

USE OF PROBIOTICS IN PACIFIC OYSTER AND MANILA CLAM AQUACULTURE



Why Use Probiotics for Shellfish Aquaculture?

Shellfish, like any farmed livestock, may harbor disease-causing pathogens that are harmful to shellfish health and, potentially, human health. Sometimes, disease-causing pathogens, like species of *Vibrio* and *Aeromonas* bacteria, directly affect health outcomes.

Water used for larval shellfish hatcheries is typically treated by filtration, UV, or ozone which have varying levels of success at consistently reducing bacteria. One concern with these treatment systems is that they may leave organic material behind in the water while also failing to kill all bacteria, leading to increased growth of potentially pathogenic bacteria on the organic material left behind. Even if the water treatment method works perfectly, unknown bacteria from brood stock and algal food can still be introduced to hatchery systems when feeding larval shellfish (Figure 1).



Figure 1. Administering probiotics will likely be different from hatchery to hatchery, but one method is to add probiotics to algal stocks like the ones pictured here. Photo: L. Kraft.

Outside of the United States, shellfish can also be treated with antibiotics in order to manage these harmful bacteria. Studies have shown that use of these antibiotics has been linked to the development of resistant bacterial strains. Bacteria have an ability to pick up small, circular pieces of DNA called plasmids and incorporate them into their genomes. Therefore, bacteria in marine systems are capable of picking up antibiotic-resistant genes through a stray plasmid, even plasmids arising from untreated human wastewater or other non-aquacultural uses. Due to this, the European Union banned antibiotics from use in shellfish aquaculture in 2003. Probiotics provide a more environmentally friendly alternative to manage disease risks to successfully rear larvae in bivalve hatcheries.

How Probiotics Work in Shellfish Aquaculture

The World Health Organization defines probiotics as “live microorganisms that when administered in adequate amounts, confer a health benefit to the host.” Probiotics have been widely studied in several shellfish and finfish systems and have been found to provide a variety of benefits. Typically, the probiotics for these studies are bacteria that have been cultured from wild, healthy shellfish.

In shrimp and other shellfish, probiotics have been shown to improve disease resistance, increase survival, speed up growth rate, and even boost digestion. In bivalve shellfish, most of the research has focused on improving disease resistance to improve survival, growth, and settlement.

When used preventatively, probiotics can reduce more than just bacterial diseases. Studies have shown that preventative probiotics reduce bacterial, parasitic, and viral infections in shellfish. Probiotics can work via several different mechanisms, including:



1. excluding pathogens through competition for nutrients,
2. producing antimicrobial substances, or
3. stimulating their innate immune system.

Probiotics may be administered by introducing multiple isolates to shellfish production at the same time, but they are often studied individually to tease out the efficacy of each individual isolate.

Purchasing and Administering Shellfish Probiotics

Most often, beneficial probiotics are either fed to shellfish as supplements to their algal feed or added to the water that they are reared in. Adding probiotics to shellfish hatcheries will be different for each system due to variability in species treated, water quality, and concentration of the probiotic needed, based on the volumes of culture water (Ralph Elston, Aquatechnics, Inc., personal communication). Sometimes the probiotic producer may suggest adding them to algal stocks (Figure 1). In rare cases, they can be used to precoat the setting surfaces for metamorphic larvae. Based on the most promising, current probiotic treatment protocol from the National Oceanic and Atmospheric Administration's (NOAA) Milford Laboratory, the freeze-dried probiotic strain is added to the culture water in hatchery tanks during the two to three week period during larval development. While growing larvae are fed the standard hatchery algal feed daily, freeze-dried probiotics are added at the appropriate concentration (based on tank size) to 48-hour-old larvae every other day after water changes. Aerators in the tanks should sufficiently mix probiotics into the seawater. Probiotics continue to be added until larval settlement occurs (about two to three weeks).

As of early 2024, only one company in the Pacific Northwest has probiotic lines for sale commercially: [Aquatechnics](#), located in Sequim, Washington. Despite a current lack of commercial probiotic strains on the market, several labs are in the shellfish probiotics research or development stage, including Chris Langdon's, PhD, at Oregon State University, Tim Green's, PhD, at Vancouver Island University, and the NOAA's Milford Lab.

Recent Discoveries in Shellfish Probiotics

Researchers in Chris Langdon's lab at Oregon State University recently published results showing that when a single application of a cocktail of three beneficial probiotic bacterial isolates is added to Pacific oyster or Kumamoto oyster larval cultures, the larvae show increased resistance to pathogenic *Vibrio* infections and higher survival through metamorphosis. The NOAA Milford Lab's most promising probiotic line similarly reduces oyster larvae mortality due to *Vibrio* infection in both laboratory pilot-scale studies, where oyster larvae were reared in 12-liter buckets, and commercial hatchery-scale production trials.

Probiotics may also mitigate heat stress and show potential to help with summer mortality events. Recent research from Tim Green's lab at Vancouver Island University has shown that their probiotic strain, when introduced at the hatchery phase, can help protect oyster spat from a controlled laboratory challenge that simulates a marine heatwave and *Vibrio* infection.

Research on probiotic use in bivalve shellfish is relatively new. Much of the research so far has focused on testing the beneficial bacterial isolates against pathogenic bacteria in small-scale cultures instead of focusing on realistic, hatchery-like, large production tanks. This allows researchers to test new bacterial isolates for potential benefits much faster than if they were tested in larger, more complex systems, but it does mean that further testing is needed before beneficial bacterial lines may be ready for use. Furthermore, much of the research conducted so far has looked at shrimp and finfish production, so more research is needed on the economically important shellfish species in Washington, like the Pacific oyster.

Probiotics may provide additional ways to improve larval and adult shellfish health but will not be a silver bullet solution. As with any management guidelines, probiotics are intended to be added to enhance animal health in hatcheries; however, it will still be necessary to apply good husbandry practices.

Further Reading

Akhter, N., B. Wu, A.M. Memon, and M. Mohsin. 2015. Probiotics and Prebiotics Associated with Aquaculture: A Review. *Fish & Shellfish Immunology* 45(2): 733–741. <https://doi.org/10.1016/j.fsi.2015.05.038>.

De, B.C., D.K. Meena, B.K. Behera, P. Das, P.K. Das Mohapatra, and A.P. Sharma. 2014. Probiotics in Fish and Shellfish Culture: Immunomodulatory and Ecophysiological Responses. *Fish Physiology and Biochemistry* 40: 921–971. <https://doi.org/10.1007/s10695-013-9897-0>.

Food and Agriculture Organization/World Health Organization (FAO/WHO). 2001. Evaluation of Health and Nutritional Properties of Powder Milk and Live Lactic Acid Bacteria. *Food and Agriculture Organization of the United Nations and World Health Organization Expert Consultation Report* 1–34.

Kapareiko, D., H.J. Lim, E.J. Schott, A. Hanif, and G.H. Wikfors. 2011. Isolation and Evaluation of New Probiotic Bacteria for Use in Shellfish Hatcheries: II. Effects of a *Vibrio* sp. Probiotic Candidate upon Survival of Oyster Larvae (*Crassostrea virginica*) in Pilot-Scale Trials. *Journal of Shellfish Research* 30(3): 617–625. <https://doi.org/10.2983/035.030.0304>.

Lim, H.J., D. Kapareiko, E.J. Schott, A. Hanif, and G.H. Wikfors. 2011. Isolation and Evaluation of New Probiotic Bacteria for Use in Shellfish Hatcheries: I. Isolation and Screening for Bioactivity. *Journal of Shellfish Research* 30(3): 609–615. <https://doi.org/10.2983/035.030.0303>.

Maas, E.W., R.M. Latter, J. Thiele, A.M. Waite, and H.J. Brooks. 2007. Effect of Multiple Antibiotic Treatments on a Paralytic Shellfish Toxin-Producing Culture of the Dinoflagellate *Alexandrium minutum*. *Aquatic Microbial Ecology* 48(3): 255–260. <https://doi.org/10.3354/ame048255>.

Madison, D., C. Schubiger, S. Lunda, R.S. Mueller, and C. Langdon. 2022. A Marine Probiotic Treatment against the Bacterial Pathogen *Vibrio coralliilyticus* to Improve the Performance of Pacific (*Crassostrea gigas*) and Kumamoto (*C. sikamea*) Oyster Larvae. *Aquaculture* 560: 738611. <https://doi.org/10.1016/j.aquaculture.2022.738611>.

Prado, S., J.L. Romalde, and J.L. Barja. 2010. Review of Probiotics for Use in Bivalve Hatcheries. *Veterinary Microbiology* 145(3–4): 187–197. <https://doi.org/10.1016/j.vetmic.2010.08.021>.

Ringø, E. 2020. Probiotics in Shellfish Aquaculture. *Aquaculture and Fisheries* 5(1): 1–27. <https://doi.org/10.1016/j.aaf.2019.12.001>.

Sohn, S., K.M. Lundgren, K. Tammi, R. Smolowitz, D.R. Nelson, D.C. Rowley, and M. Gómez-Chiarri. 2016. Efficacy of Probiotics in Preventing Vibriosis in the Larviculture of Different Species of Bivalve Shellfish. *Journal of Shellfish Research* 35(2): 319–328. <https://doi.org/10.2983/035.035.0206>.

Soltani, M., K. Ghosh, S.H. Hoseinifar, V. Kumar, A.J. Lymbery, S. Roy, and E. Ringø. 2019. Genus *Bacillus*, Promising Probiotics in Aquaculture: Aquatic Animal Origin, Bio-active Components, Bioremediation and Efficacy in Fish and Shellfish. *Reviews in Fisheries Science & Aquaculture* 27(3): 331–379. <https://doi.org/10.1080/23308249.2019.1597010>.

Van Doan, H., M. Soltani, and E. Ringø. 2021. *In Vitro* Antagonistic Effect and *In Vivo* Protective Efficacy of Gram-Positive Probiotics versus Gram-Negative Bacterial Pathogens in Finfish and Shellfish. *Aquaculture* 540: 736581. <https://doi.org/10.1016/j.aquaculture.2021.736581>.

References

Elston, R. n.d. Aquatechnics, Inc.

By
Laura J. Kraft, Cranberry and Shellfish Extension Specialist, College of Agricultural, Human, and Natural Resource Sciences, Washington State University
Christopher Langdon, Professor of Fisheries, Coastal Oregon Marine Experiment Station, Hatfield Marine Science Center, Oregon State University
Timothy J. Greene, Canada Research Chair in Shellfish Health and Genomics, Vancouver Island University



WASHINGTON STATE UNIVERSITY
EXTENSION

Copyright © Washington State University

WSU Extension publications contain material written and produced for public distribution. Alternate formats of our educational materials are available upon request for persons with disabilities. Please contact Washington State University Extension for more information.

Issued by Washington State University Extension and the US Department of Agriculture in furtherance of the Acts of May 8 and June 30, 1914. Extension programs and policies are consistent with federal and state laws and regulations on nondiscrimination regarding race, sex, religion, age, color, creed, and national or ethnic origin; physical, mental, or sensory disability; marital status or sexual orientation; and status as a Vietnam-era or disabled veteran. Evidence of noncompliance may be reported through your local WSU Extension office. Trade names have been used to simplify information; no endorsement is intended. Published May 2024.