Agriculture and Aquaculture: Food for Thought

When ruminant animals such as goats, sheep, and especially cattle digest their food, it gets processed in their systems by way of fermentation. This process breaks the food down over time and produces methane, a powerful greenhouse gas that contributes to our rapidly warming planet when expelled to the atmosphere in the traditional biologic routes; i.e., flatulence or burps. Researchers have found that 37% of methane emissions from human activity are the direct result of our livestock and agricultural practices.

The problem becomes more apparent considering the sheer scale of livestock raised for meat production throughout the world. A single cow produces between 154 to 264 pounds of methane gas per year. Not counting for the emissions of any other livestock, 1.5 billion cattle, raised specifically for meat production worldwide, emit at least 231 billion pounds of methane into the methane into the atmosphere each year (Our World in Data). Because methane is such a potent greenhouse gas (see Box), there is great interest in curbing its production. A number of companies and start-ups are investing in plant-based products that mimic meat's flavor and and texture, while others focus on lab-grown alternatives, both of which would lessen the need for animal farms and their associated emissions if more widely adopted.

Methane is More Potent than CO2?

Gases that trap heat in the atmosphere are called greenhouse gases. Water vapor is the most abundant greenhouse gas in our atmosphere, but carbon dioxide and methane are the principal greenhouse gases contributing to our increasingly warm planet; and their impacts vary greatly. By percentage, carbon dioxide (CO_2) is the major component of greenhouse gases, but methane is the second highest and its impacts are both more potent and less widely understood. Although it persists in the atmosphere for much less time than CO_2, its warming impact is much more powerful. "According to Drew Shindell, a professor of climate sciences at Duke University's Nicholas School of the Environment, three factors determine the power of a gas to alter the earth's climate: how efficiently it absorbs heat, how long it lasts in the atmosphere, and how much of it is present. As it turns out, methane performs pretty well on all fronts" (NRDC). Though CO_2 is more abundant and stays in our atmosphere longer, methane is more damaging. In fact, as a greenhouse gas, methane is 28-times more powerful than CO_2 on a 100-year timescale and 80-times more powerful over 20 years.

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The hunt is already on to investigate whether similar results can be produced from aquaculture products in animal feed with a type of red seaweed, *Asparagopsis taxiformis,* showing the most promise. This seemingly innocuous plant could one day lower methane emissions by as much as 98% in cattle with only a 0.20 percent addition to that animal's feed per day. While not as efficient, other aquaculture products such as *Asparagopsis armata*, native to the Northeastern Atlantic and Mediterranean Sea, have been shown to be effective in dairy cows, reducing their methane emissions by 67% with only a 1% seaweed mix. Although results are promising, scaling up production as a widely available feed additive is still in the developing stages, as is the ability to introduce and market these products. Nevertheless, the aquaculture industry is well-positioned to enter this innovative field in a way that will one day provide local and global benefits by offering a reproducible emissions reduction technology at an affordable price. Regional aquaculture ventures – based on regional availability of effective seaweed varieties – could become local sources of feed additive, supporting local economies worldwide and keeping production costs low.

Aquaculture's potential goes well beyond animal feed, especially in the Southeast New England Program (SNEP) region where it is still a nascent industry reliant on oysters for greatest economic value. According to the Massachusetts Aquaculture Association, aquaculture ranks fifth in value of all agricultural products and is among the state's fastest growing agricultural sectors, with oyster

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farming alone ranking third in value of all landed seafood in Massachusetts. Beyond their value as food, shellfish (primarily oysters) are also seen as a low-tech nitrogen reduction intervention for waterbodies impaired by nutrients. Although the continued efficacy of this application is still being quantified, oyster reefs have a demonstrated effect on water quality, filtering up to 50 gallons of water per oyster per day. Oysters can remove nitrogen (stored in their tissue and shells) and promote higher denitrification in the sediment. Oyster reefs also promote biodiversity by serving as shelters for thousands of species. In an ongoing SNEP-funded project, a team at UMass Dartmouth has been determining baseline conditions at Cockeast Pond – a saltwater pond with a high level of nitrogen enrichment – in order to measure the total potential restorative impacts of newly deployed oyster populations. After compiling nearly a decade's-worth of data, the team plans to apply their technique for water quality restoration via oyster aquaculture to several areas along the Westport River.

In the Town of Orleans, oyster aquaculture is being used as a nitrogen reduction approach in Lonnie's Pond, where excess nitrogen has impaired the water and habitat. Aquaculture at this site will help the town meet the goal of reducing roughly 660 pounds of Nitrogen per year (lbs-N/yr) as part of the town's overall Nitrogen Management Plan. Partnered with Ward AquaFarms, the town deployed approximately 1.5 million oysters into Lonnie's Pond in 2019 with the goal of removing 165 lbs-N/yr through oyster farming, constituting 25% nitrogen removal of the total 660 lbs-N/yr target. The oysters were deployed in mid-July and harvested in December. The total net removal was 136 lbs-N, fulfilling 82.5% of the goal. Previous years showed that longer deployments can increase nitrogen removal, therefore future considerations should include increasing the deployment time by deploying earlier.

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As these industries continue to develop throughout the SNEP region, there are additional opportunities to innovate. For aquaculture oysters, questions remain as to how much of an increase in supply the wild oyster market can absorb without seeing an equal increase in demand. Although the potential benefits of oystering are large, new uses for the increased supply will be required to allow the aquaculture industry to continue its expansion. One potential avenue could include their sale as nutrient-rich fertilizers, which could negate some of the need for new fertilizers currently being brought into the region. Throughout Cape Cod, fertilizer use is the second highest controllable source of nutrient pollution in coastal embayments (Cape Cod Commission).

In aquaculture production, multi-crop ventures that cultivate oysters, salmon, and kelp within the same area in a closed-loop production process are known as Integrated Multi-Trophic Aquaculture (IMTA); species grown in this system require zero inputs (no fertilizers) and benefit from cohabitation of other species within the system. The presence of kelp provides habitat and shelter for fish and shellfish, whose excrement then nurtures the kelp. In addition, IMTA allows for increased nutrient removal, as seaweed can sequester five times more carbon than land plants and uses dissolved inorganic nitrogen to grow. Studies from the Lindell Lab at Woods Hole Institution of Oceanography have shown that a multi-crop farming of seaweed in conjunction with oysters can remove more nitrogen from impaired waters than a traditional mono-crop venture alone. This innovative aquaculture concept can help to rebuild ecosystems and can be used to restore nutrient impaired waters, while also creating a lucrative industry for famers in the area without requiring much additional space.

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The potential to expand aquaculture throughout the SNEP region is significant. with numerous designs to emulate and markets to tap. Benefits abound from improving regional water quality, to supporting agricultural ventures while simultaneously reducing powerful greenhouse gases emitted from livestock or strengthening local economies in the sale of aquaculture products. Not to mention the knock-on benefits associated with cleaner water and air. Aquaculture is a nascent industry that deserves further research and local investment – this is just the beginning.

An unlikely pair: multiple types of seaweed have been shown to reduce the methane emissions of cattle when added to their feed. If these feed additives can be produced at scale, there could be the promise of a sizeable market for a nascent industry while simultaneously addressing a major source of greenhouse gas emissions. More widespread acceptance of plant-based diets would also significantly reduce emissions from food production. (Photos from Flickr, each with a Creative Commons license).