Science AMA Series: We're NOAA scientists exploring ways to clean up our nation's coastal waters, and we're finding some unlikely heroes: shellfish. Ask Us Anything!

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ABSTRACT

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Hello Doctors Bricker & Rose!

What a beautiful notion!

So, would I be right in thinking that shellfish used for this purpose would never be edible for humans (and perhaps not great for the rest of the foodchain?) - or is it the case that they process any toxins fairly well (with time) to the point that their flesh is 'clean' enough? Piggybacking on that, I am curious as to whether it leaves trace elements in the layers of their shell?

Industrial scale oyster beds, for pearl rather than meat, is the first thing that comes to mind. But is that actually the most efficient way of filtering? It's high density, but I am sure there are a number of things to consider from capacity of an organism to filter, breeding/growth rate and lifecycle. Which are the most promising in the bigger picture?

EDIT (P.S.): If I may have a third helping: How do you propose to track how much each shellfish farm is owed in order to reimburse them? I think it'd be interesting to know how you are working to solve that one.

Kwindecent_exposure
SB: We think so too!

Nitrogen itself is not toxic to people, in fact, it is a building block of all life. So shellfish grown in a location that just has excess nitrogen or other nutrients would absolutely be edible (and would be delicious!) However, locations that are high in nutrients may have other problems that would restrict aquaculture for human consumption. If there are high abundances of bacteria, for example, the shellfish would have to be used for another purpose (animal feed, fertilizers, are two options that come to mind).

Trace elements and nutrients are included in the shell as the shell is built, layer by layer.

Work by Colleen Higgins at Virginia Commonwealth University and colleagues has demonstrated that shellfish size is correlated to nutrient content in the shellfish body. So if a farmer can demonstrate how many shellfish of what size were harvested, we can be fairly confident in the nutrient removal that has

been achieved.

In Europe large scale mussel farms are being used specifically for their water cleaning abilities. Our research here in the US shows that the removal of detritus and phytoplankton (microscopic algae) that serve as food via bivalve shellfish filtration can be useful when compared to total inputs but typically removes only a small fraction compared to nutrient inputs. Shellfish filtration might be best thought of as a tool within a comprehensive nutrient management plan that includes land based traditional measures and removal from the water via shellfish. However, the removal from the water provides immediate benefits such as water clarification that are valuable on an ecosystem level, for example lessening the organic material available to cause hypoxia and allowing seagrasses to grow in places they might not have due to turbid waters.

You can read more about actual modeled nitrogen removal rates by shellfish in our recent paper: http://www.sciencedirect.com/science/article/pii/S0025326X14008078.

When you use the word 'nutrients', what compounds do you mean more specifically? What are the impacts of these nutrients on other marine organisms? What impact does the removal of these nutrients have on surrounding marine life?

TheTimtam
SB: When we refer to nutrients we are typically talking about nitrogen and phosphorus (and mostly nitrogen). The reason we focus on nitrogen in marine waters is that this is a nutrient in short supply and so often limits plant (i.e. algae) growth. People add a lot of nitrogen to a coastal or estuarine ecosystem from wastewater treatment, septic systems, fertilizers, runoff from storms, etc. This excess nitrogen (far above natural levels) causes marine plants to overgrow, leading to a bunch of environmental problems such as hypoxia, fish kills, nuisance blooms of seaweeds and phytoplankton, and loss of important habitat.

Read more about what we're doing to study excess nutrients, also called eutrophication (http://coastalscience.noaa.gov/projects/detail?key=249)

If the ph balance of the ocean changes, how does it affect shellfish?

dmareddit
JR: Research suggests that responses vary by species and by stage of life (larvae vs. juvenile vs. adult). The effects of ocean acidification are also compounded by a variety of other environmental factors, which makes it difficult to make generalizations. There is a lot of research ongoing to figure out specific impacts on specific species, by NOAA and academic scientists. For more information on NOAA research, check out: http://oceanacidification.noaa.gov/

There is also a recent meta-analysis you might find interesting by Kroeker et al. 2013 published in Global Change Biology.

Thank for you taking the time to do this AMA! I'm from the appropriately named Oyster Bay, New York and just attended the annual Oyster Festival. I love shellfish and it's satisfying to know that eating them is contributing positively to the environment.

Before industrial exploitation of oysters in the 19th-20th centuries, theeastern oyster was incredibly common in the bays and estuaries of the East Coast, with population densities perhaps 100 times what they are today. Anyone who's seen the Chesepeake today would find it hard to believe, but the Bay's waters used to be incredibly clear, with visibility reaching up to 20 feet because of the oyster's amazing filtering capability. My question is, do you ever see those population levels of oysters returning to our waters? What kind of 'infrastructure' and

timeframe would the oysters need to recover completely and effectively filter water to the same extent they previously did? What would be the cost per square mile in your estimation of facilitating this recovery?

twominitsturkish
JR: There are many organizations and people working to restore oysters to high population densities in both New York and Chesapeake Bay (two of our study sites). Restoration efforts have met mixed results, although projects are becoming more successful as we gain knowledge about how to site appropriately and improve strategies to counter environmental challenges (for example, raising reef structures off-bottom to prevent siltation). I am not a restoration practitioner so unfortunately I don't know numbers on cost per square mile for reef building, although I imagine it varies quite a lot depending on the location.

NOAA's Restoration site has a lot of great information about oyster restoration: http://www.habitat.noaa.gov/restoration/techniques/oysterrestoration.html.

NOAA's Chesapeake Bay Office is also part of large oyster restoration effort in the Bay: http://chesapeakebay.noaa.gov/oysters/oyster-restoration.

In New York, we've been working with the Billion Oyster Project as well: http://www.billionoysterproject.org/.

The oysters in the Chesapeake Bay have suffered from diseases like MSX and Dermo, vastly decreasing their populations, with many negative effects, including the increased turbidity of the bay waters. Some years ago there were proposals to introduce asian oysters into the bay with resistance to those diseases. Those proposals were voted down and instead there were attempts to breed resistance into the native species. Can you discuss the reasons for the rejection of the asian oysters? How different would they have been from the oyster species already in the bay? Is there any reason to believe species that feed on or depend on the native species wouldn't have switches to the non-native oysters? From a seafood perspective, are the asian oysters significantly different in size, texture or taste?

shiningPate
SB: The Atlantic States Marine Fisheries Commission had a workshop on this exact subject, in which NOAA scientists participated. They also published a report. (http://www.asmfc.org/uploads/file/sr74AsianOysterWorkshop.pdf).

Additionally, NOAA's Chesapeake Bay Office is a great resource for information on non-native oyster research for the Bay. (http://chesapeakebay.noaa.gov/monitoring-and-research/non-native-oyster-research).

There are many different species of Asian oysters. One Asian oyster grown here on the West Coast in the U.S. is the Pacific Oyster, Crassostrea gigas, which is native to the Pacific Coast of Asia. You can read about differences in Pacific Oysters and Eastern Oysters (Crassostrea virginica), which are the main oysters farmed in the Chesapeake Bay, on NOAA's Fishwatch website (http://www.fishwatch.gov/).

Although there isn't a definitive test for taste since it is a highly personal preference, there were arguments against using C. gigas because they didn't taste as good and I agree :-)

I noticed that you specifically mentioned clams, oysters and mussels. Would the legged shellfish such as shrimp and lobsters not be as effective? Why?

DoubleDot7

JR: Clams, oysters, mussels, and other bivalve shellfish are filter feeders, and they feed on naturally-occurring plankton in the environment. The cultivation of shrimp and lobsters requires the addition of food, which adds nutrients to the environment.

Could you please compare the potential impact of shellfish filtration near-coastal ocean waters to the impact that Zebra Mussels have had on the Great Lakes? The water quality has improved vastly, but Zebra Mussels remain an invasive species, and I wonder about any long-term impacts on biodiversity, including loss of native species and disruption to fisheries.

Thanks!

misterthirsty
SB: The impact of shellfish on nearshore water quality provides many ecosystem benefits including (potentially) fewer 'dead zone' events, regrowth of seagrasses and increased habitat for coastal marine fish and other organisms. We recommend using native species for projects that are targeting nutrient removal to avoid problems with invasive species like have been seen with zebra mussels.

Thanks for doing this AMA Drs. I'm from Southern Maryland and come from a long line of watermen. My brother currently commercial crabs, my grandfather grew up hunting, trapping and fishing on the Patuxent and his father was involved with the tobacco trade back when the steamships were still running up and down the river. Your research hits very close to home and I want to thank you guys for all that you do for our nations waterways! It's important that people understand the severity of the decline in water quality and what it means for everyone. I've heard stories about how much cleaner the water used to be and about the decline in species diversity over the last century and I'm excited that you guys are working on a solution. I have a few questions for you. What are the biggest hurdles you are facing in your research? Generally, is there much support from local governments in bioextraction efforts? Do you think its possible to see a major reversal of pollution levels in the Chesapeake Bay and surrounding watersheds in the next 10 years?

ThatsQuacktaaaastic
SB & JR: You are very welcome! We are grateful that our research is appreciated.

One hurdle is getting the data at the appropriate time and space scales that are needed to make our analyses and model simulations. We rely on federal, state, and local support for the work that we do, and we have had great experiences working with local governments. There is great interest and much research being conducted globally on the potential for nutrient removal through bioextraction. Locally the Chesapeake Bay Program (http://www.chesapeakebay.net/) and Oyster Recovery Partnership (http://www.oysterrecovery.org/) have established a panel to review the possibility of using oysters as a best management practice in Chesapeake Bay. (http://www.chesapeakebay.net/groups/group/bmp_expert_panels)

We see shellfish as one of many tools that are available to resource managers seeking to improve water quality in our estuaries. We hope that with continued coordinated efforts by all stakeholders, and a comprehensive approach to nutrient management, improvements will be possible in the next decade.

I was curious how much of this is being accompanied by algae growth as well. I know that IMTA systems rely on both bivalve and algae growth and that many forms of algae also have a large commercial market. Are there plans to create a similar system or is the main focus on shellfish for now?

michigan52
JR: What a great question! We are primarily working on shellfish, but have colleagues (Charles Yarish

and Jang Kim) working on seaweed-based nutrient removal just up the road from me at the University of Connecticut.

NOAA has also been working over the last several years with researchers at University of New Hampshire (UNH) through UNH Sea Grant to build and research an IMTA (integrated multi-trophic aquaculture) system. Check out their work: https://seagrant.unh.edu/news/unh-led-team-designs-aquaculture-raft-provide-four-season-source-seafood-and-sea-veggies.

Shellfish and seaweeds are a great team because shellfish use nutrients in the particulate form (=plankton and organic material), while seaweed use nutrients in the dissolved form. Having both at a site expands the nutrient removal possible. The market for seaweed in the United States is growing, and there are shellfish growers currently experimenting with adding seaweeds to their existing farms.

Read more about IMTA at Smithsonian's Ocean Portal:http://ocean.si.edu/blog/aquaculture-comes-full-circle

Check out some photos of what a real IMTA system looks like: https://www.flickr.com/photos/nhseagrant/tags/multitrophicaquaculturerafts/

Hi Scientists. I am an Environmental Consultant based out of Washington State. The Environmental Protection Agency recently directed the Washington State Department of Ecology to adopt stricter pollution control measures to protect public health. Currently, the fish consumption rate, depending on the pollutant regulated, is estimated to be between 6.5 and 54 grams per day, and the acceptable cancer risk rate is estimated at 1 in 1,000,000. There are many populations of higher than average fish consumers (Tribes, sport fisherman) in the sate that eat much more than this average. Industry in Washington state will suffer if the rules that the EPA has suggested are implemented because it will be financially burdensome to implement the stricter pollution control measures. My question is, although shellfish can be used for "bioextraction," what are the implications for public health? Although there are many pollutants already in the ocean, why are agencies still only regulating pollution discharge with the health of the "average" person? It seems like more could be done in terms of controlling the pollution discharge at its source, rather than waiting for it to be accumulated in staple food sources and hope that people don't get cancer.

clockradiofloss
SB & JR: In places where bivalve shellfish are used for nutrient bioextraction, they can still be consumed as long as there is no other contamination that would make them unsuitable for consumption such as pathogens, heavy metals or organic carbon contaminants. In places where contaminants exist, the shellfish harvested should not be sold for human consumption, and state shellfish sanitation programs are in place to ensure that harvested shellfish are safe for the public to eat.

We absolutely agree that reducing nutrients at their sources should be a key focus of nutrient management programs, and in fact, there have been major federal and state efforts underway for decades to do just that. However, nutrient problems in coastal environments persist despite these efforts. This may be due to the inherently difficult nature of dealing with nonpoint sources of nutrient and nutrients from atmospheric deposition. We believe that resource managers should use all the tools available to them to reduce excess nutrients in the environment, and that shellfish are one of these tools.

The National Estuarine Eutrophication Assessment looks at excess nutrient levels in the nation's estuaries and their current eutrophication condition (http://coastalscience.noaa.gov/projects/detail?key=249).

Historically, Pearl Harbor was referred to as the breadbasket of Hawaii, capable of providing massive amounts of food in a sustainable manner, but since the early 1900s, overfishing and environmental degradation have taken their toll. The oil spilled in the WW2 bombing was likely the last straw, but today, the harbor is nearly a dead zone and anything out of it is not fit for human consumption. There has been talk about reintroducing oysters to the harbor, since the native species seems to have died out entirely.

Do you think this is possibly a realistic option to deal with the type of damage the harbor has sustained? How resilient are oysters to algae blooms caused from agricultural runnoff, or oil seeping from 70 year old battleships sank in the harbor?

Fearlessleader85
JR: I am not familiar with the ecology of Pearl Harbor, so can't comment specifically on that site. However, based on what you have described, I can say that oysters feed on algae, so if the algal blooms are microalgae and not seaweed, they would be a source of food. A large population of shellfish can exert what is known as "top-down control" on algae, meaning that they eat the algae faster than they grow, and thus may be able to prevent a bloom from occurring.

Unfortunately, I do not have expertise in effects of oil on shellfish physiology, so I can't help you there.

Are the freshwater ones equally good at filtering?

Thank you for doing this!

dorksai
JR: Yes! Freshwater shellfish are great filter-feeders too. While Suzanne and I don't work on freshwater shellfish, Niveen Ismail and colleagues at Stanford University recently published some nice work documenting improvements to lake water quality by a freshwater mussel: http://pubs.acs.org/doi/abs/10.1021/es5033212?journalCode=esthag

Would such a facility look/work something like this? Or would it need to be arranged in a different way to optimize nutrient reduction?

Or, perhaps you prefer a less-structured approach that just creates a healthier environment for shellfish?

If I may double-up my question, would it be possible/desirable to have the filter feeders hosted in a barge array such that they could be moved to the 'dirtiest' water in an estuary on any given day?

(thank you for doing an AMA on a topic that is more important than most people realize, considering 40% of Americans live in counties adjacent to ocean(meaning ocean health is directly in their local habitat))

altkarlsbad
SB: It is our great pleasure to spread the word about the mighty oyster!

Yes, an aquaculture facility does look like this and does do the bioextraction work we are discussing. As long as the water can get through the mesh to the oysters so they can filter the water, they can do their work. Because they are suspended, there is no difficulty with them being covered in sediment on the bottom but fouling (growth of algae and other organisms) on the cages must be cleaned off so that water can flow through.

A moveable barge is an interesting idea! Depending on the size of the system and the water flow, the water quality probably doesn't change so much on a day to day basis and the barge might be placed

permanently at a location known to be the 'dirtiest'. Then the concern would be about whether depuration is needed prior to consumption.

There is often some debate within the public, local stakeholders, and even agencies about the ecosystem services of shellfish (carbon sequestration, water quality, nursery habitat, shoreline stabilization, etc.). What are some of your favorite peer-reviewed articles that make the case for shellfish, especially in the context of competing uses and habitat.

sc10uba
Here are some of our favorites:

Newell 1988 (http://www.oyster-restoration.org/wp-content/uploads/2012/06/Newell-1988-filtering.pdf)

Lindahl et al. 2005 (http://www.bioone.org/doi/pdf/10.1579/0044-7447-34.2.131)

Kellogg et al. 2014 (http://www.sciencedirect.com/science/article/pii/S0272771414002789)

Beck et al. 2011 (http://bioscience.oxfordjournals.org/content/61/2/107.full)

Beseres Pollack et al. 2013 (http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0065314)

Rose et al. 2014 (http://pubs.acs.org/doi/abs/10.1021/es4041336)

Filgueira et al. 2015 (http://www.int-res.com/articles/meps_oa/m518p281.pdf)

Bricker et al. 2014 (http://link.springer.com/article/10.1007%2Fs10498-014-9226-y)

Silva et al. 2011 (http://www.sciencedirect.com/science/article/pii/S0044848611004388)

Ferreira et al. 2007 (http://www.sciencedirect.com/science/article/pii/S0044848606009094)

Saurel et al. 2014 (http://www.int-res.com/articles/aei2014/5/q005p255.pdf)

Grabowski et al. 2012 (http://bioscience.oxfordjournals.org/content/62/10/900.full.pdf+html)

Hi Docs!

Fishery Biologist here.

In regards to the field of oceanic/fishery biology and ecological research, how did you make your way to work for NOAA and what tips would you give to achieving the goal of working at the federal level to upcoming biologist this day in age?

Thanks!

shittydiks
SB: My path to NOAA began in graduate school where I partnered on projects with NOAA researchers. I was fortunate a position was available when I finished. My research at the time was different, though still pollution related and the research on eutrophication and aquaculture came about as an offshoot of my eutrophication research with diverse partners.

Working with NOAA researchers as an intern or through NOAA sponsored research is a good way to achieve your goal.

JR: I agree with Suzanne's recommendation to work with NOAA researchers and apply for NOAA internship programs. The Hollings Scholar program, the Knauss Fellowship, the National Research Council Postdoctoral Fellowship, the AAAS Science and Technology Policy Fellowship, and the Presidential Management Fellows program are all ways to gain experience working with the agency. I

started out working jointly for NOAA and EPA as the science coordinator for the Long Island Sound Study. It would probably be a good idea to get involved in marine policy while still in grad school, by taking science policy classes and by participating in local policy initiatives.

Here is a link to student opportunities at NOAA:
http://www.education.noaa.gov/Special_Topics/Student_Opportunities.php

I believe in the recent past their had been efforts to reintroduce clams to the Hudson bay New York to try and clean or atleast improve the water quality. Do you know how well that has worked so far?

zynix
JR & SB: There are a number of projects underway in the NY/NJ region to use clams and oysters to reduce nutrients.

NY/NJ Baykeeper and the Billion Oyster Project have been focusing on oyster restoration in New York Harbor: http://nynjbaykeeper.org/resources-programs/oyster-restoration-program/ and http://www.billionoysterproject.org/

A project in Barnegat Bay called 'ReClam the Bay' (http://reclamthebay.org/) in their 2014 annual report state that they have "now trained over 164 Certified Shellfish Gardeners who, with other ReClam the Bay volunteers, have put about 13 million clams and 3.9 million oysters in Barnegat Bay since we started in 2005". The actual success of re-establishment and water cleaning of clam populations does not appear to have been quantified.

The Nature Conservancy has an active clam restoration program underway in Great South Bay:
http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/newyork/oceans-coasts/li-great-south-bay-shellfish-restoration.xml

Hi Docs!

Mussel lover over here. My question is regarding population levels of such shellfish. Do you believe that increasing the population of said shellfish would help clean the oceans? If so would it be increasing in population in each colony (unaware of proper shellfish farming terminology) or increase the number of shellfish farms, or perhaps both? Would increasing the populations bring any adverse reactions?

Thanks!

TriviuMx
SB: Increasing populations of bivalve shellfish will increase the filtration of particles from seawater and would increase the removal of nutrients through bioextraction. The increase in total number of shellfish is the point of interest, it doesn't matter if it is in a farm or colony/mussel bed, if there are more shellfish there will be more filtration. However, there is a limit to how many shellfish can reside within a waterbody that is determined by food availability but also the removal of waste products. This limit is called the carrying capacity. If a waterbody is overloaded with shellfish above the carrying capacity threshold, or there is not a strong current to take wastes away, then it is possible that waste products would cause water quality problems.

If you had access to a long-endurance, mobile robotic surface vessel, what data would you be most interested in collecting (or what sensor suites would you be most interested in deploying)?

denga

SB & JR: Wouldn't that be a great tool to have? We would measure the variables needed for our model simulations, although some of these variables cannot yet be measured by automated sensors. These variables include temperature, salinity, chlorophyll, particulate organic matter, total suspended solids, dissolved organic nitrogen, and dissolved oxygen. We would also measure current speeds which in the model are used to estimate the delivery of food to the oyster farms.

Check out how we use these data for our models (http://coastalscience.noaa.gov/projects/detail?key=59).

Will warming water cause a plankton bloom? If so, what affect will this have on species that eat plankton?

monkeydave
JR: Phytoplankton blooms are influenced by many factors, including light, temperature, nutrient availability, and grazing pressure. Many phytoplankton blooms are a normal part of seasonal coastal cycles. I do not think there is scientific consensus on the effects of warming water on plankton blooms at this point. Predicting impacts on shellfish is even more difficult given that warming would have both direct impacts on physiology and indirect impacts via their food sources.

What kind of partnerships does the NOAA have with universities?

futoncrouton
SB: NOAA has strong collaborative research partnerships with universities, funding external research by university scientists. NOAA scientists have close collaborative partnerships with university scientists. Many of these collaborations are through NOAA Sea Grant (http://seagrant.noaa.gov/), which has 33 programs across coastal US States and territories.

Can you use oyster farming adjacent to salmon farming to make salmon farming less environmentally damaging?

sbhikes
JR: This is a practice known as Integrated Multi-Trophic Aquaculture, and is being actively explored around the world, including here in the U.S. The co-culture of finfish with shellfish and/or seaweeds has been successfully practiced for a very long time in Asia.

NOAA has also been working over the last several years with researchers at University of New Hampshire (UNH) through UNH Sea Grant to build and research an IMTA (integrated multi-trophic aquaculture) system. Check out their work (https://seagrant.unh.edu/news/unh-led-team-designs-aquaculture-raft-provide-four-season-source-seafood-and-sea-veggies).

Here are some photos of what their IMTA system looks like (https://www.flickr.com/photos/nhseagrant/tags/multitrophicaquacultureraft/).

Read more about IMTA at Smithsonian's Ocean Portal (http://ocean.si.edu/blog/aquaculture-comes-full-circle).

Hello, Doctors. My questions are fairly simple. What is currently being done to ensure the long-term (as in past our generation) clean up and preservation of our coasts and their shellfish habitats, as well as the habitats of others? Secondly, what can people on the inland, who might not be able to help directly, do to help your efforts?

PhantomLink29
JR: There are tons of people and programs working on this very hard problem and it's not really

feasible to summarize all their efforts here! Most large bodies of water (estuaries, bays) have dedicated teams of stakeholders working to improve water and habitat quality in that specific ecosystem. These teams include everyone from local, state and federal agencies, to NGOs, to passionate individuals. Keep in mind that many inland waters drain to coastal waterbodies, so improving inland water quality can also improve our coasts!

What effect will the increasing acidity of our oceans have on the viability of shellfish cleansing those oceans of excess nutrients?

liberal_libertarian

JR: To my knowledge, no one has looked specifically at ocean acidification effects on filter feeding itself. This seems like a potentially interesting area of future research.