ENVIRONMENTAL SCIENCE JOURNAL FOR TEENS

MAY 2017

How can we protect fish better?

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Associate Editor:
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Abstract

People love eating fish, fishing for them, and seeing them underwater while snorkeling or diving. In fact, fish provide billions of dollars to the U.S. (and world) economy each year. Unfortunately, *overfishing* has depleted many fish populations. How can we protect them better, to ensure *sustainable fisheries* that keep us fed and support our economies in the future?

Protecting fish while they are *reproducing* is a critical part of an effective fisheries management plan. But to do this, we need to understand when and where *spawning* (fish mating) happens.

We analyzed over 30 years of *data* from the southeast Atlantic coast of the US. This allowed us to create models to predict the locations of *spawning grounds* and other factors that are important for fish reproduction, such as time of the year and ocean characteristics (water temperature and features on the seafloor).

Introduction

Do you like to eat fish? If so, you're not alone. People all over the world love eating fish, and have been catching them for thousands of years. Fishing is a huge industry that contributes significantly to local economies along the coast. The Atlantic reef fish industry along the southeast coast of the U.S. alone is worth billions of dollars.

If we want to keep eating fish, we need to keep local fish populations healthy and protect them from overfishing (catching them at too small of a size or at too high of a rate). Fish populations are especially in danger when female fish are caught before they can lay eggs, and thus won't be able to have *offspring* (babies). Scientists and economists have therefore suggested (and sometimes already implemented) many "safe zones" (also called *Marine Protected Areas or MPAs*) for fish in areas where they reproduce (their *spawning grounds*).

But how do we know where exactly these areas are? And when do fish come there to spawn? Do fish return to the same spawning grounds year after year to mate and reproduce? Most importantly, could we design a model that could predict where certain fish would spawn, so that we could protect them better? We looked at over 30 years of fish data to find out.

Most female marine fish don't really "lay" eggs - they release them into the water column and the males release clouds of sperm. The mixing of eggs and sperm results in external fertilization, often of millions of eggs at a time. The eggs are then carried by ocean currents for several days. The larvae emerge and are carried further, but may swim up or down to manipulate the direction of their travel. Eventually the larvae settle out of the water column into nursery habitats, which are often nearshore reefs, estuaries, seagrass beds, saltmarsh creeks, or mangroves swamps.

Methods

Luckily for us, many scientists have been collecting tons of data on Atlantic reef fish over the last three decades. We specifically screened all these data for the following types of information:

- Fish species, sex, and whether or not they have recently spawned
- Time of year (season) when spawning occurs
- Water temperatures
- Water *salinity*
- Water depth of spawning grounds
- Underwater *topography* (imagine mapping the height of mountains but just doing it upside down and under water)
- Moon phase

These factors may be important in determining good conditions for fish to spawn. By analyzing them, we wanted to create models (mathematical formulae) that could predict the location and characteristics of spawning grounds for the following Atlantic fish species: Gray Triggerfish, White Grunt, Red Snapper, Vermilion Snapper, Black Sea Bass and Scamp (Fig. 1).

Lastly, we tested how accurate our models were in predicting spawning grounds by comparing our predictions to information received from fishermen or collected by other scientific studies.

Moonlight, or the phase of the moon, can be an important factor for animal activity. For instance, some animals are much less active when the moon is full, because a bigger moon means more light and therefore a higher likelihood of being found and eaten by predators. Some fish use moon light phases as a cue to synchronize mating (releasing eggs and sperm at the same time, to make sure they find each other in the ocean). But we do know that some fish lay more eggs during certain phases of the moon, while others seem less dependent on moon phases.

Figure 1:
Top: Black seabass "posing" for the photographer.
Middle: Red snapper (Photo credit: GRNMS)
Bottom: Vermillion snapper (Photo credit: MARMAP/SERFS)

Results

Interestingly, we found that most of the fish species we looked at used the same spawning grounds year after year (Fig 2). Sometimes, different species use the same spawning grounds at different times of year.. Many fish also have a preferred spawning season.

So what about our models – could they really predict under which conditions fish would reproduce? Comparisons to information collected from other sources suggested they worked pretty well. We were able to predict peak spawning conditions for most of the species in our study. For example, we found that Vermilion Snapper like to release eggs in water with temperature between 20.5 and 21.6 C and about 52-63 m deep, just before the new moon in August.

Please, see Figure 2 on Page 3

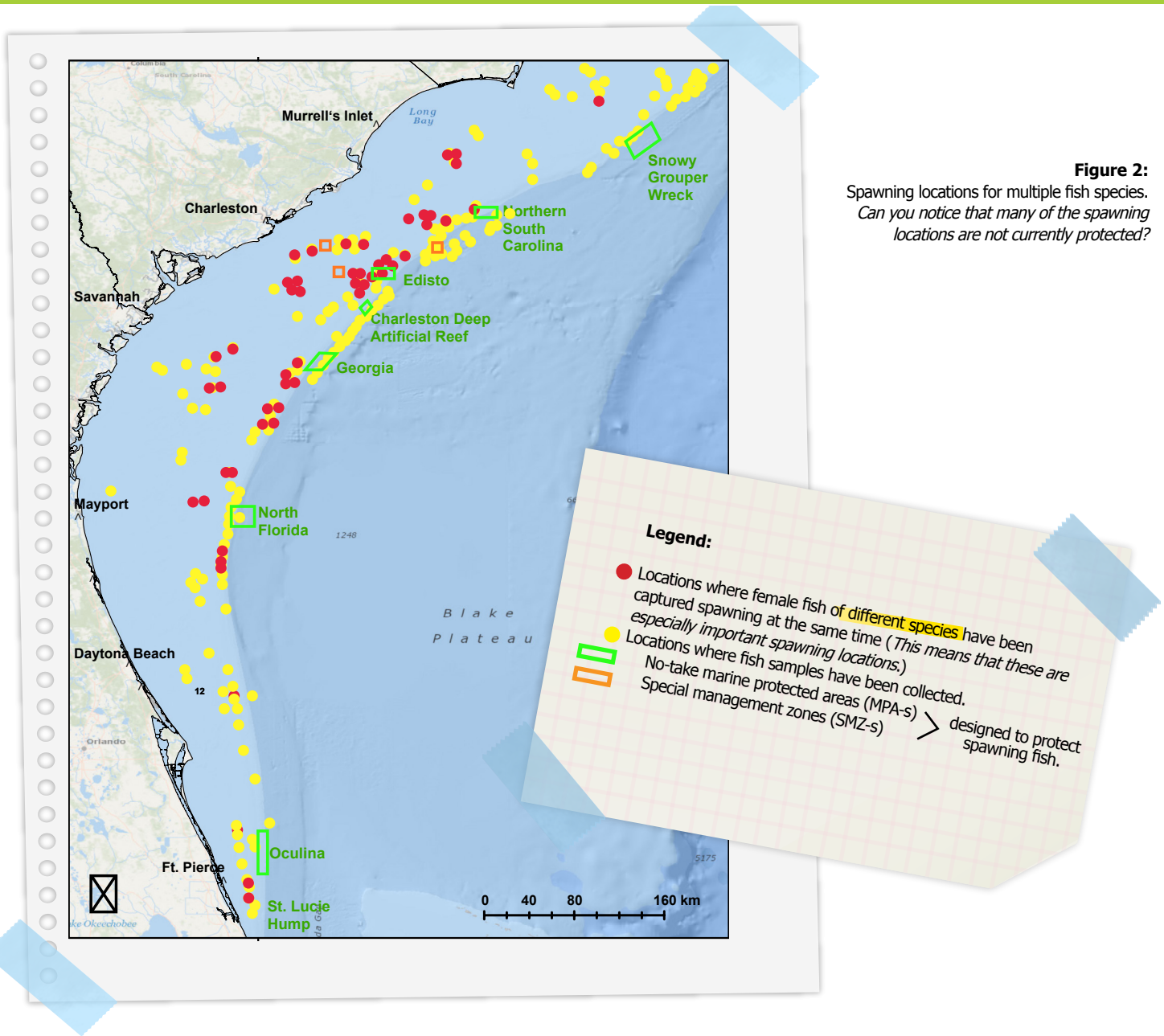

Figure 2:
Spawning locations for multiple fish species.
Can you notice that many of the spawning locations are not currently protected?

Discussion

Our study is important because the populations of many fish that humans like to eat are depleted. We believe that protecting fish during spawning is one of the most effective ways to maintain healthy population sizes. But in order to do that, we have to have better knowledge of when and where fish spawn. Then we can establish - or expand - safe zones where fish are protected from being caught during times when they reproduce. These places and times are critical for promoting sustainable fish populations, and help ensure there will be plenty of fish in the sea. Sometimes, seasonal protection during spawning times makes more sense than protecting certain areas all year long.

Finally, despite all the existing studies on fish, it is clear from our analysis that more year round studies of Atlantic reef fish spawning activities are needed to fully understand what is going on. We especially lack information for the winter months because the seas are rougher and it's harder to do science on boats offshore in the winter. However, some of the most important reef fish species (including most groupers) reproduce in the winter.

Moreover, we found that many fish species have a preferred water temperature for spawning. As we saw for the Vermilion Snapper mentioned above, this temperature range is fairly narrow. And because global climate change is warming not only temperatures on land, but also in the ocean, we need to closely observe how these changing temperatures will impact fish spawning in the future. Only then can we successfully protect all these tasty and valuable fish populations.

Conclusion

Fish are a prime example that we humans can't just use up all the resources we want simply because they taste good or make us lots of money. If we catch too many fish, their populations might collapse, and will be lost for the future. We therefore have to make sure to protect fish when they are most vulnerable, like during reproduction.

In order to do this, we need to continue studies on fish biology to best understand how to protect fish effectively. Luckily, there are many organizations concerned with protecting fish. Check out this guide that will help you make better (seafood) choices for a healthier ocean:

https://www.fishwatch.gov/.

Glossary of Key Terms

Data – we're talking about *scientific data*, which are any type of real world fact or information related to a question scientists are investigating. Data points for this study were what type of fish were caught, their sex, their reproductive state, and other variables that had to do with their spawning grounds in the ocean.

Fishery – a population of water-based animals (fish, shrimp, etc.) caught for food or for sale.

Reproductive state – whether they were female, and whether they were within 24 hours of spawning based on examination of their ovaries. Female fish "hydrate" (absorb water in) their eggs prior to spawning, and their gonads contain "post-ovulatory follicles" immediately after ovulating or spawning.

Marine Protected Areas (MPAs) – protected areas of seas, oceans, or estuaries. MPAs restrict human activity in order to protect natural or cultural resources. In this case they limit or prohibit fishing for the purpose of conservation and long-term sustainability.

Reproduction – creating offspring, or in more plain English: making babies. Animals have to reproduce so their species endures when the adults get old and die.

Salinity – tells us about the concentrations of salt in a liquid (in our case: seawater). Basically, how salty an ocean is. Usually, it's measured in grams of salt per kilogram of seawater. Different oceans (and even different regions of the same ocean) have different salinity. Salinity and temperature affect the density of seawater, and determine where in the water column spawned eggs will drift.

Sustainable – the quality of not being harmful to the environment or depleting natural resources, and thereby supporting long-term ecological balance. In the United States, sustainable fisheries management requires removing no more than the maximum number of fish possible that still leave enough to recreate that maximum number in subsequent years.

Synchronization – making sure things happen at the same time. In this case, fish want to synchronize laying eggs and sperm, so the two can meet in the water. Plus, when a great numbers of individuals reproduce at the same time, this creates so many fertilized eggs that egg predators (such as whale sharks) cannot possibly eat them all. Many fish use moon phases in order to synchronize reproduction.

Spawning grounds – These are areas in the ocean where female and male fish meet to mate. The females lay eggs, and the males release sperm, which then meet in the water, resulting in fertilized eggs. Many fish species have distinct areas for spawning to which they return year after year.

Topography – is the study of the shape and features of the surface of the earth. This could apply for underwater areas, as well. (Although technically the correct term there is "*bathymetry*", which is the study of the topography of the ocean floor).

Overfishing – when we deplete a fish population below acceptable levels by either catching them too small or harvest them too fast so that the adults cannot produce enough offspring to replace themselves.

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Marine protected areas:
http://marineprotectedareas.noaa.gov/

Check your understanding

1. Why should we protect spawning fish?

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2. Current Marine Protected Areas may not be enough to protect Atlantic reef fish. Why?

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3. You've heard that moon phase might have an impact on the spawning of fish. Why could that be?

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4. How might global climate change impact fish in the oceans?

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5. How can *you* personally contribute to keeping fish populations sustainable in the ocean?
