National Geographic,* a Sinopean amphora of the 5th to 4th century BC.
33 Tserkin & Sokolov 1971; Casteel 1976, 130-132.
34 Lapin & Lebedev 1954, 197-214.
35 Curtis (1991, 6-26) discusses the terminology for the range of salted fish products and their method of production. For a very early study of fish processing in the northern Black Sea area, see Köhler 1832. Also of note are Minns 1913, 440 and Danov 1962.
36 Marčenko, Žitnikov & Kopylov 2000, 175-181 concerning fishing and fish processing.
37 Marčenko, Žitnikov & Kopylov 2000, 175.
38 Grakov 1954, 144.
39 Marčenko, Žitnikov & Kopylov 2000, 177.
40 Marčenko, Žitnikov & Kopylov 2000, 179.
41 Šelov (1970, 186) has proposed that drying fish was the primary method of preservation at Tanais.
42 Gajdukevič 1952a, 15-134; Gajdukevič 1971, 376-378.
43 Gajdukevič 1952a, 55-72.
44 Gajdukevič 1971, 185-186.
45 Gajdukevič 1952a, 15-134.
46 Curtis 1991, 126.
47 Gajdukevič 1971, 485.
48 Gajdukevič 1971, 408.
49 Marti 1941c, 103. Marti 1941b, 94.
50 Gajdukevič 1952b, 135-220; Gajdukevič 1971, 378.
51 Gajdukevič 1952b, 207, fig. 125 & 126.
52 Tichij 1917; Semenov-Zuser 1946, 237-246; Mongait 1959, 199; Brašinskij 1968, 96-97; Kadeev 1970, 5-26. Kadeev & Ryzov 1973, 76-80; Romančuk 1973, 45-53; Romančuk 1977, 18-20; Mack 2003, 86. Undoubtedly not all tanks functioned simultaneously. According to Romančuk (1977, 18-20) many of the tanks only contained material from the medieval period.
53 Belov & Strželeckij 1953, 32-236.
54 Kadeev 1970, 14.
55 Mack 2003, 86.
56 Belov & Strželeckij 1953, 59-60.
57 Kadeev 1970, 14.
58 Mongait (1959, 188) is probably referring to the cisterns in block XV-XVI published by Belov & Strželeckij (1953, 32-236). For their function, see Mack 2003, 86.
59 Kadeev 1970, 15.
60 Vinokurov 1994, 154-170. Zolotoye excavated in 1987 and Salatčik in 1990.
61 Vinokurov 1994, 166-167.
62 For estimates, see Vinokurov 1994, 167.
63 After completion of this manuscript, I was informed by staff in the museum in Anapa, ancient Gorgippia, that cisterns possibly for salting fish were found in

excavations during the construction of the modern harbour, but that no record of the excavations exist. It may be these cisterns that Alekseeva refers to without reference in her book: *Anticnyj gorod Gorgippija* (Moscow 1997) 168.

64 Kadeev 1970, 25. It is however, as shown above, not entirely clear exactly how many vats were operating simultaneously in Chersonesos.

65 Kadeev 1970, 20-26.

66 Hoddinott 1973, 221, but without references. *RE* 1, s.v. Anchiale 1, col. 2103 does not mention salt production. Today a salt museum is being constructed at the site.

67 Curtis (1991, 118-129) offers a general survey of the sources. Trapezous, Sinope, Amastris, Tieon, Herakleia Pontike, Kalchedon and Byzantion are among the cities noted for their fish products, and an association of fishermen is known from Odessos (*AE* 1928, 146).

68 I wish to thank Alex Gantos, Assistant Director of the Sinop Regional Survey, for sharing this information.

69 Gajdukevič 1971, 376.