The Benefits of Expanding Seaweed Farming in the Puget Sound

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With the effects of human caused climate change becoming more severe as time progresses, there is an increased urgency to find responses that will combat these effects. One such response to environmental change that is currently being tested is seaweed farming, also known as kelp farming or seaweed aquaculture. Seaweed farming has many positive impacts, including ecological and agricultural benefits. Seaweed can help combat ocean acidification and reverse its effects, is a sustainable food source for humans and livestock, and can be used as a fertilizer, along with other potential benefits. Despite these positive impacts, there is currently only one commercial seaweed farm in the Puget Sound. Blue Dot Sea Farms, located outside of Hood Head, Washington, at the north end of the Hood Canal, was established to study the impacts of seaweed farming on ocean chemistry as well as the possibility of farming shellfish with seaweed. Since the establishment of Blue Dot Sea Farms many individuals have applied for permits to start their own operations, but due to the difficult permitting process none have been established yet (Banse, 2022). According to the National Oceanic and Atmospheric Administration (NOAA), seaweed is the fastest growing aquaculture sector in the United States, but the industry is still in its developmental stages (NOAA Fisheries, 2020). There is substantial evidence that suggests a well planned expansion of the seaweed farming industry in the Puget Sound could lead to significant positive environmental impacts for the area.

Seaweed, a term used to describe many species of aquatic photosynthetic algae, has been collected and used by humans in East Asia in some form for at least 1500 years (Hwang et al, 2019). Modern cultivation began in this area around the 1950s, and has since rapidly expanded (Hwang et al, 2019). The seaweed grown in many of the areas in East Asia is primarily harvested for food and is also used in other products such as hydrocolloids, which are used as binders (Valderrama, 2012). Seaweed is growing in popularity as a food in the United States, and about ninety five percent of the seaweed used for food is imported (Sherriff, 2022). The market for this sustainable, healthy food remains relatively untapped in the United States, and Washington state has the opportunity to be at the forefront of it.

There are many species of seaweeds and kelps that are native to the Puget Sound, including sugar kelp (*Saccharina latissima*), the main species that is cultivated in the United States. Sugar kelp is a

species of brown algae that naturally occurs from Alaska down to California, according to the Puget Sound Estuarium. It also is native to many other areas around the world. As its name suggests, sugar kelp has a notably sweet taste, which is a large part of the reason it is so widely cultivated by humans. Sugar kelp is the species currently being grown at Blue Dot Sea Farms, as well as many other farms in states including Alaska (Stopha, 2020) and Maine (Maine Fresh Sea Farms, 2015). Another important species to the Puget Sound ecosystems is bull kelp (*Nereocystis luetkeana*), which has been experiencing population declines according to the Puget Sound Restoration Fund. Recovery efforts are already underway to restore populations of bull kelp, and farming this species could help increase their population. There are various other seaweeds native to the Puget Sound, including red algae species, which are also being farmed in Europe and the Americas (Garcia-Poza et al, 2020).

The ecological benefits of seaweed farming are extensive. The seaweed itself acts as a carbon sink, sequestering CO_2 that is in the water and producing oxygen through photosynthesis (Duarte et al, 2017). Roughly thirty percent of the CO_2 released from fossil fuel emissions gets absorbed by the ocean, which acts as a massive carbon sink (NOAA, 2020). This increased level of CO_2 lowers the pH of the water in the ocean in a process commonly called ocean acidification. Ocean acidification has many negative impacts on the organisms that live in aquatic habitats. One impact that is important to Puget Sound ecosystems is lowered calcium carbonate levels through a series of chemical reactions, which greatly affects the native mollusks, who make their shells from the free floating calcium carbonate in the water (NOAA, 2020). Seaweed's role as a carbon sink in a local environment allows for more normal levels of calcium carbonate to return to the area, which would lead to higher mollusk populations.

Mollusk populations have also been declining due to lowered oxygen levels from an increase in algae blooms, which are also toxic to them and other species (Washington Department of Fish and Wildlife, 2019). While the species of algae that cause these blooms are native to the Puget Sound, an excess of them can be deadly to other aquatic organisms by causing suffocation (King County, 2020). The blooms can even be harmful to humans due to the toxins they produce. Oysters are filter feeders, removing excess nitrogen from the water (NOAA Fisheries, 2021). This nitrogen, which often comes from agricultural runoff, can lead to the toxic algae blooms forming (NOAA Fisheries, 2021). Higher oxygen and lower CO₂ levels from seaweed would lead to more mollusks, which would subsequently lead to lower nitrogen levels, allowing less algae blooms to form. This is how seaweed can increase mollusk populations in the Puget Sound, which is why farms such as Blue Dot are focusing on farming oysters simultaneously with their kelp. As more research is done on operations that integrate seaweed and shellfish farming, more evidence is found that this method increases the overall health and biodiversity of ecosystems. Combined seaweed and shellfish farms have also been shown to offer habitat and shelter for many fish species, and evidence suggests that biodiversity is higher in areas around these operations (NOAA Fisheries, 2021).

Agriculture is a large part of Washington state's economy, with the three largest commodities being apples, milk, and cattle according to the Washington State Department of Agriculture. Cattle are well known for being methane (CH₄) producers, which is a significant contributor to the greenhouse effect. One methane molecule can be over twenty five times as effective at trapping heat in the atmosphere as one CO₂ molecule, although they are much shorter lived (Environmental Protection Agency, 2022). A variety of seaweed species, including kelp, have a long history of being used as a livestock feed, all the way back to Ancient Greece (Makkar et al, 2016). There is evidence that shows substituting a small amount of seaweed into cattle's diets can drastically reduce their methane emissions. One recent study showed that replacing just 0.5% of a steer's diet with red algae can decrease the methane they produce by up to 82% (Roque et al, 2021). This treatment was not found to have any effect on cattle growth or final beef quality or taste. With cattle and milk production being two of the largest agricultural industries in the state of Washington, limiting the adverse effects these industries have is critical to the environmental health of the area. Much research still needs to be conducted to determine all of the effects of using seaweed as a cattle feed, but this early evidence suggests that farming seaweed in the Puget Sound and feeding it to cattle in Washington can substantially decrease methane emissions from this industry without any detrimental impacts.

Seaweed is also being tested as a fertilizer by farmers. If the seaweed is not harvested from the farms, then all of the carbon it sequestered would just return to the systems it was captured from when the seaweed decomposes. To mitigate this impact, seaweed that is not used for food is being tested as a natural, renewable fertilizer. Fertilizers like this are necessary because worldwide soil is suffering from degradation due to a variety of factors, such as erosion, repeated tilling, and chemical contamination, which has left soil less productive (Baumhardt et al, 2015). In the United States soils have lost about half of the organic matter that makes them fertile, which could lead to more food insecurity (Baumhardt et al, 2015). Using seaweed as a fertilizer can return some of this carbon to the soil, boosting agricultural production while simultaneously removing the carbon from the water. This is already being tested in Washington on a small Whidbey Island farm (Washington Sea Grant, 2020). Meg Chadsley, an ocean acidification specialist with the Washington Sea Grant, is quoted saying "'It's always going to be good to get carbon out of the water and back onto land. That's where the carbon started before we began releasing it by burning fossil fuels—so, ultimately, we need to get the carbon back there.'" (Washington Sea Grant, 2020).

Although there would be many benefits to seaweed farming in the Puget Sound, there are also potential downsides to the establishment of these farms. Seaweed takes in heavy metals and toxins such as mercury, lead, and arsenic (Makkar et al, 2016), which can be beneficial for ecosystem health but prevents the seaweed from being safe for human or livestock consumption. This is generally in such low quantities that the seaweed is still safe to eat (NOAA Fisheries, 2022), but because of these concerns rigorous testing would be necessary to make sure each crop of seaweed harvested would be safe for whatever its intended use is.

For populations that use kelp forests as habitat, harvesting can be detrimental. Wild kelp harvesting has been shown to decrease fish abundance and bird foraging in Norway (Makkar et al, 2016). However, farming the kelp in a controlled environment would decrease the need for wild kelp harvesting and could actually protect those populations. If critical species using the seaweed farms as habitat would be harmed by harvesting actions, the harvests can be modified to best balance human and ecological benefits.

There are also individuals who are opposed to certain actions that have been proposed so far, and their concerns must be considered. The permitting process for two aspiring kelp farmers around Vashon Island, Washington, has generated many public comments, many in opposition to the establishment of the farms. There is concern that birds or marine mammals could become entangled in the lines used in these operations (Banse, 2022). There is no evidence yet that this is an actual phenomenon occurring in current seaweed farming operations, so further study is required to determine the risk of this occurring (Campbell et al, 2019). Until sufficient research is done, any future seaweed farms in the Puget Sound should include reasonable measures to protect wildlife from being harmed by the structures used to grow the seaweed.

The other major concern voiced by the people of Vashon Island is that placing these farms next to highly populated areas will be detrimental to the waterfront views that are important to those who live there, creating a more unnatural environment (Banse, 2022). These viewpoints are important to consider because people will often pay more for these types of properties, and actions that would take away from this value would not be fair to them. There is a debate currently happening about the actual impact that future seaweed farms will have on the appearance of the water, and if there is determined to be a significantly noticeable difference to the appearance of an area then highly populated shorelines may not be the best place for these farms. Placing the seaweed farms in areas that are sparsely populated, of which there are many around the Puget Sound, could give the same ecological benefits while addressing the concerns of residents of the area.

Overall, expanding seaweed farming in the Puget Sound would be very beneficial to the area. It could help solve some of the ecological problems the area is facing, such as ocean acidification and decreasing kelp and mollusk populations. Implementing seaweed into agricultural practices in Washington state could significantly decrease methane emissions and help fertilize degraded soils. When proper steps are taken to make sure that seaweed is farmed and used safely and responsibly, seaweed farming has the potential to be a great asset to the people and environments of the Puget Sound.

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