

SOME JELLYFISH LIKE IT HOT!

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YOUNG REVIEWERS:



ARIN

AGE:9



ARSH

AGE:11



SANKET

AGE:10

When you go to the beach, it might seem like there are more jellyfish every summer. Is this true? We study the barrel jellyfish, which lives in the Mediterranean and Black Seas. Since the end of the XIX century, many scientists and interested members of the public have been recording the sightings of this jellyfish along the coasts. We collected this information to see whether jellyfish numbers are increasing with the warming of the ocean waters. We found that, due to the warming of the sea caused by climate change, the barrel jellyfish are appearing earlier in the year, and there are greater numbers of barrel jellyfish in some regions now compared with years past. Although other factors, such as food, predators, or habitat changes may also affect marine species, our results indicate that ocean warming could have direct effects on living organisms, changing the functioning of marine ecosystems.

WARMER WATERS ARE INCREASING SOME JELLYFISH POPULATIONS

Human activities are changing the natural composition of Earth's atmosphere, causing our planet to warm up in recent decades. This atmospheric warming causes an increase in ocean temperature, which changes the way marine ecosystems work [1]. There are two main consequences: first, the areas where ocean organisms live are changing; and second, some species disappear from their original habitats [2] while others resist the changes and even thrive in the warmer environment, like some jellyfish species [3, 4].

You may already be familiar with jellyfish—they are fascinating animals. The body of a jellyfish is shaped like an umbrella, is gelatinous, mainly clear in color, and has tentacles and/or **oral arms** around its central mouth. Jellyfish are composed of about 95% water, and they do not have brains or hearts. Jellyfish have lived in the seas since even before dinosaurs walked the Earth! Throughout Earth's history, jellyfish survived through all the climate changes that many species, including the dinosaurs, could not tolerate. So, it seems that jellyfish are particularly resistant to environmental changes.

In 2013, a team of researchers showed that some jellyfish are increasing in number, but not all species, and not in all locations [4]. Why are some species increasing in number—is it because the oceans are getting warmer? We tested this idea in the Mediterranean and Black Seas (Figures 1A,B).

ORAL ARMS

Anatomic structures of jellyfish, located around the mouth, which hold the stinging cells injecting venom in jellyfish prey or predators.

Figure 1

(A) Map of the world, with a magnifying glass zooming in on the study area. (B) We studied barrel jellyfish populations in the Mediterranean and Black Seas. (C) The scientific name for the barrel jellyfish is *Rhizostoma pulmo*.

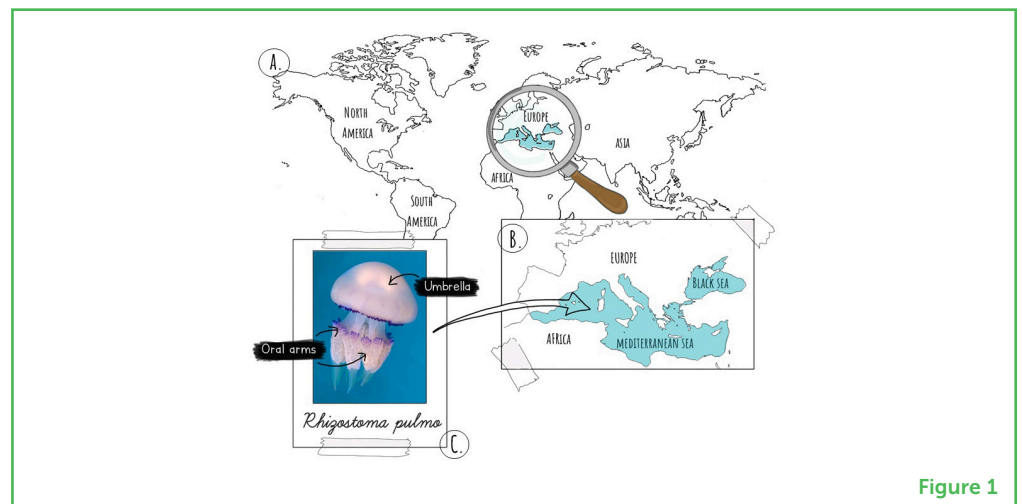


Figure 1

WHICH JELLYFISH DID WE STUDY?

Tiny or large, round or flattened, along the coasts or in the deep ocean, there are hundreds of jellyfish species in the world. It is difficult to study all of them. In this article, we will tell you about one species, the barrel jellyfish (Figure 1C). This species lives only in the Mediterranean and

Black Seas. These seas are almost completely surrounded by land—in the north by Europe, in the south by Africa, and in the east by Asia (Figure 1B), so it is a well-defined area to study.

We focused on the barrel jellyfish because it is one of the most common Mediterranean jellyfish, but it has not been studied as much as other jellyfish species. It is also one of the biggest jellyfish in the area, and its large size makes it easy to spot. Adults measure 30–60 cm in diameter, which is roughly the size of a bicycle wheel. Finally, it is easy to recognize thanks to the blue/violet-colored band bordering its umbrella (Figure 1C).

FISHING FOR INFORMATION

Humans have been investigating nature for hundreds of years. Scientists from universities, museums, or research institutions perform studies and publish their results in scientific journals. But non-scientists can help with this research, too! There are programs around the world studying birds, butterflies, plants, stars, and even jellyfish, in which anyone can participate as a volunteer. Through such programs, people can observe nature and share their sightings online. For example, if you are interested in butterflies, you can take photographs of the species you find in your garden or neighborhood and upload them to an online platform created by scientists [5], indicating the location, date, and number of butterflies you saw. The scientists can then identify the species and study when and where they appear based on many observations by volunteers. This is called **citizen science** (see a *Frontiers for Young Minds* article about it here [5]) and it has increased the amount of information available on wild species such as jellyfish. Thanks to the internet, an observation made by a volunteer in Tunisia, for example, can easily be seen by a researcher in France. For our study, we did not need to go out to collect new information, or ask people questions, because all the information we needed was already on the internet.

Our study analyzed almost 150 years of observations, from 1875 to 2019, obtained from published scientific research and from observations uploaded to the internet by volunteers. We also needed to know the sea temperature during all those years. Some temperature data were obtained by satellites and the sea temperatures of the past were calculated from mathematical equations. All this information is freely available on the internet, and once we had it all, we could evaluate whether there is a relationship between the numbers of jellyfish and sea temperatures.

CITIZEN SCIENCE

Scientific studies conducted by people (volunteers) who are not necessarily researchers. Volunteers report their sightings and scientists gather data that could be difficult to collect on their own.

PHENOLOGY

Study of an organism's life-cycle events (mating, migration, hibernation, etc.) and how these are influenced by seasonal and yearly variations in climate.

BIOGEOGRAPHY

Distribution of a species in a region shaped by environmental factors.

WHAT CLUES DID WE FOLLOW?

Using the data we gathered, we studied various characteristics of the barrel jellyfish. First, we studied its **phenology**, which means the life-cycle events of an organism, such as reproduction or migration, and how they are influenced by climate variations across seasons and between years. For each year, we identified the months when the jellyfish were present in the water column. By comparing years, we could see whether this period changed over time—did barrel jellyfish appear earlier or later, and did they remain in the water column for a shorter or longer time?

Second, we characterized the **biogeography** of the barrel jellyfish in the Mediterranean and Black Seas. This means that we tracked changes in the places where they could be found. Our analysis showed that the numbers of jellyfish and the places where they were found differed depending on the year.

JELLYFISH ARE OBSERVABLE FOR A LONGER PERIOD OF TIME

During a typical year, barrel jellyfish can first be observed in the water column in spring, when the sea temperatures start to rise. They disappear during the winter when sea temperatures decrease. However, the exact date when barrel jellyfish appear for the first time, or when they disappear, can change from year to year.

Before 2010, barrel jellyfish were present from June to December, for 7 months out of 12. After 2010, the jellyfish appeared earlier in spring, with the first observations in April, but they still disappeared in December. So currently, this species is present in the water column for 9 months. In other words, since 2010, barrel jellyfish have been observed in the sea for 2 months longer than they were previously observed (Figure 2). We also observed that the sea temperature is warming up earlier in the year, due to global warming.

Figure 2

Presence of the barrel jellyfish in the Mediterranean Sea before and after 2010. You can see that, after 2010, barrel jellyfish have been present for about two more months.

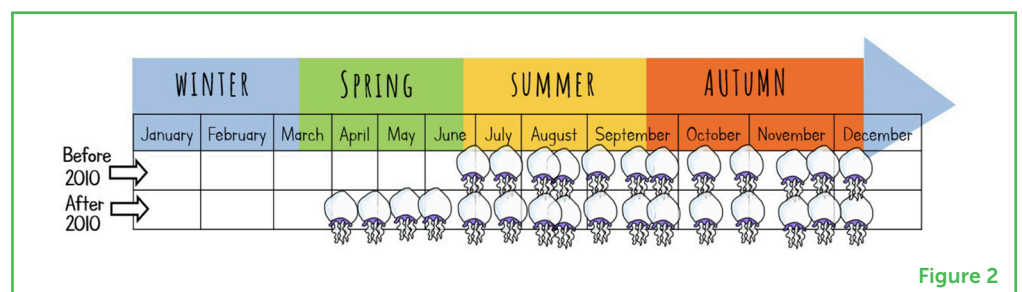


Figure 2

MORE JELLYFISH IN THE MEDITERRANEAN SEA

Our results showed that, as sea temperatures have warmed, the number of barrel jellyfish has increased in the Mediterranean and Black Seas. Before 2010, jellyfish were present in low numbers, while after 2010, they became numerous everywhere. By numerous, we mean that there is at least one jellyfish in one cubic meter of water—the equivalent of one jellyfish in eight bathtubs of water. This increase in jellyfish numbers is particularly noticeable over the past 10 years. Warmer water has not only resulted in increasing numbers of jellyfish, but has also changed the places where they can be found. Barrel jellyfish are now often observed where they were rarely observed before, such as along the coasts of Tunisia or in the Aegean Sea (Figure 3).

Figure 3

Changes in the number of barrel jellyfish in several regions of the Mediterranean and Black Seas, before and after 2010. The orange magnifying glass shows Tunisia, and the purple magnifying glass shows the Aegean Sea. In both regions, barrel jellyfish are common now but were rarely seen before 2010.

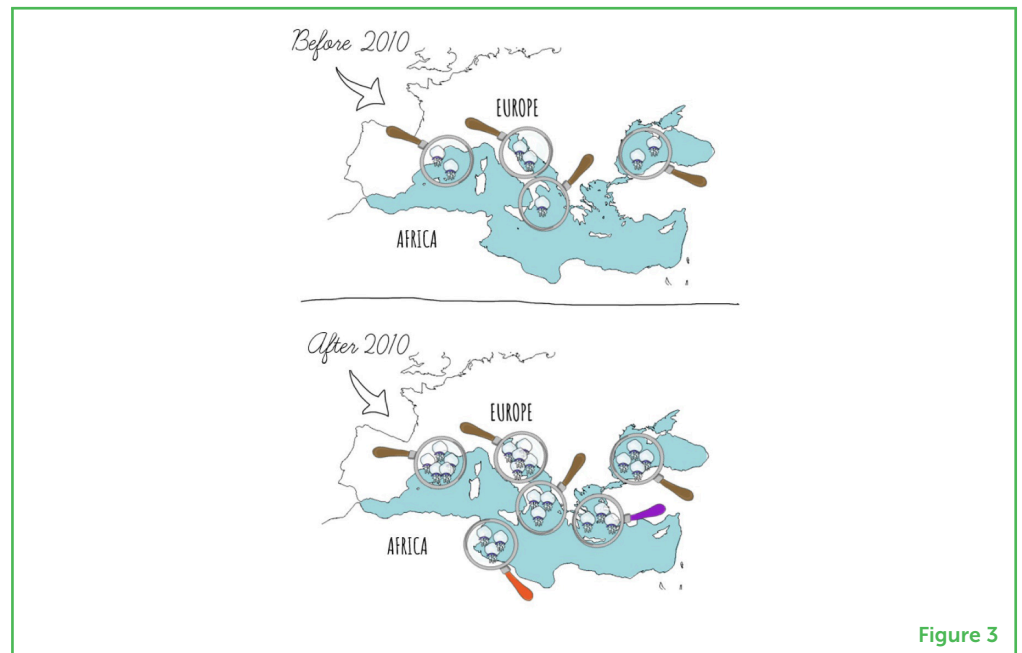


Figure 3

MORE JELLYFISH, LESS FISH

This study shows that global warming can change the life of some species. In this case, warming waters seem to benefit barrel jellyfish, allowing them to increase in number. However, increasing temperatures can cause problems for other species [2]. For example, jellyfish eat **plankton**, shrimp, or mollusks; and fishes compete with jellyfish for the same foods. The numbers of these fishes could decrease if jellyfish become more numerous, as there would be less food for the fishes. In addition, jellyfish can eat fish eggs and larvae. An increase in the number of jellyfish eating these young fishes could reduce the number of adult fishes. Human activities could also be affected by the ecosystem changes caused by rising sea temperatures. Some fishers catch a lot of jellyfish in their nets, reducing the numbers of fish they catch—so they have fewer fish to sell or eat. But maybe

PLANKTON

Aquatic organisms with diverse shapes and sizes unable to swim against currents; instead, they drift along with tides and currents.

there will be some positive consequences of increasing jellyfish numbers, too. The barrel jellyfish can be eaten by humans, maybe, in the future, we will see this jellyfish on our plates.

UNANSWERED QUESTIONS

We still are not completely sure that rising temperatures are the only cause of the increasing numbers of barrel jellyfish. The jellyfish's predators are being overfished and decreasing in number, so fewer jellyfish are being eaten. Other human activities in coastal areas could also accelerate the increase in barrel jellyfish. **Eutrophication** of coastal waters can increase the amount of jellyfish food [4], helping to boost their populations. Eutrophication is a process by which water becomes overly enriched in nutrients, often from fertilizer run-off from farms or from other forms of water pollution. Eutrophication also reduces the oxygen concentration in the water—a condition that jellyfish tolerate better than most animals [4]. Finally, an increase in human-made hard structures, such as ports and sunken ships, could benefit some jellyfish species [4].

There is still much more to learn about jellyfish, their whereabouts, and their behaviors, so the research continues! A lot of the information used for this research came from citizen science. So, we need you to enter your jellyfish sightings and contribute to future research! Your help is greatly appreciated!¹

¹ See <https://observation.org/>; https://jellywatch.org/node/add/new_sighting.

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ORIGINAL SOURCE ARTICLE

Leoni, V., Bonnet, D., Ramírez-Romero, E., and Molinero, J. C. 2021. Biogeography and phenology of the jellyfish *Rhizostoma pulmo* (Cnidaria: Scyphozoa) in southern European seas. *GEB* 30:622–39. doi: 10.1111/geb.13241

REFERENCES

1. Hoegh-Guldberg, O., and Bruno, J. F. 2010. The impact of climate change on the world's marine ecosystems. *Science* 328:1523–8. doi: 10.1126/science.1189930
2. Ariza, A., Lengaigne, M., Menkes, C., Lebourges-Dhaussy, A., Receveur, A., Gorgues, T., et al. 2022. Global decline of pelagic fauna in a warmer ocean. *Nat. Clim. Change* 12:928–34. doi: 10.1038/s41558-022-01479-2

3. Richardson, A. J., Bakun, A., Hays, G. C., and Gibbons, M. J. 2009. The jellyfish joyride: causes, consequences and management responses to a more gelatinous future. *Trends Ecol. Evol.* 110:1000–5. doi: 10.1016/j.tree.2009.01.010
4. Condon, R. H., Duarte, C. H., Pitt, K. A., and Graham, W. M. 2013. Recurrent jellyfish blooms are a consequence of global oscillations. *Proc. Natl. Acad. Sci. U. S.A.* 690:3–20. doi: 10.1073/pnas.1210920110
5. Giovos, I., Charitou, A., Gervasini, E., López-Cañizares, C., Tsiamis, K., and Cardoso, A. 2021. On Darwin's steps: citizen science can help keep an eye on alien species. *Front. Young Minds* 9:520201. doi: 10.3389/frym.2021.520201

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YOUNG REVIEWERS

ARIN, AGE: 9

I am 9 years old and I am in 4th grade. Did you know I love to play soccer? I think you would also like soccer too. My favorite food is, of course, Italian, it is... breasetta! I also like pizza like most people. The foods I do not like are mushrooms and bengana (Indian food). My favorite hobbies are learning about flying things, soccer (like I said before), and playing video games (of course). My favorite color is green and I like a game called perplexes. I also like a game called Beat that! When I have free time I like to finish up books or do NitroType (It helps practice your typing skills). My favorite holiday is, of course, Christmas! Things I need to practice more on is reading longer and more content books for long periods of time. I want to be part of this reviewing activity because I enjoy learning and I want to improve my subject skills, especially science.



**ARSH, AGE: 11**

Hi! My name is Arsh and I am a 6th grader. I like pizza, swimming, tennis and you get the jist. I would like to be a young reviewer because I would like to read all the articles and share my thoughts on it while making it better. I am thankful to get an opportunity like this.

**SANKET, AGE: 10**

Hi, my name is Sanket. I am 10 years old. I live in Southern California and go to Clara Barton Elementary school. I am in 5th grade. My favorite subjects in school are science, social studies, history, and maths. I like snow sledding and basketball. I also like to know about different countries of the world.

AUTHORS**VALENTINA LEONI**

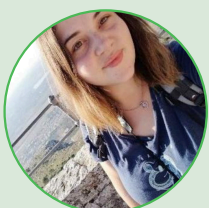
I grew up in Uruguay, where my father taught me to respect and admire the nature and the diversity of my country. During my biology career, I started to study jellyfish and realized how much is still unknown about them. Now I am doing my Ph.D. at the University of Montpellier, investigating these fascinating animals and how environmental changes affect them. I enjoy spending time with children doing what I did as a child—observing and learning about plants and animals. I love birdwatching, cycling, and camping in my free time. *valentina.leoni@umontpellier.fr

**NATHAN CAZELLES**

My name is Nathan and I am 24 years old. I am a very curious person, I like to understand how our world works. In particular, I am concerned about the Human impact on plants and animals. That is why I chose to study these phenomena as part of my master's degree in ecology at the University of Montpellier, in the south of France. My goal is to become a researcher-teacher, to constantly discover things and share knowledge. I enjoyed writing this article with my peers, I hope you will appreciate reading it.

**NOÉMIE DURON**

Between spring's hopeful new blossoms, fall's exquisite array of colors, winter's magic, and summer's energy, each season abounds with unique types of natural beauty to explore and admire. This is Noemie's way of life. She is a fun loving, energetic, and passionate student of biology. After an intensive two-year course drinking in the beautiful complexity of biological life, she moved on to a master's in ecology engineering and biodiversity management at the University of Montpellier. Art is her language and optimism is her banner.

**FANNY JUILLARD**

I am a 24-year-old student and my name is Fanny. I am quite sensitive and altruistic, and I have always been curious about how our world works. This combination creates my current passion for popular science. I also really like photography—it is a way to stop the time for a few seconds. I hope you enjoyed this article!

**JOHANNA THEYS**

My name is Johanna and I am 23 years old. I am currently studying ecology for a master's degree in Montpellier, a city in the south of France. Originally, I come from a small village in the Alps, the mountains between France, Italy, and Switzerland. I believe this is where my interest in ecology comes from. I am also passionate about birds and drawing comics. I hope you will enjoy reading our article about the rise of the barrel jellyfish population in the Mediterranean Sea!

**JUAN CARLOS MOLINERO**

I am researcher at the French National Research Institute for Sustainable Development. My scientific interests focus on plankton ecology, from individuals (life history, plasticity) to food web structure and function, long-term ecosystem changes, and macroecology.

**CLAUDIA SIMÓN**

I am a Uruguayan biologist and teacher. I love working with teenagers and children, discovering together how wonderful nature is. I have worked mainly with freshwater organisms, and I have recently started working with greenhouse gas emissions from agriculture. I support citizen science initiatives that involve working with children in the city I currently live in, Colonia del Sacramento.

**DELPHINE BONNET**

I have been a researcher in zooplankton ecology at the University of Montpellier for 15 years. Before developing a strong interest in studying jellyfish, I traveled in Europe and overseas to work on small planktonic crustaceans called copepods. I enjoy showing students how plankton is a beautiful and fascinating world, most of which is invisible to the naked eye. Climate change and plastic pollution are two of my major concerns, and I am trying to contribute to understanding their impacts on the functioning of ecosystems.

†These authors have contributed equally to this work