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What do baby fish make of oil spills?

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Abstract

Since people started drilling for oil there have been accidental oil spills at sea that are harmful to marine life. For instance, birds and other animals get covered in the thick oil and many die as a result. Although some of the negative impacts of oil spills are immediately noticeable, the long-term effects on animals like fish are less certain. Therefore, we wanted to determine what effect a major oil spill can have on the number and "health" of recently hatched fish *(larva* is singular, *larvae* is plural) in a marine environment. We studied the impacts of the Deepwater Horizon oil spill (DWHOS) and found that the number of Red Snapper larvae did not change before, during, and after the spill but the health of larvae was poorer after the accident. Although we cannot conclude that the oil spill caused this decrease in health, we think that some combination of factors that coincided with the event negatively impacted larval Red Snapper.

Introduction

Humans use crude oil for all sorts of things: to run our cars, fire our power stations and make electricity, and make aviation fuel to fly our planes. But where does it come from and what happens when oil extraction go wrong?

People gather crude oil from under the seabed with special equipment on an oil rig. In April 2010, there was a large accident on a rig called the Deepwater Horizon off the coast of Louisiana that spilled about 700,000 metric tons of oil into the ocean. In this article, we're going to call this event the Deepwater Horizon oil spill (DWHOS) (Fig 1).

We looked at the effects of the DWHOS on Red Snapper, a fish species that is popular among commercial and recreational fishers and important to the US fisheries in the Gulf of Mexico (Fig 2). Would there be more or less larvae after the oil spill? Would their health change? We set out to answer these questions and to see if any differences were related to the oil spill, environmental changes, or if a combination of factors played a role.

Figure 1:
Oil spilled out of the Deepwater Horizon for 87 days and it spread for 40,000km^2. That's an area 10 times the size of Rhode Island.

Figure 2:
The Northern Red Snapper (*Lutjanus campechanus*) can grow up to one meter in length and weigh up to 80lb!

Methods

We collected plankton (drifting microscopic marine organisms) samples that included Red Snapper larvae at two research stations (Fig. 3) off the coast of Alabama that were contaminated by oil from the spill. Sampling occurred from May through November from 2007–2011 and during 2013 (we couldn't collect samples in 2012).

First, we counted the number of Red Snapper larvae in the samples. Second, we measured their weight and various body lengths to get an idea of their health and how well they were growing (Fig. 4). Third, we looked at environmental data (wind speed, wind direction, water temperature, and the amount of freshwater coming out of a large bay near our sites, which is known as freshwater discharge) collected from three other research stations to see what effect these other changes might have on the larvae. Finally, we compared our results over the years before (2007-2009), during (2010), and after the spill (2011 and 2013), across months, and at the two plankton stations.

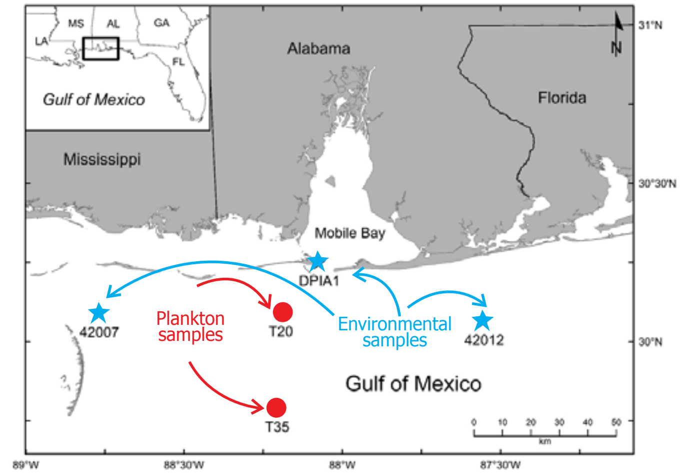

Figure 3:
Map of the research area. We took plankton samples (including the Red Snapper larvae) at T20 and T35
We took environmental data readings at 42007, 42012 and DPIA 1

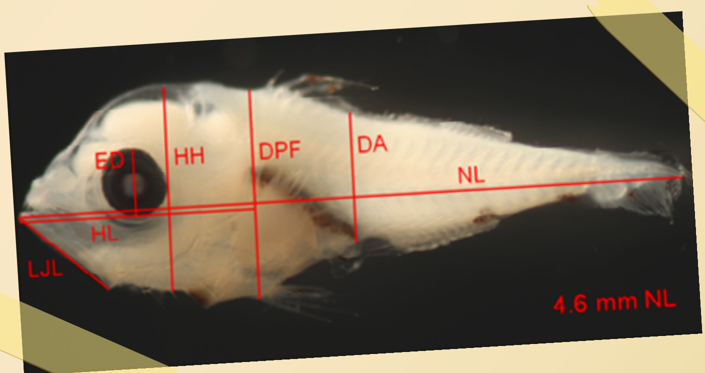

Figure 4:
Red Snapper larva showing all the measurements we took (in mm):

NL= notochord length
DPF = depth at pectoral fin
DA = depth at anus
HL = head length
HH = head height
ED = eye diameter
LJL = lower jaw length

Results

The number of Red Snapper larvae in the plankton surveys changed across months within each survey year, but overall there was little change in the number of larvae in the years before, during and after the oil spill.

Regarding the growth of Red Snapper, we found that the larvae were generally skinnier and in poorer condition in the years during and after the oil spill compared to before it (figure 5a). Within each year the Red Snapper larvae were worse off in June but their condition improved as the summer progressed.

Additionally, the larvae from the offshore research station T35 were better off than those from the inshore station T20, which is closer to the bay.

Finally, we found that larvae were in "better shape" when the environment had less natural freshwater discharge from the local bay. We then did some clever math to take out the effect of the environmental factors that we measured. After removing those, we still found that the larvae were in poorer condition in the years during and after the oil spill than before it.

Figures 5a is a **box-and-whiskers plot**. In such plots, the boxes capture the middle 50% of the observations (including the middle value, or median, shown as a horizontal bar), and the whiskers capture the middle 80%. Circles represent more extreme observations.

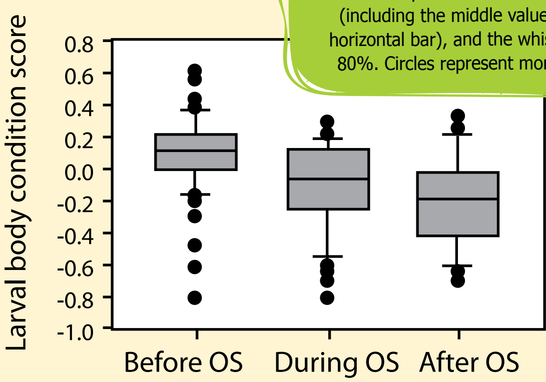

Figure 5a:
We measured the length of different parts of the larvae to show how healthy they were (larval body condition) scored from -1.0 to 0.8. (Higher scores mean healthier larvae.) OS = oil spill.

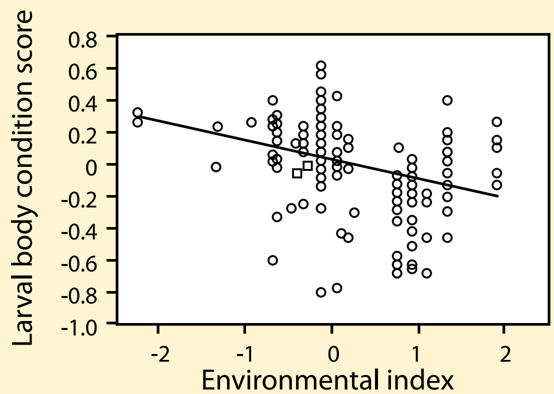

Figure 5b:
The larvae we measured were less healthy when more freshwater came out of the local bay. The Environmental index reflects multiple environmental measures. In our study, it was largely (but not solely) related to the freshwater discharge. (Higher number = higher freshwater inflow.)

Discussion

Although it would seem that toxic oil and dispersant (a chemical used to break up oil) would cause larval numbers to decrease, we actually found that the amount of Red Snapper larvae didn't change over the years. This is likely due to a complex relationship where larval counts were indirectly affected for several other reasons besides just the oil spill.

One possible explanation is that the government closed many Red Snapper fishing areas during the spill which would result in more adult fish that can reproduce than normal. Another possibility is that the adult Red Snappers might have swum away from the most contaminated areas of the Gulf of Mexico to areas around our research stations (which were relatively less affected by the oil) to spawn their eggs.

We also found that Red Snapper larval condition was relatively poor in years after the spill, in earlier months within years, and at the sampling station closer to shore. However, we weren't able to conclude that it was the oil that made the larvae less healthy. Instead, our findings suggest that some combination of conditions relating to the DWHOS and environmental factors negatively impacted larval health.

This decline in condition may have been due to there being fewer planktonic prey available which generally means less food for Red Snapper larvae and slower growth. Also, when more freshwater flowed into the gulf from the bay, the Red Snapper larvae were less healthy. While this was a strong relationship we're currently not certain why increased freshwater, which is colder and has lower salinity, would impact health.

The number and "health" of young Red Snapper is particularly important. If larvae aren't growing well then they're less likely to reach maturity, reproduce, and contribute to the adult population of Red Snapper in the Gulf of Mexico. Going forward, we can learn more about the condition of Red Snapper spawned in 2010 by looking at how their predators and prey were impacted by the DWHOS.

Conclusion

When we observe events in complex environments like the ocean it can be very hard to provide evidence that one thing caused another to happen (we call this a cause-and-effect relationship). This is because there are so many factors that we have no control over that can directly or indirectly change the thing being studied.

It's much easier to change just one thing at a time, keeping everything else constant, in a controlled experiment. Unfortunately, this just isn't possible in the sea where the environment is always changing: water temperature, salinity, other organisms. The list goes on!

Glossary of Key Terms

Commercial fisheries – The people and companies who catch fish to sell them

Crude oil – Naturally occurring, unprocessed petroleum. Created from fossilized marine animals that have been squashed by the weight of the sea and the sea bed over millions of years

Freshwater discharge – The amount of fresh water that runs into the sea from a river or bay

Habitat – The place, or type of place, where an animal lives

Oil rig – A man-made station built out at sea where we drill for crude oil

Oil spill – When oil escapes from the container or pipeline that it's meant to be stored or moved in, and gets into the sea or onto the land

Larvae – The young of a species of fish

Plankton – Small microscopic animals that float in the sea, including the eggs and larvae of many fish species

Predator – An animal that's above another in the food web. One that might eat the animal we're studying!

Prey – An animal that's below another in the food web. One that the animal we're studying might eat!

Recreational fishing – People who catch fish for fun and for their own food

Salinity – The salt content of the sea. High salinity means there's a lot of salt, low salinity means that there is not as much

Significant – A result that is likely not due to chance, but rather due to a real process.

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NOAA's report on Deepwater Horizon oil spill
http://www.gulfspillrestoration.noaa.gov/sites/default/files/wp-content/uploads/Chapter-2_Incident-Overview.pdf

How does oil impact marine life?
http://oceanservice.noaa.gov/facts/oilimpacts.html

Check your understanding

1. Why do you think our samples showed larger, healthier larvae towards the end of the summer?
2. If the larvae are less healthy, why do you think this might mean that fewer fish develop to become adults?
3. What effect do you think the closure of fisheries during the DWHOS would have had on the number of Red Snapper larvae in our samples? Why is that?
4. If you were a scientist on our team, what studies would you suggest that we do next to follow up on this one?