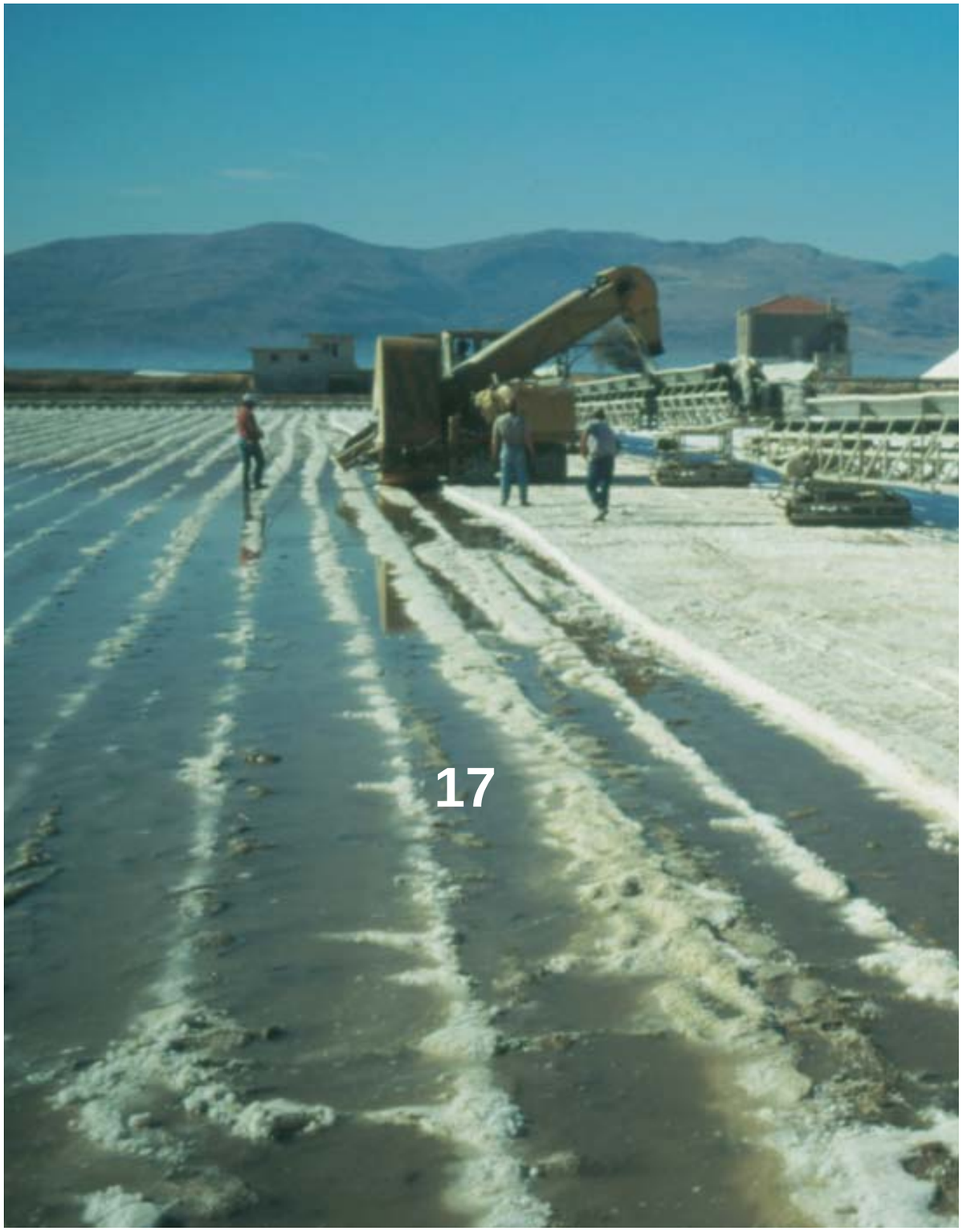


Chapter 2

Technology and Present Situation

Salt-making know-how of Polichnitos salina

Theodora Petanidou

The salina of Polichnitos is known to have been operating in an organised fashion since early Ottoman times. The oldest reference on the know-how of salt-making at Polichnitos is from 1889. Then, of great importance was an existing *pre-basin*, probably filled by storm-floods and supplying 23 basins of unknown salinity levels, where the salt was produced. In 1912, however, we have evidence that the salina was using the method of *successive evaporation ponds*. The description mentions a total of 39 ponds working without the help of a pre-basin: four as sea-brine reception ponds, three *low-concentration evaporation ponds* (also called *outer* or *cold* ponds, locally *cryóggela* meaning cold ponds), 17 *high-concentration evaporation ponds* (also called *inner* or *hot*, locally *psístres*) and, finally, 15 *crystallisers* or *crystallisation pans* (locally *alopígia* or *tigánia*) where common salt was deposited. The salina was run by five permanent employees (director, secretary, and three keepers), while most of the work was carried out by summer workers hired on a non-permanent basis. There is no reference to the frequency of salt harvests carried out during the salt-making period.

The most interesting feature of the salina was the presence and operation of three wind-pumps, two of wood and one of iron. All three of them, in good working condition in 1912, helped to transfer brine from the sea to the reception ponds. There is no trace of them in the salina today. It is worth mentioning that up to now Polichnitos is the only Greek salina known to have ever employed such a wind-pumping system.

Besides the wind-pumps, the salina of Polichnitos was until recently (the 1970s) using hand-operated decanting-shovels or *lavoútes*, which have been widely used throughout Greece. So far there is no evidence that horse-operated draw-wells, known to have operated in the salina of Anchialos (the modern Pomorie) in the 1930s and that of Messolonghi in 1905, have ever been used on Lesvos.

After the liberation of the island in 1912, the salina came into Greek hands, thereafter following the sweeping mechanisation as elsewhere in Greece (diesel engines, larger compartments and, especially, larger crystallisers). Up to 1988, when the salina joined the Hellenic Saltworks S.A., it was semi-mechanised, and many locals found occasional work during the single harvest in late summer. The interrelation between the salt-making business and the locals has weakened since the Company invested in full mechanisation of the salina in the early 1990s.

Before its full mechanisation, i.e. until the early 1980s, harvesting was carried out manually, mainly with local labour, employing several specialist workers: those breaking the salt crust with an axe and collecting the salt with the help of a kind of flat-edged rake (*sírtis*) in small piles where the salt was left to dry for a few days; those shovelling the dry salt into *Decauville*

‹ Mechanized harvest in Polichnitos salina.

Photo: Hjalmar Dahm

wagons which were then pulled by horse on iron rails and transported to the open-air depot (*alónia*) where it was stored in piles. The wagons had to be pulled up to the piles, where they were turned over manually in order to be emptied. The emptied salt was carefully cleaned of impurities by women and children, and packed down carefully in order to form a uniform and closely-packed stockpile. The salt pile, surrounded by small gutters which carried off rainwater, was covered on top with tiles to protect it from bad weather.

Today the salina, fully industrialised (totally electric pumping and mechanical harvesting, washing and storing in piles) and with a potential yield of 10,000 tons, is run by Hellenic Salinas S.A. The only relatively traditional feature that has remained from the past is transport, even today carried out with the help of Decauville wagons, nowadays pulled by diesel engines.

The production process (*continuous evaporation*) is simple: first, sea-water is concentrated until it reaches saturation point. The circulation of brine, which flows through large compartmentalised evaporation ponds of successively higher concentrations, is carefully controlled. Next, from May to August, salt is continuously deposited in rectangular crystallisers, which do not take up more than 8% of the overall surface of the salina. At the end of the salt-making period, in September, an 8-15 cm layer of salt covers the bottom of the crystallisers. Then, the crystallising basins are emptied from bitterns and harvested by special mobile harvesters that collect the salt in strips 1-3 m wide along the short side of each crystalliser. The dikes separating the crystallisers are still narrow, preventing access by large vehicles. Finally, the salt is mechanically rinsed in the washing plant and stored in a large stockpile.

One of the most important features of the salina is the locality in which it is situated: an area of major interest (of primary production, renowned local food, wildlife and landscape to be protected). Such characteristics can certainly be combined with the tertiary sector, especially tourism related to salt-making of the past and the present.

› The Decauville wagons are still in user in Polichnitos

Photo: Hjalmar Dahm

Figueira da Foz – Organisation and evolution of salinas on the Mondego Estuary

Renato Neves

From the end of the 18th century to the beginning of the 20th, the Figueira salinas occupied approximately the same areas: the north bank (S. Pedro), Morraceira Island, and on the south bank (Lavos). The establishment of the salinas depended on the characteristics of the alluvial soils, which would normally be occupied by marshes or rush-beds. Another essential factor was the existence of waterways, or the conditions for them to be opened, allowing the production to be taken away by river, because connections from most of the salinas to the road network were only built in more recent times.

Unlike other Portuguese regions, particularly the Sado Estuary, the intensification of rice cultivation did not lead to a significant land use change of areas previously occupied by salinas. The expansion of rice seems to have occurred mainly at the expense of vineyards on the lowlands.

The 1950s may be considered the height of salt production in Figueira da Foz. At that time almost all the area available for salinas was occupied. According to a 1954 inquiry, the total area allocated for salt production was about 798 ha, distributed between 17 salinas in Vila Verde (S. Pedro), 141 in Morraceira and 71 in Lavos. Production that year reached 32,612 tons.

In that period, as had already happened in the past, though there was some exportation through the port of Figueira and by railway, part of the production was reserved for local and regional markets, either for use in fishing, especially cod and sardine, of which Figueira had large fleets, for the food industry (bread, sausages, cheese and olive oil presses), or for domestic use, which at the time had a much higher per capita consumption than nowadays, due to the lack of other means of preserving food.

This regional market, situated in the interior, seems to have been of considerable size. Carried by muleteers and fishermen (which still happens with the latter), the salt was taken to warehouses from which it was redistributed, as is shown by the curious placename *Carregal do Sal* (meaning storage, distribution or load of salt), a place 100 km NE of Figueira.

After the mid-1970s a inland series of events considerably changed the production and commercialisation of salt. The Figueira salinas gradually lost their position as an important activity in local economy, and were abandoned, converted to other activities or destroyed for industrial, urban, port and road occupation.

Thus, when ALAS was implemented, there were only about 12 salinas left on Morraceira Island and 17 in Lavos, and the Vila Verde group had been completely destroyed. Most of the producers were over 65 years old, and for many of them work in the salinas was a secondary activity maintained through a mixture of fondness, tradition and working habits deeply ingrained in their personalities.

Salt technology in Figueira

The different kind of compartments into which Figueira salinas are divided can be organised into three groups: *viveiro*, *comedorias and praias*. Locally, when referring to the salina (*marinha*), salters exclude the *viveiro*, including in that category only *comedorias* and *praias*.

Viveiro – a compartment that receives water directly from the *esteiro* (waterway) through a *greiro* (sluice). Its interior is cut into *arruelas* (parallel demarcations) intended to make the water circle in a serpentine fashion – *serpentina*. Where the *viveiros* are owned and managed collectively, which is very common in Figueira salinas, the *arruelas* delimit the plots (*parcéis*) corresponding to the area of each of the owners of the salinas supplied by those *viveiros*.

Sapal – this is an area of the *viveiro* with a different shape, allowing an increase in salinity. The water goes out of this compartment from the *viveiro* to the *comedorias*.

Comedorias:

Vasa – this is the most uneven zone of the salina, and normally the largest compartment.

Entrebanhos – generally rectangular in shape.

Cabeceiras – these are situated after the last compartments.

The *comedorias* are separated from the *praias* by a canal – the *malhadal* – that runs at right angles to the compartments.

Praias:

Sertões – these receive the solution from the *cabeceiras*. Three *sertões* equal the width of one *cabeceira*.

Talhões – these are placed directly after the former. In a favourable year it is possible to extract salt from these compartments.

Talhos da praia do meio – this constitutes the real crystallisation surface of the salina, where the salt is extracted. If it is the only crystallisation surface, the salina is *singela*. If there are contiguous tracks – *talhos da praia de baixo* – the salina is *dobrada*, as happens in a small area of the salina that was acquired by Figueira da Foz Municipality (*Corredor da Cobra* = Snake's Corridor).

The *praias* are separated from the *mota* (external wall of the salina) by a canal, the *entraval*, from where it is possible to drain away water to the exterior through an underground conduit – the *cubo* – that connects the salina to the waterway. Connecting the various compartments between the *sertões* and the *praias*, secondary canals – *carreiras* and *caneiros* – run at right angles to the *malhadal* and the *entraval*. The demarcations between compartments are called *marachas*, when the compartments are of the same kind, or *marachões*, when they divide different kinds of compartments. In the case of *talhos* the *marachões* are called *silhas*.

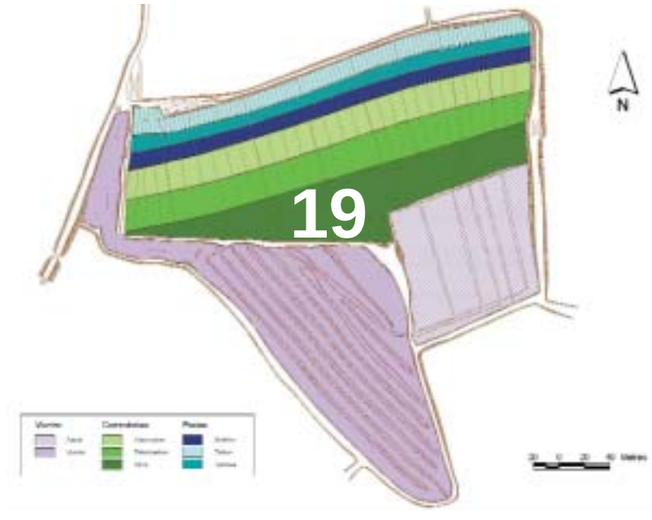
During the management of waters inside the salina – *governo da marinha* – it is often necessary to take water from the *entraval* to the *malhadal*, increasing the salt content of the solution coming from the *cabeceiras*. Due to the difference in topography, this operation is performed using the *bomba* (pump).

Entrebanhos, *sertões*, *silhas*, *talhões* and *vasa* are terms used exclusively in the Figueira salinas. They do not occur in any other Portuguese salt-producing regions.

The production cycle

At the beginning of May, the salters *assentam praça* (start work). The production cycle goes as follows:

– The salina is drained, leaving a small amount of water in each compartment.
– *Esburras* (collapsed mud walls) are built up.
– Mud and slime are removed from the salina, using the *ugalho* (rake) and the toothed rake.
– Cleaning starts from the *vasa* to the *praias* and, once they are clean, the water is drained. The *caneiros* are cleaned with the *tamanco*, a wooden tool with a shape and dimensions similar to the internal section of the *caneiros*.
– At the spring tides of late May water is taken into the *viveiros*.
– From the *viveiros*, water passes to the *vasa*, and from there, at one-day intervals, to the successive compartments.
– The second cleaning begins and the water from the *praia de baixo* passes through the *entraval*, to the *sertões*. The water from the *praia do meio* passes to the *praia de baixo*. The *talhões* flow off to the *praia do meio* and the *marachas* and *caneiros* undergo any necessary repairs, while the water from the *sertões* passes to the *talhões*.
– The salter *tranca* (holds the solution) in the *cabeceiras*.
– When the first salt crystals appear in the *talhos* and *talhões*, the salter dissolves them in *vasa* water and sends this saturated solution to the *sertões*. To perform this, the waters are beaten with the *ugalho* or thrown by the *cabaço* (bucket). In the compartment where they are received it is usual to put an apparatus designed to prevent erosion – thus the *combeiro* works like a shock absorber.
– Once again uncovered, the *talhos* of the *praias* are compacted with the *círcio* (a roller weighing about 100 kilos). This is a delicate operation because the bottom should attain an ideal compactness in order to collect the salt. If it gets too dry breaches will appear; if drying and compactness are insufficient the bottom will become too slimy and the suspended particles will pollute the salt. After this stage the salter will start the routine operations of the harvest.
– Coming from the *talhões*, the water quickly crystallises in the *talhos* of the *praias*, and the *reduras* (salt harvests) begin, at 3 to 5-day intervals. Daily, the salina is *moirada* (different solutions are moved around to contiguous compartments). After every five to seven *reduras*, the "mother-waters" remaining in the *talhos* are drained to the *entraval*. The production process is maintained so long as the weather allows, but does not normally extend beyond the end of September.



Compartments of a Figueira da Foz traditional salina

Source: Mãe d´água

Piran salinas

Peter Deržek

The basic structure of the Sečovlje salinas consists of recent sediment brought down by the local brooks running into the Gulf of Piran. The salinas are arranged in such a way as to make good use of the existing natural conditions for the traditional production of saturated brines and of natural sea salt with intensive labour.

Sea-water with a salinity of 3.5 ^{0}Be (1 ^{0}Be corresponds to approximately 1% salinity) enters the highest evaporation areas at high tide. To alter the intensity of evaporation, the quantity of the water flow with free fall through the evaporation areas is manually regulated with wooden barriers (gates). Water pumps are mainly used to empty the salinas (when there is heavy rainfall) and to shift concentrated brine to pre-basins in the crystallisation facilities where saturation is achieved: the required evaporation is nearly 90% of the initial volume of sea-water.

In good weather conditions, the production of brine is higher. The surplus of produced brines (22-23 ^{0}Be) is preserved in reservoirs for activation after heavier rainfall or at the beginning of a new season of salt production.

Salt crystals are formed by natural evaporation of the saturated brine in the crystallisation pans (*cavedini*), the surfaces of which are covered with a layer of *petola*. *Petola* is a stromatolitic weeded carpet that is used in the process of salt crystallisation; it is composed of gypsum, carbonate minerals and blue-green algae. In this process, the salt produced is uniform, has a pleasant taste and contains traces of sea-water elements that are good for health. *Petola* is unique to the salinas of Sečovlje and Strunjan. When *petola* is correctly made, salt does not need washing and retains its original properties.

Another feature of the salinas of Sečovlje and Strunjan is the daily manual harvesting of the crystallised salt in the basin with wooden scrapers (*gaveri*). In the layer of the basin the salt is scraped or raked with *gaveri* into heaps (*grumi)*. Here the salt partially drains, then it is loaded with spades into hand-driven carts running on tracks, and pushed by hand to small deposits, manually unloaded and shaped into heaps with a ridge and natural incline, so it can drain further. The drained salt is sorted and carried to the main deposit. Selected salt that is to be used for food purposes is stored in a warehouse with a wooden floor where it can dry in a natural way. The rest is stored in open deposits and covered with thick foil. The salt has uniform crystals of medium size and low dry bulk weight.

The leftovers of the used brine (*aqua madre*) is poured off into the assembly channel (*lida*), where it is diluted and pumped out to the sea. A proportion of the main brine is stored in a concrete tank for therapeutic bathing purposes for tourists in local health resorts.

The factors influencing the technology of salt production in the Secovlje salinas are the following:

- the salinas layout and the appropriate ratio between the net crystallisation area and the brine production area, suitable for the climatic conditions on the site. In Lera sector, where the

‹ Piran salters making *petola*, an algal carpet important for the purity of salt

Photo: Hjalmar Dahm

salinas area is complete, the ratio is 1:12; in the whole active area the ratio is 1:19

- the initial density of the seawater that is used in the production of basins. The average summer density in the Gulf of Piran ranges from 3.4 to 3.60 ^{0}Bé
- the usable range of the saturated water in the crystallisation facility, which in salt harvesting is limited to 29 ^{0} – 30 ^{0}Bé
- the required density of the basins at the last stage in the production of brines from 22^0 to 24 ^{0}Bé
- the intensity and quantity of natural evaporation in the salt production season, which in the climatic conditions of the northern Adriatic is on average 7 to 8 mm of water per day
- the quantity of rainfall and its distribution in the salt production season
- the relative impermeability of local materials for the construction of the salinas
- the height of the salinas compared to average sea level, and the gradients that usually depend on the available ground
- the range of high and low tide
- the time required to prepare brine concentrations in the working basins
- the expertise and physical ability of the employees
- the quality of the salt basins' infrastructure.

Traditional salt production is a seasonal activity. The quantity of salt harvested depends on weather conditions, the crystallisation area available, the salters' knowledge, and maintenance of the salt basins. The latter, together with the preparation of the crystallisation

process, is of utmost importance for the quality of the salt produced.

The most important part of traditional salt making is crystallisation. This is based on many remarkable features including the bio-sediment (*petola*), and the daily manual collection of crystallised salt. The *petola* on the surface of the crystallisation pans (*cavedini*) is a living biotope and requires care over the whole year to keep it in sound condition, with complete and compact layers. The crystallisation area is the lowest area of the salinas, utilising natural flows and movements, and is therefore most sensitive to flooding in heavy rains. Flooding causes erosion and deposition of sediment, under which *petola* begins to decay unless the deposits are removed as soon as possible. The crystallisation facility is made from sediment, like other facilities, and requires continuous maintenance and consistent care with the water regime over the whole area of the salinas.

The whole year's work in the salinas, including the preparation for the traditional procedures of salt making and the preservation of biodiversity and sustainable (economic) use of salinas, requires 86% of manual labour and 14% machine-aided work, not includingsalt harvesting, transport and storage.

Crystallisation accounts for the major part of costs, namely 56.70%, of which 53.50% is manual labour costs and 3% mechanical work costs (transport of mud), not including salt collecting, transport and storage.

Analysis of the process and operations in crystallisation shows that the largest proportion of labour costs is for additional seasonal supplying and feeding the crystallisers, i.e. 45%.

Table 2.1 – Surface of the different parts of the Secovlje salinas (in hectares)

LERA Sector	
Channel	4,960
Evaporation areas:	13,992
First evaporation area	125,292
Second evaporation area	55,900
Third evaporation area	32,800
Crystallisation area:	32,707
Net crystallisation surface	19,582
Servings	11,200
Reservoirs	10,290
Road, pathways, repair workshops	1,564
LERA sector – used surface:	244,775
Total LERA sector	263,513
FONTANIGGE Sector – partial usage	175,000
Secovlje – used surface:	435,025
Total surface of Secovlje salinas:	593,000

Pomorie salinas – technology and present situation

Milcho Skumov & Stanka Zheleva

The salinas in Pomorie are situated close to the town in the north, the so-called Town salinas, and in three other sites: Khonyat, Malak Geren and Golyam Geren (see map). Their geographical situation is very good for salt-making: along with the town, they are exposed to the sea and to the winds that facilitate evaporation. The yearly rainfall is low, especially during the working months. The Town salinas is the oldest, dating from time immemorial. The salt works in Golyam Geren were built in the 1890s.

The natural source of salt water for the salinas in Pomorie is the Black Sea, where the concentration of sodium chloride is 1.8%. This is considerably lower than that of the oceans worldwide, and it is not suitable for salt-making purposes. Therefore the water for the salinas originates from Pomorie Lake, which is a lagoon supplied by the sea. In fact, the lake is used as the first evaporating basin, and the water in it reaches a salt content of 3 to 6-7%. The four sites mentioned above are accordingly situated near the lakeside (see map). The water that comes from the lake flows gradually through a few evaporating basins (*tigáni*) and after reaching a concentration of 26-27%, moves to the crystallising pans, where the sodium chloride is crystallised.

There are two types of technology in the Pomorie salinas. The first one is called *anchialo* technology (Anchialos is the old name of Pomorie, used before 1934). This is an old, traditional technology for salt production, which was predominant in the 1920s. The size of the crystallisers is 80-100 m^2 and the salt is collected every

Pumping the water with a *lavût*

Photo: Hjalmar Dahm

6-8 days, depending on weather conditions. This was the method of production in the Town, Khonyat and Malak Geren salinas. But at the end of the 19th century, on the Golyam Geren site they began to enlarge the salinas to 20,000 m^2, of the so-called *fóken* type with a single salt harvest at the end of the season.

The surface of the *anchialo* salinas is divided into squares with paths, 50 cm wide, called *kaváli*. The side boards of these paths are made of pine and they have a life of about 25 years, because sea-water impregnates them. When the salina is filled, the concentrated brine comes through a channel, which ends in the salinas with a partition called a *sirtár*.

There is a fixed number of evaporators (*tigáni*) in each type of salina. The water from the salt lake flows into the evaporators by means of a *kéleve* – a machine for raising water from a lower to a higher level. The *kéleve* is made of wood, and has a mechanism of two cogwheels with crossed axles. One of the cogwheels is operated by horsepower, and a wheel with containers for the water is fastened to the axle of the other cogwheel. When this wheel rotates, the water from the lower point rises and pours into the higher channel and from there flows out into the higher basin. The water from an evaporator (*tigán*) at a lower level flows into an evaporator at a higher level by means of a *lavút*, a large wooden spoon tied to a carriage.

The water in the evaporator is concentrated by the sun and the wind, and thus prepared and almost at the point of crystallisation, it flows in the crystallising pans through narrow channels. The water is 3-5 cm deep and allows crystallisation of the salt for eight days, if the weather is fine.

The preparation of the area was the very first task before the salinas was built. As the area near the town is flat, there was a slight gradient so that the water could flow away in a certain direction. The beds of the saltpans were prepared as follows: the area was cleaned of black earth and where possible was covered with clay, smoothed down and rammed. After that, the area was laid with a 10-cm layer of black sand from the coast (with higher concentration of ferrous oxides) and flooded with the concentrated seawater. The process of ramming has been done for a while but the sand is also compressed for extra stability. Due to the different kinds of salts that seawater contains and the rich ferrous mineral content of the sand, the bed, called *maika* (mother), is stable and smooth. If the "mother" cracks it is fixed in the way described. Year after year salts cover the "mother", which increases in thickness to about 0.5 cm. This additional cultivation of the "mother", together with ramming and levelling, is called *patosvane*.

The daily work during the crystallisation period includes breaking up the thin skin of salts, known as *ganídi*, that covers the upper layer of the pans. This process is called "breaking the *ganídi*" and it facilitates water evaporation. After crystallisation, the salt is heaped up with a rake, to drain the water and the lye. Then, using two boards known as *hiróphtia*, the salt is loaded onto wooden wheelbarrows and is carried to the places where it is to be stored. In the past (a hundred years ago), the salt was carried in crates. The salters usually work barefoot in the pans, but sometimes they put on galoshes, because of the corrosive effect of the salt. With 7-8 harvests of salt in a summer season, salt production is 50 kilos per square metre.

The salt produced is preserved in piles near the crystallising pans in order to "ripen". The storage area is called the *kumulotóp*. The "ripening" of the salt produced consists of removing organic contamination and magnesium salts. These organic substances become oxidised, and the lye (containing magnesium salts) adheres to the crystals, becomes thinner and drains away from the salt. At the end of the season, the salt that is in store is carried away in wagons.

The advantage of the *anchialo* method of salt production is that there is less possibility of losing production when it rains. The rain is less likely to dissolve the salt in piles because it is covered with a skin of crystals. The disadvantage is that the salt is crystallised from concentrated saltwater, which contains more and more of the other salts in the lye. This is why, at the end of the season, the salt contains more and more magnesium and other salts from the lye and the salt crystals are smaller. The right method is to remove the remaining lye and add concentrated water after the salt crystallises. As people usually say, good salt is produced from "virgin water" in which the salt has still not crystallised. The *anchialo* method of salt production is more labour-intensive.

In the *fóken* method, the crystallisers are filled with concentrated salt water of 24-25 °Bé to a depth of 8-10 cm; water at the same concentration is added every day, and a layer of 5-8 cm with large crystals is finally formed. The lye is removed, the concentrated salt water flows in for washing out, and the salt is collected. The *fóken* method of salt production is better than the *anchialo* because the salt is much purer, but this method is at the mercy of the rains during the production season. It is less labour-intensive because the salt is collected 1-2 times in a season.

Today, the salinas in the area of Khonyat, Malak Geren and Golyam Geren function as a single productive unit. The evaporating basins are divided into four groups and the flow of the water in each group is gravity-powered, but from one group to another it is by means of electric pumps. The first group consists of five basins, of 66.9, 45.9, 36.2, 20.1 and 11.8 ha. The second group (Khonyat), has basins of 7.9 and 11.3 ha. The third group, in Malak Geren, has basins of 1.6, 6.2, 4.9, 8.0, 5.3 and 11.2 ha, while the fourth group (Golyam Geren), of 20.6, 13.3, 3.9 and 4.5 ha.

Since the mid-1960s, the Town salt works have gradually been filled in and built upon. Today, urbanisation is almost complete, the area of the salinas is being returned to its owners before the 1947 nationalisation, and it is to be turned into a housing area. But 2.5 ha of the salinas will remain, as part of the Salt Museum of Pomorie. They are of the *anchialo* type and they will be an example of the old technology of salt production in Pomorie. The salinas out of town in Khonyat, Malak Geren and Golyam Geren were rebuilt in the 1980s and work with the *fóken* technology. They are also to be returned to their owners but they will not change their function.

Salt production in Pomorie has been an occupation for local people since ancient times. The locals are also involved in vine-growing, trade, fishing, etc. In fact, most of the salters are small landowners and they earn their living not only from salt production, but also by working on the vineyards and other occupations, outside the salt-producing season. According to the tradition in this area, only men and their sons produce salt, while the women take care of the house.

At present, following the urbanisation of the Town salinas and the introduction of the new *fóken* technology, the number of salters has greatly decreased. The new ownership of the salinas and the need for technological and organisational changes will lead to changes in the number of salters and in their social structure. It can be assumed that during the next decade, a new balance will be established in this branch of the Bulgarian economy.

Inland salinas in the Iberian Peninsula

Katia Hueso & Renato Neves

Salt-making in the countries around the Mediterranean basin is usually associated with huge white piles of white gold close to the shore, with flamingos, herons and other waders colouring the horizon, or with remote, deep, hidden salt mines further inland. Little does one suspect that there are also solar evaporation salinas on the high plateaux, in the mountains or on the endless plains of the Iberian Peninsula, far from any of its coasts.

The Iberian Peninsula, although relatively small (approximately 550,000 sq. km.), shows a wide variety of climates, ranging from wet Atlantic in the northwest to arid in the southeast. However, in its central part, the weather is characterised by hot dry summers and cold dry winters, flanked by mild wet springs and autumns. It is the hot, dry summers that make salt-making by solar evaporation possible.

Why is there salt in the middle of the Iberian Peninsula? In the Tertiary Era, a large sea covered virtually the whole inland area of this peninsula. Then, a series of tectonic movements raised the level of the land and the inland sea was transformed into a number of shallow, highly saline lakes. Due to low rainfall, the sun slowly evaporated the water, leaving behind a 200-metre thick crust of salt on the spots where these saline lakes had been. Later the terrain folded a number of times, burying the salt beds a few metres below the surface. In certain areas, the salt bed has a layer of underground water underneath, which springs up to the surface, dissolving the salt on its way up and emerging as brine.

In a study by José Altimir Bolva, Director of Salinera Catalana S.A., published in 1945, of all the salt-making facilities in Spain, 75% were inland salinas (Table 2.1.1).

Table 2.1.1 – Salt-making facilities in Spain in the period 1930-1945[a]

	No. of facilities	%
Coastal salinas	43	19
Inland salinas[b]	167	75
Salt mines	12	5
Total	222	100

[a] Altimir Bolva, J. (1945) La Sal en el Mundo I. Ed. Al servicio de la industria salinera, Barcelona.
[b] Solar evaporation

Of these salinas, none are now in use in Spain and only one – Rio Maior – is still working in Portugal. The reasons for this massive abandonment are the strong competition from coastal salinas, which have a longer production season due to the more favourable weather conditions, and the improvement in the road and rail transport network in the first half of the 20th century. In Table 2, the effect of this is easily seen. The number of working inland salinas fell from 167 in the 1940s to 47 in 1995. Approximately half of the production of these inland salinas was then sold directly as brine, so the production figures for crystallised salt would be much lower than these 95,000 tonnes. At present, no inland salinas in Spain are producing crystallised salt any more and only a few of them sell brine (Table 2.1.2).

Table 2.1.2 – Salt-making facilities and their production in Spain in 1995[a]

	No. of facilities	%	Production (Tonnes)	%
Coastal salinas	24	35	1,372,494	32
Inland salinas[b]	32	47	95,688	2
Salt mines	12	18	2,882,772	66
Total	68	100	4,350,954	100

[a] Instituto Tecnológico Geominero de España (1997) Inventario nacional de recursos minerales de cloruro sódico y sales potásicas. Madrid.
[b] Solar evaporation

But the factors that led to the economic death of inland salinas also preserved them from massive industrialisation, and they therefore now stand as silent witnesses of a glorious past and host an incredible pre-industrial architectural heritage that should be preserved before it is too late.

The history of salt-making in Spain is fairly consistent within its territory. The first written documents relating to the salt industry date from the early 12th century, when King Alfonso VII declared a salt monopoly by annexing the salt-making facilities until then in private hands to the Crown's possessions. Since that date all salt-making facilities in Spain passed successively from private hands to the Crown and to the Church, surviving several salt monopolies. The last of these was abolished in 1869 and all the facilities were sold to private entrepreneurs, who exploited them and sold their salt on the open market.

In this article, we would like to show four examples of inland salinas in the Iberian Peninsula. Each of them has its own particular method of salt-making and all are well worth protecting for their architectural and cultural heritage. This is only a humble effort to show the diversity and beauty of inland salinas in Spain and Portugal.

The Salinas of Imón and La Olmeda (Spain)

These salinas lie on a high plateau in Central Spain and are 55 hectares in area. They were rebuilt for the last time in the 18th century. There are three main storage buildings in each one and La Olmeda also has a small village, plus a chapel, for the seasonal workers. All these buildings are made of stone and supported by pinewood beams. The storage buildings are like cathedrals in their dimensions: 1,500 square metres in area and 30 metres tall.

In these salinas the working procedure is simple. The brine is pumped with waterwheels and channelled to evaporation pools and from there to crystallisation pools, the salt being harvested in the summer months. The waterwheels are of Arabic design and are housed in small circular buildings of great architectural value because of their supporting structure. The paths and the floors of the pools are made of stone, also of Arabic design.

The Salinas of Añana (Spain)

The salinas of Añana lie in a deep V-shaped valley in a mountainous area of northern Spain. Due to the steep slopes of the valley, the evaporation and crystallisation pools have been built in terraces, under which the salt is stored. There are more than 5,000 crystallisation pools of about 20 square metres each, which stand on wooden pillars, giving an air of lightness and fragility to the salinas complex.

The crystallisation pools form groups of 50-60 that are owned by the same person, making about 80 owners of these salinas, who work independently.
The salt-making procedure in Añana starts with the brine, which is channelled from the springs on the upper side of the valley to the evaporation pools through open pipes that hang some distance from the ground on wooden pillars. From there, it is distributed to the storage wells of the different owners, following a pre-established schedule of brine distribution. From these, each owner distributes the brine to the crystallisation pools, storing the produced salt under each pool.

The Salinas of Poza de la Sal (Spain)

These salinas also lie in a V-shaped valley, but much shallower than that of Añana. They are a complex of pools built on the slopes, supported by stone walls of different heights, in order to keep their surface horizontal. Interesting buildings include the entrances of the galleries, the administration building and the pools themselves, all made of stone and wood, dating from the 18th century.
Although these salinas are considered solar evaporation salt works, they also use salt mining techniques to obtain the brine. From the top of the hill that encloses the valley, fresh water is conducted by gravity from a gallery, which draws it through a seam of salt underneath the surface. The brine is then channelled to large storage wells that lie further down the valley and, from there, to crystallisation pools. Once the salt is harvested, it is stored underneath the pools.

The Salinas of Rio Maior (Portugal)

The Rio Maior salinas, whose documented history goes back at least 800 years, are the only inland salinas in Portugal to have maintained uninterrupted operation. It should be noted, however, that there are other places in which this resource has been exploited on an intermittent basis and on a smaller scale, but virtually no trace of these remains.
The salinas are located in a valley, with calcareous soils, used mainly for agriculture (orchards, vineyards and market gardens), but there are also dense areas of scrubland, dominated by kermes oak (*Quercus coccifera*). The whole area is part of the Serra de Aire e Candeeiros Nature Park, and is also included in a Natura 2000 site.
The salinas cover an area of around 27,000 m^2, divided into 470 *talhos* (crystallising pans), each of approximately 35 to 50 m^2. All the water comes from a well, around 9 m deep and 3.75 m in diameter, situated inside the salinas. Formerly, the water was raised by a device called a *picota*, but today this is done by a power-driven pump. The water circulates through a network of channels (*regueiras*) which take it to a series of ponds (*esgoteiros*) that function as evaporation areas, from which it is then channelled to the crystallising pans. In favourable conditions, crystallisation can be achieved in 24 hours. The water has a high sodium chloride content and the salt produced, without any kind of treatment, is 96% NaCl.
The saltworkers, known locally as *marinheiros*, are local farmers who own or rent the *talhos* and who belong to a cooperative that is responsible for the salt harvest, currently between 1,500 and 2,000 tons a year. As this activity is centuries old, there is a strong local culture surrounding salt production, as can be seen in the layout of the salinas, the wooden warehouses with their characteristic locks made from the same material (similar to those used in the salt warehouses of Figueira), and the manufacture of *queijos de sal*, literally 'salt cheeses', so called since they are cheese-shaped blocks of very fine salt, as well as a specific vocabulary.

The salinas attract many visitors today, and some of the warehouses have been converted into sales outlets for handicrafts, and the sale of salt direct to tourists is an important source of income for the salters. However, while there is still a market for this type of salt, enabling the activity to survive, the traditional nature and authenticity of the product, as well as the salinas themselves, are to some extent being compromised by mismanagement of the local environment and changes in traditional practices, such as replacing the beds of the pans with concrete, the use of plastic, and inadequate maintenance of the channels.

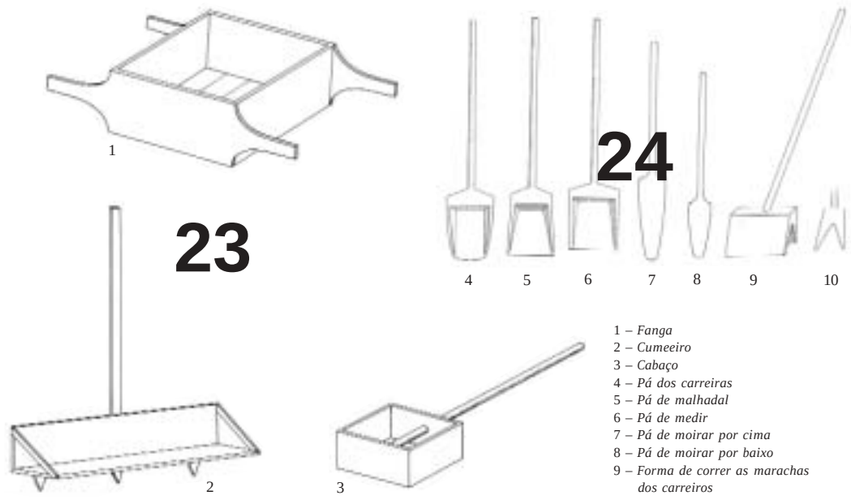
^ Inland salinas are unique cultural landscapes (photo from Imón – Spain)

Photo: Renato Neves

Implements and tools used in traditional salinas

Renato Neves

As traditional salt production follows a set of roughly similar general principles everywhere, the activities of saltworkers are more or less the same in all regions: cleaning the channels, maintaining the divisions, raking out the salt from the crystallising pans and transporting it to storage areas or warehouses. These basic operations are performed from Brittany to the Black Sea.
Wood is the obvious material to use when working in a highly saline environment, since salt helps to preserve it, and this is why it is chosen for the saltworkers' implements. In Figueira da Foz, even the forks used by the saltworkers to eat their food were made from the wood of the tamarisk, the only tree able to withstand the high salt content of the soil.



› Some tools used at the salinas of Figueira da Foz

Drawing: Marcos Oliveira

The tools can be grouped into the following types according to the nature of the operations involved:
Construction and cleaning – Here shovels and moulds are the basic implements, and they come in a great variety of shapes and sizes according to different circumstances. In many cases, their width depends on the width of the channels, and they take their name from the type of channel in which they are used. Thus in Figueira, for example, we find *malhadal* and *carreiras* shovels.
Compaction – For the work of compacting the beds, many regions have opted to use large cylinders, fashioned from either stone or wood.
Harvest – The basic tool for this operation is a toothless rake. There are sometimes two types for use in different situations: one for raking the salt into small pyramids or rows at particular points, and the other for lifting it out from the bottom of the crystallising pans to reception areas on top of the walls or divisions. The length of the rake varies from region to region, depending on whether the salt-workers operate from inside the crystallising pans or only from the divisions.
Transport – Various methods are used to transport the salt from the crystallising pans to storage areas or warehouses, such as wicker or wooden baskets and trays. With the coming of the modern industrial age, many of these materials were abandoned in favour of plastic containers. Other common items of equipment were handbarrows and wheelbarrows, of which some locally made examples, specially designed for this task, still exist.
Apart from these implements, there is (or rather there were, since a great deal of know-how has already been lost) a series of other artefacts and processes, often specifically designed for local conditions, which are worthy of mention. These include certain methods used to cover the pyramids of salt – called *serras de sal* (salt mountains) in Portuguese – in which two types of rush were mixed with clay to form a completely waterproof protective covering, allowing the salt to be stored in the open air for the whole winter or even longer. Also in this section come certain empirical methods used to measure salinity, humidity and wind direction.

The energy issue in Mediterranean salinas

Theodora Petanidou & Renato Neves

In an almost tideless sea lacking large flat expanses of land at a conveniently low level, as in the Mediterranean, energy has been always a difficult issue for a salina. An idea of the difficulties is given when one considers the huge quantities of brine that inflow and circulate in a salina. In fact, the salt crystallisation process involves the evaporation of large quantities of water, since to produce one ton of salt, at least 30 to 50 m^3 of water are needed. The problem is how to obtain such quantities of water and how to make it circulate within a complex system of divisions and channels. Gravity is obviously the main source of force used, with the various reception tanks being located successively lower, sometimes with a difference of only a few centimetres between the levels.
However, gravity cannot always meet the supply requirements. While it is sufficient in salinas situated on the Atlantic, since the tides there are large, it is rarely adequate to supply salinas located within the Mediterranean. So, up until the advent of the industrial age and the introduction of pumps driven by petrol or electricity, the water supply in salinas was provided wholly or partly through scoops or other water-lifting devices driven by wind energy or by draught animals.
The above explains why the type of energy used for this purpose has changed considerably in the course of the last 10 centuries in the Mediterranean salinas, whereas the process of producing salt has remained almost the same. The situation is different in Atlantic salinas, where brine is driven by tides and gravity, and so the use of extra force is not required. As a result, within the Mediterranean area there are numerous examples of hydraulic solutions, where man has combined natural phenomena, such as modest local tides, with common sense or basic mechanical know-

› A windmill in Piran

Photo: Hjalmar Dahm

ledge, and found ingenious ways to solve energy problems. Although the salt production process was initially manual, it has gradually embraced technological and technical developments, firstly in the sector of brine management, and secondly in salt-harvesting. At times, man has had recourse to all kinds of draught animals, windmills, steam-pumps and, in the 20th century, diesel engines, as well as electricity. All these may explain why in most of the Mediterranean, excepting only a small fraction of the northern Adriatic, traditional salinas have ceased to incorporate technological advances.

Where geological relief allowed it, sea-water flowed into the salinas by the force of gravity. However, few salinas in the basin had the physical conditions for this. In most of them brine inflow was carried out by wind-pumps of different sizes, which also helped the circulation of brine between the evaporation ponds. Most of these wind-pumps have been destroyed in the course of the centuries, without leaving any trace, like the three wind-pumps of the salina of Polichnitos (Lesvos) in ordinary use until the first decades of the 20th century. Remnants of such wind-pumps can be seen today in Malta and in Sicily. The wind-pumps (also called windmills) of Sicily are noteworthy for their sheer size and the use of an elaborate water-lifting technique based on Archimedes' screw: at Marsala they are still in use, whereas in Trapani they have fallen into disuse. A particular type of wind-pump is that of Piran, which has been reconstructed as a demonstration piece for the local museum. The Slovenian wind-pump (called *macchina* by the saltworkers of Istria) was as extremely simple but efficient device able to take advantage of all prevailing winds, with sails also being used to adjust lifting capacity. Although geographically outside the Mediterranean, the wind-pumps in salinas of the Canary Islands are worth mentioning, with various types of construction showing marked differences in terms both of the base and of the rotors.

Where the winds were not sufficiently regular, or in combination with wind energy, brine circulation was carried out manually or with the help of draught animals. The first device we know was the *bucket-wheel*, used to ladle out brine in the salinas of Provence from the 11th century onward. This type of apparatus, pulled by mules, became very popular throughout the Mediterranean. With the capacity to lift 200 litres at 60 cm/min, these devices were in operation throughout the day, requiring 10-20 mules or more. On the other hand, when the wind was strong and steady, the animals could rest as the buckets of brine were moved with the help of *wind-wheels*. It has been found that the muleteers of the Cagliari salinas in Sardinia constituted the majority of the working force of the salinas. In fact, the name of one of its basins, *Stagno di Molentargius*, indicates the use of mules there.

In the salinas of the eastern Mediterranean, particularly in the Aegean, in almost all Greek-speaking territories we find the same hand-made structures through which brine transportation was managed. There were two main elevator types: *horse-operated draw-wells* (called *kéleve* in Anchialos), and *hand-operated decanting-shovels* (*zorno*) in the salinas of the Adriatic – also used in Figueira da Foz; *lavútes* or *anapodochária* throughout Greece and in the old Anchialos, *lavúts* in modern Pomorie). There is evidence that horse-operated draw-wells were used in the salinas of Elounda (Crete) during Venetian times, in Messolonghi until the early years of the 20th century, and in Anchialos (now Pomorie in Bulgaria) until after the Second World War. We assume that these devices were also used in the salinas of Phocaea (Phokaia), north of Smyrni that, in general, managed and spread salinas-related technology and know-how to a wider area. In fact, a large part of the labour in the Camargue salinas was made up of Phocaeans who moved to work there at the beginning of the 20th century (cf. *fóken* technology of Anchialos). The *lavoútes*, on the other hand, light, movable and not requiring many resources (space, animals, construction know-how, maintenance) were widely used both geographically (i.e. in all Ionian islands and the Aegean) and locally (i.e. within a salina).

The horse-operated draw-well was a rather complicated structure combining two main wheel systems. The first, a combination of a horizontal and a vertical wheel, was driven directly by the animal, thereafter transferring the mechanical force to a third wheel placed vertically to the brine surface. The last wheel had the form of a cage or a tympanum separated inside into small compartments, each one with a side opening. The low-level brine flowed into a compartment through the hole and was held there until the compartment was elevated to a high-level pond, into which it was freely decanted. The animal was attached to the first, horizontal wheel, driving it under the supervision of a *kelefstís*, one giving orders, hence the name for the device used in Anchialos (*kéleve*).

The hand-operated decanting-shovels or *lavoútes*, which survived until the 1950s or somewhat later in Greece, were much simpler in structure and function. An elevator like these consisted of a wooden tripod with a small shovel-shaped container hanging from it. The tripods were positioned between two ponds at different levels by the *lavoutiérides* or *lavutistés* who skilfully handled the shovels to decant low-level brine to the higher pond. This type of salt-workers' expertise survived in Greece as long as their devices did not fall into disuse, i.e. until the 1950s.

^ Windmills in Marsala – Sicily

Photo: Hjalmar Dahm

Portraits of Salters

Hjalmar Dahm

While travelling around Europe in the search of forgotten salinas I have also met with the men and women working there. Salters are humble people, yet very proud of the work they do. They are always ready to speak about their salinas, about good and bad years, the wind and the sun, about the birds in the sky and the fish in the pools. Without salters there would be no salinas. It seems obvious, but not to everybody.

Amadeu in Castro Marim, Portugal

We met in June 2001, when all the salters from Figueira da Foz had gone by bus down to the Algarve. At first the salters from the north had smiled when they saw how small the salinas in Castro Marim were. But when Amadeu received us at his salina, they were impressed. Although the season had just started, Amadeu's piles of salt were already substantial. And all the salt was *fleur de sel*, worth a lot more than ordinary coarse salt. Well over 80 years old, Amadeu explained to the visiting salters that for an old man – although fit – it was a much lighter job to collect the fine floating crystals on a daily basis than to scrape the coarse salt that required more strength and youth. Collecting *fleur de sel* kept Amadeu connected to the salinas and gave him time to advise the younger salters in their profession.

Victor in Marsalforn, Malta

On the northern point of Gozo you can discover an amazing landscape with small pools carved in the rock. Here I found Victor one day in mid-September 1994. He had just harvested the last salt of the season and was taking care of his annual product before the first autumn rains. He told me that he sold most of his salt to local bakeries, but that he was worried for the future. Few young people were interested in making salt out on the cliffs and the pressure from tourism made life difficult for a salter. Not only had the recent road works brought dust into the salinas, but more and more people used the salina area for barbecuing and as platforms for scuba diving

When I wrote my book about salt, my Swedish publisher chose this photo of Victor for the frontispiece.

Pascal in Guérande, France

Pascal had been working at the shipyards of Saint-Nazaire, just at the mouth of the Loire River. But in late autumn 1984 he was unemployed and had been accepted on the same training course for young salters as myself. We became friends and for many years we regularly worked together in the salinas, especially during the hard winter work and when bringing in the salt harvest in autumn. Pascal shares my interest in photography, although fishing is his main hobby. He could even have become a good birdwatcher. I will always remember when he called to me from the dike that surrounded my salina to ask whether there were flamingos here in Guérande. I shouted back that we are too far to the north for such birds. "I see one though", he replied, so I hastened up onto the dike and looked where he was pointing far out to the mud banks. "It is just an old whitish plastic bag", I laughed. "With a long neck and legs", Pascal added. And he was right, but I needed the binoculars to distinguish these features. This photo of Pascal is from summer 1992 and has often been published in publicity material for *Sel de Guérande*.

Antonis in Kythira, Greece

It was in June 2002 and I was working on the last images for the ALAS video. We needed images from salinas on the rocks, so I took the speedboat from Piraeus along the east coast of the Peloponnese down to the island of Kytheia. There I was met by a compatriot of mine, Göran. He is an olive grower and had also just started in the salt business. We made an appointment with Antonis and the next morning went out in Antonis' boat to collect salt before the sun rose high and the temperature became unbearable. Carefully Antonis picked up the frail crystals with his metal strainer. Göran was admiring the skill of the old man and at the same time trying to memorise the gestures. I filmed and got some of the best images for the video thanks to this old salter.

Manuel and António in Figueira da Foz, Portugal

Renato Neves and I called them "the boys". These two experienced salters are the true pillars of the salina *Corredor da Cobra* that the Municipality of Figueira da Foz bought right at the beginning of the ALAS project. With enthusiasm they restored the salina that after many years produced its first salt in summer 2001. We met each time I came to Figueira, and one day in September that year I spent the whole day with them. Manuel took me on a long walk in the area. We crossed canals, looked at all the old buildings, and saw many abandoned salinas in the southern part of the area that have been converted to fish-farms. It had started to rain when we came back to the old warehouse, but António had lit a fire and started to bake potatoes in a thick layer of salt. "The boys" grilled both *bacalhau* (salted cod) and fresh sardines. The meal was excellent, washed down with Manuel's own wine.

Dario and Rinaldo in Piran, Slovenia

The first time I came to Piran in 1994, I was taken care of by Zora, Boris and Flavio. At that time the salter in the museum salina was called Dario. He worked there with his wife, and I remember that he made several small salt piles in the pans. In 2001 I came back and met Rinaldo. He was scraping the salt wearing a boot on his right foot. He had probably cut his foot and when you expose a cut to salt it heals very slowly, so by wearing a boot he aided the healing. He swiftly scraped together the crystals with his *gavero*, and formed the harvest into one single pile. I found it less aesthetically pleasing than Dario's small pyramids.

Rinaldo is much appreciated by all the young people that attend the training sessions for salters, probably because of his life-long experience in salt-making.

Eros in Cervia, Italy

When I saw the small *camilione* salina in Cervia for the first time, one early morning in September 1997, Eros was probably enjoying a strong *café espresso* in town. Anyhow, there was nobody to be seen, but in the industrial salina just across the road the Decauville trains were bringing in the harvest. Four years later, I finally met Eros, a true lover of artisanal salinas. It was in the evening, and together with his society friends he had just scraped the daily salt. On the other side of the road all activity had stopped: the industrial salina was abandoned, a victim of globalisation.

Every summer afternoon the members of *Gruppo Culturale Civiltà Salinara* meet at the salina, to scrape the salt, fill the pools with new brine and carry out the salt in the peculiar long-handled wheelbarrows. Then they enjoy a glass of cool white wine and solve most of the world's problems just as the sun sets. Sometimes a group of tourists arrives and is welcomed; salt always need a bit of explanation. Then it is high time for Eros to take his motorcycle and go into town and open the doors to the local salt museum.

Kyriakos in Pomorie, Bulgaria

In August 1998 I went to Pomorie for the first time. Kyriakos was as always – I learned this later – on his salina. He comes very early in the morning, checks the water-levels, milks his cow and starts to scrape the salt. Lately he has also undertaken the construction of scale models of old salina tools and animal-driven pumps. He will stay until the sun sets. "There is always something to do on the salina", he tells me. Well, that is what I think he told me because the first

‹ Kyriakos with his wheel barrow im Pomorie

Photo: Hjalmar Dahm

year my Greek was not so good. Yes, Kyriakos speaks in Greek because he belongs to the Greek minority of a town that 2,500 years ago was already a Greek settlement on the shores of the Black Sea, Anchialos. As the years passed and I came to Pomorie more often we also understood each other more easily, my Greek getting progressively better.

Kyriakos is very attached to his small salina, the only one of the old Anchialos salinas still in operation. His two grandsons Giorgi and Nikolas assist him as much as they can, full of admiration for their grandfather.

All photos by Hjalmar Dahm