Rebutting Marine Aquaculture Myths and Unfounded Criticisms

National Aquaculture Association[1]

A variety of tenacious myths have persisted for decades[2] to be presented as facts to the public and Congress.[3] The U.S. fish and shellfish farmer cultures aquatic animals within a very complicated legal, husbandry and science-driven environment. We believe that critics are unfamiliar with this environment. Our responses to these pernicious myths does not lend itself to short, simple answers; although, we have worked to be as succinct as possible.

Myth: American commercial fishing and marine finfish aquaculture cannot coexist

The claim that commercial fishing and marine aquaculture cannot coexist has been made for the last 39 years and has been proven false for 23 coastal states where the production of Atlantic salmon, oysters, clams and mussels has grown, prospered and in many instances was led by commercial fishermen. Globally, commercial fishing has continued in concert with the growth in marine aquaculture production, and in the few instances where marine sea cages have been constructed and operated in the United States, i.e., Hawaii, Maine and Puerto Rico, those farms were welcomed by commercial and recreational fishermen.

The United States appears to be the only coastal nation not to have recognized and acted upon a global imperative to increase sustainable protein production with wild-caught and farm-raised seafood being a major component.[4] Food and Agriculture of the United Nations reported in *2018 State of World Fisheries and Aquaculture: Meeting the Sustainable Development Goals:*[5]

> "Total fish production in 2016 reached an all-time high of 171 million tonnes, of which 88 percent was utilized for direct human consumption, thanks to relatively stable capture fisheries production, reduced wastage and continued aquaculture growth. This production resulted in a record-high per capita consumption of 20.3 kg in 2016. Since 1961 the annual global growth in fish consumption has been twice as high as population growth, demonstrating that the fisheries [wild-caught and farm-raised] sector is crucial in meeting FAO's goal of a world without hunger and malnutrition (page vii)."

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[1] The National Aquaculture Association represents farmers across the United States that raise aquatic animals and plants destined for food, bait, ornamental, recreational fishing markets and as fertile eggs, larvae, fingerlings or shellfish seed to stock farms for grow-out. We are a U.S. producer-driven, non-profit association incorporated in 1991 that for 27 years has worked ensure the aquaculture industry's sustainability, profitability and development occurs in an environmentally sustainable manner. For more information, visit http://thenaa.net/.

[2] Goldberg, R. and T. Triplett. 1997. Murky Waters: Environmental Effects of Aquaculture in the United States. Environmental Defense Fund, Washington, DC.

[3] Mail Buoy. 2019. Finfish aquaculture has no place in U.S. waters. National Fisherman. (https://www.nationalfisherman.com/viewpoints/national-international/finfish-aquaculture-has-no-place-in-u-s-waters/ accessed April 8, 2019).

[4] Béné, C., M. Barange, R. Subasinghe, R. Pinstrup-Andersen, G. Merino, G. Hemre and M. Williams. 2015. Feeding 9 billion by 2050 – Putting fish back on the menu. Food Security 7(2): 261-274.

Helvey, M., C. Pomeroy, N.C. Pradham, D. Squires and S. Stohs. 2017. Can the United States have its fish and eat it too? Marine Policy 75:62-67.

[5] UN-FAO. 2018. State of World Fisheries and Aquaculture: Meeting the Sustainable Development Goals. Rome. Licence: CC BY-NC-SA 3.0 IGO (http://www.fao.org/fishery/sofia/en accessed January 28, 2019).

> "In 2016, 37 countries were producing more farmed than wild-caught fish. These countries are in all regions except Oceania, and collectively they account for close to half of the world's human population. Aquaculture accounted for less than half but over 30 percent of national total fish production in another 22 countries in 2016 (page 18)."

And

> "With most fishery stocks expected to remain maximally sustainably fished or overfished for at least the next decade, aquaculture must bridge the growing gap between supplies of aquatic food and demand from a growing and wealthier global population (page 144)."

Domestic wild capture fisheries cannot expand to meet the ever-increasing demand for seafood, given harvest restrictions that are designed to ensure sustainable wild fish populations. Without an increase in domestic aquaculture, this country will continue to rely heavily on foreign supplies, resulting in serious food security, food safety and environmental concerns, as well as the perpetuation of significant trade imbalances. Enforcement programs will have to be expanded and funded to weed out adulterated, illegal, unreported and unregulated products. The environmental and social impacts of aquaculture in other countries with few environmental and labor regulations will continue to be driven by demand in the U.S. market.

As farmers that produce a perishable product competing with the rest of the world for a small sliver of the U.S. seafood market, we believe our focus and the focus of U.S. fishermen should be on becoming the best and most efficient farmers and fishermen that we can be. Complaining that we cannot co-exist does not serve a shared goal of providing domestically produced product for the growing U.S. and global markets. By focusing on our collective ability to compete in world markets we will help preserve working waterfronts and ensure that coastal communities will remain resilient. Our competition is not each other, but low-cost foreign producers who do not have to comply with strict regulations.

Myth: Oceanic marine net pens or sea cages are factory farms that in US waters would contribute marine pollution caused by excess feed, untreated fish waste, antibiotics, and antifoulants.

Excess feed, untreated fish waste and nutrients

The claim that offshore marine aquaculture causes well-documented environmental harm is unfounded. A recent peer-reviewed paper analyzed nutrient contributions to the ocean by an offshore fish farm composed of 16 to 22 sea cages with a standing crop that ranged from 1.3 million to 3 million pounds of fish.[6] The authors reported,

> "While continued monitoring will be necessary to evaluate the long-term effects on the benthic and water column ecosystems, the data reported here indicate that the net effect

[6] Welch, A.W., A.N. Knapp, S.E. Tourky, Z. Daughtery, G. Hitchcock and D. Benetti. 2019. The nutrient footprint of a submerged-cage offshore aquaculture facility located in the tropical Caribbean. Journal of the World Aquaculture Society. (https://onlinelibrary.wiley.com/doi/epdf/10.1111/jwas.12593 accessed April 8, 2019).

> of the nutrients emitted by the aquaculture facility in coastal Panama has been minimal over the duration of the time that monitoring has occurred (page 12)."

Considering offshore marine fish production in the context of oceanic ecology, the authors commented (internal citations omitted):

> "…nutrients of the sort discharged by aquaculture facilities are not, ipso facto, pollution. N [nitrogen] and P [phosphorus] lie at the base of the ocean's food web and drive the primary production that, in turn, drives global fisheries production. A growing body of literature supports the notion that large-scale nutrient inputs from aquaculture facilities can have positive effects on fisheries over large (regional) spatial scales. These studies correlate the installation of large-scale aquaculture facilities with increases in fish stock biomass, as well as the mean trophic level and aggregate amount of wild fishery landings in a region. These studies suggest that nutrients flow quickly through phytoplankton at the base of the trophic pyramid and up to higher-order consumers (page 15)."

A peer-reviewed analysis reported that a global literature search found "A total of 70 publications, spanning 1999 to 2016 used the term "offshore aquaculture" and were biologically focused (page 4)."[7] Notably, these studies concerned farms located in the USA, Spain or Germany and for those studies they summarized:

> "…studies that focused on potential ecological impacts of offshore farms, although few (n = 17), tended to report no significant effect. Modeling the probability of a measurable impact based on these studies revealed a 'farm ecotone' of ~90 m[eters]; beyond this distance, evidence of an environmental impact being extremely unlikely (page 7)."

Farms must conform to federal regulations to efficiently feed optimal feed formulations, reduce feed loss, maintain feeding equipment, train employees in efficient feeding practices, and record feed efficiency (conversion of feed to the amount of fish produced).[8] In the U.S. farms must comply with strict discharge standards and are closely monitored against a set of environmental impact metrics. If they exceed those discharge standards or impact metrics their NPDES permits can be rescinded. Without a valid NPDES permit they must cease operations.

Antibiotics

The United States severely restricts the availability and use of aquatic animal medicines via the Food, Drug and Cosmetic Act. Other chemicals (e.g., disinfectants, detergents or other cleaning agents) that may be used by aquaculture facilities are regulated by the U.S. Environmental Protection Agency (EPA). The U.S. Food and Drug Administration reviews and approves aquatic animal medicines utilizing the same regulatory paradigm as that for human medicine (e.g., effectiveness to mitigate disease, effects to the animal, effects to the environment directly

[7] Froelich, H.E., A. Smith, R.R. Gentry and B.S. Halpern. 2017. Offshore aquaculture: I know it when I see it. Frontiers in Marine Science. 4(154):1-9.

[8] EPA. 2006. Compliance Guide for the Concentrated Aquatic Animal Production Point Source Category. Washington, DC. (https://www.epa.gov/sites/production/files/2015-11/documents/caap-aquaculture_compliance-guide_2006.pdf accessed March 1, 2019).

or indirectly, risk to human health).[9] There are no antibiotics approved for use on marine fish such as cobia, snapper, flounder, halibut, cod or any of the other candidate fish for offshore marine aquaculture.[10] Antibiotics can only be used in conformance to label instructions or as prescribed by a veterinarian. Federal regulations require that farms report medication use prior to administering a medication and following treatment.[11] A farm must describe potential chemical use in their EPA permit application and conform to permit conditions if use is allowed.[12] In most cases those permit conditions require environmental monitoring to detect any possible antibiotic residues. If residues are detected farms are required to change their operations to reduce any risk of environmental impacts.

Antifoulants

Offshore marine fish farms must comply with federal regulations applicable for all marine use of antifoulants as does every commercial or recreational watercraft owner, navigation buoy manufacturer or public or private entities that maintain buoys and markers, and similarly for antifoulants applied to marine structures. In the case of commercial net pen farms most farms have eliminated the use of antifoulants on nets and are using mechanical robotic net cleaners.

The use and application of antifoulants in the marine environment is regulated by EPA under authority granted the Clean Water Act and Federal Insecticide, Fungicide, and Rodenticide Act. Antifouling coatings registrants must obtain approval from the U.S. EPA's Office of Pesticide Programs, which oversees periodic pesticide registrations and reviews, and regulates pesticide use to prevent significant adverse effects on non-target organisms. Containers of antifoulants include EPA approved label instructions regulating storage, handling, application, and disposal. The EPA's Office of Water is responsible for implementing the Clean Water Act, and similar statutes designed to maintain aquatic ecosystems to protect human health; support economic and recreational activities; and provide healthy habitat for fish, plants, and wildlife.

Myth: Fish Meal and Fish Oil in Fish Feeds is Unsustainable

Within the United States considerable public and private research investment has been made with the goal of reducing the amounts of either ingredient in diets that will yield excellent animal health, growth and final products with desirable human nutritional benefits. The National Oceanic and Atmospheric Administration and U.S. Department of Agriculture[13] support a research initiative to:

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[9] Please visit https://www.fda.gov/animalveterinary/developmentapprovalprocess/newanimaldrugapplications/default.htm for more information.

[10] Quick Reference Guide to Approved Drugs for Use in Aquaculture (Second Edition) (https://www.fws.gov/fisheries/aadap/PDF/2nd-Edition-FINAL.pdf accessed January 29, 2019).

[11] EPA. 2006. Compliance Guide for the Concentrated Aquatic Animal Production Point Source Category. Washington, DC. (https://www.epa.gov/sites/production/files/2015-11/documents/caap-aquaculture_compliance-guide_2006.pdf accessed March 1, 2019).

[12] Ibid.

[13] Rust, M.B., F.T. Barrows, R.W. Hardy, A. Lazur, K. Naughten and J. Silverstein. 2011. The Future of Aquafeeds. NOAA/USDA Alternative Feeds Initiative. NOAA Technical Memorandum NMFS F/SPO-124 (https://www.westcoast.fisheries.noaa.gov/publications/aquaculture/alternativefeeds_aquafeeds_final.pdf accessed April 23, 2019).

> "…identify and prioritize research to develop feeds that will allow the aquaculture industry to increase production in a sustainable way that does not put additional pressure on limited wild fisheries, that maintains the human health benefits of seafood, and that minimizes negative environmental effects of the use of alternatives (page 1)."

An example of the progress made in fish feed through private investment is the recent announcement by the Illinois Soybean Association describing the successful incorporation of a plant-based ingredients in a tuna feed. Please see https://www.ilsoy.org/article/pioneering-soy-based-tuna-feed.

Turchini et al.[14] authored an in-depth review paper examining the progress to replace fish meal and fish oil in compounded feeds, aquatic animal nutrition, feed manufacture, nutrient complementarity and functionality, and related advances in research and application. The authors report:

> "…fish nutritionists have endeavored to develop aquaculture feed (aquafeed) formulations that support or enhance growth of cultured fish while controlling costs. Much of this effort has been focused on reducing reliance on limited marine resources. Whereas cultivation of herbivorous and omnivorous species has readily transitioned to feeds containing little to no fish meal (FM) or fish oil (FO), such formulations have been more difficult to implement in the feeding of carnivorous fish and crustaceans. Despite the various challenges, these efforts have been successful in a broad sense. Fish meal and FO inclusion rates have dropped steadily over the past 20 years, and feed prices—while increasing—are not as volatile or as high as they would be if the old formulations were sold today (page 13)."

They also note that:

> "…one could argue that this approach [testing alternatives to fish meal and/or fish oil] has reached (or will soon reach) the point of diminishing returns. Most raw materials that could feasibly serve as protein or lipid sources in aquafeeds have now been tested in at least one if not more cultured aquatic species. The search for alternatives yielded substantial insight when so many raw materials had yet to be evaluated in aquafeeds. As the number of truly novel resources dwindles, testing of raw materials as direct substitutes for FM/FO is less likely to yield advances beyond marginal, incremental progress (page 16)."

The goal of their paper is to convincingly argue that a change in direction is needed. Feed research should refocus for a "…greater emphasis on nutrients, including those not considered strictly nutritionally essential … to encourage further evolution of the industry and to efficiently move aquaculture nutrition beyond the incremental advances achieved in recent years (page 33)."

[14] Turchini, G.M., J.T. Trushenski and B.D. Glencross. 2019. Thoughts for the future of aquaculture nutrition: Realigning perspectives to reflect contemporary issues related to judicious use of marine resources in aquafeeds. North American Journal of Aquaculture. 81: 13-39.

The U.S. aquaculture community utilizes feed formulations that strive to achieve appropriate nutrition rather than focusing on fish meal or fish oil as an indicator for sustainability. Farms should be recognized for utilizing compounded feeds appropriate for their aquatic animal and production system.

Myth: Escaped farm-raised fish adversely impact wild fish stocks

Farming fish in state waters, less than three miles from the coast and within coastal inlets and bays, is practiced to a limited extent in Maine and Washington. A 2014 analysis led by NOAA scientists reported for farms growing Atlantic salmon in nearshore waters:

> "[U.S.] Marine fish farms are required to comply with regulations similar to those of other food-producing and marine industries. Existing U.S. regulations address the environmental effects of net-pen aquaculture effectively. Technological progress, better monitoring, and adaptive oversight of the U.S. net-pen aquaculture industry have resulted in sustainable, affordable, and domestically produced seafood (page 520)." [15]

An in-depth analysis concerning the risk of farming Atlantic salmon in Puget Sound, far from their natural range and in proximity to several Pacific salmon species, was completed by NOAA in 2002.[16] The authors reported:

> "…the risks associated with escaped Atlantic salmon are low, in particular:
- The expectation that Atlantic salmon will increase current disease incidence in wild and hatchery salmon is low.
- The risk that escaped Atlantic salmon will compete with wild salmon for food or habitat is low, considering their well-known inability to succeed away from their historic range.
- The risk that salmon farms will adversely impact Essential Fish Habitat is low, especially when compared to other commonly accepted activities that also occur in nearshore marine environments.

> …there appears to be little risk associated with escaped Atlantic salmon, in particular:
- There is little risk that escaped Atlantic salmon will hybridize with Pacific salmon.
- There is little risk that Atlantic salmon will colonize habitats in the Puget Sound chinook salmon and Hood Canal summer-run chum salmon ESUs [evolutionary significant unit].
- There is little risk that escaped Atlantic salmon will prey on Pacific salmon.
- There is little risk that existing stocks of Atlantic salmon will be a vector for the introduction of an exotic pathogen into Washington State.
- There is little risk that the development of antibiotic-resistant bacteria in net-pen salmon farms or Atlantic salmon freshwater hatcheries will impact native salmonids, as similar

[15] Rust, M.B., K.H. Amos, A.L. Bagwill, W.W. Dickhoff, L.M. Juarez, C.S. Price, J.A. Morris Jr. and M.C. Rubino. 2014. Environmental performance of marine net-pen aquaculture in the United States. Fisheries 39(11): 508-524.

[16] Waknitz, F.W., T.J. Tynan, C.E. Nash, R.N. Iwamoto, and L.G. Rutter. 2002. Review of potential impacts of Atlantic salmon culture on Puget Sound chinook salmon and Hood Canal summer-run chum salmon evolutionarily significant units. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-53. (https://www.nwfsc.noaa.gov/publications/scipubs/techmemos/tm53/tm53.pdf accessed March 1, 2019).

antibiotic resistance often observed in Pacific salmon hatcheries has not been shown to have a negative impact on wild salmon.

A recent and highly publicized net pen collapse and escape of farm-raised Atlantic salmon in Puget Sound resulted in state legislation phasing out nonnative fish culture when existing permits expire. An initial analysis by the Washington Department of Natural Resources concluded:[17]

> "What were the implications for the Puget Sound ecosystem from the Cypress Island Atlantic salmon net pen failure?
>
> 1. To date, there is no evidence that the escaped Atlantic salmon were eating native fauna nor is there evidence that they were sexually mature.
>
> 2. Over time, the fish in the marine system contracted native pathogens and have shown decreasing health status.
>
> 3. Atlantic salmon have been found in a limited number of rivers in Puget Sound (Skykomish and Skagit rivers). Atlantic salmon have not been seen at any DFW [Department of Fish and Wildlife] hatchery despite monitoring. There is no indication that Atlantic salmon have been caught in Nooksack drainage or at Whatcom Creek Hatchery drainage. DFW was present at the chum spawns in late fall at Bellingham Technical College and did not see any Atlantic salmon in Whatcom Creek.
>
> 4. The limited numbers of Atlantic salmon found in the freshwater system appear healthy. There is no evidence that they were feeding in the freshwater system nor were they sexually mature. The Atlantic salmon in freshwater may survive for some time.
>
> Monitoring through the winter and the subsequent fall will be critical to know if the Atlantics remain in the freshwater systems and if they are reproducing (page 113)."

Public concern following the escape focused on the presence of piscine orthoreovirus (PRV) in escaped Atlantic salmon that were tested for pathogens. Subsequent analysis revealed:

> "The ubiquitous nature of piscine orthoreovirus (PRV), its apparent historic presence in wild Pacific salmonid stocks in the Pacific Northwest and the lack of clear association with disease in Pacific salmonids suggest the virus poses a low risk to wild species of Pacific salmonids."[18]

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[17] Clark, D., K. Lee, K. Murphy and A. Windrope. 2018. 2017 Cypress Island Atlantic Salmon Net Pen Failure: An Investigation and Review. Washington Department of Natural Resources, Olympia, WA. (https://www.dnr.wa.gov/sites/default/files/publications/aqr_cypress_investigation_report.pdf?vdqi7rk&6zpmtj5 accessed March 1, 2019).

[18] Pacific Northwest Fish Health Protection Committee and Myers. 2017. Piscine orthoreovirus (PRV) in the Pacific Northwest appears to be of low risk to wild Pacific salmonids. Informational Report No. 10 (https://www.dnr.wa.gov/sites/default/files/publications/PRV%20whitepaper%20revised%20Sept%202017.pdf?3c0h5&g0ewylow29 accessed March 1, 2019).

And state agency analysis of public comments further rebutted concerns that a unique pathogen or disease had been introduced.[19]

Maine net pen farms culture Atlantic salmon in proximity to Gulf of Maine Atlantic salmon population that is listed as endangered under the authority granted by the Endangered Species Act. Through a collaborative effort by the farming and environmental community a salmon containment policy was created in 2002.[20] Containment management is based upon a hazard analysis critical control point program and has resulted in no escapes since 2003.[21]

Myth: Federal regulations, permitting and environmental review processes are inadequate to manage offshore fish farms.

In the United States, since the 1970s, the U.S. Environmental Protection Agency (EPA) has held authority to regulate discharges from fish farms (e.g., nutrients, chemicals and solid waste) under several iterations of the Clean Water Act. More recently, environmental groups sought EPA re-evaluation of the Clean Water Act standards applied to aquaculture.

During a four-year period, between 2000 and 2004, the agency completed a detailed technical review of its then-current standards and modern aquaculture methods, including those used for marine aquaculture. Formal rulemaking was conducted to ensure that Clean Water Act regulations for aquaculture met all standards of environmental protection mandated by Congress. In that process, the EPA determined, contrary to the position of environmental groups, that the proposed and adopted revised regulations assured environmental protection.

Other current federal regulatory authorities, unilaterally or in partnership with the states, provide enforceable standards to protect navigation and navigational aids, water and benthic quality, food safety, drug and chemical use, aquatic animal health, endangered species, wild fishery stocks (with respect to potential aquaculture impacts to those populations), marine mammals, migratory birds and essential fish habitat. The existing and newly proposed aquaculture permitting procedures also provide an opportunity for coastal states to comment on proposed federal permits and leases associated with offshore marine aquaculture. Existing laws applicable to aquaculture operations include, but are not limited to, the Animal Health Protection Act; Animal Medicinal Use Drug Clarification Act; Coastal Zone Management Act; Endangered Species Act; Federal Food Drug and Cosmetic Act; Federal Insecticide, Fungicide, and Rodenticide Act; Federal Water Pollution Control Act (Clean Water Act); Lacey Act; Magnuson-Stevens Fishery Conservation and Management Act; Marine Mammal Protection Act; Migratory Bird Protection

[19] Washington Department of Fish and Wildlife. 2018. WDFW review of Wild Fish Conservancy's Feb. 15 news release on presence of virus in escaped Atlantic salmon. (https://www.documentcloud.org/documents/4381114-WDFW-Response-to-Wild-Fish-Conservancy-Release.html accessed March 1, 2019).

[20] Whoriskey and Goode. 2003. Finding resolution to farmed salmon issues in eastern North America. Atlantic Salmon Federation. (http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.180.6133&rep=rep1&type=pdf accessed March 1, 2019).

[21] Please visit: https://www.maine.gov/dmr/aquaculture/reports/documents/ReportedEscapesofFarmedAtlanticSalmoninMaine.pdf.

Act; National Environmental Policy Act; Outer Continental Shelf Lands Act; and Rivers and Harbors Act.

Through rulemaking, judicial rulings and an opportunity to comment on significant federal permitting by other federal agencies, the U.S. Environmental Protection Agency, National Oceanic and Atmospheric Administration, U.S. Department of Agriculture, U.S. Army Corps of Engineers, U.S. Coast Guard, U. S. Department of Defense, Federal Aviation Administration, U.S. Fish and Wildlife Service, Bureau of Ocean and Energy Management, and state agencies (agriculture, natural resources, and environmental protection) have an important regulatory role relative to offshore aquaculture and, in particular, the coastal states are provided an opportunity to comment on proposed federal permits and leases associated with offshore marine aquaculture.

Current regulatory authority exists to appropriately protect marine water quality and benthic environmental systems, manage fish escapes, protect wild fish stocks, marine mammals and migratory birds, protect essential habitat, require responsible drug and chemical use, ensure safe navigation, and assure consumers that they will have access to safe foods. Indeed, it has been argued, and we agree, that:

a. The regulatory environment in the United States has become increasingly stringent in recent years in terms of both the number and complexity of regulations that affect U.S. aquaculture.[22]

b. Especially difficult is the lack of a lead agency at both federal and state levels to effectively coordinate and streamline regulatory and permitting processes that result in timely decisions and more certainty for investment in new enterprises and expansion of existing operations. The overall cumulative effect has been continued increases in the regulatory costs and risk faced by aquaculture growers in the United States[23] .

Myth: Farm-raised fish will displace US fisheries and are cheap and of low-quality

Fundamentally for U.S. farmers it is very difficult to produce "cheap" fish in the United States because of the plethora of federal and state natural resource and environmental regulations focused on aquatic animal culture, possession, sale and health, water use and quality, land use and access to markets and local, state and national labor, safety, and business regulations and permits.

As examples of U.S. prices for farm-raised catfish and tilapia versus imported products. The 2018 average pond bank price for U.S. grown live catfish was $0.949 per pound, the average price for fresh fillet was $4.54, the average price for frozen fillet was $4.04 per pound. In

[22] Engle, C.R. and N. M. Stone. 2013. Competitiveness of U.S. aquaculture within the current U.S. regulatory framework. Aquaculture Economics and Management 17(3): 251-280.

[23] Ibid.

contrast, the average 2018 price for imported catfish frozen fillet from China was $2.54 per pound and frozen fillet from Vietnam was $1.64 per pound.

Most U.S. tilapia producers sell whole, live fish to regional markets where price can be quite variable. During 2018, the national farm gate price ranged from $1.50 to $3.50 per pound depending upon region. Using a 33% yield to fillet, the meat value (not including transportation and processing) would have been $4.50 to $10.50 per pound. In contrast, the average 2018 price for imported fresh fillet tilapia was $3.05 per pound and frozen fillet tilapia $1.68 per pound.

Competition with US Wild-Caught Fisheries

The National Oceanic and Atmospheric Administration (NOAA) produced a thoughtful and constructive economic analysis.[24] The editor wrote a summary within Chapter One commenting upon potential competition between farmed and wild-caught seafood (internal citations omitted):

> "The effect of increased U.S. aquaculture on U.S. wild caught fisheries will depend in part on whether new markets are created for increased U.S. aquaculture production, how fast and at what volumes new production comes to the market, whether new U.S. aquaculture production is a substitute for existing wild catch or imports, and whether U.S. fishermen participate in aquaculture production.
>
> At the NOAA National Marine Aquaculture Summit in June 2007, and in other venues from the Gulf of Mexico to the Pacific Northwest, some commercial fishermen and others have expressed concern that aquaculture will hurt wild harvest in the United States. It is clear that aquaculture products, whether imported or domestic, compete with wild caught fisheries. They also compete with chicken, beef, and pork. Studies have also shown that global aquaculture production, notably of salmon and shrimp, contributed to reduced market prices for U.S. wild caught and farmed U.S. shrimp and for U.S. salmon caught from both wild and hatchery raised and released stocks.
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> What is also clear – and often missing from the discussion of competition – is that competition will exist with or without domestic aquaculture. The marketplace is global and demand for seafood products is growing. The United States cannot meet consumer seafood demand through wild caught fishing activities alone. Seafood imports and other forms of protein, such as beef and chicken, already provide significant competition. Seafood business executives speaking at the National Marine Aquaculture Summit said that if seafood is not available from U.S. sources, their customers are demanding that they get it somewhere else. The challenge therefore is to integrate aquaculture into domestic seafood production so that U.S. boat owners, fishermen, processors, and marketing companies can benefit directly (page 8)."

Competition with Global Farmed Production

Knapp (2008) utilized the history of Alaskan salmon to support a step-wise progression of events when farm-raised seafood enters a market. He hypothesized:

[24] Rubino, M. (ed). 2008. Offshore Aquaculture in the United States: Economic Considerations, Implications & Opportunities. U.S. Department of Commerce; Silver Spring, MD; USA. NOAA Technical Memorandum NMFS F/SPO-103. (https://spo.nmfs.noaa.gov/sites/default/files/tm103.pdf accessed March 1, 2019).

> "In the short run, aquaculture tends to lower fish prices by increasing the supply of fish, harming fishermen but benefiting consumers." However, "over the longer run, aquaculture tends to increase the demand for fish as consumers become more familiar with fish; as fish become available in more locations, at more times, and in more product forms; and as fish farmers engage in systematic marketing to expand demand. Increasing demand tends to offset the effects of higher supply, resulting in less of a decline in fish prices (page 182)."[25]

Knapp then reported these "short run" events: a decline in wild-caught Alaskan salmon prices during the late 1980s followed farm-raised Atlantic salmon entry to the global market and other factors (i.e., large wild salmon harvests, a recession in Japan, and declining consumer demand for canned salmon). The dramatic growth in salmon supply during the 1990s corresponded with growth in U.S. salmon consumption by an enthusiastic public that found high-quality, fresh salmon everywhere in the marketplace (retail and foodservice) at attractive prices. However, the "longer run" outcomes beginning in the early 2000s were: prices increased for wild-caught and farm-raised salmon as farm-raised production increased. And, under the pressure of this competition, certain wild-caught salmon captured prices typical of the 1980s through aggressive marketing and improved product handling.

These outcomes are somewhat unbelievable against a backdrop of unrelenting innovation by the Atlantic salmon farming community and rapid expansion wherever sea conditions could support fish production. Kumar and Engle (2016) reported (internal citations removed):

> The Atlantic salmon industry overcame several biological, ecological, and disease constraints throughout its history. Advanced automated feed monitoring systems provided greater resource and environmental management efficiency. Commercialization of genetic and vaccination programs improved growth and survival while nutritional developments reduced the use of fishmeal and oil while improving performance. Such continued technological advances resulted in continuous growth in Atlantic salmon production with significant reductions in cost of production. The Atlantic salmon industry is one of the leaders in terms of biological knowledge and production technology, raising a very resource-efficient species that is often termed "the super-chicken of the sea (page 145)."[26]

[25] Knapp. G. 2008. Potential Economic Impacts of U.S. Offshore Aquaculture *in* Rubino, M. (ed). 2008. Offshore Aquaculture in the United States: Economic Considerations, Implications & Opportunities. U.S. Department of Commerce; Silver Spring, MD; USA. NOAA Technical Memorandum NMFS F/SPO-103.

[26] Kumar, G. and C.R. Engle. 2016. Technological Advances that Led to Growth of Shrimp, Salmon, and Tilapia Farming, Reviews in Fisheries Science & Aquaculture, 24(2):136-152.

Cost Competitiveness

Within the NOAA analysis, specific attention was focused on the basic economics of offshore aquaculture and discuss major factors which might affect the costs, prices, profitability, and competitiveness.[27] In summarizing an in-depth analysis, the author noted:

> "In competing with wild fisheries, in general, it will be difficult for U.S. offshore aquaculture to compete with those for which supply is year-round, reliable, and abundant. However, where wild fisheries are unable to meet market demand for a species at particular times, in particular locations, or for particular product characteristics, competitive opportunities will be created for aquaculture, including offshore aquaculture.
>
> At its current scale and given current technology, offshore aquaculture is a relatively high-cost way of growing fish. Currently, in the United States and elsewhere, offshore aquaculture is probably able to compete with inshore aquaculture only under limited circumstances, such as:
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> - When offshore farms are able to supply market niches which cannot be supplied by inshore farms, for reasons such as a lack of suitable sites, regulatory constraints, and transportation costs.
> - When offshore weather and wave conditions are relatively mild, reducing the costs of building and operating offshore facilities relative to inshore aquaculture.
> - When offshore farms enjoy significantly better water conditions than inshore farms, enabling faster growth or better survival.
> - When offshore farms are able to take advantage of cost-lowering synergies with other facilities or activities, such as existing inshore farm facilities or offshore oil rigs (page 47)."

Predicting the future is anything but an exact science and the author succinctly writes as much by noting:

> "The true test of the economic potential of any industry is the market. No offshore aquaculture industry can develop in the United States without an enabling regulatory structure. Only by letting offshore aquaculture be tried can we learn what its economic potential might be (page 48)."

Product Quality

The U.S. domestic aquaculture industry is committed to supplying consumers with consistent, high quality, safe products that are produced in an environmentally sound manner. The marketplace success of U.S. farmed fish is consumer confirmation that we are meeting that commitment. Numerous federal and state agencies are involved with maintaining the wholesome attributes of farm-raised seafood.

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[27] Knapp. G. 2008. Economic Potential for U.S. Offshore Aquaculture: An Analytical Approach *in* Rubino, M. (ed). 2008. Offshore Aquaculture in the United States: Economic Considerations, Implications & Opportunities. U.S. Department of Commerce; Silver Spring, MD; USA. NOAA Technical Memorandum NMFS F/SPO-103.

The U.S. Food and Drug Administration works with state departments of agriculture, the Association of Food and Drug Officials, and the American Association of Feed Control Officials to regulate aquaculture food handling and processing and the manufacture of feeds to ensure that they are safe and do not contain contaminants or illegal substances as authorized by the Federal Food, Drug and Cosmetic Act and Public Health Service Act.[28]

Furthermore, the Interstate Shellfish Sanitation Conference in cooperation with the U.S. Food and Drug Administration and state agencies administers a certification program requiring all shellfish dealers to handle, process, and ship shellfish (clams, oysters, mussels) under sanitary conditions and maintain records that the shellfish were harvested from approved waters. State agencies establish standards for shellfish growing areas and regularly monitor water quality to make sure that growing waters meet those standards.[29]

Fish and shellfish packers, warehouses, and processors must comply with the mandatory requirements of the Hazard Analysis Critical Control Point (HACCP) Program administered by the U.S. Food and Drug Administration. The program identifies potential food safety hazards and develops strategies to help ensure that they do not occur.[30] In addition all domestic food groups including seafood are subject to sampling under the FDA "Market Basket Survey." This program is designed to randomly test the domestic food supply to detect any potential contaminants and chemical residues.

New rules by the U.S. Food and Drug Administration authorized by the Food Safety Modernization Act have added additional regulations for the processing, handling and transportation of animal feeds and human food. Such controls help to make farm-raised seafood products safe and wholesome foods.[31]

As U.S. farmers, we are at a very real price disadvantage and recognize import product prices as being one of our greatest challenges. In response, rather than a protectionist approach, the NAA has been working to develop markets that appreciate locally grown and high-quality fish, shellfish and seaweed products. And the NAA is working to educate the U.S. consumer of U.S. sustainable production practices, environmental stewardship and the nutritional benefits and value of buying U.S. grown foods.

[28] Please visit https://www.fda.gov/Food/PopularTopics/ucm341987.htm.
[29] Please visit http://www.issc.org/.
[30] Please visit https://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/Seafood/ucm176892.htm.
[31] Please visit https://www.fda.gov/food/guidanceregulation/fsma/.