2021

Acidic Relationship - Catostylus mosaicus and Trachurus novaezelandiae

Moira Gaffney

Acidic Relationship - *Catostylus mosaicus* and *Trachurus novaezelandiae*

Moira Gaffney

Mark Martin, SSI1 165

20 November 2020

University of Puget Sound

Abstract

Recent research into the nature of certain species of bloom-forming jellyfish (*Catostylus*) and adolescent fish has shown an oddly circumstantial symbiosis. Researchers have sometimes compared it to the relationship between species of anemone and species of tropical fish. While at times a beautiful mutualism is born, the fish gaining protection and the jellyfish gaining a convincing bait, these same jellyfish can instead eat the adolescent fish they have been protecting. There is speculation this behavior may be influenced by ocean acidity. Specifically, the Blue Blubber jellyfish (*Catostylus mosaicus*) has a mutualistic relationship with the young Yellowtail scad (*Trachurus novaezelandiae*). Under increased acidity, *T. novaezelandiae* will avoid *C. mosaicus* and will sometimes become hunted by its once-protector. Without the young fish acting as bait, the jellyfish reverts in size and has no other choice but to go after easy prey, these adolescent fish. The uncertain nature of this relationship may potentially affect population and ecosystem patterns in oceanic areas with dense bloom populations. However, research on the effects of this relationship is still new and it is not clear how applicable these effects are on the range of fish-jellyfish relationships. It is important to inquire further into this unique and perplexing relationship.

Introduction

A concerning news article, posted in June of 2016, brought to light a relationship that had previously been glossed over (Uni. of Adelaide, 2016). The seemingly simplistic relationship between *Catostylus mosaicus*, the Blue Blubber jellyfish, and *Trachurus novaezelandiae*, the Yellowtail scad has been revealed to be unique in its changing nature. The symbiosis between *C. mosaicus* and *T. novaezelandiae* is one that is common between other related species of jellyfish and fish. The jellyfish protects the adolescent fish who gain a resistence to its poison while the young fish act as bait for the jellyfish to have a steady food supply. Many other species, especially in tropical regions, exhibit these behaviors (Nagelkerken et al, 2016).

The Blue Blubber jellyfish is a blooming jellyfish native to the coastal regions of tropical Australia. The Yellowtail scad is common throughout many tropical areas, one of which being the coastal regions of Australia. The symbiosis between these two species is typically mutualistic. *T. novaezelandiae* will seek out *C. mosaicus* upon reaching its adolescent stage. Being safe from the jellyfish's poison, it will continue to be protected from predators until it reaches adulthood. In turn, the Blue Blubber jellyfish uses the adolescent fish as bait and gains a steady supply of food (Nagelkerken et al, 2016). However, biologists started noticing that under certain circumstances, the jellyfish would eat the adolescent fish they had set out to protect. This change seemed to be sudden and unprecedented, sparking new research into this peculiar relationship. What was initially thought to simply be a shortage in available food for the Blue Blubber jellyfish may be a key indicator of a much larger problem.

With these looming indicators, it becomes important to discuss the reasons this relationship is changing. Understanding what factors may be causing these shifts may allow researchers to pinpoint larger problems and begin working on solutions. The effects on the larger ecosystem must be considered when looking at the changes in the fish-jellyfish relationship. While seemingly small and isolated, this shift could indicate a much larger change in ocean life. Shifts in ocean life and environment have impacts on society, so it is also important to discuss how society is affected by something as small as the shift in a symbiotic relationship.

Discussion

To understand part of why *C. mosaicus* would stop housing adolescent *T. novaezelandiae*, it is important to understand the anatomy and lifecycle of the Blue Blubber jellyfish. Jellyfish fall under the larger umbrella species of Cnidarians, relating them to coral and anemone through their ability to sting and poison threats and prey. The typical lifecycle of a jellyfish happens as follows: eggs and sperm from mature jellyfish are released into the water, get fertilized, and become larva. The larva will settle on a hard surface, typically the ocean floor, and form a polyp, a plant-like structure rooted in the ocean floor. The polyps will then elongate and bud off many young jellyfish, spawning in reaction to sunrise. From there, adolescent jellyfish will mature and repeat the lifecycle (Alger, 2016). However, with maturity comes a rather abnormal and helpful trait.

The jellyfish has the unique ability to regress in its development, all the way to early adolescence (but not before spawning) when starved or living in harsh conditions (Alger, 2016). The Blue Blubber jellyfish is no different, so it was initially thought that the jellyfish would eat the Yellowtail scad after a lack of food in their region. Not having enough food would cause *C. mosaicus* to regress, making it unable to house *T. novaezelandiae* and instead use the adolescent fish as a food source. However, new research suggests a much more concerning cause for the change in the relationship between the Blue Blubber jellyfish and the Yellowtail scad. The primary cause of this phenomenon may be a behavioral change in the adolescent fish rather than a survival trait of the jellyfish (Nagelkerken et al, 2016).

The typical lifecycle of *T. novaezelandiae* is a classic path of egg, larva, maturity, and repeat. The fish enter their relationship with *C. mosaicus* during their adolescent stage as their size at full maturity does not allow them to have proper distance from the jellyfish stingers

(Luna, 2020). The average size of young Yellowtail scad that associate with the Blue Blubber jellyfish is 2.5 cm, allowing the jellyfish to house multiple fish during their adolescent stage (Nagelkerken et al, 2016). A primary study done on this specific symbiosis was conducted by Ivan Nagelkerken and published to the Royal Society journal in 2016. Their goal was to determine which factors influenced *T. novaezelandiae* in seeking out *C. mosaicus*, and why the relationship seemed to be turning from mutualism to predator-prey.

It was found that olfactory cues, pheromones used to signal and identify other organisms, were not important drivers in the Yellowtail scad's attraction to the Blue Bubber jellyfish, indicating there had to be another factor driving the relationship (Nagelkerken et al., 2016). Fish in normal water conditions approached the jellyfish and stayed within their proximity in a normal relationship. However, fish within the tank with a higher acidity from CO_2 were less likely to approach the jellyfish and stay within its proximity (Nagelkerken et al., 2016). *T. novaezelandiae* typically uses chemical and visual signaling to stay within a safe range of *C. mosaicus* poison. Increased acidity has altered that behavior, indicating that chemical changes in the ocean are changing the cues necessary for this relationship (Nagelkerken et al., 2016). These changes in behavior would cause the adolescent Yellowtail scad to swim without protection in nature, causing a higher mortality rate as they become easy targets of other predators. In turn, the jellyfish lose their bait and start seeking out food sources, one of which being the easily accessible Yellowtail scad. Thus, ocean acidity endangers the symbiosis between *C. mosaicus* and *T. novaezelandiae* by chemically altering the Yellowtail scad's ability to perceive the jellyfish and approach it (Nagelkerken et al., 2016). While current ocean acidity levels may not be causing this level of harm, the acidity levels used in testing were projected levels based on the rates at which marine climate is changing (Nagelkerken et al., 2016).

Another important aspect to note is that *T. novaezelandiae* does not learn schooling behavior until it reaches maturity (Takahashi et al., 2010). This means that without living in proximity to the Blue Blubber jellyfish, the adolescent fish have no defensive behaviors and become hunted in quick succession. This is true of most related species (other scad and mackerel). This change in behavior in *T. novaezelandiae* could mean that other species of scad may also be losing defensive behaviors during their adolescence with increased ocean acidity. This results in a higher mortality rate, less mature fish learning to school, and a drastic change in coastal ecosystems (Takahashi et al., 2010). Along with larger effects of oceanic changes on other organisms, these conditions threaten the balance of Yellowtail scad in the environment.

Unlike *T. novaezelandiae, C. mosaicus* and other species of jellyfish thrive under oxygen depleted conditions (Nagelkerken et al., 2016). Increased acidity makes it easier for jellyfish to catch prey; this has led to a population boom among many jellyfish, especially the Blue Blubber jellyfish (Mesa, 2015). The concerns of ocean acidity can be brushed off in context of the tests done on the Yellowtail scad because they were staged in lab tanks, however the evidence of jellyfish booms is real and provides support for the changing conditions of the ocean's CO_2 levels. *C. mosaicus* blooms seasonally in time with the adolescent fish, however recent observations have shown an increased ratio of Blue Blubber jellyfish to Yellowtail scad (Mesa, 2015). This increased population density is particularly concerning with the Blue Blubber's long lifecycle. The problem of "immortal" jellyfish, being able to fluctuate between adolescence and maturity, means extended lifespans with an increased population. An increased jellyfish population means more competition for food, so with the increasing acidity levels discouraging defensive behaviors and increasingly hungry jellyfish, the Yellowtail scad is quickly being hunted by its once protector.

Among commercial uses, the Yellowtail scad is often used as bait and gamefish, as well as a food source in the fishing industry (Luna, 2020). A decrease in the population can be detrimental to the fishing and bait industries of coastal Australia. If significant enough, the decrease in *T. novaezelandiae* populations could impact the amount of food fishing industries bring to the market in those areas. Similarly, should other species of mackerel be affected the same way *T. novaezelandiae* is, then the fishing industry worldwide could face a bait and fishing shortage. This has the potential to result in job loss and a downturn in economies that rely on the fishing industry. Combined with potentially less available food in regions that rely on mackerel fishing, these changes in ocean acidity could have adverse effects on the average person. While these effects are not currently being seen in coastal populations, there are millions of people that depend on mackerel fishing for their livelihood and stability. Indicators of these systems changing could impact a larger human community.

Conclusion

Fortunately for the relationship between *C. mosaicus* and *T. novaezelandiae,* ocean acidity occurs in large crests and falls as environmental policies change, and the jellyfish populations follow suite. This means that the relationship and population levels may not yet be doomed (Nagelkerken et al., 2016). Increased acidity has many negative implications for ocean life and balance (Logan, 2010). Increased temperatures change gas solubility, making oceans more acidic. One reason that tropical fish and jellyfish such as the Yellowtail scad and Blue Blubber jellyfish may be affected by these changing conditions is because they live in warmer areas. While booming jellyfish populations may be an indicator of increased acidity, it is not yet killing off species in non-tropical areas (Logan, 2010). Perhaps this relationship is an early indicator that steps need to be taken to protect ocean life against increased acidity.

The unique relationship between *C. mosaicus* and *T. novaezelandiae* shows that important symbioses are subject to change should environmental conditions also change. The mutualism that is seen in the typical relationship between both species is not set-in stone, but neither is the predator-prey nature of their existence. This is important to keep in mind when comparing other relationships that may differ depending on various circumstances. Changes in environment and ocean acidity cannot be ignored, and the relationship between the Blue Blubber jellyfish and the Yellowtail scad is one of many that is indicating the changes in the natural world.

Similar Relationships and Effects

Shellfish Prey: Crustaceans, Echinoderms, Molluscs

Exposure to increased acidity has caused crustaceans and certain types of molluscs to lose some of their behavioral defenses. In contrast, the increased acidity caused certain types of echinoderms and molluscs to have increased defense capabilities against shellfish. This provides more evidence that changing conditions within the ocean can affect chemical and neural signaling in marine behavior. While this was a broad analysis over different types of prey, the different reactions indicate that ocean acidity is both beneficial and detrimental to different species, just like what was seen between the Yellowtail scad and the Blue Blubber jellyfish. While there is still much uncertainty about why ocean acidification seems to be affecting predator-prey relationships far more than other types of relationships, it is clear that this is widespread across the world (Clements, Comeau, 2019).

Haliotis rufescens – Red Abalone

Increased acidity within the early development of *H. rufescens* causes a physiological change in its gene development, causing those larvae to have a lower thermal tolerance. This indicates that changes in water pH can affect the development and protein production within aquatic species. In the Yellowtail scad, ocean acidity affected them during adolescence. The idea that pH was able to affect the development and signaling within the Red Abalone to make it less thermal resistant reinforces the idea that environment plays a key role in many symbioses. If water pH can alter behavior and development, then it is reasonable to look at the ways in which different symbioses will change if their environments change (Hofmann, Zippay, 2010).

Bibliography

Alger, S.J. "**When the Going Gets Tough, the Tough Become Babies**." (posted 4 January 2016. Contribution to the Nature Education weblog entitled "*Accumulating Glitches.*" Permalink access at: https://www.nature.com/scitable/blog/accumulating-glitches/when_the_going_gets_tough/

Clements, J. C., Comeau, L. A. (2019), Behavioral defenses of shellfish prey under ocean acidification. **Journal of Shellfish Research**, 38(3): 725-742. doi: https://doi.org/10.2983/035.038.0324

Hofmann G. E., Zippay M. L., (2010) Effect of pH on gene expression and thermal tolerance of early life history stages of red abalone (*Haliotis rufescens*). **Journal of Shellfish Research,** 29(2), 429-439: https://doi.org/10.2983/035.029.0220

Logan, C. A. (2010), A Review of Ocean acidification and america's response. **BioScience**, 60: 819–828. doi: https://doi.org/10.1525/bio.2010.60.10.8

Luna S. M., (2020). *Trachurus novaezelandiae* richardson, 1843 yellowtail horse mackerel. **FishBase Consortium**. https://www.fishbase.de/Summary/SpeciesSummary.php?ID=1979&AT=yellowtail+scad

MESA, (2015). Blue blubber jellyfish. **A to Z of Oz Marine Life**. http://www.mesa.edu.au/AtoZ/Blue-Jelly-Blubber.asp

Nagelkerken, I., Pitt, K. A., Rutte, M.D., and Geertsma, R.C. (2016). Ocean acidification alters fish-jellyfish symbiosis. **Proc. R. Soc. B**, 283(1833): Full article.

Takahashi, K., Masuda, R. and Yamashita, Y. (2010), Ontogenetic changes in the spatial learning capability of jack mackerel *Trachurus japonicus*. **Journal of Fish Biology**, 77: 2315-2325. doi:10.1111/j.1095-8649.2010.02812.x

University of Adelaide, (2016). Baby fish lose poisonous protectors in acidified oceans. **ScienceDaily**. https://www.sciencedaily.com/releases/2016/06/160628221717.htm