THE ECOLOGICAL IMPORTANCE OF MEDITERRANEAN SALINAS

by John G.Walmsley

Consultant for Mediterranean Salinas & Seabird Specialist
La Bergerie, Mas de Petit Badon, 13129 Salin-de-Giraud, France.

INTRODUCTION

The production of salt is one of the oldest industries known to man, and is an essential dietary element in our daily lives. Natural salt deposits are found in many European countries in underground sedimentary rock formations and above ground in natural salt lakes and depressions. Salt is also produced in

A salt mountain in an Industrial Salina.

Salinas, a man-modified habitat generally found in coastal wetland regions of the world. Contrary to expectations, only a small amount of salt is exploited from the natural sites, while every effort is made to exploit salt from underground salt mines and from man-made salinas. Thus over the centuries salt production has been influencial in shaping the landscape of the Mediterranean coastline.

SALINAS CLASSIFICATION

Mediterranean salinas can be classified by their geographical location, size, management, and the quality and quantity of salt produced. In addition to the natural Salt lakes and inland salt mines, five salina types/categories have been identified by the author around the Mediterranean and Atlantic coastline (Table 1).

Inland Salt Mines are widely distributed throughout Europe and where salt is extracted in the form of rock salt and brine. The large Salt Lakes and depressions (sebkhas & chotts) occur in semi-arid regions of North Africa and Asia.

Table 1. Mediterranean Salina types/categories, their location and description.

Salina types/ Categories	**Geographical location**	**Salinas description & salt produced**
Inland Salt Mines & Salinas	Throughout continental Europe	Underground Salt deposits in sedimentary rocks producing Rock Salt & Brine.
Natural Salt Lakes & Depressions	North Africa & Asia	Crystalized Salt produced under natural evaporation conditions.
Primitive Saltpans or Salinas	Mediterranean & Atlantic coasts	Hand-made saltpans on rocky coastlines producing Salt- flakes & Crystalized Salt.
Rudimentary Saltpans	Southern Mediterranean coastline	Small roughly excavated lagoons (<1ha.) on low-lying coasts. Crystalized Salt is extracted byhand.
Artisanal Salinas	Mediterranean & Atlantic coasts	Series of small lagoons separated by narrow artificial dykes. Crystalized Salt & Salt flakes are extracted by hand.
Industrial Salinas	Mediterranean & Atlantic coasts	Large complex lagoon systems, fully mechanized, modern and highly productive. Smaller semi-mechanized salinas included. (Crystalized Sea-salt)
Inactive & Abandoned Salinas	Mediterranean & Atlantic coasts	Salt production has been phased out as a result of modernisation of industrial salinas.

In wet years these saline lakes have a rich biological productivity and are attractive to waterbirds, especially Flamingos Phoenicopterus ruber roseus. In dry years the high summer temperatures and intensive evaporation conditions transform these lakes into vast areas of crystalized salt. In the coastal Mediterranean strip, salt crystals found in rock pools must have inspired man to create the first Primitive Saltpans or salinas on rocky coastlines, strategically sited in areas with strong onshore winds. In the low-lying coastal areas along the southern and eastern Mediterranean shoreline, Rudimentary Saltpans and small traditional Artisanal salinas were created to fulfil the needs of the local population. In the northern and central Mediterranean many small Artisanal salinas

were exploited by families and local communities. The more productive of these were later sold and amalgamated to form the large modern Industrial Salinas of today. During the last 50 years salt production has been phased out in many small non-profitable salinas, thus creating another category of inactive or Abandoned Salinas. For a more detailed description of Mediterranean salinas see Walmsley (1997) and Sadoul et al. (1998).

SALINAS DISTRIBUTION & SALT PRODUCTION

A recent survey of Mediterranean salinas (Sadoul et al. 1998) has revealed the existence of at least 170 salinas of all categories in 18 Mediterranean countries. More data is needed from southern and eastern countries (Syria, Lebanon and Libya) to complete the picture. We now have information for 165 salinas, (90 salinas are still producing salt and 64 are inactive or abandoned salinas). Of the 90 active salinas 75% are located in northern and central Mediterranean countries, Spain, Greece, Italy, France and Portugal total 77%, while other countries have fewer than 10 active salinas each. Salinas vary considerably in size, from rudimentary saltpans of less than 1 ha. to the large modern industrial salinas of 11,000 & 12,000 ha. in southern France. Of the 64 abandoned salinas, 83% have a total surface area of only 9,230 ha. 11 salinas in Portugal, Spain, Italy and Greece have been transformed completely or partially into fish-farms and only 3 salinas (Cyprus, Slovenia & Italy) have so far acquired nature reserve status. The annual production of salt in the Mediterranean is approximately 7 million tons. France is the highest producer with nearly two million tons, followed by Turkey, Spain and Italy. These four countries produce 84% of all Mediterranean salt. Greece is ranked sixth with a total production of between 200-300,000 tons of salt per year. Although Greece has more operational salinas than France, the total surface area and annual salt production are much lower. Despite the fact that salt can be produced throughout the year in southern Mediterranean countries, there are numerically more salinas producing a much higher annual salt harvest in the northern Mediterranean countries.

THE SALINAS ENVIRONMENT

In the Mediterranean region, coastal wetlands and salinas continue to disappear as the demand for prime development land for industrial and urbanisation projects continues. For many years salinas were considered only as factories producing salt, the principal aim of any salt manager is to create optimal conditions to produce a maximum tonnage of salt per annum. The existing modern or industrial salinas cover large areas of land that were formerly natural, temporary and permanent wetlands in river deltas and coastal lagoon systems. The transformation from brackish water to saline habitats, has altered the composition of the flora and fauna communities and populations, and during the modernisation process, has also deterred some waterbird species from remaining in hypersaline habitats.

Each salina has its own chemical and physical environment and surface area, with large and small lagoons and canals separated by artificial dykes. In the

Exposed dessication mats of organic mud in low-salinity lagoons.

small traditional artisanal salinas the dykes are small narrow footpaths, but in large industrial salinas the dykes are wide enough to support heavy vehicles and maintenance machinery. Water depths are generally shallow between 30-50 cm and rarely above 1 m except in some canals. Strong winds can however displace large amounts of water, thus causing an increase in the water depth on the down-wind side of the larger lagoons and a drop in water level on the up-wind side, sometimes exposing large areas of mud. These "wind seiches" also play an important role in determining the distribution of the benthic fauna and its availability to feeding waterbirds.

In industrial salinas, windmills, fuel pumps and water wheels that were once used to raise and circulate water through canals and sluices, have now been replaced by computor controlled powerful electric pumps. The water depth and salinities however are still controlled daily by teams of experienced " Sauniers ". Each salina generally comprises of 3-4 principal salinity gradients (low, medium and high salinities & saturation in the crystalizing lagoons). In the low salinity lagoons (c. 30-70 g/l) close to the sea, the substrate is chiefly sand. In lagoons with a medium salinity range (70-140 g/l) the sand and alluvial sediments are covered by deposits of organic mud and in shallow waters Cyanobacteria (blue-green algae) develops (Britton & Johnson 1987). In autumn many low salinity lagoons are drained exposing a carpet of organic mud which forms desiccation mats. In salinities of >150 g/l gypsum ($CaSO_4$) forms a crystalline crust on the bottom of the lagoons. In the hypersaline lagoons, when the water densities reach saturation (>300 g/l), there is a precipitation of halite (NaCl) down through the water column in those lagoons where the salt is harvested. Water temperatures are seasonal and vary considerably from -2° to -10°C in winter to +25° to +33°C in summer.

ECOLOGICAL IMPORTANCE OF SALINAS

When assessing the ecological importance of Mediterranean salinas for waterbirds and animal and plant communities in relation to salina categories, we can eliminate the underground salt mines and their associated small salinas filled

Abandoned salinas would make ideal nature reserves.

with brine. Apart from the historical, cultural and aesthetic value of primitive salinas, relatively small numbers of short stay migrants and locally resident species will frequent these sites. The same applies to rudimentary saltpans, because of their location some locally breeding and migrating birds will frequent these small lagoons. Natural salt lakes have a high ecological value for waterbirds when the conditions are right. After high winter rainfall these " brackish " lakes attract large breeding colonies of waterbirds, especially flamingos. The large industrial salinas have a very high ecological value, due to the fact that they are artificial but nevertheless stable habitats, which attract coastal breeding seabirds and shorebirds, many migrating species and overwintering birds. In western Mediterranean countries artisanal salinas support few breeding waterbirds, because they are visited daily by salt workers during the summer months. Once the salt is harvested in late autumn, these salinas become important feeding and overwintering sites for thousands of shorebirds. This is particularly true for salinas in southern Portugal, which attract species like the Black-winged Stilt *Himantopus himantopus* and Avocet *Recurvirostra avosetta* (pers. obs.). After several years without producing salt, abandoned salinas become less attractive to breeding waterbirds, water circulation ceases and many lagoons dry out and there is also a decline in the number of passage and overwintering species. Despite the loss of biodiversity, their ecological value remains high, because of their potential as nature reserves. With proper management biodiversity can be restored in abandoned salinas. Table 2 summarizes the ecological values of the different salina types/categories.

With the exception of the natural salt lakes, it is clear that the salinas with high ecological values are the Industrial, Artisanal and Abandoned salinas. The physical characteristics and management of salinas provide important indica-

Table 2. The ecological values of salinas for waterbirds.

Salina types/ Categories	**Ecological values**	**Importance for Waterbirds**
Inland Salt Mines & Salinas	None *	None ? infrequent
Primitive Saltpans or Salinas	* *	Occasionally frequented by waterbirds
Rudimentary Saltpans	* *	Occasionally frequented by waterbirds
Natural Salt Lakes & Depressions	* * *	Important numbers of breeding, feeding, passage & wintering species
Industrial Salinas	* * * *	Important breeding, feeding, and wintering sites for coastal seabirds & shorebirds
Artisanal Salinas	* * *	Few breeding species, but important wintering sites for shorebirds
Inactive & Abandoned Salinas	* * *	Support breeding, feeding & wintering seabirds & shorebirds

Ecological values: * insignificant, * * low, * * * high, * * * * very high.

tors that tell us why seabirds and shorebirds are attracted to these sites. Each salina has its own clearly defined characteristics, comprising of a surface area, a series of relatively shallow lagoons and canals separated by dykes and a range of salinities (c. 30 g/l - >300 g/l). Formerly there were numerous natural and artificial islands in the lagoons, sparsely or completely covered with halophytic vegetation. On the higher dykes *Salicornia and Sueda* are the dominant species. Management techniques vary according to the type of salina and the quantity and quality of salt produced. In southern and eastern Mediterranean countries salt can be produced throughout the year because of the relatively high temperatures. In northern Mediterranean countries, extreme temperatures, high precipitation and low evaporation rates characteristic of the winter months are unsuited to salt production. In autumn low salinity lagoons are drained and excess hypersaline water is stored in reservoirs throughout the winter. During periods of heavy rain low salinity water will form in the drained lagoons, thus creating ideal feeding conditions for resident and overwintering aquatic species. The annual salt production in industrial and artisanal salinas therefore provides stable conditions in which the aquatic flora and fauna have adapted to. In the largest European salina (Salin-de-Giraud 12,000 ha.) in southern France, 25 invertebrate taxa have been identified and recorded. One species the Brine Shrimp *Artemia* has adapted particularly well to an annual salt harvest and management. The adult population dies as the water temperatures drop in late autumn and winter, the next generation overwintering in the form of resistant cysts protected by a thick membrane that allows them to survive even in extreme dry conditions (MacDonald 1980). The following spring seawater is pumped and circulated throughout the salina, and combined with the rising tempera-

The formation of a breeding colony of Flamingos on an artificial island in an industrial salina. Displaying birds in the foreground.

Artemia adults and cysts are the principal food source for many waterbirds in salinas.

tures the naupliae hatch from the cysts. By mid-summer there is a super abundance of *Artemia* throughout the range of salinities. Artemia is also the principal food source of many waterbirds, especially for Flamingos, Shelduck, Avocets, Black-winged Stilts several gull species and shorebirds. The presence of Artemia in any salina, is an important critierion when assessing the ecological importance of salinas in the Mediterranean.

Mediterranean salinas support important breeding colonies of waterbirds of Mediterranean and European concern. They comprise mainly of the order *Charadriiformes* and include the family *Laridae* (gulls a terns) which are short-legged and web-footed birds of the open sea, seashore and coastal lagoons. There are also shorebirds which are small to medium size birds with relatively long legs and bills.

The nest-site preference of some 20-30 species that regularly breed in a northern Mediterranean salina are the natural and artificial islands and dykes. There are several species of tree-nesting herons in pinewoods, and beach-nesters like the Little Tern and several shorebird species have now moved into the relative

Black-headed Gulls and Sandwich Terns breeding on a raised dyke in an industrial salina.

Winter rainfall provides ideal feeding and roosting conditions for flocks of overwintering shorebirds.

safety of salinas, away from the overcrowded tourist beaches. A more complete list of species that frequent Mediterranean salinas has revealed about 18 families comprising of over 100 species. Approximately 500,000 migratory and overwintering shorebirds spend the winter months in the Mediterranean, over half of them occur in salinas (Sadoul et al. 1998). The scarcity of the inter-tidal zone of the Mediterranean Sea, means that salinas play an important role in the annual cycle and conservation of shorebird populations, by providing major stop-over and resting places for the reconstitution of fat reserves of these long distance migrants.

ECOLOGICAL STUDIES

During the last four decades, Dr. Hoffmann (WWF) and his team of researchers at the Tour du Valat Biological Station in the Camargue, together with the Compagnie Salin du Midi (CSME), have worked together towards improving our knowledge of the chemical and biological processes of salt production and the

ecological requirements of waterbird populations in natural and man-modified saline habitats. Besides initiating ecological studies in the Camargue, Hoffmann (1958) published "An Ecological Sketch of the Camargue" and in 1964 described the biological value of an industrial salina (Salin-de-Giraud). Even then, it was clear that proposals for an integrated management of salinas would considerably enhance their conservation value (Hoffmann 1964).

The creation and management of an artificial island for Flamingos *Phoenicopterus ruber roseus* (Johnson 1982) is one of the most successful population recovery projects in the Camargue, which has attracted the attention of international organisations and the general public (Johnson 1975). The West Mediterranean Shelduck *Tadorna tadorna* population has also recovered after protection measures were enforced in France in 1962 (Anon 1962, Roux 1964), the Camargue salinas acting as a refuge and an important breeding site (Walmsley 1987 & 1993). Shelduck feeding studies during the winters of 1977-78 and 1978-79, based on faecal analysis and direct observations in the field, showed that the most important food types taken were brine shrimps *Artemia* and cysts, algal bioderm *Cyanophyceae* and aquatic beetles *Coleoptera* (Walmsley & Moser 1981).

Salinas also have characteristic plant, invertebrate and vertebrate communities, which are comparable to other Mediterranean saline habitats and show fixed seasonal patterns, species representation and distribution throughout the annual cycle. In the Salina of Salin-de-Giraud a summer survey of the invertebrate fauna (Britton & Johnson 1987) produced a total of 25 identifiable taxa of invertebrates. As one would expect, the species recorded decreased as the salinity increased, the majority of species occurring within the 40-150 g/l salinity range. At salinities above 300 g/l *Artemia* was the only species present, the next generation overwintering in the form of resistant cysts or eggs (MacDonald 1980).

Blondel & Isenmann (1973) studied the structure and composition of a breeding population of Laro-limicoles based on 5 census years. Their results showed a substantial increase in the biomass of birds, and related this to the rich food resources, as a result of important modifications to the Camargue ecosystem.

Today the emphasis is on species protection and habitat management for coastal breeding seabirds and shorebirds, which form large mixed colonies and comprise a number of threatened and endangered species. Over the years habitat loss in Mediterranean salinas has increased. This is particularly true of small natural and artificial islands in industrial salinas, which have been leveled to create large open areas of water. These islands constitute the most preferred breeding sites for waterbirds and are the least disturbed by human and animal predators (Fox, wild Boar etc.). Dykes are used as breeding sites only when traditional island sites disappear, or when islands become too overgrown with vegetation. Nest site competition and predation are other factors that limit the breeding success of waterbirds. The Yellow-legged Gull *Larus cachinnans* has adapted particularly well to the salinas habitat, with the result that there has been a spectacular population increase throughout Mediterranean France. It is also a problem species because of its predatory behaviour on other species, and

A colony of Slender-billed Gulls breeding on a dyke used by vehicles and heavy maintenance machinery.

Restored dykes are favourable breeding sites for seabirds and shorebirds.

its occupation of much of the available breeding habitat that still exists in salinas (Walmsley & Duncan 1993).

Mediterranean salinas are only now being recognised as important artificial wetland habitats. Pilot studies are also being initiated to restore lost habitat and maintain stable populations of waterbirds and plant and invertebrate communities. In 1990 the Hellenic Saltworks began a restoration project for the Messolonghi Saltworks, as part of an integrated management plan for the Messolonghi - Etolikon coastal wetland area. The principal aims were to restore lost habitat for coastal breeding seabirds and shorebirds and to maintain biodiversity in the natural and artificial wetland areas.

A recent LIFE project for the restoration of the Pialassa della Baiona lagoon system north of Ravenna, Italy, involved the Municipality and Province of Ravenna and the Mediterranean Seabird Association MEDMARAVIS (NGO). The aims were to restore the inflow and outflow of this inter-tidal lagoon system by dredging the two main canals of sediments. Artificial islands were also constructed to allow a better circulation and flow of the tidal waters and the islands managed for coastal breeding seabirds and shorebirds. This project has been extremely successful, in 1998 the islands were occupied by 600 breeding pairs of 5 species

of waterbirds, which increased to over 2,000 pairs in 1999 (Santolini et al. in press). Formerly the only available breeding habitat in the Pialassa della Baiona lagoons were the 100 plus shooting hides and platforms. A mud-flat was also created to attract migrating shorebirds as a feeding and roosting site. The occupation of these artificial habitats by birds, coincides with an important decline of species breeding in the Po Delta region (Fasola pers comm.).
In the western Mediterranean the Albufera de Valencia Natural Park, Spain, is a coastal wetland lagoon and RAMSAR site of over 3,000 ha. A 64 ha saltmarsh (Raco de l'Olla) has been managed for waterbirds since 1992. Several artificial islands constructed in the reserve now attract several thousand pairs of coastal breeding seabirds and shorebirds each year (Dies, in press). These successful Italian and Spanish pilot projects are clear indications that there is the need to restore lost habitat for coastal seabirds and shorebirds. They also show that practical management projects can be implemented at little cost in other natural and artificial wetland sites in the Mediterranean region.

CONSERVATION OF WATERBIRD POPULATIONS

Industrial salinas cover large areas of land that host populations of rare, endangered and protected wildlife species. The owners and managers of salinas automatically become the custodians of this wildlife, which at times may lead to conflicting situations between the needs for salt production and conservation. It is important therefore to build and maintain good relations between industrialists and biologists through dialogue, so that solutions to conflicts can be found, that will allow both salt production and conservation to be harmonized at reasonable costs.
A typical case study in France, revealed that the destruction of breeding islands for coastal seabirds and shorebirds has forced many species to breed on less favourable sites on dykes bordering the lagoons, from which the crystalized salt is extracted. A conflict arose during the chick-hatching period, when many hundreds of chicks fell into the hypersaline water. The chicks were unable to return to the dykes, the down and feathers became clogged with salt and they died. The birds were accused of "polluting and reducing the quality of the salt". A further conflict arose later in the breeding season as the adult terns and gulls began to moult their body feathers, which were blown into the salt water. During the next two years I was able to considerably reduce chick mortality by implementing practical management methods, in this case by erecting a 20-30 cm high netting along the side of the dykes, which stopped the chicks from falling into the brine. For some species it was possible to attract them to breed in less sensitive sites away from the crystalizing lagoons, by using artificial tern and gull decoys made from one of the polstyrene composites (Walmsley 1994).
For the Messolonghi Salina I recommended that artificial islands be constructed and certain dykes restored, without interfering with salt production and management. The profiles of the islands were also designed so that they did not inhibit the water flow. I was later informed that several islands were constructed and that waterbirds did breed on them, but unfortunately there was no follow-up to this project.

Protective netting on the edge of salt lagoons can prevent chicks from falling into the hypersaline water.

Artificial islands need to be budgeted for and managed for the target species one hopes to attract. In spring coastal seabirds and shorebirds associate together and form large mixed breeding colonies. Within these colonies each species has its own micro habitat which is the nest site. Artificial islands may start off as open areas of dried mud or sand mixed with gravel and shells, but will change as vegetation becomes established. This process will accelerate as the higher emergent plants take hold. If there is no intervention the vegetation cover will increase and open areas will decrease. Changes may also occur in the avian species composition. Little Terns and Avocets prefer the more open sites, while gulls and other terns can support a certain amount of vegetation. Without proper management however, the biodiversity of species and numbers breeding on artificial islands can quickly decline if the islands are allowed to become too overgrown.
There are other examples of habitat and nest-site management in Mediterranean salinas and wetlands that show what can be achieved with close cooperation and collaboration. Once islands are occupied, a monitoring programme of the breeding populations will provide opportunities for long term studies of population dynamics in these important functional wetland sites.

CONSERVATION OF MEDITERRANEAN SALINAS

Mediterranean salinas are national heritage sites with cultural, economic and aesthetic values in which biodiversity can be maintained. Active salinas are also functional wetlands where salt production and conservation are closely linked to world trade and to competition within the salt industry. The existing salinas are today considered as prime development land for industrial and urban development projects.

The acquisition and transformation of abandoned or inactive salinas into lucrative fish-farming enterprises is expanding in the Mediterranean (Spain, Portugal, Italy and Greece). Combining salt production and aquaculture is at present an unknown quantity and one that should include strict measures of control. Fish-farms and aquaculture cover a range of species from aquatic plants to fish, molluscs and crustaceans, grown or reared in closed cages, ponds and salt lagoons in salinas. Creating the right conditions for introduced species is one thing, but confining them to a given number of lagoons is more difficult, especially in an intricate saline ecosystem. If species escape and reproduce, it could cause an imbalance and possible decline of the original aquatic flora and fauna. The long term effects may even result in the complete disappearance of *Artemia* populations and other aquatic invertebrates, and a decline in the number of seabirds and shorebirds.

Fish-farming and salt production are not compatible. Well established fish-farms inhibit the natural functioning of biological productivity and consequently there is a major loss of biodiversity. Waterbirds, especially fish-eating species are considered as pests and illegal methods (shooting, barbed wire, nylon lines) are used to dissuade protected species from frequenting these sites.

Before any more salinas disappear, inventories should be made of all salina types, combined with environmental impact studies (EIAs) that will show which are the ecologically important salinas. Further analyses can be made to select sites as future nature reserves and those that can be transformed into fish-farms.

Several years ago I prepared a project proposal aimed at the conservation of the flora and fauna of Mediterranean salinas. It also aimed at producing a Mediterranean Salinas Directory that could be used as a conservation tool, to protect an international network of ecologically important salinas. On a national level, salinas directories can be compiled by implementing the guidelines of this project. I would strongly recommend that Greece, which is one of the leading salt producing countries in the Mediterranean, collaborates in this worthwhile project. Once all the data has been gathered, it will be possible to draw up a list of priority salinas for the conservation of wildlife communities. They will also be included in a national inventory of fully protected sites, where economic objectives are harmonized with conservation and management. Finally, an international inventory of all priority salinas in the Mediterranean can be drawn up and proposed as a list of important Mediterranean wetlands to be protected by the International Conventions.

REFERENCES

Anon, 1962. Protection de la Bernache Cravant et du Tadorne de belon en france. Bulletin d'Information, Bureau International de Recherches sur la Sauvagine. Newslatter No.16: 18.

Blondel, J. & Isenmann, P. 1973. L'èvolution de la structure des peuplements de Larolimicoles nicheurs de la zone saumâtre de Camargue. Terre et Vie, 27: 62-84.

Britton, R. & Johnson A.R. 1987. An Ecological Account of a Mediterranean Salina: the Salin de Giraud, Camargue (S.France). Biological Conservation 42: 185-230.

Dies, J. I. (In press). Habitat management for gulls and terns at Albufeira de Valencia, Spain, preliminary results). In: (Eds) P. Yesou & J. Sultana, Proceedings of the 5th MEDMARAVIS Pan-Mediterranean Seabird Symposium, Malta, 29 Sept.-3 Oct. 1998.

Hoffmann, L. 1958. An Ecological Sketch of the Camargue. British Birds, vol. LI: 321-349.

Hoffmann, L. 1964. La valeur des salins comme milieux biologiques. Project Mar, I.U.C.N., N.S. 3: 410-413.

MacDonald, G. H. 1980. The use of *Artemia* cysts as food by the Flamingo *Phoenicopterus ruber roseus* and the Shelduck *Tadorna tadorna.* In The Brine Shrimp *Artemia salina,* 3.Ecology culturing, use in aquaculture, (eds.) G.Persoone, P.Sorgeloos, O. Roels & E. Jaspers, 97-104. Wetteren, Belgium, Universa Press.

Johnson, A.R. 1975. Camargue Flamingos. In: (Eds.) J. Kear & N. Duplaix-Hall, Flamingos, T. & A.D. Poyser, Berkhamsted, U.K. 246p.

Johnson, A.R. 1982. The construction of a breeding island for Flamingos in the Camargue. In: D.A. Scott (ed.), Managing Wetlands and their birds, 204-208. International Waterfowl Research Bureau, Slimbridge, U.K.

Roux, F. 1964. Situation du Gibier d'Eau (Anatides) en France Continentale et Atlantique en 1963. First European Meeting on Wildfowl Conservation (Proceedings), St. Andrews Scotland 16-18 Oct. 1963. 51-58.

Sadoul, N, J.G. Walmsley & B. Charpentier 1998. Salinas and Nature Conservation. Conservation of Mediterranean Wetlands No.9, Tour du Valat, Arles (France), 96 pages, (In French & English).

Santolini, R., P. Boldreghini, X. Monbailliu, A. Vistoli & J.G. Walmsley (In press). Prime nidificazioni su dossi artificiali nella Pialassa della Baiona (RA). Avocetta.

Walmsley, J.G. & M.E.Moser, 1981. The winter food and feeding habits of Shelduck *Tadorna tadorna* in the Camargue, France. Wildfowl 32: 99-106.

Walmsley, J.G. 1987. Le Tadorne de Belon *Tadorna tadorna* en Mediterranee occidentale. L'Oiseau et R.F.O. Vol. 57, 2 : 102-112.

Walmsley, J.G. & P. Duncan 1993. Industrial Salinas in the Camargue and the conservation of breeding seabird populations: 285-293. In: Aguilar et al. (eds.), Status and Conservation of Seabirds. Proceedings of the 2nd Mediterranean Seabird Symposium Calvia, 21-26 March 1989.

Walmsley, J.G. 1994. Un approccio pratico alla gestione ambientale nelle Saline del Mediterraneo : 147-168. In: (eds.) X. Mobailliu & A. Torre, La gestione degli ambienti costieri e insulari del Mediterraneo. Edizioni del Sole, Collana, Mediterranea, 430 p.

Walmsley, J.G. 1997. Mediterranean Salinas, Distribution, Salt Production & Conservation. (In) Proceedings: Nature & Workmanship, Artificial Wetlands in the Mediterranean Coast. INSULA, UNESCO Building, Paris: 152 pages.

Salt production and conservation are compatible.