frontiers FOR YOUNG MINDS

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COASTAL LAGOONS: IMPORTANT ECOSYSTEMS

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YOUNG REVIEWERS:

ANTHONY
AGE: 14

BURUK
AGE: 15

ELILL
AGE: 15

YUHENDRA
AGE: 11

Coastal lagoons are parts of the Earth's coastline, where the ocean meets the land. They are important zones both for living things and for our economy. Coastal lagoons contain various kinds of habitats that provide homes for many animals and plants. Thus, they provide many valuable natural resources to people living and working in those areas. In this article, we describe what makes coastal lagoons attractive and important to plants, animals, and people. We also give examples of human activities and pressures that disrupt the lagoons close to where people live. Despite the damage human activities can cause to coastal lagoons, if countries respond with the right management measures, we have hope that the condition of coastal lagoons can improve, so that they will exist long into the future.

WHAT ARE COASTAL LAGOONS?

A **coastal lagoon** is a shallow body of water along the coast, which is separate from the ocean but connected to it by one or more **inlets** (Figure 1A) [1]. The lagoon that surrounds the city of Venice, in Italy, is a good example. Coastal lagoons range in size from 0.01 km^2 to 10,000 km^2 and they are found along 13% of the Earth's coasts [1, 2]. For example, the Ria Formosa lagoon in Portugal, where our institute (CIMA) is based, covers an area of 180 km^2.

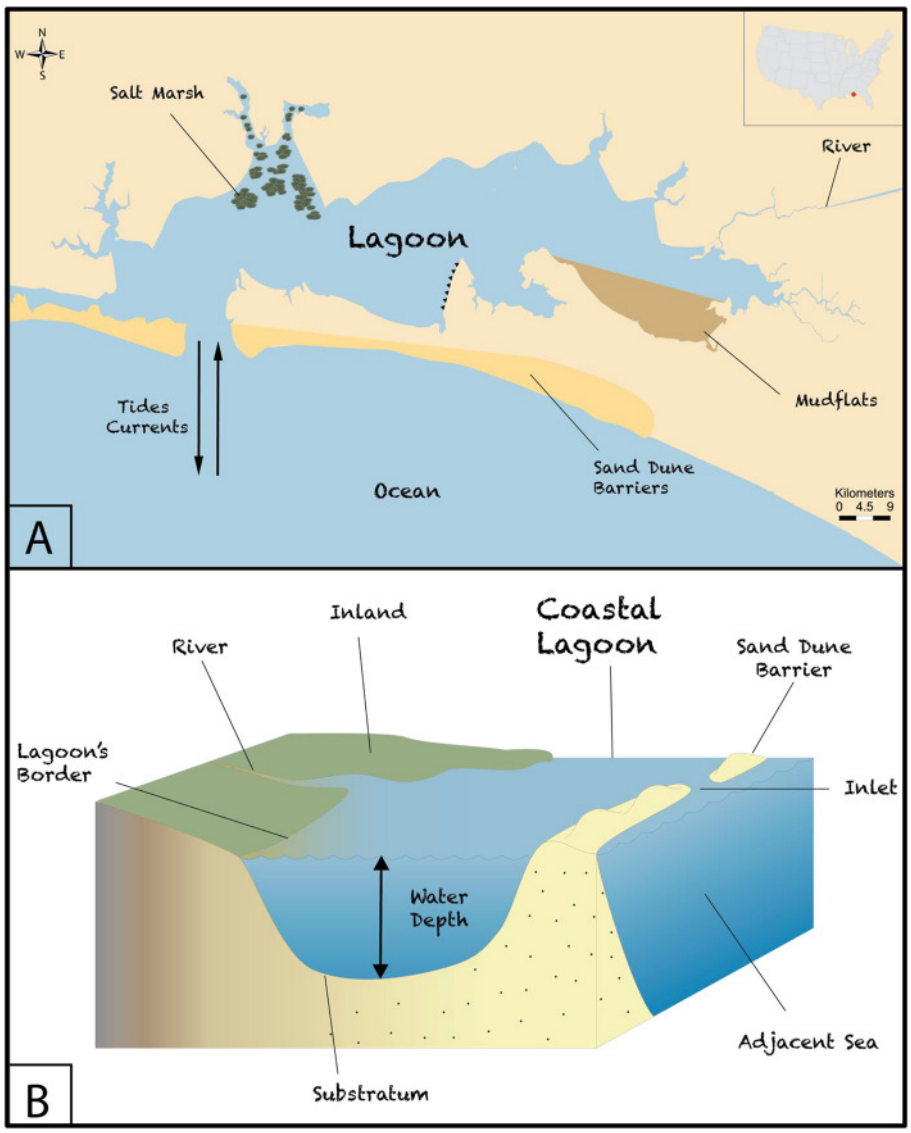

Figure 1

Lagoons are linked to the sea (Figure 1B), so their waters are mostly **saline** (salty). Coastal lagoons include wetlands such as saltmarshes and mangrove forests, as well as seagrass meadows. These are essential habitats for many species.

COASTAL LAGOON

Coastal lagoon is a shallow body of water along the coast, is separate from the ocean but connected to it by one or more inlets.

INLET

Inlet is an indentation of a shoreline, usually long and narrow and means an entry.

Figure 1

(A) Coastal lagoons are found along the coasts. They are mostly separate from the oceans, but they have one or more inlets that allow ocean water to flow in and out. **(B)** A 3D image of a coastal lagoon, showing its characteristics.

SALINE

Saline is a consisting of or containing salt.

CHARACTERISTICS OF COASTAL LAGOONS

Lagoons are commonly found along coasts. They are shallow—<2 m deep—and the water is -mixed by waves and currents. Coastal lagoons are found all over the world. Figure 2 shows examples of lagoons in the Mediterranean region, where we live and work. Venice Lagoon, also known as the "Queen of the Adriatic" and the "Floating City," is one of the world's most famous lagoons. Venice is known for its natural beauty, architecture, and artwork.

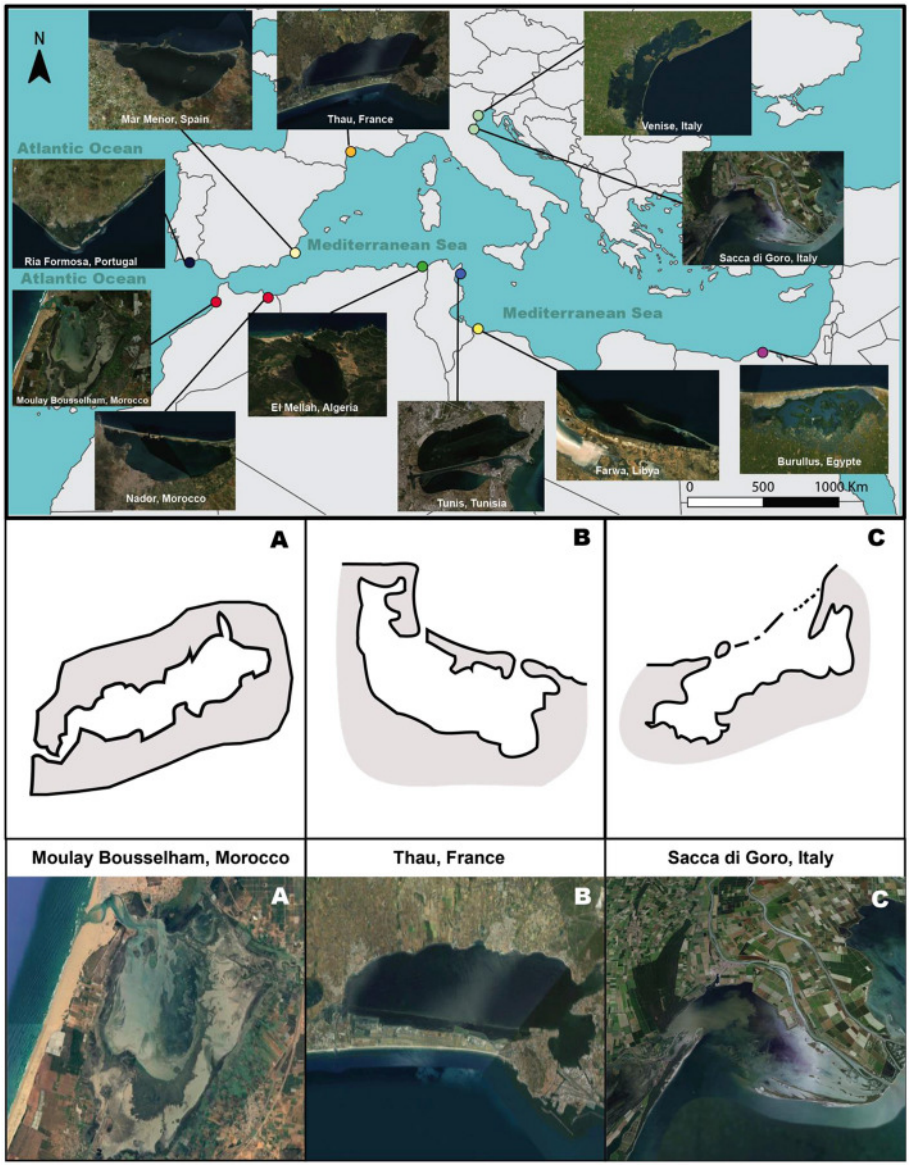

Figure 2

Figure 2

In the top panel, you can see the locations of some lagoons in Southern Europe and North Africa. **(A)** Moulay Bousselham, in Morocco, contains an example of a chocked lagoon, **(B)** Thau, in France is an example of restricted lagoon, and **(C)** Sacca di Goro, in Italy is an example of a leaky lagoon.

There are 3 main types of coastal lagoons [1]. *Choked lagoons* form along coasts where there is high wave energy. They have a single long, narrow entrance channel (Figure 2A). *Restricted lagoons* may have several channels or inlets. They consist of a large, wide water body, usually parallel to the coast (Figure 2B). *Leaky lagoons*

are elongated water bodies parallel to the shore, with many ocean entrance channels. They form along coasts with strong tidal currents (Figure 2C).

HOW DO HUMANS USE LAGOONS?

AQUACULTURE

Aquaculture is a controlled cultivation of aquatic organism such as fish and shellfish, and other organisms.

Lagoons are home to many species of plants and animals. For instance, there are more than 621 species of aquatic plants and 199 species of fish in Mediterranean coastal lagoons. This biodiversity makes coastal lagoons attractive places for to humans to carry out many recreational activities and to find food. Important activities include fishing, **aquaculture**, agriculture, tourism, boating, and building marinas and harbors (Figure 3A). For instance, more than 3,000 people in the Sacca di Goro region of Italy work in aquaculture [3]. Faro International Airport was built on **land reclaimed** from the Ria Formosa Lagoon, so that tourism could develop in the region. Furthermore, many people (like us!) find lagoons to be nice places to live and relax!

LAND RECLAMATION

Land reclamation is a process of creating new land from the sea.

LAGOONS ARE UNDER PRESSURE

Human activities can result in multiple pressures on coastal lagoons. Example of these pressures include underwater noise from boat engines, pesticides from surrounding agriculture, pollutants from industrial facilities, and the conversion of lagoons into land, which is called land reclamation (Figure 3B). There are many examples of how changes in land use have affected lagoons. For example, the switch to rice production in Sacca di Goro (Italy) led to an increase in the amount of nutrients flowing into the nearby lagoon. Sometimes, the ways land was used in the past have long-lasting consequences. For instance, mining activities stopped many years ago in areas surrounding the Mar Menor Lagoon (Spain), however, there is still metal pollution in the lagoon from those mining activities.

HUMANS AFFECT LAGOONS AND LAGOONS AFFECT HUMANS

GROYNES

A shore protection structure built perpendicular to the coastline.

EROSION

Erosion is geological process in which earthen materials are worn away and transported by natural forces such as wind or water.

Human activities and pressures can change lagoon ecosystems [4]. There are many examples of this. Construction projects can modify the shape of a lagoon's inlet, which can alter the water exchange between the sea and the lagoon. Construction of ports or structures called **groynes** can change the way waves hit the shoreline near parts of a lagoon, which can cause **erosion**. Erosion can increase the risks of flooding and storm damage, which may affect humans. Changes in water quality can also lead to changes in the lagoon ecosystem. For example, if the ecosystem of a coastal lagoon is damaged, this can cause important fish to die, which can affect the fishermen who work there and the people who normally eat the fish they catch. There are numerous other examples of ways that degradation (breakdown) of lagoons can impact human welfare (Table 1) [5, 6].

Figure 3

(A) Human activities that occur in and around coastal lagoons. **(B)** Some human activities can put pressures on lagoons.

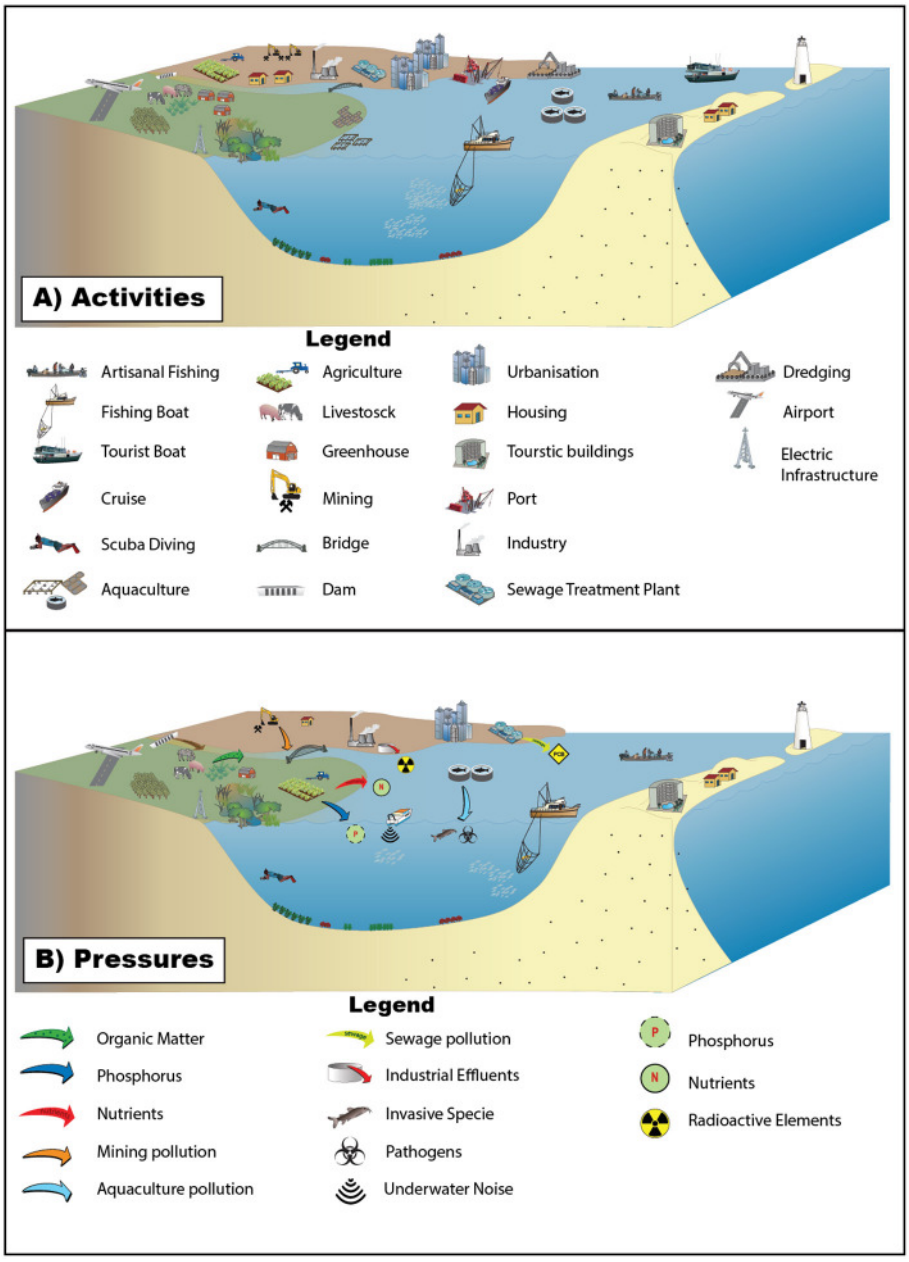

Figure 3

HOW CAN WE PROTECT LAGOONS?

Identifying vulnerable coastal lagoons allows managers to prioritize responses and management measures and to protect endangered lagoons. The responses can be at the local level (such as one lagoon and its surrounding area), or on a larger scale (such as the entire Mediterranean region). Fortunately, there are many different measures that can be implemented to improve the health of coastal lagoons. These measures can be applied alone, or several can be implemented at once. Here are some examples.

Table 1

How does degradation of lagoons affect humans?

Lagoon	Impact on human welfare
Ria Formosa (Portugal)	Clam production declined during the last decade and is projected to decline by 120 tons every year. This would be equivalent to a loss of about 1,200,000 € per year.
Sacca di Goro (Italy)	Introduction of the invasive Manila clam has replaced the local species.
Mar Menor (Spain)	Jellyfish blooms affect tourism, especially swimming.
Nador (Morocco)	Aquaculture activities were stopped in 2010 due to pollution. This impacted the availability of seafood and caused loss of 28% of local jobs.
Farwa (Libya)	Mercury contamination from a nearby oil company was detected in fish and oysters. This is a serious health risk to those who eat these organisms.
Burullus (Egypt)	Changes in salinity and chemical pollutants have affected fish diversity, causing a decline from 32 to 25 species.

Table 1

REED BEDS

Natural habitats, filled with aquatic plants called reeds, found in floodplains such as coastal lagoons.

First, nature-based solutions use plants, such as **reed beds**, to reduce any excess nutrients in lagoons. This improves the water quality and the amount of oxygen in the water. Second, awareness-raising campaigns started by local people can be very effective. For example, people can work with local schools to organize educational field trips and clean-ups around the lagoons. Third, all sorts of fines, taxes, and other types of fees can be used to manage lagoons. For example, there could be fines for littering or harvesting protected species like seahorses and sea cucumbers. Fourth, networks of scientists can exchange useful findings and information, which can provide new knowledge about how to better manage coastal lagoons. For example, a community of Italian lagoon scientists started a network called Lagunet, which prompted the formation of other networks in France, Greece, Spain, Portugal, North Africa, and some Baltic countries, and culminated in the formation of EuroMegLag, an international network of coastal lagoon scientists[1]. Finally, new research is needed to protect coastal lagoons. Examples of important projects are the DITTY project[2] studying South European lagoons [5, 7], and the SouthMedLag project studying North African lagoons. The SouthMedLag project (short for South Mediterranean Lagoons), analyzed 21 North African lagoons in Morocco, Algeria, Tunisia, Libya, and Egypt, 11 of which were studied in detail [4, 8]. The research was conducted by African and European scientists to assess the North African lagoons and provide management solutions.

THE FUTURE OF LAGOONS

The Earth's population is growing, temperatures are getting warmer, normal weather is being replaced by unusual storms, and sea levels are rising. Climate change is real, and all these changes will affect lagoons worldwide. As scientists, we believe that coastal lagoons will exist for years, but their features will change rapidly over the next

[1] http://www.euromedlag.eu.

[2] The DITTY project stands for "development of an information technology tool for the management of Southern European lagoons under the influence of river-basin runoff".

few decades. If citizens and governments act now, we can still help lagoons by learning to work with nature rather than against it. From reading this article, you have learned why coastal lagoon exist, what their main features are, why they are important, what issues lagoons face, and how we help to fix those issues. We can all learn from history and contribute to building the future of these spectacular coastal lagoons—it is as easy as ABC: (A) Alone—start with your own actions. (B) Behave responsibly toward the environment. (C) Communicate with your friends and family about this story! Spread the word so we can all help protect coastal lagoons!

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

ANTHONY, AGE: 14
Hello, my name is Anthony. I am a 9th grade student from Why Not You Academy, a new charter school in Des Moines, Washington. I have many hobbies that include playing the piano, playing video games, and watching anime. I love school and enjoy the many aspects of science and are thrilled to be a reviewer for "Frontiers for Young Minds."

BURUK, AGE: 15
Hello, my name is Buruk Yoseph. I am a current 9th grader at Why Not You Academy, a school located in Des Moines, Washington. I have been involved in a several math and science competitions, I love watching and physically playing sports, I love reading books (my favorite being the Harry Potter series), and I enjoy TV shows and Movies that include Comedy, Drama, and lots of Action. I am interested in pursuing

careers ranging from Engineering, to Medicine, and Software. I have a curious mind, and I love learning. I am also deeply thrilled to be a reviewer for "Fronters for Young Minds."

ELILL, AGE: 15

Hi! My name is Elill and I am 15 years old. I like reading non-fiction books, studying and spending time with family. I also enjoy Star Wars movies. My favorite subjects in school are Science, History and Maths.

YUHENDRA, AGE: 11

Hi! It is great to be a reviewer. I am 11 years old and I like science and maths. They are my favorite subjects at school. As a past time I do lego, read books, and spend time with my family. I also like to play video games.

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