THE APPROPRIATE SIZE OF SALTWORKS TO MEET ENVIRONMENTAL AND PRODUCTION REQUIREMENTS

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INTRODUCTION

Sea salt or solar salt (when obtained from salt lakes) depends on the evaporation of saline water thanks to insolation and dry wind blowing and its subsequent crystallisation. Salt field size has to meet the following features for condenser and crystalliser establishment:

(a) large littoral territory characterised by flat block of impervious soil with deep sea anchorage nearby,
(b) climate favouring high evaporation rate with little rainfall when salt is being harvested.

Weather and market conditions oblige modern salt producers to optimise technical factors impacting on salt itself. Saltworks[1] require to be designed and operated by taking into account a major factor, their size. The surface of a number of saltworks located around the Mediterranean basin is too small for the introduction of mechanical means and processes, which would make their operation more efficient thanks to reduced cost and increased capacity.
It is crystal-clear that there is no future for salt manufactured in cottage units using labour intensive methods with no quality control. Large plants employing modern methods of production based on mechanisation, computerisation and quality control are, since the advent of the industrial revolution, in a position to supply a large number of outlets, like the chloralkali industry, which is the main source of salt production in various countries.
Size adjustments depending on local conditions are possible further to specific

[1]Although salinas is also in use, saltworks will be retained as the most common wording in the salt industry.

studies. But salt simply harvested by hand in small scattered salt gardens does no longer make sense unless it is considered as a traditional activity within folklore. The quality of such coarse salt is low because of its high content of magnesium, moisture and impurities. As far as human consumption is concerned, the speculation upon "niches", which refer to marketing only, cannot be used as an argument in favour of primitive gathering at the end of the XXth century.

Does sea salt production depend on the size of salt facilities? An answer has to be given from a qualitative and quantitative point of view. Over the centuries the question has been rather underestimated. Provided that the local requirements were met, it did not matter that the salt harvest be carried out in one single estate or accumulated by adding individual gathering from a number of gardens. Moreover quality concern was not systematically leading merchants to select production sites and producers to improve salt standards until they changed their mind under competition pressure. At the end of the Middle Ages, white salt from the South substituted increasingly the Bay salt in Northern Europe.

The size of salt facilities appeared later as a major factor for an adequate meeting of the changing demand. Although there is a marked trend to consider that scale change took place in the XIXth century in order to supply precisely the developing salt-based industries - a good example being the establishment by Pechiney of huge saltworks at Salin de Giraud - it would presumably be erroneous to consider that size optimisation of solar saltworks for whatever reason or whatever purpose has not emerged before that time. Cicero evoked the completion of wide saltworks on the Eastern coast of Egean Sea[2] operated with abundant workforce.

1. PRODUCTION

Climatic and topographical factors have to be taken into consideration prior to the selection of the most appropriate site for a solar saltworks. This selection depends on other parameters than climatology or pedology: wide flat surface areas, as impervious as possible, sea water uncontaminated by dilution or pollution are the major factors which govern brine concentration and evaporation as well as salt crystallisation. Whereas the evaporating ponds do not require a well defined shape, the crystallisers must be built in such a way that they provide the best expected conditions for optimal crystallising and rational harvesting (machines). Therefore, particular attention will be paid to their shape and their floor, which depend themselves on the geographical location and the pedological situation of the saltworks they relate to.

1.1. Generalities

It is assumed that cristalliser total surface has to represent 1/10th of the surface of the corresponding evaporating ponds. Thus their respective size will con-

[2] Cicero, De imperio Cn. Pompei, VI, 14-16, CUF, p.165. " familias maximas quas in salinis habent... "

tribute to optimise the process and to increase the yield. Crystallisers in series (a given number of ponds connected in series) are operated in such a way that increasing brine concentration will be kept under control in order to avoid the presence of secondary salts beyond limits determined in advance. In the reverse, "independent crystalliser method", which is implemented in traditional saltworks with small scale production, does not prevent their presence and high moisture content as a result of the making up for the water loss (evaporation) by supplying fresh brine. These salts have a detrimental impact on the evaporation properties of the brine as elaborated below. They crystallise out and spoil the deposited salt. Although the aforesaid method is simple and suitable for traditional salt gardens, salt quality is generally below the existing standards for either food or industry salt grade.

If the water supply to saltworks has to be interrupted because of hard rainy conditions (winter), it is obvious that salt producers have to try and preserve the brine which has reached a consistent concentration degree. Large volume reservoirs are necessary for storing brine. Thanks to them, brine close to saturation point will be available for crystalliser supply at the beginning of the dry season (until new saturated brine from evaporating ponds takes over). Increasing the brine reservoirs at Messolonghi some years ago resulted is an approximately 25 per cent increase in salt production.

1.2. Quantitative aspects

A tentative typology for solar saltworks is appended to the present paper in order to summarise which technical characteristics prevail in accordance with the size of the existing facilities. It makes sense to focus on saltworks of the temperate climate type but casual reference to the other types is not excluded. See appendix 1.

In temperate climate, solar saltworks can yield 50 to 150 tpa of salt per ha (crystalliser). Therefore a very large area must be available if annual output has to exceed several tens or hundreds of thousand tons. Since climatic conditions can vary widely from year to year, the nameplate capacity of the designed saltworks should be 25 to 30 per cent greater than the anticipated demand for salt to be met.

The harvested amount may not be sufficient to meet the customer requirements. Therefore a buffer stock will be maintained, aimed at neutralising yield variations. The stockpile depends on the available storage space (stockpiling and reclaiming operations). For such reasons a large estate offers a variety of solutions to the owners of modern saltworks with large scale production. This is not the case for primitive saltworks or traditional saltworks with small scale production.

Solar salt production in Malta is primitive. It does not exceed 2,000 to 3,000 tpa. The salt ponds which are hewn from rock, are usually operated by one or two workers who carry the brine and gather the salt by hand.

A major problem in Portugal remains the size of most of the solar salt facilities. As long as competition and market development did not interfere with the pro-

duction process, the workers used to walk barefoot in brine, to drag salt with a rake and to carry it on their shoulders to the storing piles, and small saltworks met the requirements of cottage production. There were 1,200 salterns or saltworks. In half of them the production never exceeded 250 tpa. During the 60's, a study of potential facilities indicated that, rather to merge small plants into larger ones, it would be more advisable to initiate production in two suitable places on the Algarve coast with areas from 500 to 700 ha. Each plant should yield about 50,000 tpa of good quality salt (low content of magnesium, moisture and impurities). Solar salt production averages currently 120,000 tpa in Portugal (of which 90 tpa harvested in Algarve).
Similar steps have been taken in Greece where, "not so long ago, most of the saltworks still had the traditional design, method of operation, and means of harvesting salt established in the 1920's". The Messolonghi Salt Works S.A. was established in 1978 to modernise the existing salt facilities and increase their productivity. The saltworks located in Messolonghi cover an area of 1 240 ha where the topographical conditions are excellent (very slight altitudinal range). Their mechanisation has been very successful. Since 1989, the company has mechanised five of the other saltworks operated in other places with positive results. The quantity was increased. The quality was improved. In 1997, total production amounted to 190,000 t.
The current status of Mediterranean saltworks is summarised in appendix 2 which has been produced from two different sources. The first one relates to Greece, the second to the Mediterranean basin. The study undertaken by a team of experts involved in a recent research related to the conservation of wetlands in this area is a valuable data base with maps[3] and statistics. One of the above-mentioned maps is reproduced as appendix 3. It shows the distribution of operational saltworks throughout the Mediterranean region.
Over 168 Mediterranean sites have been duly investigated, data are available for 165 saltworks located in 18 countries:

- 90 are producing salt
- 64 are lying idle[4]
- 11 are turned into other activities.

Aquaculture (fish farming) appears to be an optimal alternative for traditional saltworks with small scale production. Its achievements are also suitable for various salterns, contributing by the way to an increased protection of threatened ecosystems. Another map, as appendix 4, summarises the situation with this respect.
A table with production figures compiled by the Bureau of Mines and the

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[3] The author is very grateful to John G. Walmsley for granting the permission to have the two mentioned maps reproduced with this presentation.
[4] 83 per cent of them represent only 9 230 ha to be compared to 12 000 ha at Salin de Giraud or 10 800 ha at Aigues Mortes with a total capacity of 1.2 Mt of sea salt.

European Salt Producers' Association for 1997 emphasises that nearly 50 per cent of crystallised salt production in the Mediterranean border-countries depend on solar evaporation in this area, whereas rock salt extraction represent respectively 32 per cent by dry mining and 18 per cent by solution mining and/or vacuum evaporation. Such a significant percentage is basically to be explained by the existence of modern saltworks with large scale production. Traditional saltworks with small scale production are no longer meeting market requirements unless certain local conditions still prevail that justify, to a limited extent, remote methods and human bondage...

SALT PRODUCTION IN THE MEDITERRANEAN BASIN, 1997
(in 1000 metric tons)

	Production	Sea salt	Rock salt	Evaporated salt
Albania	10	10	-	-
Algeria	250	50	200	-
Croatia	20	-	20	-
Cyprus	10	10	-	-
Egypt	2 000	1 000	1 000	-
France	3 300	1 200	730	1 370
Greece	190	190	-	-
Israel	800	50	-	750
Italy	2 830	1 270	1 030	530
Lebanon	30	30	-	-
Libya	30	20	10	-
Malta	3	3	-	-
Morocco	170	30	140	-
Portugal	670	120	550	-
Slovenia	7	7	-	-
Spain	2 280	980	1 160	140
Syria	115	-	115	-
Tunisia	400	400	-	-
Turkey	2 330	2 220	90	20
Yougoslavia	30	30	-	-
TOTAL	**15 475**	**7 620**	**5 045**	**2 810**

Sources : ESPA (1997) Bureau of Mines.

1.3. Qualitative aspects

1.3.1. Secondary salts

The preparation of the saturated brine is carried out in evaporating ponds. There is a continuous flow from sea water to saturated brine and at any point the concentration has a definite value. As concentrations remain constant, the expected crystallisation of the salts less soluble than sodium chloride always occurs in the same ponds. The salt which is gathered from the crystallisers may be contaminated by secondary salts like calcium sulphate and magnesium chloride and sulphate. These mineral substances and insolubles (sand, clay) must be eliminated when the harvested salt is intended for human consumption or for industries requiring pure salt. This is the reason why modern saltworks are equipped with a washing plant. The above-mentioned impurities are swept away by the clean saturated brine used for this purpose.

Calcium sulphate remains present in the sodium chloride saturated brine in the crystallisers although a part forms deposits in the last-stage condensers which have to be periodically scraped clean. The fine grains of calcium sulphate on the outside of the salt crystal are eliminated with the insoluble matters. Crushing the salt permits the elimination of calcium sulphate remaining within the salt crystal.

Magnesium salts are by far the largest elements of the soluble salts remaining in the brine. Thus the accompanying brine has to be treated in order to meet the specifications corresponding to quality salt. Salt washing is not always performed in traditional saltworks with small scale production. The low grade of the product is compensated by marketing arguments.

Certain small scale producers allege that their "non-treated salt" is "rich in oligo-elements". Sodium chloride is known to contain trace elements irrespective of its production route. To pretend that traditional sea salt contain iodine is not a fair practice indeed. Food grade salt requires quality assessment whereas cheap imports and cottage products do not meet the provisions of the Codex Alimentarius standard for this type of salt.

1.3.2. Computerisation

Computer models for the concentration ponds and crystallisers provide the basis for the required brine control strategy (quality of the end-product) for salt field operation either based on continuous flow of brine transfer volume requirements between the pond series[5] so that brine densities and levels be maintained. Moreover, evaporation rates are doomed to vary due to changing seasonal and other weather conditions.

The models developed by different companies contribute to a more efficient utilisation of brine through the blending of various brine streams. Details on computer models are not to be described in the paper. Actually, the mere mention of "computerisation" or "modeling" as a means to optimise salt production thanks to data collection and brine flow control is done to emphasise that this strategy is only applicable in modern saltworks with large scale production. In the salt facilities at Dampier (Australia), which have a capacity of 3.5 million tpa, a radio telemetry system linked to a base computer is used at the platform collecting data and controlling brine status whereas the salt field is more than 100 km^2 in area.

[5] A single series of ponds is the most common layout. But ponds can be arranged in several series.

Computerised brine movement management has been developed at Salin de Giraud (France) where the salt field has a capacity of 800,000 tpa. The corresponding programme involves the daily entering all over the year into the data base of information relating to brine levels and concentrations in the 87 ponds where the brine concentrates. It also implies that the same information is integrated for the 70 crystallisers during the salt productive season. Meteorological data are also recorded. The area of the salt field exceeds 10,000 ha.
Named "SEASALT", the computer program is providing a valuable assistance to saltmen, more especially where a wet winter season characterises climatology and affects the pond operation cycle. It is designed in such a way that it is easily adaptable to other saltworks. Computerisation is a tool for decision assistance with regard to the crystalliser surface to be harvested, the use of equipment and the extension of the harvest period aimed at producing high quality salt.
Other computer models have been elaborated to calculate the optimal area and the corresponding performances of solar ponds according to their initial and final brine concentrations (based upon the composition of crystallised salts expected to deposit during the period of evaporation).

1.4. Side aspects

1.4.1. Energy recovery

Two Israeli experts proposed in 1954 that the principle of heating within the solar pond be evaluated from a commercial point of view. The use of artificial salt-gradient ponds was then envisaged as an alternative to provide thermal energy to heat buildings or to generate electricity. A first test pond with an area of 600 m^2 was designed in 1960 where a temperature of 95°C was attained. A 1 100 m^2 pond established close to the Dead Sea bank in 1975 reached 103°C. The largest pond covering 7,000 m^2 was completed in 1978 at the Ein Bollek site. Brine from that pond has been used to drive a turbine producing 35 kWh on a continuous basis.
Experiments have not so much developed because of relatively low prices prevailing for conventional energy and, later on, of nuclear energy competition. But such uses of solar energy would reactivate and stimulate research on the many variables affecting this solar pond application, which could also be integrated in the processing of mineral substances like

- anhydrous sodium sulphate (tests in Turkey)
- sodium carbonate (Owens Lake, CA).

Such approach requires basically an excellent insolation and large size facilities.

1.4.2. By-product recovery

The residual bitterns from sea water used for the production of sodium chloride contain various compounds, the valuation of which has paved the way to a great deal of research. A technology has been developed that allows an economic production of by-products (mineral substances) from salt facilities of at least 200,000 tpa capacity, and possibly, larger. The process consists of continued

solar evaporation of the bitterns with a sequential brine flow in the ponds. The direct recovery of sodium sulphate from sea bittern is not possible. A method has been investigated in the past by Indian experts. It is based on the preparation of an intermediate salt fraction called "sels mixtes", and the subsequent obtention of Glauber's salt by using the reciprocal salt pair diagram at 25°C and at 0°C. The Glauber's salt is then dehydrated converted to anhydrous sodium sulphate.
Mixed salts are collected in several groupings and then treated by selective crystallisation and flotation. Even though a 200,000 tpa saltworks is rather small, the economics to produce potassium sulphate (K_2SO_4) would theoretically make sense. As plant size is a dominant factor with respect to market requirements, this process has to be evaluated by taking into consideration the fact that there will be a competitive disadvantage to the large plants designed to produce these substances via other routes...

2. ENVIRONMENTAL ASPECTS

It is generally admitted that the evaluation of ecological optimum in relation to human activity like solar salt production is rather difficult to be carried out for a given ecosystem. As far as solar salt production is concerned, the use of land (salt fields and adjacent facilities) on a wide scale meeting environmental requirements for a natural resource is exploited not only in the least detrimental way for the biota but also with marked advantages to wildlife. A large saltworks looks like a natural park, the ecological equilibrium of which is maintained by skilled saltmen.
A large saltworks permits, due to the location, the size and the shape of the various ponds, their connection or their integration in a much more complex ecosystem of wetlands and makes sure that unique biotopes will not be disturbed by human presence (tourism) or intensive activities (agriculture, fisheries). Nowhere is the sustainable development principle better implemented than in modern saltworks with their hypersaline fields properly managed. Salt lakes and saltworks are "the epitome of all types of wetland" (Petanidou).

2.1. Landscape

Along certain coastlines, there is a continuous littoral sand drift. At estuaries, upland storm water drains into the sea during the wet season (winter rain). Sand accumulation on the shore is to form a bar, which will casually cut off the backwater from the sea. The solution to the related problem is direct pumping, which prevails for sea water intake within the natural framework of various modern saltworks. Where certain primitive or rudimentary saltworks are affected by such altered conditions in salt making, production is generally interrupted and the biological requirements of animal and vegetal life are no longer met. Brackish water has a detrimental effect on a number of species and the absence of water flow management as well (Portugal, Italy).
Plenty of rivers flow into the Mediterranean Sea. The control of the water flow up the river is sometimes contributing to increased erosion of the coast line. For

a number of years[6], the recession of the Camargue coast has been increasing. The reason for this phenomenon lies in the control of the flow of the Rhone river thanks to the construction of several dams. The alluvial deposits brought formerly by this river and its tributaries like the Durance river, most of torrential type, are now trapped upstream. An acceleration of the erosion process has induced Salins du Midi, known to operate large saltworks at Salin de Giraud and at Aigues Mortes, to investigate the ways and means to protect the littoral against the consecutive loss of land.
Land stabilisation and protection are of importance for the saltworks (water transit and evaporation) and for the whole ecosystem at risk of destruction. Should the owners of such large estates have not developed a protection system in order not to have their salt producing capacities destroyed, nothing would have been done in due course to stabilise the coastline. The solution consists in a combination of dykes and jetties of alternatively 90 and 50 m positioned every 200 m.

2.2. Biota

The solar evaporation of sea water is not only a physical process regulated by man to better produce salt. Mention has also to be made of an organic contribution from the biological communities within the pond system. Their contribution to the evaporation process can influence the production of salt in a beneficial way or in a detrimental one. The quality and quantity of the salt production is strongly influenced by the hydrobiological activity in solar salt operations.
Modern saltworks with large salt ponds and brine control deserve environmental praise for they facilitate the biological diversity of organisms in relation to various factors that are operative from feeder canal (sea water intake) to crystallisers (salt).
High salinity and low nutrient availability are two major parameters known to increase from a chronological point of view in primitive or artisanal saltworks and a limited number of species is in a position to resist to this environmental stress and to survive there. In large salt fields, these parameters are governed by space, varying from pond to pond, so that the species are well adapted to the limiting impact of changes in biotic factors. Experts (Davis, Sorgeloos) recommend that ponds be arranged in " several series of anastomosing or diverging circuits ". Such arrangements allow different flow rates (brine), and permit selective maintenance of the ponds without impacting negatively on biota and salt yield.
As already emphasised, the salt field is a global ecosystem. Its interest is not restricted to life within the ponds. The biota that constitute the ecosystem are closely interrelated and interdependent, should they be autotropic or heterotropic. Autotropic organisms are supported by their own production. Heterotropic organisms are depending on the production of organic matter by the former or generated by other systems.
There are different tropic levels, which are briefly reminded to the reader in appendix 5. There is no need to focus on the corresponding species except for

[6] At least, since 1744...

addressing the birds considered as an illustration of what can happen. The birds are attracted by saltworks, which constitute a large wetland complex because there is a combination of positive factors directly benefiting to them in terms of nesting or breeding sites and constant protection (no traffic, no hunting). The situation is somewhat different in traditional saltworks with small scale production. where there is a constant back and forth motion. Moreover, certain bird species are polluting salt (dejection, feathers). As they also frequent land-fill sites where a number of organic wastes are released, their role is rather detrimental for salt quality whereas cottage production is rarely washed.

2.3. Man

From both ecological and anthropological viewpoints, there is no conflicting situation when and where salt production and the conservation of nature are sensitive to the same considerations and the same regulations[7]. A sine qua non condition is the choice offered by a large salt field to maintain the ecosystem free from uncontrolled human access (tourism and tourism-related activities like marina establishment).

This attitude is systematically reinforced by a close cooperation between salt producers and researchers like biologists and ornithologists. This cooperation includes the extensive use of given areas for birdlife observation, the production of leaflets and brochures for the visitors, the construction of observation huts, the systematic recording and description of species and tropes, the drafting of maps, and the issue of appropriate studies for substantiating this common love of nature.

CONCLUSIONS

The interaction between salt production and nature protection is a matter of fact. The point is to make sure that the size of the saltworks meets the requirements of the corresponding ecosystem. Cottage production of sea salt is no longer appropriate for it does not pave the way to quality, which is neither controlled during the process nor later on. It seems to be an alternative to mere abandon. It fails to bring elements for a positive solution. Since it is only aimed at ecosystem preservation or conservation, it tends to subordinate agricultural standards to environmental conditions. The requisite conditions for well-designed saltworks are no longer brought together due to this very subordination. Moreover, huge human presence (cottage production is labour intensive, and ecotourism is based on numerous visitors) is known to have a disturbing effect on various species. What has been admitted as a temporary solution in a few sites would not be applicable as a general recommendation.

The priority consists in leaving salt producers operating large salt fields to do their best by taking harmoniously into account nature protection and market satisfaction.

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[7] The major references for the European Union are the Directive 79/409/EEC on wild birds and the Directive 92/43/EEC on flora, fauna, and biotope.

[8] Aristoteles, Meterologicon, I,14.

Other considerations based on longer term have also to prevail. "The same parts of the Earth are not perpetually wetlands or dry areas. Changes are taking place, indeed. The sea and the Earth are not unvariable. Today the sea reaches a place which has been seen as a continental one in the past. And this land will emerge again in the future[8]". The surface of the sea is very unstable. Climate alteration is presumably the main cause of eustatic changes. The deformation of the Earth's crust by tectonic movements produces relative sea level changes that differ from place to place.

Assemblages of fresh water, brackish and marine biotas are good indicators of sea level evolution, and beach rock too. Botanical macroremains contribute to sea level reconstruction by determining the former degree of salinity. Archaeological vestiges and historical data concerning salt-related activities (construction of marine fishtanks, ceramic used for garum distribution) have also proved to be useful in estimating the above-mentioned changes.

Initiated in the late Holocene Age, a number of sea level changes have modified human occupation around the Mediterranean basin. A great part of what is now Adriatic Sea was then a wide fluvio-lacustrine plain. Sicily was separated from Tunisia by narrow straits. Most of the Aegean islands were part of the mainland. In the same line, regions like Sahel or Yemen, which are now known as arid, saline and inhospitable areas, had been attractive and suitable for man sedentarisation. This was shown recently by lacustral sediments identified in the Al Hawa area, which depends on the Ramlat as Sab'atayn desert. Around 8,000 BC, a lake was there thanks to climatological factors like important precipitations (monsoon). The present Agorgott sebkha corresponds to a former saline lake situated in the Taudenni basin between 8,200 and 3,800 BC. The salt deposits left when the lake evaporated are still mined and salt tiles sold in Mali.

Since Holocene, some things have changed. The environmental compliance is not enough to secure raw material supply. Continuous improvement implies that any site with marginal importance for salt production be evaluated with respect to site-specific objectives. An airport does sometimes make sense for economic development and employment.

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APPENDIX 1

A TENTATIVE TYPOLOGY FOR SOLAR SALT WORKS

☐ **Salt works of the Portuguese (Aveiro) type**

- small size of the ponds
- independant crystallisers
- salt gathered frequently (by hand)
- limited duration of the harvest

☐ **Salt works of the temperate climate type**

- large condensers and crystallisers
- crystallisers in series
- mechanisation (havesting machines)
- limited duration of the harvest

☐ **Salt works of tropical (or pertaining to the desert) climate type**

- variable but rather large ponds
- harvesting machines whenever possible
- unlimited duration of the harvest (salt floor)

APPENDIX 2

CURRENT STATUS OF MEDITERRANEAN SALT WORKS

Primitive salt works
- Kythira salt works

Semi-traditional salt works
- Tourlis salt works

Fully mechanised salt works
- Messolonghi salt works
- Kitros salt works

Source: Th. Petanidou, Conserving nature, we produce salt throughout Greece (Hellenic Salt Works), 1994.

Primitive salt works
- Xweini salt works, Gozo (Malta)

Rudimentary salt works
- Port Said salt works (Egypt)

Traditional salt works with small scale production
- Efni salt works (Lebanon)

Modern salt works with large scale production

➢ enlargement or revamping of traditional salt works
- Aigues Mortes (France)
- Margherita di Savoia (Italy)

➢ recent salt works
- Salin-de-Giraud (France)

Salt works lying idle

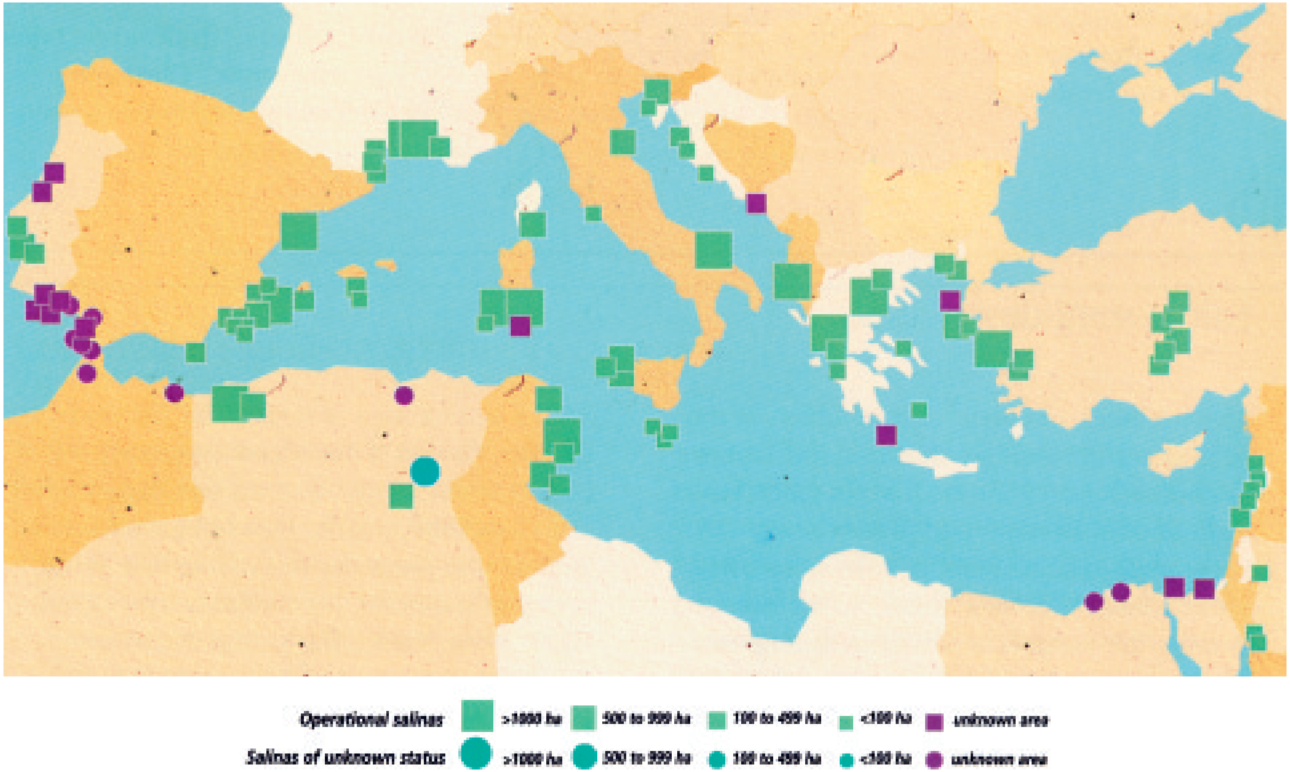
➢ turned into aquaculture
- Sicily
- Huelva area (Spain)

➢ museum
- Secovlje, Piran (Slovenia)

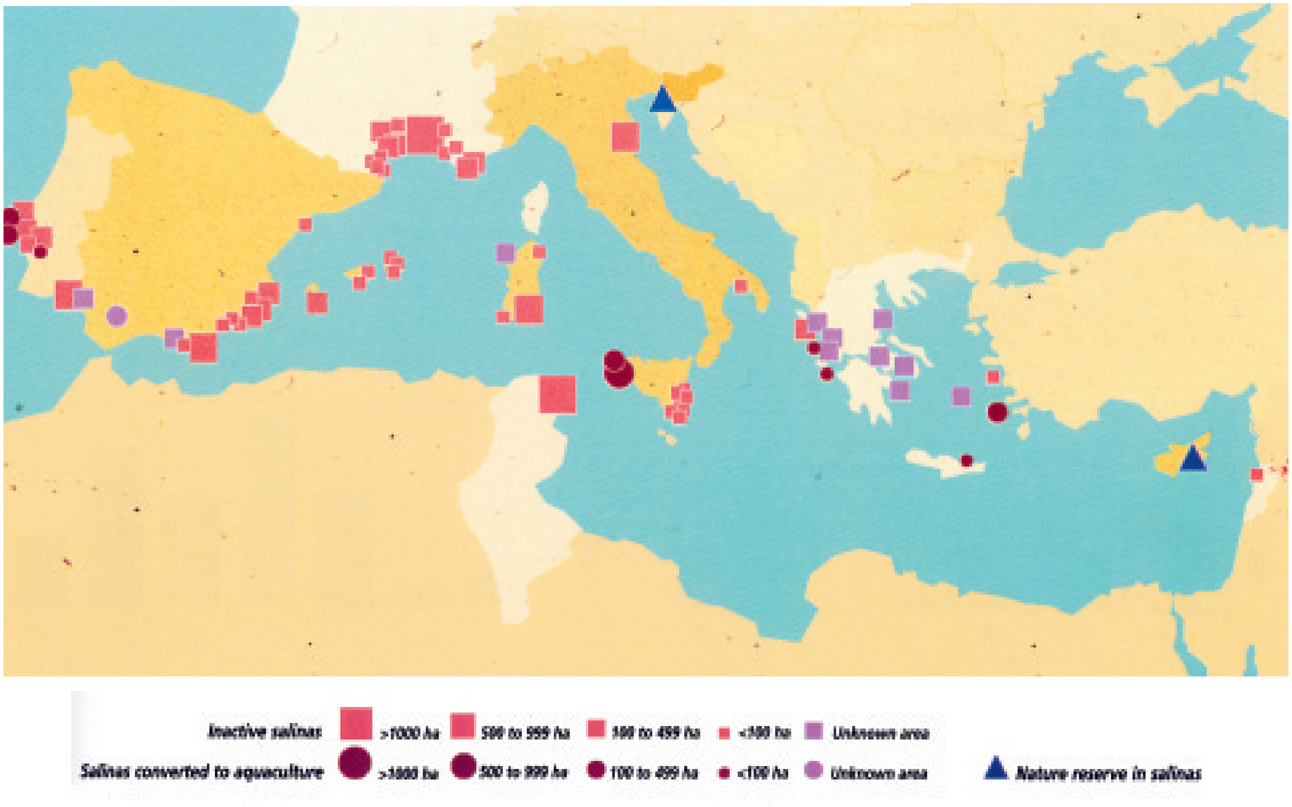
➢ wild

Source: N. Saboul, J. Walmsley, B. Charpentier, Les salins, entre terre et mer (Med Wet), 1998.

APPENDIX 3


Operational salinas
>1000 ha
500 to 999 ha
100 to 499 ha
<100 ha
unknown area
Salinas of unknown status
>1000 ha
500 to 999 ha
100 to 499 ha
<100 ha
unknown area

APPENDIX 4


Inactive salinas
>1000 ha
500 to 999 ha
100 to 499 ha
<100 ha
Unknown area
Salinas converted to aquaculture
>1000 ha
500 to 999 ha
100 to 499 ha
<100 ha
Unknown area
Nature reserve in salinas

APPENDIX 5

DIFFERENT TROPIC LEVELS IN A SOLAR SALT FIELD

☐ **1st tropic level**

- organisms living in saline water
(phyptoplancton, microscopic algae)
- halophyties
(halophilous plants)

☐ **2nd tropic level**

- a variety of species depending on water salinity
(aquatic insects, shrimps)

☐ **3rd tropic level**

- fishes and birds

☐ **4th tropic level**

- organisms that break down organic matter into inorganic elements
(recycling); they form the substratum for the growth of bacteria and fungi.