

Turning ecological management into economic value: The case of the Aigues-Mortes salt-marshes, Camargue, France

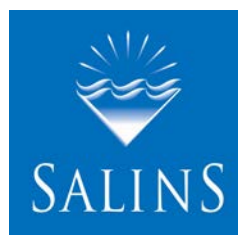
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The company Salins du Midi, affiliate of Salins Group, manages three salt-marshes in the South of France. Those sites represent an ecological interest of major importance in France and Europe. The hydraulic management is favourable to the reception of 230 species of birds, 300 species of plants, 21 species of reptiles, amphibians and mammals and at least 11 species of fish and a specific shellfish *Artemia salina* adapted to salty environments.

Since 2006, the company has implemented many actions to conserve that biodiversity especially on the Aigues-Mortes salt production site: the creation of 45 nesting islets, the restoration of 20 reproduction sites, the creation and maintenance of 200 artificial nests to attract Pink Flamingos, the installation of replicas to attract birds, actions to limit the disturbance by the Yellow-legged Herring Gull, the elimination of invasive plants, burying electrical cables, hydraulic restoration works, prevention initiatives in the work schedules so as not to disturb the birds and destroy the plants, protection barriers for protected flora, collection of waste and limiting visits. Salins du Midi also signed the Natura 2000 Charter, which is a tool for subscribing to the respect of good environmental practices over a 5-year period. For those actions, the company was awarded the “Prix Entreprises et Environnement” (Business and Environment prize) awarded by the French Ministry of Ecology in December 2013.

This type of ecological management allows for the development of several economic activities. Firstly, it increases the positive image of the company and its products. This is also a selling point in the framework of calls for tenders. The commitment to the Natura 2000 charter allows an exemption from the land tax what represents an important earnings each year. Since 2009, Salins du Midi has developed an ecotourism activity on the Aigues-Mortes site with a new 3-hour 4-wheel drive guided tour to discover the specific landscapes and the nature of the salt-marshes. The ecological management allows for a fishing activity. Thanks to the hydraulic management, fish can develop in permanent low salinity ponds and the *Artemia salina* shellfish develop in temporary high salinity ponds. In this case, the company is paid according to the quantities taken. Salt-marshes can also support new technology.

Since 2011, an experiment to create a new High Frequency Surface Wave Radar able to monitor maritime zones up to 200 nautical miles off the coast has been implemented. This radar could detect small boats, pollution and be a tool to follow the currents and tides. The tranquillity of places and the presence of permanent high salinity ponds were the main criteria for choosing the salt-marshes of Aigues-Mortes as the experimental site. It consists of an installation of wooden posts and cables used as the receiving antenna. For the moment, the Company rents a part of its grounds for the implementation of this project but

hopes to have more opportunities when this technology is finished. The company is still favourable to the development of new economic activities on the salt-marshes compatible with salt production and nature conservation.

1. ECOLOGICAL ACTIONS CARRIED OUT ON THE AIGUES-MORTES SITE

The company Salins du Midi, affiliate of Salins Group, manages three salt-marshes in the South of France. Those sites represent an ecological interest of major importance for France and Europe. The hydraulic management is favourable to the reception of 230 species of birds, 300 species of plants, 21 species of reptiles, amphibians and mammals and at least 11 species of fish and a specific shellfish *Artemia sp.* adapted to salty environments (Séjourné & Constantin, 2008; Séjourné, 2013). Since 2006, the company has implemented many actions to conserve this biodiversity especially on the Aigues-Mortes salt production site (Séjourné & Matrat, 2009; Séjourné, 2012).

1.1. Actions for 7 endangered nesting species of Terns, Gulls and Avocets

The salt-marshes are essential reproduction sites for seven endangered bird species including Terns, Gulls and Avocets. They can host up to 100% of their French or Camargue populations (Pin & Sadoul, 2006-2013).



Avocet

Recurvirostra avosetta



Mediterranean Gull

Larus melanocephalus



Little Tern

Sterna albifrons



Common Tern

Sterna hirundo



Slender-billed Gull

Larus genei



Gull-billed Tern

Gelochelidon nilotica



Sandwich Tern

Sterna sandvicensis

1.1.1. Creation of islets

Thanks to the creation of 45 nesting islets and the restoration of 20 reproduction sites from 2006, the population of those birds has been increasing on the salt-marshes. The number of pairs increased fivefold on average over the period 2006-2013. The artificial reproduction allows for better nesting conditions (no possible access by predators, presence of some vegetation as shelter, and so on) and shows a better number of chicks per pair that is essential to renew the population. It is thus important to continue the creation of islets (Pin & Sadoul, 2006-2013).



In 2008, the only French breeding colony of the slender-billed gull was observed on an artificial nest created in 2006 on the Aigues-Mortes salt-marshes.



In 2013, islet building by a Mechanic shovel with boards to be able to progress in the pond



Test of load bearing during the works



The islet created in January 2013 sheltered the only nesting site of the Slender-billed Gull in the Camargue



Nesting Slender-billed Gulls



Islet before restoration



Islet after raking and removal of vegetation



In 2009, some shelters were installed to protect the chicks from the predators

1.1.2. Specific management to limit the disturbance by the Yellow-legged Herring Gull

On the long term, it also appears necessary to set up specific management to limit the disturbance by the Yellow-legged Herring Gull, which has been increasing on the Mediterranean coastline since the 1950's and which competes with the other colonial Charadriiforms species of patrimonial interest (Sadoul & Walmsley, 2000).

Two innovative methods to limit the reproduction of the Herring Gulls have both been tested since the winter of 2006-2007 on the Aigues-Mortes salt-marshes. These experiments aim, in the long run, to completely free these islets from Herring Gulls in order to allow for the return on these sites of small colonial Charadriiforms. One of the principal criteria sought by the Herring Gulls to select its nesting site is its inaccessibility to the terrestrial predation. The site is all the more attractive as this condition is constant year after year. Consequently, the loss of the isolation of the islet must involve a progressive abandonment by the early breeders. It is the objective targeted by the first method of temporarily installing a footbridge, connecting the islet to a dyke, in order to allow the passage of predators. Two sites were thus arranged during the autumn of 2006 and were the subject of a particular follow-up: an infra-red camera was installed on each of the two islets at the end of the footbridge in order to identify the predators and to count the intrusions.



Anti-Herring Gulls footbridge



Fox on a footbridge by the infra-red camera

The first results of the experiment carried out to limit the disturbance by the Yellow-legged are mixed. The use of the footbridges has produced positive results with a clear fall in the frequentation of the islets by Herring Gulls which finally left 1 of the 2 islets. After the withdrawal of 1 of the 2 footbridges in 2012 the birds of patrimonial interest have not come back yet (Pin & Sadoul, 2006-2013).

The second method aims to scare the colonies of Gulls at the time of their installation from January to March in order to limit the numbers of nesting couples and in April to poison the couples which have settled. It is expected that the combination of these two methods on the same colony will involve a fast and continuous decrease in the Gull's breeding. However, this effect will only be assessed in the years to come. In the event of success, it would have the advantage of rapidly freeing the sites, decreasing the breeding population, while limiting the dispersion of the birds onto other sites. Periodic 'frights' are carried out by the installation of an inflatable automatic device called the Scarey-Man[®]. This method has been tested on 3 sites of the Aigues-Mortes salt marshes.



Yellow-legged Herring Gull



Automatic scarecrow

The first results of the experiment are mixed. The Gulls have left 2 of the 3 islets but the birds of patrimonial interest haven't come back for nesting. In 2014, after the withdrawal of the Scarey-man at the end of March, the Yellow-legged Herring Gull have come back to nest (Pin & Sadoul, 2006-2013).

1.1.3. Installation of decoys

For the moment, the low quantity of decoys installed on the islets of the “Avant-pièces de la ville” to attract Gulls, Terns and Avocets of patrimonial interest have not shown good results. We decided to test a high quantity of decoys in 2014 by installing 26 decoys of the Common Tern and 26 decoys of the Mediterranean Gull. These new decoys do not seem to be attractive for birds for the moment but we will continue to test this method.



Decoys of the Common Tern

1.2. Actions for nesting Great Flamings

Since 2009, the islet creation, the annual renovation of 200 artificial nests and the 4 decoys installed to attract nesting Great Flamings haven't been successful yet.



Grape harvest buckets used to create the artificial nests



Flamingos artificial nests on the islet



Modelling of an artificial nest



Installation of 4 decoys on the islet

In April 2014, nesting flamingos have installed for nests on a smaller islet dedicated to species of Gulls, Terns and Avocets and on dykes. The eggs and the chicks may survive on the islet but it will be more complicated on the dykes for they will not be protected from the predators such as foxes. To prevent fox attacks, 6 traps have been installed. This installation is an exceptional event and represents the only nesting site of the Great Flamingos in France. Next winter, we plan on improving this nesting site by increasing the size of the islet and creating a new islet from the already existing dyke.



In April 2014, the only nesting site of the Pink Flamingos in France is observed on the Aigues-Mortes saltmarshes

1.3. Elimination of invasive plants

To preserve the terrestrial and amphibious environments related to salt lagoons, it is necessary to implement several management actions including the elimination of invasive plants. The invading species have for the last 20 years been an important subject in ecology because of their progressive extension, the increasing damage they produce on the environment and the lack of knowledge of their operating cycle (Callaway & Maron, 2006).

The presence of invasive species on the natural environments of the Camargue has already been identified (Costa, 2005). Many habitats related to salt ponds, within approximately 1,200 ha, are of main ecological interest according to the Habitats Directive (Pallu, 2006) and are threatened by invasive plants.

Six invasive species have been detected and located on the Aigues-Mortes salt-marshes : the Pampas Grass (*Cortaderia selloana*), the Groundsel-tree (*Baccharis hamilifolia*), the Desert false-indigo (*Amorpha fruticosa*), the Water-primrose (*Ludwigia sp.*), the Russian Olive (*Elaeagnus angustifolia*) and Ice plant (*Carpobrotus sp*) (Pallu, 2006 and Beck, 2009). It is important to set up preventive, eradication and control actions towards these species to preserve the biodiversity (Hulme, 2006). Those species are systematically detected and charted on the saltworks. The staff daily inspecting the site is involved in the early detection of those species in order to limit the interventions. From 2006 until now, 30 seedlings of *Baccharis halimifolia* were cut at ground level and certain stumps were treated with specific phytocides (Costa, 2005). In 2007, on-site observations showed that the operation was profitable for the treated stumps while the seedlings which were simply cut presented suckers. Using a mechanical shovel and by hand, 105 plantations and 30 m² of seedlings of *Cortaderia selloana* were cleared, then evacuated in order to be destroyed in accordance with the recommendations (Costa, 2005). The Ice plant (*Carpobrotus sp*) have been extracted by hand over a 210 m². Four plantations of Russian Olive were cut at the base at ground level and treated with specific phytocides. The result of this action was not positive and allowed the development of other plants. So we decided to stop any action on this species.



Pampas Grass *Cortaderia selloana*



Manual elimination of the Pampas Grass



Carpobrotus sp.



Manual elimination of Carpobrotus



Elaeagnus angustifolia



Groundsel-tree *Baccharis hamillifolia*



Desert false-indigo *Amorpha fruticosa*



Water-primrose *Ludwigia sp*

Therefore, it is now planned to continue these actions of elimination and control of the development of invasive plants in general.

1.4. Burying of electrical cables

The company Salins du Midi is the owner-manager of the Aigues-Mortes salt works electricity network. Most of the electric lines are above ground and 50 km long. The staff observes regular collisions between cables and birds resulting in material damage and the mortality of birds. In October 2009, a collision between flamingos and the electric line provoked a fire leading to damages in the natural areas. The Mediterranean salted meadows and the Mediterranean and thermo-Atlantic halophilous thickets were burnt on approximately 0.5 ha. The burying of this particularly sensitive portion of electric line seems to be a solution adapted to avoiding the problems of collision between birds and electric lines as well as the regular damage of the natural habitats. Since 2012, about 10 km of electrical cables have been buried.



Machine used to bury electrical cables



Electrical cables

1.5. Hydraulic restoration works

This action allows to preserve and to restore the coastal salt lagoons by preserving the salt works hydraulic systems (control of the water circulation and the gradients of salinity). It also allows the good conditions of reception of several water bird species on the salt works to be kept. Any disturbance of the salt-works hydraulic management would lead to the failure of the reproduction and disturb the food supply of certain bird species.

The lagoons of the salt-marshes are permanent or temporary water areas the surface and salinity of which are variable. Those areas correspond to former ponds and natural lagoons that were modified and reorganized for salt. They have the peculiarity of being characterized by a gradient of salinity and hydraulic management that goes against the natural cycle. They are separated from the sea by a sand ridge and fed with sea water in an active way. There is no permanent natural exchange between the salt lagoons and the sea.

On the salt-marshes, we distinguish between permanent or temporary salt lagoons of low salinity, characterized by the presence of aquatic vegetation (*Zostera and Ruppia*), of fish and a variety of aquatic invertebrates, and permanent or temporary salt lagoons of high salinity (> 70g / L) home to large quantities of shellfish *Artemia spp.*, the food resource of numerous water birds.

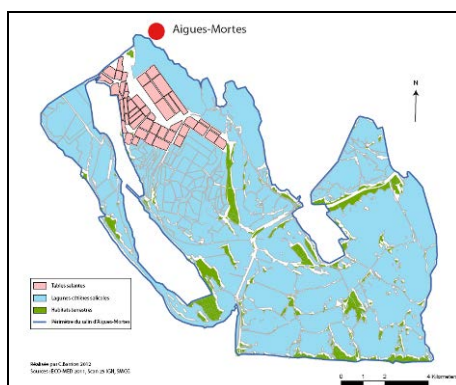
The hydraulic management, which corresponds to the flooding of the salt-marshes in spring and in the preservation of the levels of water during summer, is favourable to the reproduction and food supply of birds. These particular conditions, different from those of the natural areas that dry out in summer, allow:

- ✓ An isolation towards the predators of the reproduction sites of colonial Charadriiforms of patrimonial interest. The salt-marshes are of major importance for the conservation of 7 species of birds of European Interest (Directive Habitat Appendix I), hosting sometimes up to 100 % of breeders in France for the Slender-billed Gull, Mediterranean Gull, Sandwich Tern and Gull-billed Tern.
- ✓ The presence of available aquatic food resources for numerous birds of patrimonial interest

In spring and in summer, the salt-marshes' management induces a gradient of salinity favourable to the development of varied food resources. The ponds of low salinity are characterized by the presence of aquatic vegetation, fish and a variety of aquatic invertebrates. The ponds of high salinity ($> 70\text{g / L}$) are home to large quantities of shellfish *Artemia sp.*, which numerous birds, especially flamingos, feed on. *In France in summer, the salt-marshes of the Camargue (Aigues-Mortes and Giraud) are home to about 50 % of the latter's national population.*

In autumn and in winter, the hydraulic management, corresponding to the drying out of certain ponds, is favourable to the reception of wintering and migratory birds such as limicolous. The limicolous feed on invertebrates in mudflats formed by the dried up ponds. The salt marsh is a privileged zone for the reception of 25 species of coastal limicolous which justified the designation of the Special Protected Area (SPA)" Petite Camargue laguno-marine : *the 2 salt marshes of the Camargue (Aigues-Mortes and Giraud) are home to the majority of wintering and migratory costal limicolous of the Camargue.*

In total, the salt-marshes have 336 hydraulic sluice systems. Each year, Salins du Midi carries out hydraulic restoration works to produce salt and maintain the specific biodiversity of its salt-marshes. Since 2012, the commitment of the company to the European project Life + MC-Salt (see <http://www.mc-salt.eu>) has allowed to co-finance the restoration of 11 hydraulic sluice systems and 1 pumping station.



Localisation of the costal lagoons



Costal lagoons and dunes



Restored hydraulic sluice system



Old Hydraulic sluice system

1.6. Protection barriers for plants

The Aigues-Mortes salt-marshes host 278 species of plants. Among these species, 20 are protected. One species of Maresia *Malcomia nana* considered extinct from France was observed in 2007 on the site. To protect it from pedestrians or car traffic, some stone blocks have been installed.



The Aigues-Mortes salt-marshes are the only site in France to host the *Malcomia nana*



Blocks installed to protect the *Malcomia nana*

1.7. Prevention initiatives

The salt-marshes managers have followed environmental training. It is very important to choose the period for the works. For example in 2012, the staff delayed the renovation works of the dykes by one month so as not to disturb the nesting Kentish Plover (*Charadrius alexandrinus*). Maps of the protected plant species and the habitats have been drawn, so that during salt production works, they can be accommodated. Since 2012, a specific tool has been developed to prevent the destruction of plants or natural habitats and the disturbance of animals during the works carried out by external societies. It is part of the security prevention plan when the works are implemented in the natural areas. Furthermore, 15 panels have been installed on the site to remind the users of the good environmental practices (see <http://www.mc-salt.eu>). Three birdhides have been installed to limit the disturbance of the birds during the tourist or media visits.

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Protected plant marked by a picket site

Plan of biodiversity prevention

Panel at the entrance of the



People using the birdhide



Information panel

1.8. Collection of waste

An annual operation « Clean beaches » has been carried out on the Aigues-Mortes salt-marshes for several years with the participation of the staff and their families and friends. Furthermore, the staff is used to systematically picking up any waste observed on the salt-marshes.



Collection of the waste on the beach



Evacuation and sorting of the waste

1.9. Commitment to the Natura 2000 Charter

In 2009, Salins du Midi also signed the Natura 2000 Charter of the Petite Camargue for a 5-year period on 6,294 hectares of wetland. Signing it, the company acknowledges the exceptional ecological and patrimonial values of habitats and endangered or rare species on a European scale and is committed to conserve them.

The main commitments are :

- ✓ To conserve the dunes, the woods, the Mediterranean halophilous thickets, salt meadows and salt steppes,
- ✓ To maintain salt hydraulic management favorable to the waterbirds on the lagoons,
- ✓ Not to introduce invasive plants in a voluntary way,
- ✓ In case of the presence of nesting bats, to warn the Natura 2000 animating structure (*see <http://www.camarguegardoise.com>*),
- ✓ To authorize the Natura 2000 animating structure to organize scientific follow-ups,
- ✓ To inform the salt-marshes users of the commitments,
- ✓ To increase public awareness on the respect of the natural areas and the species targeted by the Natura 2000 Red.

The main recommendations are :

- To channel tourism activities to limit the disturbance of the birds,
- To limit as much as possible motor vehicle traffic on the dunes,
- To inform the Natura 2000 animating structure of the appearance of any invasive plants or animals and of any new projects.

1.10. Limiting and controlling visits

It is very important to limit and control the visits of the salt-marshes to ensure the protection of the salt production material and the quiet conditions for birds. The entries are controlled by the guardroom at the entrance to the site. Every visitor is identified and has the authorization to enter.



Guardroom at the entrance of the salt-marshes

The “sauniers”, workers managing the level and the salinity of the water, circulate every day on the salt-marshes. Caretaking and monitoring of the site are part of their job. A person who lives on the salt-marshes is also dedicated to the caretaking of the site.

2. Economic valorisation of the ecological management

The ecological management implemented on the salt-marshes allows for the development of several economic activities.

2.1. The sale of salt

The ecological management carried out by Salins du Midi has been awarded several prizes since 2005 :

- Prix Entreprises et Environnement organised by the French Ministry of Ecology in 2013,
- Grand Prix Natura 2000 granted by the French Ministry of Ecology and ADEME in 2011,
- Belleuropa Prize organised by the European Association of Landowners ELO in 2007,
- Anderswall Prize awarded by the Swedish Foundation Anders WALL, Friends of the Countryside, the Executive Management of the Environment and the Royal Agricultural Academy of Stockholm in 2005.

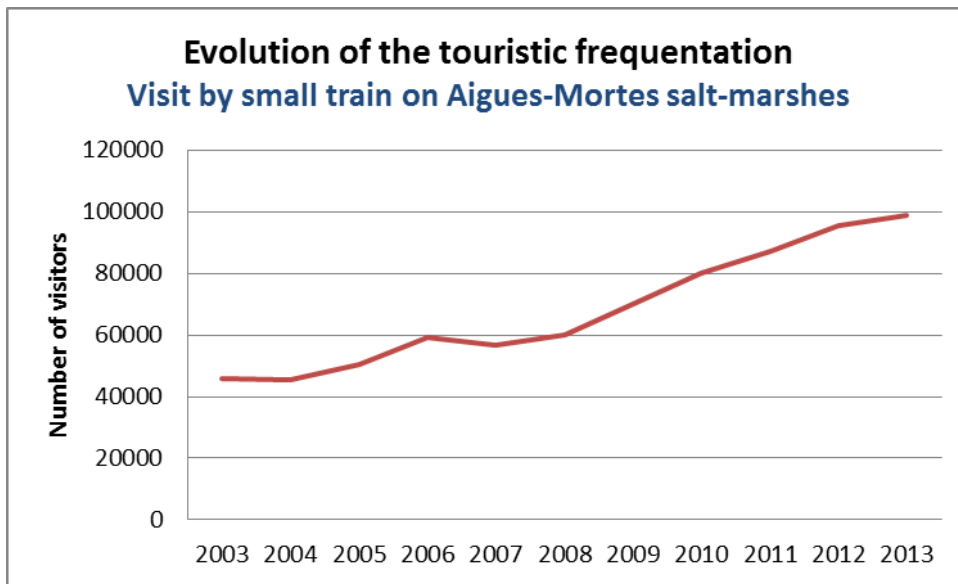
Those awards give a good image to the company and their products for consumers, clients and suppliers. This is also a selling point in the framework of calls for tenders.

This positive image is regularly maintained by communication actions on nature and salt : TV, radio, magazines, newspapers, websites (see <http://www.salins.com>, <http://www.labaleine.fr>, <http://www.saunierdecamargue.fr>).

Furthermore, the commitment to the Natura 2000 charter allows for an exemption from the land tax which represents a saving of 90 000 Euros per year, so less charges for the salt production.

2.2. Ecotourism activity

Since 1998, short train visits for up to 50 people have been proposed for tourists on the Aigues-Mortes site (see <http://www.visitesalinsdecamargue.com>). In an hour and a half, people get to discover the salt tables and production. The number of visits has increased from 46,000 in 2003 to 99,000 in 2013.

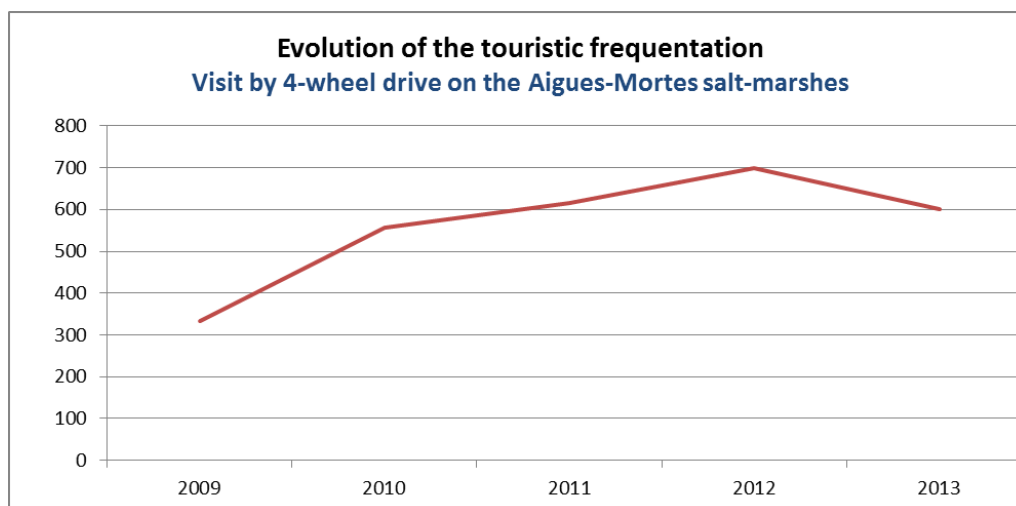


Short train visit



Salt tables where the salt is harvested

Since 2009, the company has developed an ecotourism activity on the Aigues-Mortes site with a new 3-hour 4-wheel drive guided tour to discover the landscapes, nature and production of the salt-marshes over three and a half hours. The number of visits has increased from 333 in 2009 to 600 in 2013.



Visit by 4-wheel drive



Great White Egret *Egretta alba*

The visit of the salt museum is part of the two tours. A documentary explaining the link between salt production and biodiversity has been under development since 2013 in the framework of the Project Life + MC-Salt. It will be broadcasted in 2015.



Former tools used for the salt harvest



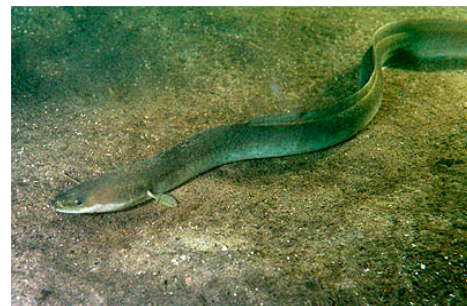
Salt cellars

2.3. Fishing activity

The ecological management allows for a fishing activity. Thanks to the hydraulic management, fish such as Eels *Anguilla anguilla* and *Atherina boyeri* can develop in permanent low salinity ponds. In this case, the company is paid according to the fish quantities taken that represents about 1,450 kg of Eels and 750 kg of *Atherina boyeri* in 2013. These quantities have decreased over the last years (Groupe Salins, 1993). In 2015, the company and scientists will study the possibility of improving the Eel stocks by returning them to the sea in autumn to reproduce in the Sargasso Sea and the sustainable management of the fishing activity. It is important to take into consideration the species of Eel *Anguilla anguilla* because of its endangered status. The *Artemia* spp. (*A. franciscana* and *A. salina*) shellfish, which develops in temporary high salinity ponds, is also fished on the site with about 12 to 15 tonnes per year which represents about 10% of the sites resources (Gout, 2014).



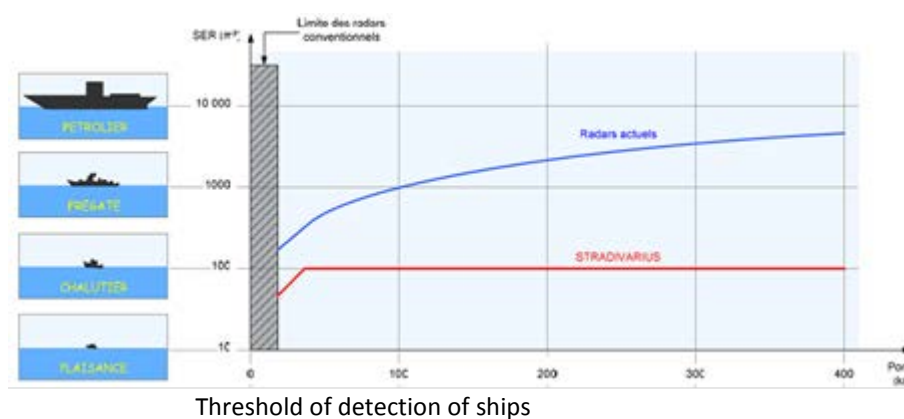
Artemia sp.



Eel (*Anguilla anguilla*)

2.4. New radar technology

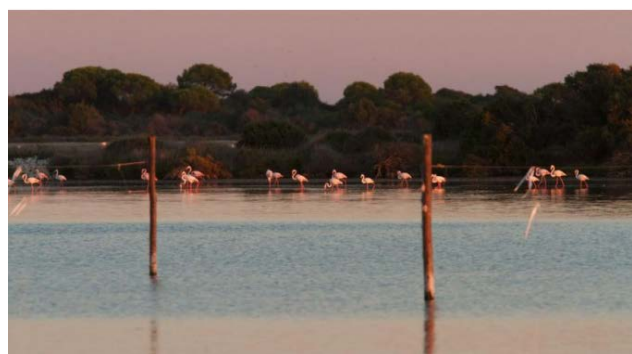
Salt-marshes can also help new technologies. Since 2011, an experiment to create a new High Frequency Surface Wave Radar able to monitor maritime zones up to 200 nautical miles off the coast has been implemented by “TéléDiffusion de France”. This radar called “Stradivarius” would be able to detect small boats, monitor pollution and be a tool for measuring currents and tides.



The tranquillity and the protection from storms and the permanent high salinity were the main criteria for choosing the pond “Sangliers” on the Aigues-Mortes salt-marshes as the experimental site. It consists of an installation of 12 Sweet chestnut tree wooden posts and Stainless steel cables used as the receiving antenna. This material was chosen for a question of landscape integration and was accepted by the environmental authorities such as the regional natural park of the Camargue. An ecological study has been carried out to assess the impact of the radar on the birds the results of which have been integrated into the project by the installation of fluttering plastic tapes on the cables to avoid collisions between the birds and cables. “Télédiffusion de France” currently leads campaigns of measures at least twice a year. The first results have been positive (Jezequel, 2012). At the moment, the Company rents out a part of its grounds for the implementation of this project but hopes to have more opportunities when and if this new technology develops.



12 antennas consisting of 3 wooden pickets



Great Flamingos and antennas

3. Conclusion

An ecological management of the salt-marshes considering habitats, birds, plants and fish is favourable to the development of several sustainable economic activities. Studies are still being carried out in order to develop new economic activities such as the production and use of the Algae *Dunaliella salina* full of carotenoids.

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