

## The Vicissitudes of a Coastal Lagoon from the 19<sup>th</sup> Century to the Present Day

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### Abstract

An account is given of the man-made alterations in the ecology of Lesina, a large (5328 ha) shallow lagoon on the south Adriatic coast of Italy, alterations motivated by the necessities of fish production, reclaiming land for agriculture, and eliminating malarial marshland. Up to 1851 the ecosystem was ruled by entirely natural forces. In that year an artificial outlet to the sea was dug in addition to the existing natural one. In 1903 a second artificial sea channel was opened. By the 1950s all the surrounding freshwater marshes (ca 1500 ha) had been drained and a dike built around the perimeter of the basin. Underwater trenches in the lagoon have been dug to facilitate water circulation. Pollution has become evident in the last fifty years. Three years ago a small harbour for sea-going fishing vessels was constructed at the entrance of one of the sea channels.

### 1. INTRODUCTION

Lesina Lagoon lies on the south Adriatic coast of Italy (see Map). It has an oblong shape, extending parallel to the coast for 22.4 km, with a width varying between 3.8 and 1.4 km. The mean depth of the waters is 0.7 m with a maximum of 1.15 m. The waters are brackish showing a permanent gradient from east to west. In the eastern part where freshwater flows in values always stay lower than that of the sea (36 ‰ S), whereas in the western part salinity often exceeds marine values in summertime when evaporation is high. When the lagoon is at mean sea level its surface area is 5328 ha but, before being diked in the 1950s, it used to expand an extra 1500 ha (a total of 6673 ha under water) during the rainy season in autumn and winter.

This marshy area of expansion was around the margin of the eastern half of the lagoon. Two artificial canals (Acquarotta, Schiapparo) connect the lagoon with the sea. These channels were dug in 1853 and 1903 respectively; before that there was one main channel, S. Andrea, and several minor ones (Acquarotta, Zappino, S. Maria, S. Placido, Caùto, Morella, Gravaglione, S. Focato) which, however, were simple ditches dug by hand across the sand spit to the sea as the season required.

The mean annual rainfall in the area is 455 cm and the evaporation rate from the water surface is 10 mm in summer, 6 mm in spring and autumn, and 2 mm in winter. Its catchment basin extends to 604 km<sup>2</sup>, more than ten times the water basin.

At the eastern extremity three large karst springs of freshwater (S. Nazario, Lauro, Fiume Longo), flowing from the foot of the Gargano massif about 2 km away, contribute ca 2000 l/sec. Before the reclamation works of the first half of the 20<sup>th</sup> century, these springs conferred a freshwater character to the eastern marshes. Within the catchment basin are the towns of San Nicandro, Poggio Imperiale, and Lesina with a total of 30,000 inhabitants. The depuration plants of these towns contribute 60 l/sec of freshwater to the lagoon (Breber 1999).

### 2. THE FISHERY

Since remote times Mediterranean lagoons have attracted men for reason of their rich fishery. A good lagoon can yearly yield 100 kg/ha and more of commercial fish. The catch is usually composed of eel (*Anguilla anguilla*), seabass (*Dicentrarchus labrax*), gilthead seabream (*Sparus aurata*), grey mullet (*Mugil cephalus*), *Liza aurata*, *Liza saliens*, *Liza ramada*, *Chelon labrosus*), and silverside (*Atherina boyeri*), but the list can be quite longer, including molluscs and crustaceans, in the case of a specific lagoon.

The critical aspect of a lagoon fishery is that nearly all of the commercial species spend only part of their life cycle in lagoons. These bodies of water provide rich feeding grounds but are not suitable for reproduction, so in order to breed the fish are obliged to return to the sea.

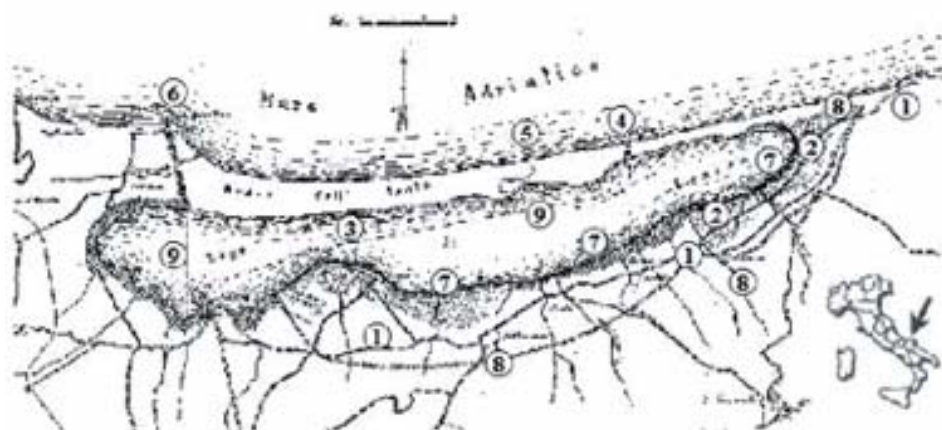


Figure 1: Lesina lagoon showing relevant features and engineering works (Colacicco 1955). 1. Lesina-Rodi road, 2. Eastern marshes, 3. Division of 1811, 4. Schiapparo channel, 5. S. Andrea channel, 6. Acquarotta channel, 7. Dike, 8. From left to right, freshwater springs of S. Nazario, Lauro and Fiume Longo, 9. Underwater trench.

Fish like to enter lagoons especially at the end of winter as newborn fry, whereas for the sexually mature the urge to migrate back to the sea comes in autumn at the onset of the breeding season. The years between the stage of fry and that of sexual maturity are spent in the lagoon.

The connection between lagoon and sea is obviously of strategic importance for the stocking of a lagoon. It is of utmost importance that the seamouth be open during the spring months when millions of fry swarming in coastal waters are wanting to swim in. This outlet to the sea forms naturally when the lagoon, swollen with the rains of autumn and winter, brims over the sand spit which separates it from the sea and scours out a channel. In well-run fisheries the men do this artificially by means of constructed canals equipped with watergates; the usual time for keeping them open is from March to May. As the lagoon discharges, its level evens out with that of the sea, the outgoing current slackens and the canal is then subject to becoming obstructed with sand washed in by the sea. The other period of the year when a link with the sea is necessary is in autumn. The watergates are opened so that the sexually mature fish, feeling the call of the sea, rush for the channel and thus are caught in the weirs. In unmanaged lagoons the fish may have problems finding their way out because by the end of summer the outlet is usually blocked with sand. The only chance for them is when autumn storms send surges over the bar obstructing the channel. The fish are then seen to rush furiously through the wash in the few seconds between one surge and the next.

In conclusion, it should be clear that the build up of water during autumn and winter is fundamental in the economy of a lagoon fishery because this produces the spring outflow which is what attracts the fry in the sea and is therefore the means by which the lagoon is stocked (Bullo 1902).

### 3. PROBLEMS BEFORE 1811

Before the elimination of the feudal system of land tenure in 1811, the fishing rights in Lesina lagoon were shared by the lord and by the local citizens. The townfolk of Lesina could fish for home consumption or for sale within the community, while the right to export the produce abroad belonged exclusively to the holder of the fief. The eel fishery made this fief far richer than the usual land holdings. There was much chronic abuse, of course, on the part of the locals running their own contraband business with outsiders, which recurrently lead to open clashes with the lord's agents. There were also disturbances coming from outside.

The forever fluctuating state of lagoon ecosystems and that of Lesina in particular has in various ways vexed and confounded the rationalistic schemes of man. The uncertainty of the landward boundary, the ecotone striding saltwater, freshwater and solid ground, of Lesina lagoon became the cause of a dispute between the townships of Lesina and nearby San Nicandro, which began more than four centuries ago and has not yet been solved.

The quarrel broke out when men from S. Nicandro were caught placing nets in the lagoon to which the townsfolk of Lesina presumed exclusive fishing rights.

According to the law *De Salariorum* by king Ferdinand I (1482-83), the common right to practice fishing belonged to the inhabitants whose territory bordered on the body of water concerned. Now the territory of Lesina did not simply border on the lagoon but encompassed it entirely and the main preoccupation of the community and of the lord was to jealously keep the fishery for themselves. The first documented protestation of the lesinesi concerning the inroads of the nearby people from S. Nicandro on their fishing rights is dated 1539 (Colozzi 1932).

The bona fide boundary between the fiefs of Lesina and that of S. Nicandro was the public road which links Lesina to the towns of Rodi and Vico to the east (see Map). The road ran along the south boundary of the lagoon ecosystem just above the high water mark during the season of flood. During the period of low water, however, the edge of the lagoon would recede at least 1,100 m from the road leaving bare 1,581 ha of marshy land. Now, could the sannicandresi honestly claim that they bordered on the water, and thus claim common rights to fishing, even if only during the season of flood and even if there was a public road in between? The sannicandresi expectedly considered the water's edge as the limit to their territory and not the road, especially since the marsh tended to flood less and less with the passage of time as the ground level rose with the soil washed down from the hills. The sannicandresi were shepherds and farmers, while the lesinesi were exclusively fishermen, so that the former had far more interest in the marsh than the latter, where they could take their cattle to graze and open up the drier portions to cultivation.

The lesinesi of course could not countenance this aggressive policy of their neighbour, which was not only little by little subtracting 1,581 ha of territory, but furthermore outrageously insisted on claiming fishing rights. The lesinesi refused to renounce the stretch of marsh especially since this territory pushed the sannicandresi back from the brink of the open lagoon and thus nullified their claim to fishing rights according to the law *De Salariorum*. There were further complications. The management of the fishery required raising the level of the lagoon at least one meter above sea level by the end of winter.

This meant that the lesinesi themselves of necessity caused the lagoon surface to expand horizontally, flooding the marshes, and making it reach the border of S. Nicandro, thus creating a situation contrary to their own legal interests. Legal actions and violent clashes between the two communities succeeded through the centuries.

Up to this time the problems that affected Lesina lagoon through the centuries were purely of social and economic nature, and the ecosystem was still largely unaffected although, as mentioned above, there had been some loss of area from build up of silt at the eastern margin and the interchange with the sea was to a certain extent governed artificially since it was such a crucial factor in the success of the fishery. Heavy tampering with natural forces came as a consequence of the abolition of the feudal system in 1810 (Colozzi 1932).

#### 4. PROBLEMS AFTER 1811

The elimination of the feudal system brought by the Napoleonic period meant that fiefs were to be converted into private property and there was to be no more shared use of the land. In the case of Lesina this meant that the rights of the lord and of the local citizens over the lagoon could no longer be exercised promiscuously. The Royal Commissary on the 8<sup>th</sup> June 1811 proceeded to split the property of the lagoon between the former lord and the townsfolk. The eastern two thirds of the lagoon became the private property of the ancient feudal holder and the western one third was given to the citizens for their own fishing (see Map). The prohibition for the locals to trade outside their community was lifted so that they now too, if they wanted, could sell fish abroad. The Commissary gave permission to the lesinesi for digging a new sea channel to serve their own part of the lagoon but this project would not be put into effect until many years later. At this point the owner of the two thirds made a deft and rather high-handed move. In 1823 he obtained from the mayor of Lesina the perpetual lease (*emphyteusis*) over the one third of the lagoon belonging to the township. In this way the lesinesi lost all vestige of the right to fish. The contract did recognise, however, the other common rights of less consequence such as the snaring of coot, the gathering of dry wood on the spit separating the lagoon from the sea, and the gathering of reeds and rushes in the marsh.

This deal gave the private owner the possibility of finally exploiting the rich eel fishery all for himself while the township received a rent which would, on the face of it, ease the tax load on the citizens.

The owners who had held the lagoon as a fief from 1753 to 1810, and then as private property from 1810 onwards, put it up for sale in 1836. But now the spirit of the times had changed and the new owners found that the locals were not so docile as heretofore and not at all reconciled with how the situation had evolved. The new attitude of the populace was heralded by the illicit opening in 1851 of a new sea channel (Schiapparo) at the eastern end of the lagoon (see Map). This was almost certainly done by the sannicandresi in order to lower the level of the water which was flooding their plots in the marsh (Rosano *et al.* 1903).

The town council of Lesina now began a long war and by means of captious legal means started to sabotage the management of the fishery in order to demoralise the owners and, in the long run, make them relinquish their rights.

The legal device used by the mayor was the following: conceded that the lagoon was undisputed private property, the one or more channels which linked it to the sea were, however, classified as public waters and thus did not come under the authority of the owners. The mayor of Lesina now declared that on the grounds of public health these outlets to the sea should be kept permanently open.

The incidence of malaria was very heavy locally and the exhalations of the marshes were in those days thought to be the cause. By keeping the outlets to the sea open and the level of the lagoon as low as possible, the fringing marshes would not flood and thus less prone to form gases from the decomposing vegetation. For the owners this was a dirty trick. As explained at the beginning, the opening and closing of these channels during definite periods of the year is fundamental in managing and sustaining the fishery. The owners, therefore, refused to comply but the mayor did not relent and in 1873 convinced the Ministry of the Interior to order the opening of Schiapparo channel. The mayor managed for several years to have his way, letting the fish escape to the sea in winter, hindering the ascent of fry in spring, and so causing heavy losses to the owners.

The owners in the meantime managed to bring the Ministry round to their point of view and in 1882 obtained a new decree which permitted the closing of Schiapparo channel in winter in order to raise the water 0.9 m above mean sea level.

Schiapparo channel had by now become a consolidated structure of masonry with floodgates and had superseded the channel of S. Andrea, which for centuries had been the main link with the sea but had lately been allowed to fill up with sand (see Map).

The mayor retaliated and on his own authority ordered the floodgates to be left open and seals put on them, he also prohibited the placing of fish weirs in the channel as these too were considered an obstacle to the discharge of water, and he even went so far as to forbid the fishing for eels in the lagoon with dragnets since this practice, by tearing up the bottom vegetation and thus making it die and rot, was the indirect cause of the smells which were then thought to be the origin of malaria.

It is worth noting on the side that this strategy used by the mayor of Lesina against the owners went to the benefit of the other enemy, S. Nicandro. Keeping the outlets permanently open and leaving the marshes dry and accessible resulted in the complete takeover of these lands by the squatters from the neighbouring town.

In 1902 the central government, tired of this quarrel, appointed a committee of experts to investigate the whole business and to possibly come up with a definitive solution. The resulting reports (Bullo 1902; Nazzani 1904) showed some sympathy for the owners' point of view and did make clear to the central authority the necessity of raising the level of the lagoon during winter.

It is in these very years the discovery was made that it was not the marsh gases (methane, H<sub>2</sub>S), as heretofore universally believed, the cause of malaria but the protozoan *Plasmodium* transmitted by the females of the *Anopheles* mosquito. The idea that the draining of marshes would solve the problem lost nearly all of its original motive since any puddle, the same drainage ditches of the reclamation works were quite sufficient for spreading the agent. This discovery did not stop the general trend of turning wetlands into farmfields because, in any case, it allowed the elimination of the existing common rights, judged an useless remnant of an obscure age. The only legal way the owner had to extinguish the servitude of common rights was to transform and improve his property, and the draining of a marsh was then considered as such (Breber 1997).

In 1905 a yet another decree from the Ministry of the Interior swung the situation back in favour of the mayor of Lesina. The increase in level of the lagoon during the autumn and winter months was reduced from 0.9 to 0.3 m, the fish weirs in Schiapparo channel could stay but the prohibition of fishing for eels with dragnets was left.

The owners of Lesina lagoon, who had by now become very discouraged of their chance of ever seriously controlling the fishery and were also aware that the government was about to declare the lagoon public waters, changed their strategy completely and started to promote the draining and reclamation of the entire complex (Camera dei Deputati 1915).

By turning the lagoon into fields this would certainly settle the matter once and for all: the area would remain private property, there would be no more poaching of fish, no more common rights to respect, and all the legal grounds of the town council for heckling with the excuse of public health would vanish forever. But such a drastic project was destined not to be.

In 1903 the Acquarotta channel at the western end was finally accomplished nearly a hundred years after it had been initially proposed (see Map).

In 1924 the lawcourt of Bari passed a judicial determination recognising the common right of the townsfolk of S. Nicandro to fish in the lagoon (Colozzi 1931). This was considered preposterous by the lesinesi. They, who had lived off the lagoon for centuries and identified with it, were now the only party excluded from this resource: the owners had their commercial fishing rights, the sannicandresi had had their common right to fish finally accepted, while the emphyteusis contract of 1823 with which the lesinesi had forfeited their right to one third of the lagoon was still considered valid.

In 1925 the mayor of Lesina tried another move. He declared that, according to his reckoning, the owners had not paid the full amount of the dues for the emphyteusis for the last three years and for this reason, according to the terms of the contract, the third part of the lagoon should now revert back ipso facto to the township of Lesina.

But all this manoeuvring on the part of the various parties was preempted by the government who in the meantime had been drawing up a comprehensive plan intended to solve all aspects of this business. To begin with, the waters of Lesina lagoon were definitely decreed to be public (1934), without possibility of reclaim, so that the question of the emphyteusis contract of 1823 between the township of Lesina and the owners was once and for all settled. The onetime owners were furthermore "asked" to cede 60% of their commercial fishing rights to the communities of Lesina (30%) and of S. Nicandro (30%). The conflict arising from the winter flooding of the now largely cultivated marshes of the eastern portion of the ecosystem was going to be settled by building a dike around the lagoon at the low-water perimeter so that the level of the lagoon could be raised for the purpose of the fishery without expanding its surface. These works (see Map), planned in 1925, were terminated in the 1950s. The springs of S. Nazario, Lauro and Fiume Longo proceeded to be canalized and conveyed straight into the lagoon. At the same 25 km of underwater trenches within the lagoon basin were dug in order to increase the penetration of seawater (Colacicco 1955).

The virtual conclusion of the 134 years war between the private owners and the local community arrived in 1943 during the Allied Occupation following World War II when the military authorities, petitioned insistently by the township, gave over 99% of fishing rights to the locals (Colacicco 1955). After the war there was a last halfhearted attempt by the other party to ask for its due but the request was simply ignored and the matter died there.

It must be realised that even in the days when the power of the feudal holder and later of the private owners seemed legally and politically complete and undisputed, it was very difficult if not impossible to stop the locals from doing much what they wanted with regards to exploiting the lagoon. Once in a while enforcement would be tried, with even people killed in the process, but to no avail in the long run.

When the lagoon came completely under the control of the local communities a period of decadence in the fishery management began. One initiative in the 1970s was the digging of long and wide underwater trenches. These were supposed to help water circulation and to offer refuge of deeper water to the fish during cold and hot spells of weather.

A lagoon fishery requires a determined centralised management but when the organisation is bottom-up involving several fishermen's cooperatives the tendency is towards every-man-for-himself, leading to overfishing and to the neglect of the spring stocking operation. The mayor of Lesina did manage for a certain while, on his authority, to coordinate the fishing policy, but by the 1980s the situation had become anarchical. The yield in fish had by now dropped to less than 40 kg/ha/y and the fishermen had dwindled to about 40 units most of whom were pensioners rounding off their income. Only very recently in the last four years has there been a serious effort to reinstate a properly run lagoon fishery. New fish weirs have been installed in the sea channels, the watergates are opened and closed at the proper time with regard to the fish migrations, and fishing rules are enforced. It should be remarked that even now the waters are not allowed to increase more than 0.5 m above mean sea level to prevent harm to the vegetable crops of the sannicandresi from the seepage of brackish water through the dikes.

With regards to the conflict with S. Nicandro dating back to the XVI<sup>th</sup> century, more than one battle has been lost by Lesina, but the war is still on. The fishing rights of S. Nicandro, both common and commercial, have been recognised and the territory of the former eastern marshes has come definitely in the possession of the vegetable gardeners from this town.

These squatters were once or twice challenged by the legal owners, the same who had once been the owners of the lagoon, before the twenty years expiry of usucaption, but as I am writing they are still there. The town of Lesina, on the other hand, still considers this territory under its jurisdiction and has just recently (2000) managed to avoid an underhand coup by S. Nicandro to take it over, steered by a quisling councillor of Lesina, actually an infiltrated sannicandrese.

With the undersigning of the Ramsar Convention (1971) the Italian government has finally renounced its policy of draining wetlands, which had begun early in the 19<sup>th</sup> century and continued right into the 1960s. Now the surviving wetlands are to be conserved especially for the benefit of wildfowl and so in 1981 the eastern portion (970 ha) of Lesina lagoon has become a bird sanctuary by decree of the Minister of Agriculture.

In 1991 Lesina lagoon was included within the newly instituted Gargano National Park but a portion has been left out for the benefit of the duck shooters.

## 5. DISCUSSION

What have been the long term ecologic and economic results of all the changes in the ecosystem brought by man?

If the engineering works ensured the draining of the freshwater marshes enabling the land to be cultivated, it also had the effect of changing the salinity of the eastern basin to the point that about 500 ha of once brackish waters have since become freshwater invaded by reed growth (*Phragmites australis*) which is unsuitable for fish production. Considering that the 1500 ha of since-reclaimed freshwater marsh had once been habitat for eels and the 500 ha of brackish water, now become a congested reed brake, once yielded eels plus seabass, gilthead seabream, grey mullet and silverside, the drainage works have subtracted about a third of the area suitable for fish production.

The new agricultural land which took the place of the marsh around the perimeter of Lesina lagoon may be distinguished in two parts. The part along the western and southern shore today yields industrial crops such as wheat, sugar beet, tomatoes, and sunflower. This type of agriculture does not survive today without EEC integration. The new land at the eastern extremity has instead produced lucrative market gardens. Thus only about a third of the reclaimed land has in the long term given rise to self-supporting agriculture.

Surrounding the lagoon with a dike has eliminated the once very wide ecotone of shallow water which was the habitat of the large category

of wader birds. Today the conservation of this type of territory would be given top priority.

The digging of underwater trenches has negatively affected the benthic environment which is where most of the biotic production takes place in lagoons. The trenches which were dug in 1970s have in the meantime mostly filled up and are nearly even with the rest of the lagoon bottom but have yet to be re-colonised by eel grass (*Zostera*, *Cymodocea*, *Ruppia*) although this plant, which is a very important component of the ecosystem, is present in luxuriant growths on both sides of the track (Breber *et al.* in press).

The last decades have seen sewage pollution come to the fore as a prime ecological factor. Most of the pollution reaching the lagoon comes from the badly-functioning sewage-treatment plants of Lesina, Poggio Imperiale and San Nicandro, and from the intensive fish culture which uses the waters from S. Nazario spring. Taking 60 g to be the daily B.O.D. for every inhabitant, it may be calculated that the lagoon every day receives about 1800 kg of B.O.D. from the towns, with an addition of 750 kg/day in summertime because of the holiday residents. Localised heavy macroalgal growth and anaerobic conditions are the result. Here too one feels the loss of the freshwater ecotone of reeds and bulrushes with its high depurating capacity: one hectare of shallow freshwater wetland is capable of removing 21.7 kg of BOD per day (Breber 1999).

In 1994 the fishermen of Lesina decided to use the seaward entrance of Acquarotta canal as a harbour for their sea-going fishing vessels. This has had a negative influence on the spring migration of fry because the resulting noise, soiled water, lights, movement and unnatural obstacles at the very point of entry to the lagoon constitute a strong deterrent. Another negative factor are the long moles into the sea that were built on both sides of the sea channels. Considering the way fry swims in the shallow water along the shore, these moles at angles to the coast are an obvious obstacle along their course into the lagoon.

The institution of a bird sanctuary and recently of a national park has not as yet implemented any form of active management of the environment.

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