

UNESCO World Heritage Site Initiative

Description:

These are the eight distinct volcanic crater lagoons formed in Nicaragua at different moments in time. They are scattered over a few hundred kilometers and with sizes between .16 and 8.38 square kilometers of surface area and between 10,000 and 500,000 years of age. Six of them are already protected areas, partly by their isolation and steep slopes which are both scenic and vulnerable to impacts on their very limited basins. Each lagoon is unique, both because of its age, and by characteristics of water, size, depth, and species it contains.



The two most accessible of Nicaragua's lagoons are Apoyo and Xiloa, which are the most developed in terms of tourist infrastructure and where the most detailed studies have been conducted on lagoons within the country. There are two other lagoons, Masaya and Tiscapa, which have been negatively impacted by human waste, compromising their water basin, due to their close proximity to population centers. Another lagoon, the Asososca Lagoon in Managua, serves as a source of potable drinking water for Managua where proper controls are set in place to protect it. Finally, the lagoons of Monte Galan, Asososca Leon and Apoyeque are the most difficult to access and quite far from populated areas and as a result, have experienced minimal impact.

To date, there exists various scientific studies in support of the Apoyo and Xilola lagoons, but very little is known about the other six. Each lagoon has between three and seventeen different species of fish, many of them endemic, meaning that they only exist in these lagoons. Still scientific studies continue to find ways to clarify the taxonomy and origin of the above mentioned species. To date, we have described three new endemic species found in the Xilola Lagoon and six endemic species found in the Apoyo Lagoon. Others species are waiting to be described in the other lagoons, which the exception of Apoyeque where genetic studies demonstrate that all of the fishes there are of recent origin.



What makes these lagoons so unique is that individually they represent their own laboratory of evolution, however together, they represent an aquatic galapagos and something similar to what can be found on the volcanic archipelago islands. There, one island alone is of great interest, but together, the entire set of island allows for comparative studies and this was what allowed Darwin to advance his Theory of Evolution. Currently, the future opportunity is no less dramatic, opening up the possibility to advance the Theory of Evolution. It is not to say that the present Theory is mistaken, but instead, we have an opportunity to perfect the mechanisms of the formation of new species. Another aspect is that on the Galapagos Islands a certain type of bird formed several species on the different islands due to the isolation and differences in each environment. The same has happened in the lagoons, but contrary to the Galapagos islands, it seems that in every lagoon only one ancestor divided into several species within the same lagoon. This same process has happened in several

lagoons and in different periods of time. This allows us to study exactly how the environment and timeframe played a role in the formations of new species. Each lagoon therefore has the same touristic potential for scuba diving, and the new species are already calling attention to the world of aquaculture as much as for pets, as for the purposes of crops for feeding purposes.

Justification for Outstanding Universal Value:

As previously mentioned, each lagoon has its own unique and indigenous species, many of which still lack description and formal recognition. They are their own isolated laboratories of evolution over tens of thousands of years. There exist little to no comparable examples than those of the collective Galapagos islands. Locally the lagoons are recognized by their natural beauty, but their scientific potential is gaining fame for the growing emphasis on the convergent evolution that exist between and within each lagoons. It is to say that each lagoon has multiple species that arose from only one ancestor which spread from one lagoon to the next resulting in similarities between lagoons. For example in Lake Xiloa, there is the species known by name *Amphilophus amarillo* and it specializes in eating snails while possessing a strong jaws and teeth to grind. However, its next closely related species, the *Amphilophus sagittae*, instead eats fish utilizing its sharp fine teeth and extended body and head for speed. In Apoyo, there exists its own similar counterparts in the species *Amphilophus chancho* and *Amphilopus zaliosus*, with one having a massive body and grinding teeth for eating snails, and the other known for being a specialist in eating fish. The surprising thing is that the species that look very much alike between lagoons are actually much more distant than those who do not look alike within the same lagoons. These results have already been highlighted in the very best scientific journals, notably of *Nature* and *Science*, calling scientific attention worldwide.

Characteristics of Each Lagoon

All of the lagoons are characterized as closed water basins which offer a high degree of endemism and isolation but at the same time renders them vulnerable to irreversible changes by contamination both by chemicals and garbage alike.



XILOA LAGOON

Xiloa Lagoon:

Its surface area is 3.75km² with an average depth of 60 meters. The max depth is about 88m while the total volume is about 225,000 cubic meters. The pH is 7.9, turbidity secchi average 2.5 meters, (but may vary between 1.5 and 4m), and has a coastal area of 1.4km². Due to the proximity to Lake Managua, and the fact that it can overflow as it almost did during Hurricane Mitch, can attribute to the existing diversity of the fish. Its age is estimated at ten thousand years. This lagoon has been studied more often and in more detail than any other.

Only three new cichlid species endemic to the Xiloa lagoon were described: *Amphilophus sagittae*, *Amphilophus xiloensis*, y *Amphilophus amarillo*. It is possible that there is one more species to describe in this lagoon related to *Amphilophus labiatus*. Unfortunately, this species is not very common and we do not have much material at hand. In addition to the endemic and newly described species, the lagoon hosts the following known species with the name: *Parachromis dovii*, *Parachromis managüense*, *Astatheros longimanus*, *Arcocentrus rostratus*, *Astatheros centrarchus*, *Hypsophrys nicaragüense* *Amatitlania nigrofesciatum*, *Neetroplus nematipus*, *Melanuris jiloensis*, *Dorosoma chavesi*, *Synbranchus marmoratus*, *Rhamdia nicaraguesis* y *Goboiomoros dormitor* y *Poecilia* sp. Therefore, this lagoon covers more than one species ... at least 17 species of which approximately four to seven may be endemic.



APOYO LAGOON

Apoyo Lagoon:

Its surface is 21.1 km² with an average depth of 142 meters. It is the deepest of all lagoons with a maximum depth of more than 200m, and also the largest with 3 million cubic meters in volume. It is the largest even in its turbidity which has been reported as 3m secchi, this measure is erroneous and typically the visibility covers the 20 meters, being the clearest of the lagoons. The pH of 8.1, somewhat alkaline but less than almost all other lagoons. The age of this lagoon is also estimated in only 10,000 years. Its coastline is a very reduced .4km², descending with a very steep slope in almost all its surroundings.

Fish have been studied here for more than a decade and at least seven endemic species are known, six of which have been formally described. These are: *Amphilophus astorquii*, *Amphilophus chancho*, *Amphilophus flaveolus*, *Amphilophus globosus*, *Amphilophus supercillius*, *Amphilophus zaliosus*. In addition the lagoon contains the species known as the *Parachromis managuense*, *Gobiomorus dormitor* (which was introduced furtively by the local people in 1990-1991), *Melanuris sardina*, y *Oreochromis aureus*, which were introduced in at least two occasions, and finally a species known by the name of *Poecilia* – possibly *P. sphenops*. The consequence of the last introduction of *Tilapia* has been temporarily disastrous, making profound changes in the amcroalgas of the lagoon which seemed to have possibly exterminated two endemic species even before they could have been described. At present the Ictiofauna comprises of at least seven endemic species and four others of which two are of recent introductions.

Due to its size, crystalline waters, and rocky reefs this lagoon has a high potential for diving tourism and is also under pressure by investors who wish to take advantage of the spectacular scenic environment to foster large development projects, many of which are not very advisable. The current management plan has stopped all development plans and new infrastructure.



Apoyeque Lagoon

Apoyeque Lagoon:

It has a reduced surface area of only 2.5 km² but it is nevertheless very deep with an average of 53m and a maximum of 110m in depth. It is quite alkaline with a pH of 8.8 and is among the most turbid of all the lagoons reported with secchi of .7 meters at the surface, but we have found moments with nearly 2m secchi. With such turbidity the light can not penetrate very deeply and it is possible that there is a cloudy layer above and a very transparent but dark space underneath, which sometimes happens in the lagoon of Masaya. This lagoon has a very small basin and is located on a hill near the Laguna de Xiloa where access is very difficult these days. So our knowledge of this lagoon remains rudimentary. The coast covers .9 km² and is estimated to be less than 10,000 years old. Genetic studies of their fish indicate that they arrived in the lagoon just a few hundred years ago and for this reason no endemism is expected.

Only four species have been reported in this lagoon which are known as *Amphilophus citrinellum*, *Amphilophus labiatus*, *Parachromis managuense* y *Poecilia* sp. Due to its proximity to the Xiloa Lagoon and the similar characteristics between their species it makes for a high value for future comparative studies.

Masaya Lagoon:

The size of this lagoon is intermediate between the Laguna de Apoyo and Xiloa with 8.38 km². It has an average depth of 41.7 meters and a maximum of 72.5m; its volume covers 350,000 m³ and the pH is 8.6, secchi turbidity of 1m. It is not surprising to see oligotrophic nature due to a large amount of organic matter entering the lagoon from the city of Masaya. The coastal air is 2.2km² and reflects a crescent shape due to the current Masaya volcano filling 95% of the old caldera so the current Masaya lagoon is only a remaining slope of the caldera. The age of this lagoon ranges from 25,000 to 100,000 years. Due in part to its turbidity and on the other hand to its reputation of

being contaminated with all the black waters of Masaya, few studies of the fauna ictica of this lagoon have been made. In addition, the rocks consist of lava of recent origin and very sharp, so fishing with nets is very difficult.

The reported species of this lagoon are known as *Poecilia sphenops*, *Poecilia sphenops*, *Poecilia sp.* *Melanuris sardina*, *Parachromis dovii*, *Parachromis managüense*, *Amphilophus labiatum* *Amphilophus "citrinellum"*, *Asatheros longimanus*, *Neetroplus nematipus*, *Hypsophrys nigrofasciatus*, y *Gobiomorus dormitor*. At least two of these are being studied for being possibly endemic and novel for science, but their formal description have not been published.

Although the Masaya lagoon and its basin have numerous petroglyphs and a high tourist potential only if and when the lagoon is cleaned and the introduction of large amounts of organic matter and garbage is halted. The good thing is that projects are already being contemplated to accomplish this. The lagoon itself is included in the Masaya Volcano National Park so a large part of its environment is already protected.



ASOSOSCA LAGOON (León)

Asososca Lagoon (León):

The surface area of this lagoon is only 0.8km² with an average depth of 17m and a maximum of 35m making it easily possible to explore the deep areas during the dry season. It only contains about 14,000 cubic meters of water with a Ph of 9.0 making it the most alkaline of all the lagoons. With .7km of coastline, almost all the lagoon is coastal. The reported secchi turbidity of .8m should vary according to the season because we dove there on several occasions where it easily spanned 2.5m. Its age is still controversial with estimated disparities up to 100,000 years.

The studies here continue in their infancy, unfortunately someone introduced the species known as *Oreochromis mossambicus* to the lagoon, but they have not proliferated much. Also there are reports of known species with the name de *Amphilophus citrinellum* y *Parachromis managuense* más *Poecilia* sp. Preliminary studies of the *Citrinellus* indicate that they are an endemic species that is quite old. Apart from the recent introduction of the species with the name *Oreochromis mossambicus*, the lagoon of Asosoca león has been intervened and studied little. It is almost certain that the species known as *Cichlasoma citrinellum* is a new species there, with the possibility of two, but a visit to the lagoon during the breeding season is needed to find this out. The location near Leon Viejo makes it accessible to visit although there is no development around.

Asososca Lagoon (Managua):

It possesses 0.73 Km² and is almost the same size as the lagoon of Asosoca in león, but its characteristics are very different, with an average depth of 54m and maximum depth of 91 and a volume of 40,000 cubic meters. And it is expected to have an even smaller coastline of .2km² over time. It has a secchi turbidity of 3m, that is to say it has good clarity. Its origin is very recent between 5000 and 10,000 years.

The fauna ictica of this lagoon seems very reduced with only the known species with the name of *Melaniris sardina*, *Amphilophus citrinellum*, *Parachromis managuense*, y *Gobiomorus dormitory*. Here we also suspect that there are one or more species with the name *Amphilophus* endémicos, but for more than twenty years the lagoon has served as a source of drinking water for the city of Managua, and for that reason public access is restricted. The few investigations that have been carried out suggest that there is at least one new species known as *Amphilophus*, but it remains to be discovered during the breeding season.

Monte Galan Lagoons:

These lagoons are among the smallest and are a set at the base of Volcano Momotombo, the total surface covers 0.97km², with an average depth of 5.2m, maximum depth of 15m as well as being the driest of all lagoons with only 5,000m² of Water and a pH of 8.6. Although its secchi clarity has been reported as 1.8m that only covered about 60cm in a short visit at our discretion. Its coastal area is of 1km². The most interesting factor is its age of almost 500,000 years so this is the oldest lagoon in the whole complex.

Although not studied in much detail, a diverse fauna has been reported. These include the species known as *Dorsoma chavesi*, *Poecilia* sp. , *Melaniris sardina*, *Astatheros centrarchus*, “*Amphilophus citrinellum* “ *Astatheros longimanus*, *Astatheros rostratus*, *Herotilapia multispinosa*, *Parachromis managuense* y *Gobiomorus dormitor*. Many of these species suggest that there may have been some contact with Lake Managua, via overflow.

These lagoons are located inside a protected area that is not very busy and quite wild because access is restricted.



TISCAPA LAGOON

Tiscapa Lagoon:

This lagoon is the smallest of all at 0.16km², but quite deep with an average depth of 21.8m and a maximum of 39m. Its volume is 3,500 m³. It is also shrinking with a pH of 8 making it among the most moderate. Secchi turbidity is reported at 1.8m and its coastline is very small at 0.2m². The age is 10,000 years which places it among the most recent of the lagoons.

The Fauna Ictica includes the species known as *Amphilophus “citrinellum”*, *Parachromis managiüense*, y *Poecilia* sp. as far as we know, but it has never been investigated very closely. The fact is that it is difficult to access as it is in the center of Managua and has been used as a dump. Only recently have there been attempts to heal this lagoon in a rather strategic place.

The reports of fish mentioned here are based mainly on a Waidet study which was carried out in 1989. This study has 19 new distributional reports, that is to say 19 reports of species that were not known of these lagoons. From there, two lagoons, which are the Xiloa lagoon and the Apoyo lagoon, have been subjected to more detailed studies

with the result that eight new endemic species have been described. Eight other endemics may eventually be expected to come with time the studies that follow.