

Peixe Rei Solar Salt Works Project: Ecotourism and Tourism Experience as Complementary Activities

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ABSTRACT Solar salt works are more than just a human salt production activity. They represent a particular type of bionetwork that is inserted in another broader salt marsh ecosystem, richer in biodiversity. Inserted in Ria Formosa, Peixe Rei solar salt works represent an activity surrounded by other human activities that become representative of a natural and economic sustainable development. This project aim is to develop touristic activities as complementary actions from the marine salt extraction, highlighting the natural side of solar salt works and of its adjacent area as well as the historical and social environment. For that purpose, a requalification design of the tide mill that belongs to the delimited terrain tries to ensure the building of a museum in which natural, historical and social environment is shown. Also it will function as a place for workshops of marine salt production, stargazing, bird watching and salt marsh tours promotion. This will have a major role regarding environmental education and it will be developed by researchers, to further study the creation of new complementary and sustainable activities in the area.

1. BRIEF BACKGROUND OF THE AREA

Peixe Rei Solar Salt Works is located in Parque Natural da Ria Formosa (PNRF) in the Algarve south coast. It is part from Natura 2000 [1], Ramsar list and Reserva Ecológica Nacional (REN) with a rich ecological area that is classified as a specific target area that means it has special features that require action or specific actions [2]. It includes spaces with heritage value, natural and cultural, actual or potential, in need of recovery, backup, or rehabilitation. This includes areas where the dynamism of the changes that were reversed and should be subject to recovery-oriented. The high biodiversity and nature conservation needs led to the designation as a special protection area to ensure proper management to safeguard the natural resources, promoting sustainable development and population's life quality.

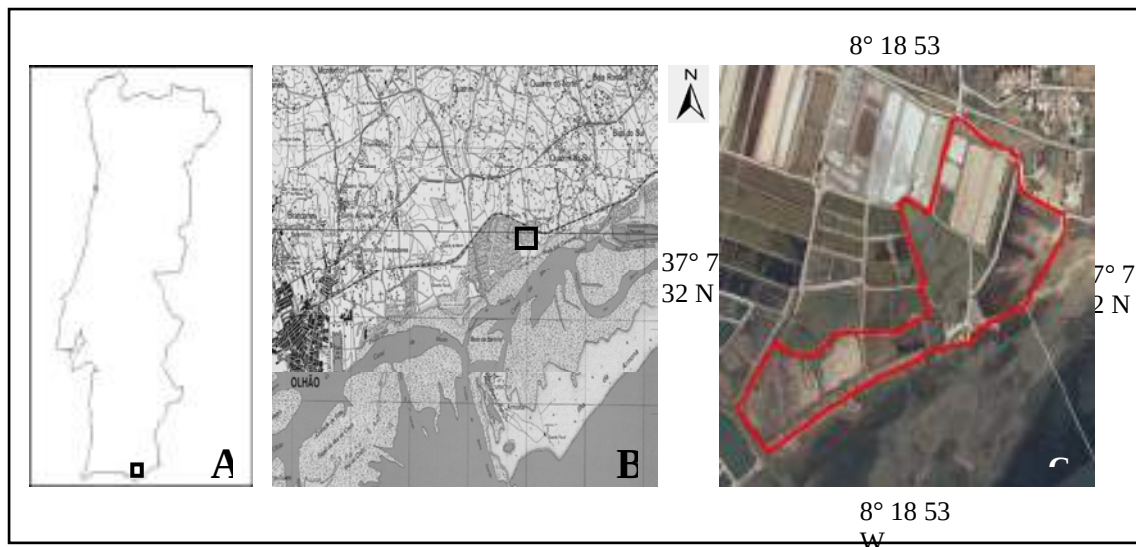


Figure 1: (A) Location of Peixe Rei Solar Salt Works in Portugal; (B) Location of the Project area in Olhão; (C) Aerial photograph of Peixe Rei Solar Salt Works with the Project area (defined by red).

2. PROJECT DESIGN

Due to the fact that Peixe Rei solar salt works has a great potential to marine salt extraction and to develop complementary activities. The owners, Filipe Silva and Sandra Silva devised a project that incorporates not only the extraction of marine salt with traditional methods but also a redevelopment of the Peixe Rei solar salt works and adjacent area, adding the exposure of natural surroundings enhancing the diversity in the area, history and social environment. The project aim is to create a set of animated recreations that will be directed to tourism and local environmental monitoring, with different occupations from the bird watching to the stargazing, the study of biodiversity, the exploitation of solar salt works activities and workshops, nautical activities, local gastronomy promotion and nature protection awareness.

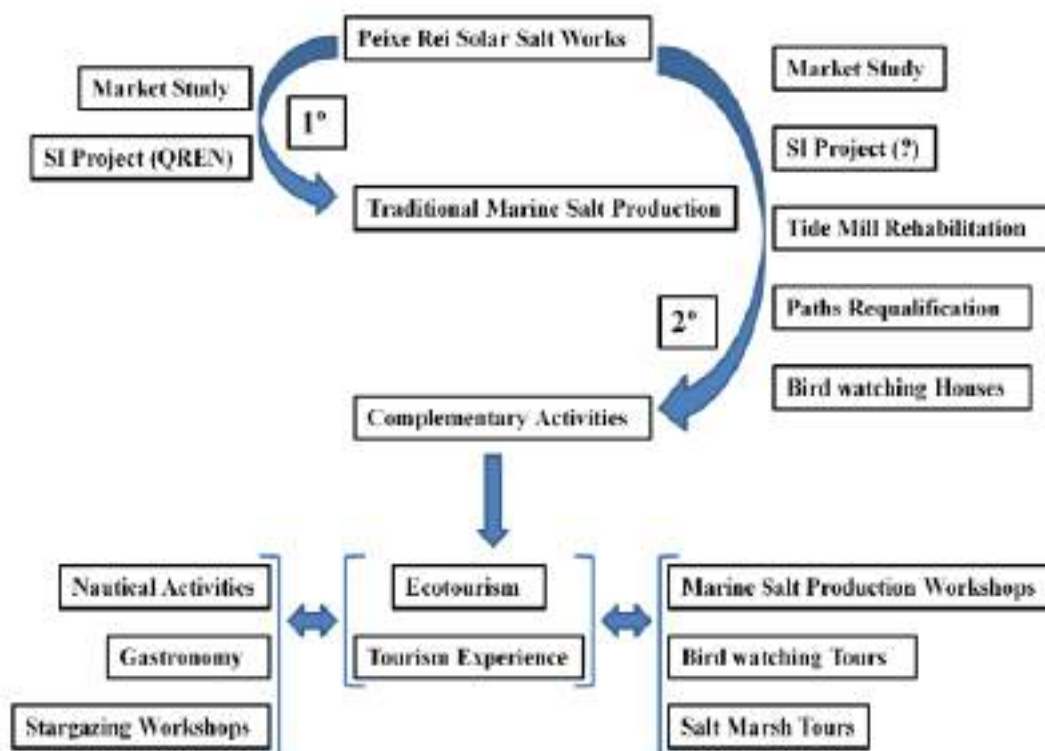


Figure 2: Chart with the first and the second Project steps

In this context, the heritage not only closes the shed built, as the natural fauna and flora, and habitats, as well as socio-cultural, respecting the traditional activities related to the experience of people in their daily contact with the space of Ria Formosa. It also aims to create conditions that allow the implementation of recreational and educational activities consistent with the interpretation and enjoyment of this landscape. To this end, there will not be any change or extension of the existing areas and volumetric spaces. Interventions around the surrounding space are associated with visiting the marine salt production, starting the ground paths for observation and study of plant species, observation and study of birds, and the possible construction of a small wooden pier, allowing a diversified analysis and knowledge of local biodiversity.

3. PROJECT SUSTAINABILITY

The sustainability of the project depends on two main variables. The first is the acceptance by ecotourists. The biodiversity, the entire environment, the history and the activities in the area should convince people to have an active role and participate. The second is the acceptance of the project by the area regulators. In fact there is a politico-bureaucratic problem, which is the inability of the institutions that regulate the area do not have favorable decisions on activities that promote changes in the area even if they could promote a great development of the area and even if they are considered environmentally friendly and respect throughout the natural area.

For us the creation of a touristic paradigm with a strong protection side promoting the enhancement of the existing natural heritage would be a sustainable act and will be beneficial for all parties.

4. ECOTOURISM AND TOURISM EXPERIENCE

The tourism market is constantly changing [3]. Several trends can be identified. Among them, are: the search for complementarities that exist in all travel options [4], the quest for authentic and the refusal of artificial lead to the development of new destinations and products where consumers can access authentic products of local culture and knowledge [5, 6]. There is a growing demand for authentic experiences [7], there is also a growing demand for experiences that represent an opportunity for the tourists to increase and expand their knowledge called tourism experience [8]. In short, the consumer no longer looks for a product but an experience in all its components [4]. In the case of Peixe Rei solar salt works ecotourism and tourism experience can be integrated as complementary activities.

5. TOURISM IN THE WORLD AND IN PORTUGAL

The world tourism prospects, including its contribution to the economic and social development are increasing. It is estimated that by 2020 international tourism will grow 4% annually and reach values of 1.6 billion tourists [9]. In Portugal it is estimated that the number of tourists in 2020 reached a value of 18,3 million. There is a significant volume of demand stimulated by the increased disposable income, motivations to travel, the exponential growth of emerging markets [10] accompanied by continued growth in traditional markets, the demographic, social and technological changes, diversification of destinations and the increasing liberalization of the sectors [7]. This causes a segmentation of markets [11]. One of the segments is ecotourism that is becoming one of the fastest-growing sectors of the tourism industry.

6. ECOTOURISTS PROFILE: THE "GREEN" CONSUMER

The "green" products play an important role in the tourism industry [12]. The future tourists believe that its presence and use of facilities perceived as "green", sustainable or "eco" tourism will not ruin the resources they visit [13]. Ecotourism, as a kind of sustainable tourism depends on environmental quality, and requires a great need to ensure that the impacts of their activities are controlled and minimized. It is necessary to maintain the ecological quality and environmental integrity at the same time it provides an attractive activity for ecotourists [14, 15]. Quality is a key factor throughout the tourism industry, with a certification of the many existing tools for the guarantee [16].

7. SOLAR SALT WORKS IN PORTUGAL AND SPECIFICALLY IN OLHÃO

Coastal solar salt works are anthropogenic supratidal habitats exploited for sea salt, which becomes progressively concentrated by evaporation [17] (Annex 1). In the middle of the XX century, the salt production from salt works in Portugal suffered a decline due to, production costs, the increase of global competition but also because of the land pressures

[18]. The appearance of semi-intensive and intensive aquaculture, the constant increase of coastal tourism and changes in hydrological regimes turned the land more expensive and inaccessible to salt works an exclusive. However the existence of new projects based in tourism, biological production, land rehabilitation, traditional know-how and environmental education could bring profitably to solar salt works [19].

Historically, Olhão was always a very important area for marine salt production. There are records of the salt activity at the site from several centuries ago. Since the Roman occupation, important traces and tradition of marine salt production were left. Its edaphic characteristics as clay soil, its plasticity and impermeability allow the construction of salt ponds. The topographic position is also an asset since there is a natural protection against winds and tides guaranteed by the barrier islands that exist ahead.

8. SOLAR SALT WORKS AND ADJACENT AREA ECOLOGY

Solar salt works activities are normally present in wetlands, more specifically in salt marshes rich in biodiversity and represent unique biological systems [20], which makes them environmentally relevant activities [21]. Many species live, feed and reproduce in a salt marsh and in a salt works area [22]. They provide the environment for biological diversity, including plants, birds, reptiles, fish and invertebrates, prevent flooding and improve water quality [22, 23]. Salt ponds adjacent ecology is the relation between the adjacent communities and environmental factors. Usually salt producers do not give great importance to its ecological value and is difficult to estimate an economic value, but it's possible to list the arguments in favor of salt works. The presence of solar salt works can control the hydrological regime, promote the area preservation, controlling natural and anthropogenic factors, can control the litter and water quality. Consequently, the decrease of litter and the increase of water quality increase the phytoplankton and macro invertebrate's diversity and biomass [25, 26]. It's a place where several species of fish fulfill part of their life cycle. Migratory birds shelter, feed and nest [22]. For that reasons solar salt works are environmentally friendly areas and ensure nature conservation [27].

An example of successful protection is the case of the salt works of Margherita di Savoia (South of Italy). A completely artificial salt ponds located in a protected area with natural interest, belonging to the Natura 2000 and Ramsar list. This salt work is the biggest in Italy, and all the parts that regulate the area agree with the role that plays in conservation, due to the lack of negative impacts [28]. Other examples of Ramsar areas, with traditional salt works are the cases of Songor Keta lagoon in Ghana [29], Yucatan in Mexico (Ortiz-Milan, 2006a) and Rajasthan in India [30].

9. BIOLOGICAL SURVEY

Given the example of this list of species (Annex 2) regarding the type of ecosystem and the type of activity, theoretically it seems like a good strategy the rehabilitation of the area. First of all, if the area is going to be used sustainably by Man, it is going to be studied and cleaned, not only improving the landscape but also increasing the knowledge of Peixe Rei solar salt works and adjacent area, biodiversity. Second, if well taken care of, consequently there will be good water quality in the surrounds, it is also a certainty that the solar ponds will continue attracting birds. Why the certainty? One should consider the main reason why

all animals including our own species move, in two words: food and water. But what makes us migrate from place to place, the search for a steady food supply. And mainly birds, they will find small aquatic invertebrates in the ponds, including *Artemia* spp. For some species this is a crucial food source, attracting many individuals not only to feed, but to also rest and find a mate. Third, if the ecosystem is healthy, flowers and vegetation will grow, and they will attract insects that will attract small mammals, reptiles and amphibians. The food web will evolve in a vigorous way. Ultimately the positive evolution of the biodiversity in Peixe Rei solar salt works and adjacent area will raise awareness and attract tourists and environmental researchers.

10. WIND MILL HISTORY AND REQUALIFICATION

The built structure present in the area of Peixe Rei solar salt works was a tide mill, built at the time when Ria Formosa was a mandatory stop of the cereals market to transform them into flour [31], however nowadays part of it is a ruin without use. So together the tide mill, the solar salt works and the surrounding salt marsh are natural and built heritages. The Project claims the structure will be rehabilitated into a museum to provide space for teaching history, workshops and research.

The importance of (natural or built) heritage in coastal management is all too evident. In fact, just by knowing the reality one is moved to respect it in its own characteristics and therefore crave some enjoyment, using it to efficiently manage the requalification. The role of historical knowledge in this process is extremely important because, by definition, the history allows for knowledge of past times, understanding and correct interpretation of this and hence an efficient design and management of the future. Thus, appreciation of heritage helps, first, to preserve the cultural identity of the people and on the other hand, tourism is an enhancer factor [32].

11. DISCUSSION

Apart from the marine salt production, the Peixe Rei solar salt works and adjacent area integrated management with complementary activities could offer a variety of requirements to the ecotourist or experience tourist: security, high level of available information, tourism product, emotional significance, influence of consumer trends and high involvement within a buying decision. It's possible to observe a traditional salt production system with the traditional know-how, the effects on the landscape, the biodiversity, the salt marsh, the history from the area and a functional old tide mill. Those touristic activities may also be a marketing tool in the construction of a "green" image, as tourists come and actively participate [8]. Consequently spreading information about the activities and the products made in the Peixe Rei solar salt works: "green" products and activities with little or no impact on the environment in which is located. The influence of consumer trends is completed by the global panorama: Sustainable and Integrated Management.

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Annex 1 – Solar Salt Works Traditional Processes

Men capture marine salt from the seawater, using ponds to keep seawater and retaining only the salts through a natural evaporation process [1]. The first pond called reservoir is fed with seawater. Here happens a decantation process [2]. The seawater flows to evaporators and its salt concentration rises continuously through evaporation, controlled by wind, precipitation, temperature, humidity and radiation. To finalize, the seawater flows to crystallizers, where continues the evaporation process, leading to a complete salt dehydration process and consequent crystallization and collection [3, 4]. The relative ratio of the various ions contained in seawater is almost independent from its overall salinity, however it is practically the same on every coast of all open seas, $35\text{g}\cdot\text{L}^{-1}$. The passage of seawater from evaporators to crystallizers usually occurs at $150\text{g}\cdot\text{L}^{-1}$ to avoid salt crystallization in evaporators ponds. This method has disadvantages to produce pure NaCl, since the salt produced contains all the ingredients of seawater. However this fact is an “innovator parameter”, the production of high traditional salt quality rich in salt diversity (carbonates, iodides, bromides and sulfates) and organic matter, but also different structural crystallization, color and taste. Modern salt works could be semi-artificial coastal ecosystems, unique in terms of their architecture [5].

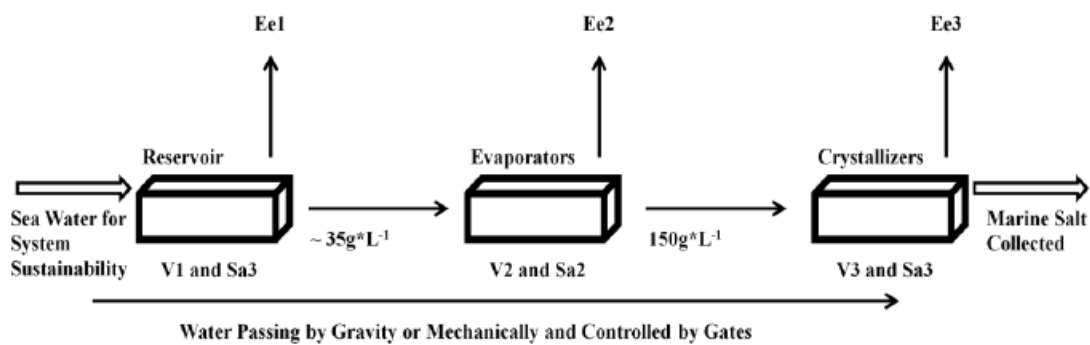


Figure 5: Steps from the Collection of Sea Water till the Collection of Marine Salt with the Relationship of Effective Evaporation, Ponds Volume and Surface Area.

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Annex 2 – Biological Survey (Birds, Other Animals and Plants)

Birds



[1] *Ardea cinerea* (Gray Heron)



[2] *Phoenicopterus roseus*
(Greater Flamingo)



[3] *Egretta garzetta*



[4] *Ciconia ciconia* (White Stork)

Portugal's biggest egret, with 90-100 cm in length. It has a big body, grayish and darker on the upper body. The head is black and white, the neck is long and the bill is straight and yellowish. The feet and legs are yellowish. The breeding season occurs between February and July, usually in colonies. It inhabits fresh or brackish waters. It feeds on fish, amphibians and small mammals.

A big bird, with 125 to 145 cm in length, young are grayish white and adults white and pink. Long neck, pinkish legs and a very thick black bill and curved. They can be seen all year around. Can be found in lagoons, shallow lakes, salt marshes, estuaries and solar salt works. It feeds mainly on crustaceans and mollusks by filtering the water.

Medium sized egret, up to 55-65 cm in length, it has white plumage, black bill and legs and yellow feet. In Portugal it has a long breeding season. It is gregarious while nesting. It is easily seen in wetlands and feeds on fish, crustaceans, amphibians and small mammals.

It has white plumage, with black primary feathers. The bill and legs are red, mostly in adults and reaches up to 100-110 cm in length. It is a migratory species that may nest solitarily or in colonies, sometimes in urban settlements near agricultural fields and wetlands. It feeds on many preys, including aquatic organisms, small mammals, amphibians and insects.



[5] *Charadrius hiaticula* (Ringed plover)

A wader with 18 cm in length. It has a complete black collar and during summer adults have orange legs and bill. It has a broad black band on top of the head and the back is brown. It can be found in open areas, beaches, saltmarshes and intertidal areas. Worms and crustaceans are the main part of its diet.



[6] *Calidris minuta* (Kentish plover)

A small wader, reaching 14 cm in length. It has a short straight bill and black legs. The back is gray in winter and brown in summer. It passes through Portugal mostly in autumn. It occurs in estuaries, rice paddies and coastal lagoons. It feeds on small aquatic invertebrates.



[7] *Limosa lapponica*
(Bar-tailed Godwit)

Around 38 cm in length. During winter it is mainly brownish and in summer, males get more reddish and females cream. The bill is quite long and narrow. It occurs in estuaries, solar saltworks and intertidal areas. It's a winter migrant and it feeds on small invertebrates.



[8] *Limosa limosa*
(Black-tailed Godwit)

Around 40cm in length with long bill, neck and legs. During summer, the face, neck and chest are reddish and the belly white with dark stripes. In winter the body is grayish with a white belly. It can be seen in beaches, estuaries, and shallow waters. Feeds mainly on crustaceans, mollusks, and fish and amphibian eggs.



[8] *Tringa tetanus* (Redshanks)

It has 27 cm in length, the legs and base of the bill are bright red. In winter the back is brown, and in summer is darker. The belly is white streaked with brown. It is seen in several wetlands and brackish saltmarshes. It eats small invertebrates and polychaetes.



[9] *Tringa nebularia* (Greenshanks)

A wader with about 32 cm in length. It has greenish legs and a long bill, slightly curved upwards. During summer its back is gray with a bit of black, and the lower body is whitish. It inhabits coastal wetlands, saltmarshes and flooded fields. Its diet consists in small aquatic invertebrates and small fish.



[11] *Platalea leucorodia* (Spoonbill)

It reaches 80 to 90cm in length. The plumage is white and the bill has a characteristic spoon shape. The legs are long and dark. The neck is elongated. It is migratory and a nesting species in Portugal. It is found in lagoons, estuaries, mud flats and coastal areas. It feeds on small fish, crustaceans, insects and tadpoles.



[12] *Sternula albifrons* (Little Tern)

Small, with about 23cm in length. The bill and legs are yellow. The tip of the wings are black and the rest of the body is white. It is found in coastal areas, nesting in dunes, salt marshes or lagoons. It preys on small fish and crustaceans.



[13] *Sterna sanvicensis* (Sandwich Tern)

It reaches 40cm in length. The bill and legs are black, as well as the cap, forming a small crest. Its back is light gray and the ventral area is white. During winter it can be seen in coastal areas such as lagoons and estuaries. It feeds on small fish.



[14] *Sterna hirundo* (Common Tern)

Can reach up to 35cm in length. It has a light gray back and a white belly. The legs are red and the bill red in summer and dark the rest of the year. It's a coastal species that feeds on small fish, insects and crustaceans. It nests on solar salt works and aquacultures.



[15] *Chroicocephalus ridibundus* (Black-headed Gull)

Reaches up to 36cm in length. From Feb to Aug it has a brown cap. The bill is red, being almost black in summer and the cap becomes a small spot behind the eye. The legs are red and the plumage varies with age, with the wings being black, brown and white. Common along the coast, solar salt works and estuaries in winter. Feeds on fish.



[16] *Larus michahellis* (Yellow-legged Gull)

It reaches 60cm in length. With a gray back, and black wing tips. Adults have yellow legs, and a yellow bill with a red spot. The head is streaked with gray during winter. Juveniles are mostly brown. Very common in Portugal, along the coast, from beaches, docks, solar salt works and urban areas, nesting in islands and cliffs. It feeds on fish and whatever it can find.



[17] *Larus audouinii* (Audouin Gull)

Reaches up to 50cm in length. The head is long and slightly flattened, the eye is dark, the bill is dark red with a yellow tip and the legs are gray. Adults have gray backs and white heads and chests. The tip of the wings is black. It is seen at beaches, solar salt works, estuaries and lagoons, nesting in rocky islands. Feeds mostly on fish and invertebrates.



[18] *Plegadis falcinellus* (Glossy Ibis)

Up to 55-65cm in length with a long curved bill. The body is dark brown, and adults have greenish reflections on the feathers. The legs are dark and long. It is gregarious, nesting near water. It is seen in coastal areas, salt marshes, rice paddies and cultivated areas. Feeds upon worms, insects and aquatic larvae.



[19] *Himantopus himantopus*
(Black-winged Stilt)

A wader that reaches 42-45cm in length. The legs are red/pinkish and very long, the neck is long, the head round and the bill is black and pointy. The body is white with the wings being black and the head might have black spots. Inhabits near salt and fresh waters. It feeds mostly on aquatic insects.



[20] *Recurvirostra avosetta* (Avocet)

With 42-45cm in length. The body is black and white. The legs are dark and the bill is curved upwards. Juveniles have a brown back. Found in shallow salt or fresh waters, estuaries, rice paddies and solar salt works. Feeds on aquatic invertebrates such as worms, insects and crustaceans.



[21] *Haematopus ostralegus*
(Oystercatcher)

Reaching around 40-45 in length. The plumagem is white and black. The eye is red, the bill is red, long and thick and the legs are pink. Found in wetlands such as solar salt works, mud flats and estuaries. Feeds on mollusks, worms.



[22] *Pluvialis squatarola* (Gray Plover)

Reaches 28cm in length. The back has a gray black pattern, in winter the belly is white, while in summer is black with the face and chest turning black as well. The bill is short and strong. Found in coastal areas, solar salt works and rice paddies. It feeds upon polychaetes, mollusks and crustaceans.



[23] *Numenius phaeopus* (Whimbrel)

Reaching up to 40cm in length. The neck and chest are brownish-yellow and the back is grayish-brown. It has a light supraciliar stripe and the bill is long and curved downwards. It can be found in mud flats, solar salt works and agricultural fields. Feeds on aquatic invertebrates, mainly crabs.



[24] *Numenius arquatus* (Curlew)

Reaching up to 50-55cm in length. The back is brown with yellowish-brown feathers. The chest is heavily barred as well as the neck. The bill is very long, curved downwards. It can be seen in estuaries, mud flats, mostly in Autumn, feeding on invertebrates.



[25] *Arenaria interpres* (Turnstone)

Sturdy, up to 23cm in length. The legs are short and orange, the bill is short. In summer the back is brown-reddish. The head and neck are white with black markings, extending towards the chest. In winter the colors turn grayish. Tolerates rain and wind, seen in rocky shores, estuaries and mud flats. They feed by scraping algae from rocks, eating insects, crustaceans, small fish and worms.



[26] *Calidris alpina* (Dunlin)

Wader with 17 to 20 cm in length. During winter the back is gray and the lower body white, in summer it is reddish brown on the back and abdomen has a black spot. It is found in coastal areas, mud flats, solar salt works and estuaries. It follows low tides to prey upon small invertebrates like worms and crustaceans.



[27] *Calidris alba* (Sanderling)

Wader with 17 to 20 cm in length. The bill and legs are black. In winter the back is light gray and the belly white. In summer the head, chest and back are black and brown. It is mostly found in beaches and sandy areas, and also in estuaries and solar salt works. It preys on invertebrates buried in the sand.



[28] *Calidris ferruginea*
(Curlew Sandpiper)

About 19cm in length. The legs and neck are long. The bill is slightly curved downwards and the rump is white. In winter the back is grayish and the belly is white. In summer the plumage is reddish-brown. It occurs mainly in mud flats and solar salt works. The diet consists in worms, mollusks and crustaceans.



[29] *Calidris canutus* (Knot)

It reaches up to 24cm in length. The bill is straight and black. The legs are greenish-grayish and short. During winter the back is gray and the belly is white. In summer the back is mottled with black and the rest of the body turns orange-brown. The rump is grayish. It inhabits coastal wetlands such as solar salt works and mud flats. Eats mainly mollusks.



[30] *Actitis hypoleucos*
(Common Sandpiper)

Small, reaching 20cm in length. White belly and brown back, chest and head. The legs are greenish. It has a white stripe that extends from behind the bill to the cheeks. Inhabits many biomes near water, riparian rivers, beaches, mud flats, lagoons and solar salt works. Its diet consists in small crustaceans and aquatic invertebrates.



[31] *Burhinus oedicnemus*
(Stone Curlew)

Reaches 40-45cm in length. The body is light brown, streaked with black. The face has patterns of brown and white stripes. The legs are long, strong and yellow. The eyes are big and yellow. It is found in open spaces with vegetation, such as dunes and fields. It preys upon terrestrial invertebrates, hunting by night.



[32] *Anas platyrhynchos* (Mallard)

Reaches 50-65cm in length. Males have a green head and a white ring on the neck. The body is grayish and dark brown, and the wings have a blue mirror. The bill is yellow. Females are browner and duller. Quite common, seen in aquatic habitats such as dams, rivers, lagoons, estuaries, etc. Breeds from May to July. The diet is variable, eating seeds, amphibians, crayfish and small fish.



[33] *Tadorna tadorna* (Shelduck)

Duck that reaches 60-65 in length. The head and neck are green, and the rest of the body white with a brown and a black streak. The bill is bright red, with a bulge in males. It is a winter migrant, and can be seen in estuaries and solar salt works. Feeds mainly on invertebrates and mollusks.



[34] *Pandion halieetus* (Osprey)

It reaches 50-55cm in length and 160cm in wingspan. The dorsal area is dark brown and the lower part of the body is white with dark bands. The head is white with a black ocular stripe. It does not nest in Portugal anymore. It prefers cliffs, estuaries and lagoons to be able to hunt for medium sized fish, in both salt and freshwater.



[35] *Circus aeruginosus* (Marsh Herrier)

It reaches 45-55cm in length and 115-135cm in wingspan. Adult males are tricolored (brown, gray and black) and females and juveniles are brown and light heads. Nests in reedbeds. Inhabits wetlands, estuaries, salt marches and lagoons. Feeds upon aquatic birds, rodents, fish, amphibians and eggs.



[36] *Turdus merula* (Blackbird)

Common bird, reaching 25cm in length. Males are black with an orange bill and a yellow ring around the eye, females are dark brown and a yellowish bill. Found in woods, gardens and parks. Nests on trees and shrubs. Its diet is comprised of worms, insects, fruits and berries.



[37] *Merops apiaster*

A quite colorful species with 28 cm in length. The body is yellow, reddish and greenish –blue. The tail is long and the bill slightly curved down. Found in forested areas, plains and open areas. Builds the nest in holes in sandy walls or in the ground. It's a spring migrant and breeds in May. It preys mostly bees and beetles.



[38] *Cisticola juncidis*

Small bird with 10 cm in length. It has short round wings and tail. The back is striped, the throat is white and pale around the eyes. It occurs in riparian biotopes, fields and saltmarshes. The breeding season is from March to September. It feeds on insects.



[39] *Sylvia melanocephala*
(Sardinian Warbler)

It has about 13 cm in length. The male has a black head and a red orbital ring. The belly is white and the back is gray. The female is similar but brownish and duller. It is common to see this species in riparian areas, woods and fields. The breeding season is between March and July. During summer it eat mostly insects and in winter add to the diet berries and fruits.



[40] *Galerida cristata* (Crested Lark)

Small with 18cm in length. It bears a crest and is mostly brown-yellow with a white belly. The chest is streaked with black. The tail is short and the bill long and slightly curved. Found in open areas, dunes, roads and farmed areas. Its diet consists of seeds, fruits and beetles.



[41] *Cecropis daurica*
(Red-rumped Swallow)

A swallow with 17cm in length. With bluish color, a rufous band on the back of the head, a cream rump, and long forked tail. They prefer valleys with streams or springs, nesting on bridges. It comes to Portugal in spring and summer. It feeds on invertebrates.



[42] *Delichon urbicum*
(Common House Martin)

It has about 14cm in length. The plumage is black-bluish on the back and white underneath and rump. It is found in urban areas near water. Nests only in man-made constructions. It preys mainly upon flying insects.



[43] *Hirundo rustica* (Barn Swallow)

Up to 18cm in length. The back is dark blue with metallic reflexes. The lower body is white. The face and throat are red. The wings are long and angular and the tail is long and heavily forked. It is associated to urban areas, living near lagoons, dams and villages. Nests in man-made constructions. It is migratory, spending spring and summer in Portugal. Feeds upon insects.



[44] *Upupa epops* (Hoopoe)

It reaches 37cm in length. The wings and tail are black and white with large bands. The head and chest are orange/brown and the belly is cream. It has a long crest and the legs are short and the bill is black and slightly curved. Inhabits dry places with vegetation cover and agricultural areas. It feeds upon insects, larvae and cocoons.



[45] *Passer domesticus* (House Sparrow)

Reaching 15cm in length. Males have a back streaked of brown and black with a gray cap. The neck is black and the belly is white. The female is duller and lacks the black in the neck. Can be found in many habitats, including urban places and cultivated fields. It feeds on seeds and man-made residues.

Salt marsh Plants



[46] *Spartina maritima*
(Small Cordgrass)

Present in temporary submerged wetlands, in estuaries and salt marshes.



[47] *Atriplex halimus*

It can be found in saltmarshes, solar salt works, ocean cliffs, salty and sandy soils near the coast somewhat disturbed. It has edible leaves. May be used as ornamental.



[48] *Arthrocnemum macrostachyum*

Flowers between April and September. Present in halophyte woods, saltmarshes and estuaries.



[49] *Halimione portulacoides*

Inhabits estuaries, salt marshes and solar salt works. When present on salty soils it can be flooded periodically.



[50] *Sarcocornia perennis* (Saltwort)

Shrubby perennial halophyte. Flowers with equal height in the cymes. Adapted mostly to upper part of saltmarshes.



[51] *Cistanche phelypaea* (Broomrape)

Yellow, present in salt marshes and estuaries. A parasite in roots of other salt marsh plants.



[52] *Sonchus tenerrimus* (Slender Sow Thistle)

Yellow flower. A ruderal species, found in cultivated fields, gardens, riparian woods and rock cracks.



Annual plant, found in prairies, road sides, open woods and dry soils.

[53] *Brachypodium distachyon*
(Purple False Brome)



The flower is white, found in solar salt works, dunes and sandy rocky substrates.

[54] *Mesembryanthemum nodiflorum*
(Slenderleaf Ice Plant)



Found in annual fields, walls, rocky formations, grasslands. Also found in dry, slightly nitrophile areas.

[55] *Lamarckia aurea* (Goldentop Grass)



Found in cultivated fields, prairies, road sides preferring sandy soils. The flowers are white-pinkish.

[56] *Silene gallica* (Common Catchfly)



Found in grasslands, road sides, farmed lands and dry areas with high nitrogen levels.

[57] *Plantago lagopus* (Mediterranean Plantain)



Found in disturbed areas, paths, coastal cliffs and urban areas. Its ecology and characteristics vary. In coastal cliffs they have sturdy leaves, while in dry areas, they appear smaller and with less flowers.

[58] *Plantago coronopus* (Buck's Horn Plantain)



A pink flower with united petals. Found in gardens, cultivated fields, grazing fields and woods. It has a high environmental plasticity, preferring dry areas.

[59] *Convolvulus althaeoides* (Mallow Bindweed)



[60] *Pistacia lentiscus* (Mastic)

Bush with a red inflorescence. Abundant in sclerophyllous woods and perennial woods. Can reach a tree size. Prefers limestone soils.



[61] *Opuntia ficus-indica* (Cactus Pear)

An exotic cacti species, with orange flowers and pear-shaped fruits. Found near roads, paths, and cultivated fields.



[62] *Limoniastrum monopetalum*
(Limoniastrum)

An exotic species with white and purple flowers. Found in halophyte woods in salt marshes, solar salt works and rarely also in coastal rocky areas.



[63] *Chrysanthemum segetum* (Corn Daisy)

An exotic species, with yellow petals. Found in cultivated and abandoned lands. Does not prefer limestone soils.



It has white flowers, with a yellow center. Found in abandoned/disturbed, urban areas. It is found less frequently individuals completely yellow.

[64] *Chrysanthemum coronarium*
(Crown Daisy)



A perennial, herbaceous plant with long, lance-shaped leaves, always growing in a basal rosette.

[65] *Taraxacum officinale* (Dandelion)



Annual plant. Found in meadows, near ponds, lagoons and water lines. Prefers temporary flooded soils and rich in silica.

[66] *Juncus sp* (Rush)



A shrubby perennial, up to 1 meter tall. Found in saline and clay soils, sandy areas, maritime habitats and rocky slopes.

[67] *Salsola vermiculata* (Mediterranean Saltwort)



[68] *Artemisia campestris*
(Field Wormwood)

Perennial, growing to 1.5m that flowers from August to September. Found at well drained sandy soils and dunes. Tolerates drought.



[69] *Limonium algarvense*
(Algarve's Sea Lavender)

Perennial, preferring dry or moist soils. It can tolerate maritime exposure. Growing up to 0.3m. It is in flower from July to October. The flowers are pinkish.

Other vertebrates



[70] *Tarentola mauritanica*
(Common Gecko)

Can reach 15cm in length. Brownish to grayish body. The back is covered with rows of tubercles, giving it a rough aspect. The belly is white. It has 5 fingers on each foot with developed nails on the 3rd and 4th finger. Nocturnal and natural climbers, feeding on a large variety of insects. Found mainly in dry areas near to human settlements.



[71] *Psammodromus algirus*
(Large Psammodromus)

Reaches up to 30cm in total length. The body is brown with two yellow/white lateral lines. It can present orange coloration on the tail and hind limbs. The belly is white and males have blue spots near the axilla. Inactive during winter. Feeds on small invertebrates and it can be found in pine woods, sandy soils and areas with shrub cover.



[72] *Oryctolagus cuniculus*
(European Rabbit)

Reaches 35-50cm in length. Ears with an inferior length than the head. Brownish fur. Mainly nocturnal breeding from October to June having several litters per year from 3-6 juveniles. Lives in family groups. Feeds mainly on leaves, grass and bulbs. Inhabits open fields, woods and farm lands.



[73] *Atherina presbyter* (Sand Smelt)

Maximum length up to 20cm. A small pelagic fish present in coastal areas and estuaries. Feeds on small crustaceans and fish larvae. It has a long, brilliant silver stripe along the flanks from head to tail.



[74] *Diplodus sargus* (White Seabream)

Common length of 22 cm. Body with 5 black and 4 vertical gray bands. Inhabits coastal rocky reef areas and feeds on shellfish and benthic invertebrates living in the sediment.



[75] *Diplodus vulgaris* (Two-banded Seabream)

Common length of 22cm. A species that occurs in rocky and sandy bottoms to depths of 160 m, but commonly in less than 50 m. The young use seagrass beds as nursery area. The adults feed on crustaceans, worms and mollusks.



[76] *Sarpa salpa* (Salema)

Common length of 30cm. The body is slender with 10 golden longitudinal stripes. It is found over rocky substrates and sandy areas with algal growth. Gregarious. The young are mainly carnivorous, eating crustaceans, and adults are herbivorous.



[77] *Chelon labrosus* (Thick Lip Gray Mullet)

Common length of 32cm. Occur inshore, entering brackish and freshwater. Occasionally migrates. Feeds mainly on benthic diatoms, epiphytic algae, small invertebrates and also detritus.



[78] *Dicentrarchus labrax* (Seabass)

Common length of 50cm. Grayish in coloration. Mouth moderately protractile. Adults are demersal, occurring in coastal waters down to about 100m depth but more common in shallow waters. They are found on various kinds of bottoms on estuaries and occasionally rivers. Feeds upon shrimps and mollusks, and on fishes.



[79] *Gobius paganellus* (Rock Goby)

Maximum length of 12cm. Coloration varies in this species. mainly marine, but may enter freshwater. Adults occur inshore in intertidal waters and in pools on sheltered rocky shores with algae cover, feeding on crustaceans.



[80] *Syngnathus acus* (Greater Pipefish)

Common length of 50cm. Light greenish to dark brown in color with variable markings, the snout is cylindrical. Found in coastal waters; on sand, mud and also rough bottoms. Common near algae and eel-grass (*Zostera*).



[81] *Hippocampus guttulatus*
(Long-snouted Seahorse)

Maximum length of 22cm. Long snout and prominent rounded eye spines. Color from dark green to brown. Occurs mostly in shallow inshore waters including littoral lagoons with algae and eel grass (*Zostera* or *Posidonia*), or even among rocks and in gravel bottoms.

Invertebrates



[82] *Artemia spp* (Brine Shrimp)

A small crustacean (15mm) that can be found in salt waters in all over the world in natural or commercial farms. It has an oviparous and an ovoviviparous reproduction.



[83] *Carcinus maenas* (Green Crab)

It is a medium sized crab. Up to about 6 cm in length and 9 cm wide. It is a voracious omnivore with a wide tolerance for salinity variation, water temperature and habitats. It burrows in substrates such as mud, sand, rock, and eelgrass. It can also occupy depths ranging from high tide to 6 meters.



[84] *Eriphia verrucosa* (Warty Crab)

Up to 7cm in length and 9cm wide. Covered with small warts and hairs. Coloration can be green-brownish with yellow dots. It can be found in shallow waters, amongst algae and rocks. Feed upon mollusks and worms.



[85] *Pachygrapsus marmoratus*
(Marbled Crab)

Up to 4cm in length, with a quadrangular and smooth carapace. With pincers of different sizes. Green and brown in color with lighter stripes. Found in rock pools, intertidal areas and under rocks.



[86] *Uca tangeri* (Fiddler Crab)

Up to 2,5cm in length and 5cm wide. A semi-terrestrial crab, that inhabits salt marshes, mudflats and sandy beaches. Inactive during high tides. Males have one claw much larger than the other. The carapace is violet, yellowish-brown or black.



[87] *Protula tubularia* (Bristleworm)

A polychaetae worm with 5cm in length and with 100 body segments. The gills are from white to red. The tube is 2-8mm in diameter. It is found attached to rocks or shells on the bottom up to 100m of depth.



[88] *Sepia officinalis*
(Common Cuttlefish)

Large, oval body up to 30-40cm with fins that extended throughout the body., With a small ventral syphon, and retractile arms. The color varies from black to gray or white, striped or mottled, capable of changing colors. Can go up to 250m depth. Found in sand. Feeds upon crustaceans and fish.



[89] *Crassostrea gigas* (Pacific Oyster)

With a large, oval, asymmetrical shell, up to 10-15cm length. With concentric rings and 6-7 radial rings. White and brown shell, and white inside. Attaches to rocks at the sublittoral, in calm waters. It is a filter feeder.



[90] *Ensis siliqua* (Pod Razor)

Long, straight shell, up to 20cm in length and parallel edges. With a dark external ligament. The shell is white, with greenish-yellowish stripes. It buries itself in sandy bottoms up to 30m of depth.



[91] *Ruditapes decussatus* (Grooved Carpet Shell)

Oval shell, up to 6-7cm in length. The surface of the valves is reticulated and growth striations. The shell is white-yellowish with brown markings and the interior is white. It buries in sandy and muddy bottoms. It is a filter feeder.



[92] *Papilio machaon* (Common Swallowtail)

Wingspan of 60-80mm. Yellow wings with black stripes and blue stripes on the posterior wings. The tip of the posterior wings is pointy. Males are bigger. It feeds on plants, mainly *Ruta chalepensis* and *Foeniculum vulgare*. Can be found in flowered prairies and gardens.

Other plants



[93] *Ulva sp* (Sea Lettuce)

A thin flat green algae growing from a holdfast, it has torn edges. It can reach 18cm in length and up to 30cm across. It grows attached to rocks or other algae by a small holdfast. The color varies from several green tones.

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