Seeking global sweet spots for marine farming

Kellyanne Batchelor asks: can restorative aquaculture feed a growing population and restore our marine ecosystems?

Aquaculture, defined as the cultivation of aquatic organisms under controlled conditions, is one of the most rapidly growing forms of primary food production, valued at US$243 billion globally. Along with this growth have come image problems. In 2000, the UK daily paper *The Telegraph* reported that nutrients discharged from Scotland's 350 salmon farms had ecological impacts effectively greater than the sewage produced by the country's population of 5.1 million people. Multiple news outlets have also raised concerns over capturing masses of wild fish for consumption by farmed fish.

Unlike fed aquaculture projects, such as salmon or shrimp farms, unfed systems extract resources from the environment. Evidence shows farming unfed organisms, specifically seaweed and bivalve molluscs (mussels, clams, and oysters), can have benefits for both humans and the environment (Fig. 1). This intentional cultivation to yield positive ecosystem and economic outcomes is known as 'restorative aquaculture'. Shellfish aquaculture can provide nurseries for commercially valuable species, as well as habitat for many others, whilst seaweed aquaculture can mitigate the local (kilometre-scale) effects of ocean acidification. Bivalve molluscs and seaweed species also assimilate nutrients from surrounding waters, improving water quality and lowering the risk of algal blooms and associated problems such as hypoxia. Benefits to people include increased food security and employment opportunities in coastal regions where unemployment is high (Figs. 2 & 3).

Figure 1. Chesapeake Bay floating oyster aquaculture. Image © Andy Lacatell.

farming seaweed and bivalve molluscs can have benefits for both humans and the environment

It appears that seaweed and shellfish aquaculture systems can help address a host of global environmental challenges and societal issues, but where should these systems go? Recent research published in the journal *PLoS ONE* revealed potential zones where aquaculture could benefit both people and nature. Researchers developed a novel index and conducted a global spatial analysis, which mapped oceanographic and geographic suitability and overlaid key environmental, socioeconomic, and human health factors. Their analysis ruled out highly polluted regions or those with poor wastewater treatment, or where aquaculture production may be compromised by failures to implement and enforce sound regulations and policies. Conversely, restorative aquaculture 'sweet spots' are those locations where favourable ecosystem and societal factors coincide. These are where, the authors of the research say, governments, international development organisations, and investors should push and drive changes in public policy and business planning to unlock the benefits of seaweed and shellfish aquaculture.

Regions boasting the most potential were found throughout Europe, North and South America, Asia, and Oceania. No regions scored 'full marks', demonstrating the counterbalance of opportunity and associated risks. For instance, the North Sea region had the highest opportunity for restorative aquaculture to combat issues like habitat loss and elevated trawl fishing pressure, but with a history of harmful algal blooms, high

microplastic concentrations and elevated persistent organic pollutants, it received a borderline human health score.

The authors point out that developing restorative aquaculture in these zones does not guarantee ecosystem recovery or provision of ecosystem services, as factors such as farm design and characteristics of the environment or culture species are highly influential. For example, unsustainably managed, intensive cultivation of bivalve shellfish could produce enough waste (as pseudofaecal and faecal carbon), beyond the carrying capacity of the local environment, to lead to localized benthic hypoxia.

The majority of high-potential zones were found in areas where seaweed and shellfish aquaculture are already established. Here, a proper assessment of the practices used is needed to identify modifications to improve ecological benefits. Given the scale of these systems, and with China being the world's largest producer of aquaculture shellfish, small steps towards ecosystem-orientated improvements could provide substantial benefits.

Aquaculture clearly needs to be correctly managed to reap ecosystem and societal benefits, and studies using large global datasets are key to forming guidance. Dr Seth Theuerkauf, lead author of the *PLoS ONE* study and aquaculture scientist with The Nature Conservancy said, 'This study is the first of its kind to aggregate global scale datasets, providing an objective, data-driven method for evaluating where opportunities for restorative aquaculture are greatest—indicating that there are high opportunity locations across the world. By collaborating with key partners, including shellfish and seaweed farmers, government agencies, and academic partners, we are leading further scientific research to better understand the specific conditions where aquaculture can provide the greatest benefits, including evaluation of different farming methods'.

Figure 2. Seaweed aquaculture off South Cornwall, UK. Image © Sophie Corrigan.

Figure 3. Seaweed harvest. Image © Robert Jones.

The Nature Conservancy is currently piloting projects to develop aquaculture as an alternative livelihood for fishers whilst providing environmental benefits for communities in coastal hotspots from the US to Belize and Indonesia.

Although illuminating, global studies using large data sets have their limitations. In the study highlighted here, areas scoring poorly were generally found in Southeast Asia, Africa, and the Middle East. Data for these areas, and many island nations, is notably lacking, meaning a proper assessment of the potential benefits of restorative aquaculture is currently unavailable to many low to middle-income countries. Where analyses show only moderate potential for these nations, the underlying challenges must be understood to ensure solutions are effective and sustainable in the long term. For example, the regions next to India and Bangladesh have promising prospects for habitat provision and alleviating nutrient pollution, but logistical issues and human health concerns knock down their score. This highlights the need to improve governance alongside addressing other core social challenges.

Studies like this not only highlight data gaps, illustrating the importance of data sharing, they also provide methods that can be translated to other habitat restoration projects like mangroves or coral reefs. Future studies must also be conducted at regional and local levels. This combination of information, at all scales, can guide aquaculture development and assist policy-makers to support the provision of benefits for ecology, economics and society.

Kellyanne Batchelor
(kellyannebatchelor@gmail.com)

Further reading

Theuerkauf, S.J., Morris Jr, J.A., Waters, T.J., Wickliffe, L.C., Alleway, H.K. & Jones, R.C. (2019) A global spatial analysis reveals where marine aquaculture can benefit nature and people. *PLoS ONE*, 14(10).

www.nature.org/en-us/about-us/where-we-work/united-states/massachusetts/stories-in-massachusetts/aquaculture-oyster-restoration/