Refuting Marine Aquaculture Myths, Unfounded Criticisms and Assumptions

National Aquaculture Association[1]

A variety of tenacious myths critical of marine aquaculture practiced in the United States have persisted for decades[2] to be presented as facts to the public and Congress.[3] The reality is U.S. fish and shellfish farmers culture aquatic animals and plants within a very complicated and expensive legal, regulatory, husbandry and science-driven environment. We believe critics are unfamiliar with this environment or have erroneously assume marine aquaculture-related environmental damage reported in other countries occurs in the United States. Our response to these pernicious myths, criticisms and assumptions does not lend itself to short, simple answers; although, we have worked to be as succinct as possible. The myths, unfounded criticisms and assumptions we address include:

The United States is not a world leader in sustainable aquaculture production by volume or value but we are in the thoughtful and rigorous development of regulatory and nonregulatory production practices, animal nutrition and health management[4], and the efficient processing and distribution of high-quality, wholesome foods.[5] A recent analysis of global marine aquaculture

---

[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 30 years has worked ensure the aquaculture industry's sustainability, profitability and development occurs in an environmentally sustainable manner. For more US aquaculture information visit http://thenaa.net/. For copies of the references cited, please email naa@thenaa.net. This analysis was revised and updated January 20, 2021.

[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] Belle, S.M. and C.E. Nash. 2008. Chapter 8 Better management practices for net-pen aquaculture *in* Tucker and Hargreaves, editors, Environmental Best Management Practices for Aquaculture. US Aquaculture Society and Wiley-Blackwell, Ames Iowa.

[5] Boyd, C.E., L.R. D'Abramo, B.D. Glencross, D.C. Huyben, L.M. Juarez, G.S. Lockwood, A.A. McNevin, A.G.J. Tacon, F. Teletechea, J.R. Tomasso, Jr., C.S. Tucker and W.C. Valenti. 2020. Achieving sustainable aquaculture: Historical and current perspectives and future needs and challenges. Journal of the World

potential concluded with a statement that is very relevant to U.S. aquaculture by highlighting the unlimited potential of the United States to be a global leader in sustainability, technology and production (internal citations deleted):

> Given the significant potential for marine aquaculture, it is perhaps surprising that the development of new farms is rare. Restrictive regulatory regimes, high costs, economic uncertainty, lack of investment capital, competition and limitations on knowledge transfer into new regions are often cited as impediments to aquaculture development. In addition, concerns surrounding feed sustainability, ocean health and impacts on wild fisheries have created resistance to marine aquaculture development in some areas. While ongoing and significant progress has been made in addressing sustainability issues with marine aquaculture, continued focus on these issues and dedication to ensuring best practices will be a crucial element shaping the future of marine aquaculture. Both the cultural and economic dimensions of development and the management and regulatory systems are critically important to understanding realistic growth trajectories and the repercussions of this growth. Our results show that potential exists for aquaculture to continue its rapid expansion, but more careful analysis and forward-thinking policies will be necessary to ensure that this growth enhances the well-being of people while maintaining, and perhaps enhancing, vibrant and resilient ocean ecosystems.[6]

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 often welcomed by commercial and recreational fishermen.

There is a global imperative to increase sustainable protein production with wild-caught and farm-raised seafood being a major component.[7] The United States has the ability to accomplish this goal while leading the world in environmental protection.[8] Froehlich et al. (2020)[9] compiled

Aquaculture Society. 51:578-633. (https://onlinelibrary.wiley.com/doi/full/10.1111/jwas.12714 accessed November 12, 2020).

[6] Gentry, et al. 2017. Mapping the global potential for marine aquaculture. Nature Ecology and Evolution 1:1317-1324.

[7] 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.

[8] Marine Aquaculture in the U.S. NOAA Fisheries (https://media.fisheries.noaa.gov/2021-01/fact-sheet-marine-aquaculture-in-the-us.pdf?null accessed January 14, 2021).

[9] Froehlich, H.E., J. Couture, L. Falconer, G. Krause, J.A. Morris, M. Perez, G.D. Stentiford, H. Vehviläinen and B.S. Halpern. 2020. Mind the gap between ICES nations' future seafood consumption and aquaculture production. ICES Journal of Marine Science. fsaa066, https://doi.org/10.1093/icesjms/fsaa066.

and analyzed past trends in farmed and wild seafood production and consumption in International Council for the ICES nations,[10] as well as the potential and need to increase aquaculture production by 2050. They found that the majority of ICES nations lacks long-term strategies for aquaculture growth, with an increasing gap between future domestic production and consumption—resulting in a potential 7.7 million ton domestic seafood deficit by 2050, which would be supplemented by imports from other countries (e.g. China)."

And concluded (internal citations removed):

> "There is historical precedent for ICES nations to be at the forefront of sustainable seafood production, whether through domestic and/or better trade dimensions. Over the decades, the exploration and implementation of new tools and strategies to better manage wild fisheries have been recognized and adopted to various extents among these nations. While great strides were made to support best fisheries practices—including governance, funding, and research support—to recover many wild stocks, much less effort has been given in most of the ICES nations to usher in aquaculture practices in a similar, but more anticipatory manner. Interestingly, we found that even with the apparent recognition by all current ICES countries that aquaculture will play an increasingly important role in future seafood production, most planning appears very short term and conservative. Development of long-term aquaculture strategies is not just about absolute production and must also include measures to advance improved husbandry, technology, and participation in the changing seafood market, ideally with sustainability leading these components. While the goals moving forward to 2050 by the ICES nations may be feasible as the growing challenges are addressed, growth predominantly depends on one country, Norway. Even if the goals are met, it does not reconcile the deficits in seafood production, requiring increases in imports of seafood, often from places with considerably fewer rules and regulations for sustainable harvest or production. In addition, lack of aquaculture consideration creates a major gap in adaptively planning for the impact of climate change on the seafood sectors domestically and from exporting countries.
>
> Governance is key to adaptive planning, and targeted policies that support, not just regulate, domestic aquaculture are needed if ICES countries wish to address the skewed production landscape. In a global setting, the restrictive and complex regulatory structures have been identified as important factors stagnating the growth of aquaculture in Europe and North America and may have resulted in declining their share of world aquaculture production (page 7)."

Food and Agriculture of the United Nations reported in *2018 State of World Fisheries and Aquaculture: Meeting the Sustainable Development Goals:*[11]

---

[10] ICES is an acronym for the International Council for the Exploration of the Sea. The ICES member nations analyzed were Belgium, Canada, Denmark, Estonia, Finland, France, Germany, Iceland, Ireland, Latvia, Lithuania, Netherlands, Norway, Poland, Portugal, Russia, Spain, Sweden, United Kingdom and United States.

[11] 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).

> "Total fish production in 2016 reached an all-time high of 188 million tons, 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 44.8 lbs 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)."

> "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. The paucity of domestic aquaculture production means domestic demand satisfied by seafood imports will continue to expand foreign unsustainable production practices, unjust labor conditions and environmental degradation in countries that lack our legal, regulatory and enforcement capacities.

Helvey et al. (2017)[12] addressed these issues noting, "The full impact of U.S. seafood consumption patterns needs to be considered at the global level in light of continuing efforts to further marine biodiversity protections. Failing to do so only serves to counteract the effectiveness of domestic actions by externalizing negative environmental costs to others (page 66)." The authors offered six solutions, presented here in-brief (pages 65-66) that should form the basic tenets of domestic farmed and wild seafood production:

1. *"Increase awareness of U.S. fisheries.* Most Americans remain unaware of the high environmental standards by which U.S. federal marine fisheries – and many state fisheries - are managed, in compliance with multiple state and federal laws.
2. *Develop U.S. domestic aquaculture to complement capture fisheries*. The global status of marine capture fisheries is considered stable; however, increased catches are considered unlikely, suggesting that aquaculture will need to play a greater role in seafood security
3. *Support sustainable fishing practices in other nations*. Such capacity-building efforts include transferring best fishing practices, technologies and monitoring practices to nations whose fisheries continue to supply U.S. markets.

[12] 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.

4. *Multilateral cooperation*. Overarching World Trade Organization consistent trade laws and regulations can help address production and trade leakages and their negative impacts across the entire ranges of affected stocks.
5. *Recognize the externalities of management decisions*. Leakage occurs when the spatial scale of intervention does not match the scale of the targeted problem. Ignoring environmental impacts associated with goods produced elsewhere creates … the 'illusion of natural resource preservation.'
6. *Treat wild capture and aquaculture fisheries as part of the food system*. Seafood represents a part of the nation's food system. Nonetheless, within the context of managing marine resources and ecosystem impacts, seafood rarely is acknowledged as a component of the human diet, despite its recognized importance as a source of nutrition and sustenance."

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: 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 Federal Water Pollution Control Act (i.e., 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.

During January 2021, the U.S. Army Corps of Engineers (Corps) revised a nationwide permit for marine shellfish farming and created two new nationwide permits for seaweed and marine finfish farming. The Corps issues nationwide permits (NWPs) to authorize activities under Section 404 of the Clean Water Act, discharges of dredged or fill material into waters of the United States, and Section 10 of the Rivers and Harbors Act of 1899, structures and work in navigable waters, where those activities will result in no more than minimal individual and cumulative adverse environmental effects.[13]

In brief:

- NWP 48, Commercial Shellfish Mariculture Activities, authorizes the installation of buoys, floats, racks, trays, nets, lines, tubes, containers, and other structures into navigable marine waters of the United States. This NWP also authorizes discharges of dredged or fill material into waters of the United States necessary for shellfish seeding, rearing, cultivating, transplanting, and harvesting activities. Rafts and other floating structures must be securely anchored and clearly marked.
- NWP 55, Seaweed Mariculture Activities, authorizes the installation of buoys, long-lines, floats, anchors, rafts, racks, and other similar structures into navigable marine waters of the United States. Rafts, racks and other floating structures must be securely anchored and clearly marked. This NWP also authorizes structures for bivalve shellfish and/or seaweed farming if the structures for bivalve shellfish and/or seaweed production are a component of an integrated multitrophic structure (*e.g.*, the production of bivalve shellfish or seaweed on the structure used for finfish farming, or a nearby structure that is part of the single and complete project).
- NWP 56, Finfish Mariculture Activities, authorizes the installation of cages, net pens, anchors, floats, buoys, and other similar structures into marine navigable waters of the United States. Net pens, cages, and other floating structures must be securely anchored and clearly marked. This NWP also authorizes structures for bivalve shellfish and/or seaweed farming if the structures for bivalve shellfish and/or seaweed production are a component of an integrated multitrophic structure.

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; Fish and Wildlife Coordination Act; Federal Water Pollution Control Act (Clean Water Act); Food Safety Modernization Act; Lacey Act; Magnuson-Stevens Fishery Conservation and Management Act; Marine Mammal Protection Act; Migratory Bird Protection Act; National Environmental Policy Act; National Historic Preservation Act; National Marine Sanctuary Act;

[13] The Federal Register notice describing the final rule for the revised and new nationwide marine aquaculture permits is posted here: https://www.federalregister.gov/documents/2021/01/13/2021-00102/reissuance-and-modification-of-nationwide-permits.

National Invasive Species Act; Non-indigenous Aquatic Nuisance Prevention and Control Act**;** Outer Continental Shelf Lands Act; and Rivers and Harbors Act .[14]

Through Executive Order, 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.[15]

Current regulatory authority exists to appropriately protect marine water quality and benthic environmental systems,[16] 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.

To inform the public concerning current net pen production practices and regulatory oversight, in 2018 the Florida Sea Grant Program funded a one sea cage experimental, demonstration farm 45 miles out from Florida's Gulf Coast. The program hosted a public workshop in 2019, Pioneering Offshore Aquaculture, consisting of production, site selection, regulatory and economic implication presentations.[17] A commercial partner, Ocean Era, Inc., applied for Environmental Protection Agency and U.S. Army Corps of Engineers permits. Estimated production by one net pen, 80,000 live weight pounds per year of the native almaco jack (*Seriola rivoliana*), is below the EPA's National Pollution Discharge Elimination System (NPDES) permitting threshold of 100,000 pounds; however, the Environmental Protection Agency examined the farm as if production exceeded the threshold, invoked the provisions of the National Environmental Policy Act and sought comments from the other federal agencies, conducted a Section 7 Endangered Species Act consultation with the National Marine Fisheries Service, consulted with the State of Florida as authorized by the Coastal Zone Management Act and posted for public comment a

[14] Price, C.S., E. Keane, D. Morin, C. Vaccaro, D. Bean, and J.A. Morris, Jr. 2017. Protected Species & Marine Aquaculture Interactions. NOAA Technical Memorandum NOS NCCOS 211. (https://repository.library.noaa.gov/view/noaa/16942 accessed January 16, 2020).

CRS (Congressional Research Service). 2019. U.S. Offshore Regulation and Development. R45952. (https://crsreports.congress.gov/product/pdf/R/R45952 accessed January 16, 2020).

NOAA (National Oceanic and Atmospheric Administration). 2019. A Guide to the Permitting and Authorization Process for Aquaculture in U.S. Federal Waters of the Gulf of Mexico. (https://www.fisheries.noaa.gov/southeast/aquaculture/marine-aquaculture-noaa-fisheries-southeast-region accessed January 16, 2020).

[15] Regulation of Marine Aquaculture. NOAA Fisheries (https://media.fisheries.noaa.gov/2021-01/Fact-Sheet-Regulation-of-Marine-Aquaculture.pdf?null accessed January 14, 2021).

[16] Aquaculture and Environmental Interactions. NOAA Fisheries (https://media.fisheries.noaa.gov/2021-01/Fact-Sheet-Aquaculture-Environmental-Interactions.pdf?null accessed January 14, 2021).

[17] Pioneering Offshore Aquaculture Workshop, June 27-28, 2019, Florida Sea Grant Program (https://www.flseagrant.org/aquaculture/openocean/pioneering-offshore-aquaculture-workshop/ accessed January 12, 2021).

draft permit and environmental analyses, as well as held a public hearing. Approximately, 44,500 public comments were submitted.

The Environmental Protection Agency granted a NPDES during September 2020 for the project that is currently being appealed. We invite and encourage your independent analysis of the multi-agency, state and federal, generated permit. The full permit package is posted here: https://www.epa.gov/npdes-permits/ocean-era-inc-velella-epsilon-aquatic-animal-production-facility-national-pollutant.

Ocean Era, Inc. also applied in October 2020 for a Rivers and Harbors Act authorized Section 10 permit from the U.S. Army Corps of Engineers.[18] The Corps will review the farm to determine whether a permit can be issued for an obstruction or alteration of any navigable water of the United States, the construction of any structure in or over any navigable water of the United States, the excavating from or depositing of material in such waters, or the accomplishment of any other work affecting the course, location, condition, or capacity of such waters. The permit was posted for public comment until November 19, 2020.

Engle and Stone (2013)[19] 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.

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 (page 274)."

State and Federal regulatory agencies incur costs and there is little appreciation by the agencies, public or the farming community of their aggregated impact. Publicly funded research is quantifying the effort and aggregated costs farms must expend to acquire and maintain permits. Peer-reviewed papers describing the scope and magnitude of regulations for sportfish, baitfish, and salmonid farming are available[20] and on-going research is analyzing regulatory costs for

---

[18] Ocean Era, Inc. Section 10 permit application: https://www.saj.usace.army.mil/Missions/Regulatory/Public-Notices/Article/2371456/saj-2017-03488-sp-krd/ accessed January 12, 2021.

[19] 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.

[20] Engle, C.R., J. van Senten and G. Fornshell. 2019. Regulatory costs on salmonid farms. Journal of the World Aquaculture Society. 50(3): 522-549. (https://onlinelibrary.wiley.com/doi/full/10.1111/jwas.12604 accessed January 8, 2020).

Van Senten, J. and C.R. Engle. 2017. The costs of regulations on U.S. baitfish and sportfish producers. Journal of the World Aquaculture Society. 48(3): 503-517. (https://onlinelibrary.wiley.com/doi/full/10.1111/jwas.12416 accessed January 8, 2020).

Van Senten, J., M.M. Dey and C.R. Engle. 2018. Effects of regulations on technical efficiency of U.S. baitfish and sportfish producers. Journal of Aquaculture Economics and Management. 22(3): 284-305.

Pacific and East Coast shellfish, catfish, tilapia, hybrid striped bass, and ornamental fish (aquarium and water gardening) farming.

As an example, 161 salmonid farms (trout and salmon) representing 94% of U.S. production across 17 states (Colorado, California, Idaho, Maine, Michigan, Missouri, Nebraska, New York, North Carolina, Ohio, Oregon, Pennsylvania, Utah, Virginia, Washington, West Virginia, Wisconsin) provided economic data to a research team that reported:[21]

- "The number of unique permits does not adequately portray the effort required by survey respondents. An individual permit may require a series of substantive (and sometimes expensive) actions on the part of the farmer that must be filed with the agency as one step in the permit application process. These can include engineering studies, surveys of wetlands, or endangered species impact studies that must be filed sequentially. Respondents reported 1,244 filings of this nature, with a mean of 12/farm (median = 6) that ranged from 1 to 135/farm. Each of these filings required time and personnel in addition to other expenses, with each filing contributing to the total complexity of what individual salmonid farms must comply with (page 531)."

- "Study results showed that the regulatory system in the United States increased on-farm costs annually by an average of $150,506, or $2.71/kg, for a national regulatory cost of $16.1 million/year. In addition, regulatory actions on U.S. salmonid farms resulted in lost markets with an annual value of $66,274/farm, lost production of $49,064/farm, and an estimated value of thwarted expansion attempts of $375,459/farm. Nationally, the value of markets lost because of regulatory actions was $7.1 million/year, $5.3 million/year of lost production, and $40.1 million/year in thwarted expansion attempts. Smaller-scale farms were affected to a disproportionately greater negative extent than larger-scale farms (page 546)."

Similarly, a recent analysis examined the regulatory costs imposed on Pacific Coast shellfish farmers. Van Senten et al. (2020)[22] reported (internal citations omitted):

- "The United States was ranked as the 8th largest producer of mollusks in 2016, with an estimated production volume of 173,700 metric tons. While the Pacific coast states of Washington, Oregon, and California represent only 22% of the total number of U.S. farms in the 2012 Census of Aquaculture; these three states accounted for 54% of the value of U.S shellfish. The major production species include a variety of clams, mussels, and oysters; with oysters accounting for the largest production value. Shellfish aquaculture on the Pacific coast of the U.S. includes the production of Pacific oysters (*Crassostrea gigas*), Kumamoto oysters (*Crassostrea sikamea*), eastern oysters (*Crassostrea virginica*), Olympia oysters (*Ostrea lurida*), Geoduck

[21] Engle, C.R., J. van Senten and G. Fornshell. 2019. Regulatory costs on salmonid farms. Journal of the World Aquaculture Society. 50(3): 522-549. (https://onlinelibrary.wiley.com/doi/full/10.1111/jwas.12604 accessed January 8, 2020).

[22] van Senten, J., C.R. Engle, B. Hudson and F.S. Conte. 2020. Regulatory costs on Pacific coast shellfish farms. Aquaculture Economics & Management (https://www.tandfonline.com/doi/full/10.1080/13657305.2020.1781293 accessed October 27, 2020)

clams (*Panopea generosa*), Manila clams (*Venerupis philippinarum*), Blue mussels (*Mytilus edulis*), Mediterranean mussels *(Mytilus galloprovincialis*), abalone (*Haliotis spp.*), and several other minor species."

- "The Pacific coast shellfish industry has contended with extensive delays in permitting resulting in high regulatory costs and substantial lost sales and opportunities. Mean annual regulatory costs for Pacific coast shellfish producers were estimated to be $240,621 per farm and $68,936 per hectare. The total annual regulatory burden for the Pacific coast region was estimated at $15.6 million per year, with an additional $110 million in annual lost sales revenue in addition to $169.9 million per year in lost business opportunities. The majority of regulatory costs captured by the study were indirect costs of compliance such as manpower for compliance, legal expenses, and changes in equipment or management for compliance; the total accounting for 85% of regulatory costs on average across the Pacific coast region."

- "Regulatory costs associated with obtaining licenses and permits across the region were 1.4 times the costs associated with ongoing monitoring, reporting, and compliance. California had the greatest total state regulatory cost ($6,158,446) and the greatest mean per-farm regulatory cost ($473,727 per farm). Study results point to regulatory constraints to growth of the shellfish industry with more than one-third reporting that regulations prevented them from expanding to meet market demand."

- Smaller-scale producers were affected negatively by regulatory costs to a disproportionately greater degree than were larger farms. Study results suggest that there is a strong need for streamlining the permitting process to achieve substantial reductions in the time required to obtain permits. The results from this study confirm that the Pacific coast shellfish industry, like the salmonid and baitfish/sportfish sectors in the U.S., is constrained by the U.S. regulatory environment; affecting the industry's ability to meet the growing demand for U.S. shellfish aquaculture products."

Myth: 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.

Feed Management and Fish Growth

Feed is a significant cost to all fish farms and can range from 50% to 60% of variable costs. As a consequence, farmers invest in employee training and infrastructure to store, handle, deliver and monitor feed to fish as efficiently and with as little loss as possible.[23] The practical aspects of feed monitoring technology is rarely presented in science literature; although, sophisticated approaches have been adopted to include cameras, Doppler radar, infrared detection, sonar

[23] Belle and Nash (2008) at 278.
Schwarz, M.H., D. Kuhn, D. Crosby, C. Mullins, B. Nerrie and K. Semmens. 2017. Good aquaculture practices. Southern Regional Aquaculture Center, SRAC Publication No. 4404.

sensors and water quality sensor arrays.[24] Current feed monitoring in the United States utilizes farm employees observing feed consumption via video for each cage in an array of cages to stop feed delivery when fish near satiation.[25]

Feed conversion ratio (FCR) (weight of feed offered/weight of fish produced) have trended downward as feed management and feed quality have improved from 3:1 (3 pounds of feed to 1 pound of harvested fish) to around 1:1.[26] Welch et al. (2010) explored every aspect of the complex topic of feeding carnivorous (fish and crustacean) marine species, reporting a FCR for Atlantic salmon of 1.3:1 and FCRs for gilthead sea bream (*Sparus aurata*), yellowtail flounder (*Limanda ferruginea*), cobia (*Rachycentron canadum*) and cod (*Gadus morhua*) of less than 1.5:1. These FCRs are well-below the most efficient feed converting agricultural animal, the chicken, at 1.9:1, and the trend in fish meal, fish oil replacement within compounded marine finfish feeds has resulted in a fish-in, fish-out ratio for fed marine finfish is approaching 1:1. They also reported (internal citations removed):

> "…alternative feed ingredients and formulations have been investigated for nearly every species of commercially important fish including, for example, Atlantic salmon (*Salmo salar*), red drum (*Sciaenops ocellatus*), cobia (*Rachycentron canadum*), turbot (*Psetta maxima*), European sea bass (*Dicentrarchus labrax*), gilthead sea bream (*Sparus aurata*), Japanese flounder (*Paralichthys olivaceus*), yellowtail (*Seriola quinqueradiata*) and rainbow trout (*Oncorhynchus mykiss*) (page 241)."[27]

Fish Density

The success of every farm growing animals, terrestrial or aquatic, depends upon the health and growth of the livestock. Fish grown at-sea in net pens benefit from standard practice of a low volume, 2% to 3%, at-harvest of fish relative to the volume of the sea cage or net pen. As a different and complimentary measure, Belle and Nash (2008) presented fish density at harvest (23 kilograms per square meter) as a loading rate of 0.024 kilograms per liter per minute at the

---

[24] Ang, K.P and R.J. Petrell, 1997.Control of feed dispensation in seacages using underwater video monitoring: effects on growth and food conversion, Aquacultural Engineering, 16 (1–2): 45-62.
Belle and Nash (2008) at 282.
Beveridge, M. 2004. Cage Aquaculture, Third Edition. Blackwell Publishing, Oxford, United Kingdom.
Føre, M., K. Frank, T. Norton, E. Svendsen, J.A. Alfredsen, T. Dempster, H. Eguiraun, W. Watson, A. Stahl, L.M. Sunde, C. Schellewald, K.R. Skøien, M.O. Alver, D. Berckmans, 2018. Precision fish farming: A new framework to improve production in aquaculture. Biosystems Engineering 173: 176-193.
Garcia, M. S. Sendra, G. Lloret and J. Lloret. 2010. Monitoring and control sensor system for fish feeding in marine fish farms. Institution of Engineering and Technology 5(12): 1682-1690.
Michel, A.P.M., K.L. Croff, K.W. McLetchie and J.D. Irish. 2002. A remote monitoring system for open ocean aquaculture, OCEANS '02 MTS/IEEE, Biloxi, MI, USA, 2002, 4:2488-2496.
Zion, B. 2012. The use of computer vision technologies in aquaculture – A review, Computers and Electronics in Agriculture. 88: 125-132,

[25] Providing links to examples of currently available feed monitoring systems does not imply endorsement by the National Aquaculture Association: AKVA Group (https://www.akvagroup.com/pen-based-aquaculture/camera-sensors/camera-systems), AQ1 Systems (http://www.aq1systems.com/farming/13510000.html), FISHBIO (https://fishbio.com/automated_monitoring), InnovaSea (https://www.innovasea.com/aquaculture-intelligence/).

[26] Belle and Nash (2008) at 279.

[27] Welch, A., R. Hoenig, J. Stieglitz, D. Benetti, A. Tacon, N. Sims and B. O'Hanlon, B. 2010. From fishing to the sustainable farming of carnivorous marine finfish. Reviews in Fisheries Science, 18(3): 235-247

average current velocity during a full tidal cycle for Cobscook Bay Maine (2.5 x 10^6 liters per minute). They compared this loading rate to that typical for trout flow-through raceways (1.5 to 2.0 Kg/L per minute) and noted net pens should be classified as low-intensity production systems (page 265).

The fish to cage volumes is extremely low when juvenile fish are introduced to containment. All of the numbers cited in this section are for market-ready fish or the highest volume of fish to volume of water within the enclosure.

Turnbull et. al (2005)[28] examined Atlantic salmon at three stocking densities within multiple cages managed under typical commercial production practices to eliminate variation in water quality, current flow and cage deformation that can occur under different sea conditions. Over the study period the authors reported, "The calculated cage density ranged from 9.7 to 34 kilogram per cubic meter, a wider range than was normal within the industry at the time (page 124)" meaning the fish represented from .97% to 3.4% of the cage volume.[29] To assess fish physical condition, i.e., welfare, they measured growth (length and weight), stress (plasma glucose and cortisol) and damage (12 assessments of fins and body). Their results were mixed as can be expected from a dynamic ocean environment. They concluded:

> "The non-linearity of the relationship between welfare and stocking density suggests that, below a critical point around 22 kg m^3 [2.2% of the cage volume] increasing density did not reduce welfare under the conditions studied on a commercial farm…It is clear from this study that good welfare can be maintained at high densities and that conversely low densities are no guarantee of good welfare (page 131)."

Hernández et al. (2016)[30] evaluated the effect of density at harvest (15, 20 and 22 kg m^3) on the performance (weight gain, three growth rate measures, total biomass, survival, and feed conversion) and profitability (selling price, cost of juveniles and feed costs) of spotted rose snapper cultured in commercially managed floating sea cages off of Mexico. They reported "…spotted rose snapper reared at harvest density of 20 kg/m^3 [2% of cage volume] exhibit improved biological and economical indices under a given set of environmental conditions (page 58)."

Fish density is a production system is a complex question dependent upon species behavior, physiology, and water quality. To test density effects, d'Orbcastel et al. (2010)[31] created a flow

[28] Turnbull, J., A. Bell, C. Adams, J. Bron and F. Huntingford. 2005. Stocking density and welfare of cage farmed Atlantic salmon: application of multivariate analysis. Aquaculture 243:121-132. (http://staff.stir.ac.uk/j.f.turnbull/papers/SD%20Cages.pdf accessed October 14, 2020)

[29] A cubic meter of water weighs 1,000 kilograms. The calculation is kilograms of fish/1,000 kilograms x 100 = percentage of fish to water volume.

[30] Hernández, C.H., C. Hernández, F.J. Martínez-Cordero, N. Castañeda-Lomas, G. Rodrígeuz-Domínguez, A.G.J. Tacon and E.A. Aragón-Noreiga. 2016. Effect of density at harvest on the growth performance and profitability of hatchery-reared spotted rose snapper, *Lutjanus guttatu*, cultured in floating net cages. Journal of the World Aquaculture Society 47(1):51-60.

[31] D'Orbicastel, E.R., G. Lemarié, G. Breuil, T. Petochi, G. Marino, S. Triplet, G. Dutto, S. Fivelstad, J-L. Coeurdacier and J-P. Blancheton. 2010. Effects of rearing density on sea bass (*Dicentrarchus labrax*) biological performance, blood parameters and disease resistance in a flow through system. Aquatic Living Resources. 23:109-117.

through system for sea bass, *Dicentrarchus labrax*, a fish commonly grown in European net pens. They found:

> "Biological performances (DFI [daily feed intake], SGR [specific growth rate]) were decreased at 100 kg m^{-3}, but no significant differences were noticed on stress response (cortisol) and disease resistance in sea bass reared in a flow through system at densities between 10−100 kg m^{-3}. These results confirmed that a high density is not a chronic stress factor for sea bass when feed access is non limiting and water renewal rate per kg of fish biomass enables maintenance of the water quality parameters (mainly O_2, CO_2, TAN) within the range of recommended levels for such species. Decrease in growth performances at 100 kg m^{-3} in both RAS [recirculating aquaculture systems] and FTS [flow through system] suggest that maximal density for sea bass should be comprised between 70 [7%] and 100 kg m^{-3} [10%], whatever the rearing system (page 115)."

Current at-harvest stocking density for Atlantic salmon is 25 to 30 kg m^3 or 2.5% to 3% of the enclosure volume (Sebastian Belle, personal communication, Maine Aquaculture Association; Jim Parsons, personal communication, Cooke Aquaculture Pacific).

Farmed shellfish cultured in a variety of production systems (seeded to the bottom, held in mesh grow-out bags or plastic or plastic-coated wire containers) provide a range of beneficial ecosystem services and products for human use.[32] An author team led by van der Schatte Olivier et al. (2020)[33] summarized the obvious, and not so obvious, benefits association with farming shellfish:

> "Bivalves are filter feeders, filtering water and particulates, creating substrates which provide habitat to act as nursery grounds for other species. Goods from provisioning services include meat, worth an estimated $23.9 billion as well as, pearls, shell and poultry grit, with oyster shell being the most important, with a global potential worth of $5.2 billion. The most important regulating services are nutrient remediation. Cultivated bivalves remove 49,000 tonnes of nitrogen and 6,000 tonnes of phosphorus, worth a potential $1.20 billion."

Excess feed, untreated fish waste and nutrients

Current farm and feed management practices refute the claims that offshore marine aquaculture causes water quality or benthic ecology damage. 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.[34] The authors reported,

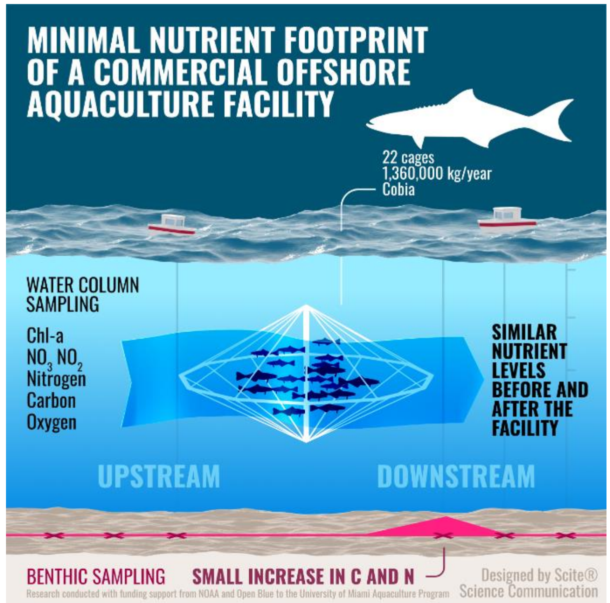
---

[32] Aquaculture Provides Beneficial Ecosystem Services. NOAA Fisheries (https://media.fisheries.noaa.gov/2020-11/Fact%20Sheet_%20Aquaculture%20Provides%20Beneficial%20Ecosystem%20Services.pptx.pdf?null accessed January 14, 2021)

[33] van der Schatte Olivier, A., L. Jones, L.L. Vay, M. Christie, J. Wilson and S.K. Malham. 2020. A global review of the ecosystem services provided by bivalve aquaculture. Reviews in Aquaculture. 12: 3-25.

[34] 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).

"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 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)."[35] 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)."

Marine net pen farms attract wild fish in considerable abundance and diversity. Fish are attracted to the pens or cages for the shelter they provide and to consume feed and particulate matter that may escape. Dempster et al. (2002) censused aggregations of wild fish around nine floating sea-cage fish farms along a 300 kilometer stretch of the Spanish coastline in the south-western Mediterranean Sea noting twenty-seven fish species were recorded at the farms, with two families, Sparidae (12 species) and Carangidae (4 species), being particularly abundant.[36]

[35] 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.

[36] Dempster, T., P. Sanchez-Jerez, J.T. Bayle-Sempere, F. Giménez-Casalduero and C. Valle. 2002. Attraction of wild fish to sea-cage fish farms in the south-western Mediterranean Sea: spatial and short-term temporal

Dempster et al. (2005) censused wild fish surrounding five Spanish net pen farms noting almost 200,000 wild fish belonging to 53 species representing Sparidae (8 species), Carangidae (6 species), Mugilidae (5 species) and Chondrichthyid rays (7 species) commonly observed.[37] Özgül and Angel (2013) compared the composition and abundances of wild fish populations around two fish farms in the Red Sea and at nearby reference locations. Fish assemblages were evaluated over three months. A total of 87,238 fishes, representing 39 species and 25 families and a number of trophic levels, were observed. Overall, the abundance, biomass, and diversity of wild fish were much greater at the sea cages than at the open-water reference sites, at both fish farms. It was noteworthy that 35 out of the 39 species observed at the farms were juveniles and adults of coral-reef fish species.[38] Dempster et al. (2005) and Özgül and Angel (2013) suggested fishing should be restricted around farms to create small, pelagic marine protected areas and to allow wild fish to serve as sinks to assimilate lost feed and particulate matter.

Consumption of lost feed by wild fish can be significant to the benefit of the waters and benthos and to the fish. Felsing et al. (2005) investigated the potential for wild fish aggregations to assimilate lost feed and particulate matter in Western Australian waters through three treatments arranged in duplicate, cages without exclusion nets (normal situation); cages surrounded by a 35-mm mesh exclusion net (preventing wild fish access to the sea bed and water column near the cage); and empty cages surrounded by exclusion nets (to control for effects from the exclusion net). In addition, four reference sites without cages were sampled. The experiment was terminated after 62 days, at a final stock density of 5.6 kilogram/cubic meter within the sea cages. Sampling found significantly greater accumulation of nutrients and fine sediments under the cages enclosed in the exclusion net than in other treatments and sites. The accumulation of nutrients at these sites was correlated to distinct changes in macrofaunal community composition, with a sharp increase in overall macrofaunal abundance and a growing dominance of capitellid polychaetes. Based on a comparison between sedimentation rates within and outside excluded areas, the proportions of the total sedimenting nutrients consumed by wild fish were calculated to be 40% to 60%. It was concluded that in the natural coastal system of Western Australia or comparable environments, wild fish are potential important consumers of cage aquaculture waste materials. The fact that sediment carbon, nitrogen and phosphorus did not increase below cages with fish and no exclusion nets suggests that the benthic fauna, including surface grazing fish, at these sites were able to assimilate much of the remaining total sedimentary nutrients.[39]

Halide et al. (2009) investigated wild fish diversity adjacent to floating fish cages used to culture groupers, *Epinephelus fuscoguttatus* and *Cromileptes altivelis*, and rabbitfish, *Siganus* spp., in

---

variability. Marine Ecology Progress Series, 242:237-252. (https://www.int-res.com/articles/meps2002/242/m242p237.pdf accessed December 4, 2020).

[37] Dempster, T., D. Fernandez-Jover, P. Sanchez-Jerez, F. Tuya, J. Bayle-Sempere, A. Boyra and R.J. Haroun. 2005. Vertical variability of wild fish assemblages around sea-cage fish farms: implications for management. Marine Ecology Progress Series, 304:15-29. (https://www.int-res.com/articles/meps2005/304/m304p015.pdf accessed December 4, 2020).

[38] Özgül, A. and D. Angel. 2013. Wild fish aggregations around fish farms in the Gulf of Aqaba, Red Sea: implications for fisheries management and conservation. Aquaculture Environment Interactions, 4(2):135-145. (https://www.int-res.com/articles/aei2013/4/q004p135.pdf accessed December 4, 2020).

[39] Felsing, M., B. Glencross and T. Telfer. 2005. Preliminary study on the effects of exclusion of wild fauna from aquaculture cages in a shallow marine environment. Aquaculture, 243(1-4):159-174.

South Sulawesi, Indonesia. The authors reported wild fishes were significantly more abundant in near-surface depths around the margins of the cages in the morning than at other times of day, and corresponding to the time when the fish within the cages were fed with formulated diets. There were 29 species of wild fishes, belonging to 25 genera, associated with the cages. Of these, 5 species were observed feeding on pellets passing through the cage: *Abudefduf vaigiensis*, *Pterocaesio tile*, *Monodactylus argenteus*, *Neopomacentrus violascens* and *Sphaeramia orbicularis*. The total biomass of wild fishes outside the cages exceeded the biomass of the fish in the cages. Aggregations of wild fishes outside the cages consumed a total amount of organic material equivalent to that of the uneaten food leaving the cages, and directly consumed 27% of the lost pellets, significantly reducing organic waste from the cages.[40]

Fernandez-Jover et al. (2007) sampled wild Mediterranean horse mackerel (*Trachurus mediterraneus*), from populations aggregated around two Mediterranean fish farms and from two natural control populations and reported differences in body condition, stomach content and fatty acid composition. They concluded, "The increased condition of wild fish associated with farms could increase the spawning ability of coastal fish populations, if wild fish are protected from fishing while they are present at farms."[41]

These studies may reflect outcomes for farms located in the exclusive economic zone of the United States managed by US farmers. Farms must conform to established production practices and federal regulations that require the efficient feeding of optimal feed formulations, feed management to reduce feed loss, feeding equipment maintenance, employee training in efficient feeding practices, and recordkeeping and reporting of feed efficiency (conversion of feed to the amount of fish produced).[42] 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 National Pollution Discharge Elimination System (NPDES) permits granted by the U.S. Environmental Protection Agency 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

[40] Halide, H., J. Jompa and A.D. McKinnon. 2009. Wild fish associated with tropical sea cage aquaculture in South Sulawesi, Indonesia. Aquaculture, 286(3-4):233-239.

[41] Fernandez-Jover, D., J.A.L. Jimenez, P. Sanchez-Jerez, J. Bayle-Sempere, F.G. Casalduero, F.J.M. Lopez and T. Dempster. 2007. Changes in body condition and fatty acid composition of wild Mediterranean horse mackerel (*Trachurus mediterraneus*, Steindachner, 1868) associated to sea cage fish farms. Marine Environmental Research, 63(1):1-18. (https://imem.ua.es/en/documentos/imem-files/research-articles/just-bayle/fernandez-jover-fatty-acids-2007.pdf accessed December 4, 2020).

[42] Belle and Nash (2008).
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).[43] 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.[44] Antibiotics can only be used in conformance to label instructions or as prescribed by a veterinarian.[45] Federal regulations require that farms report medication use prior to administering a medication and following treatment.[46] A farm must describe potential chemical use in their EPA permit application and conform to permit conditions if use is allowed.[47] 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.

Reverter et al. (2020) conducted a double meta-analysis (460 articles) to explore antimicrobial resistance and global aquaculture.[48] They calculated a Multi-Antibiotic Resistance Index (MAR) of aquaculture-related bacteria (11,273 isolates) for 40 countries. These countries account for 93% of global aquaculture production. They found:

> "Twenty-eight countries out of the 40 studied displayed MAR indices higher than 0.2, a threshold considered to be an indication of high-risk antibiotic contamination. The mean global MAR index of aquaculture-related bacteria was 0.25 (SE = 0.01). Zambia (0.56) followed by Mexico (0.55) and Tunisia (0.53) were the countries with the highest MAR indices, whilst Canada (0.02), France (0.03) and USA (0.08) displayed the lowest."

Antifoulants

Biofouling in marine environments occurs when animals and plants attach to the hard and soft surfaces associated with fish, shellfish and seaweed production gear (cages, nets, baskets, floats, ropes and anchors). The growing animals and plants will add weight and drag, restrict water flow impacting filter feeding or oxygenation, reduce marketable value or shelter pathogens and parasites. Direct economic costs to the farm have been conservatively estimated at 5 to 15% of production costs.[49]

---

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

[44] 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).

[45] Antibiotic Use in Fish: What to do when considering using approved finfish antibiotics. NOAA Fisheries (https://media.fisheries.noaa.gov/2021-01/Fact-Sheet-Antibiotic-Use-in-Finfish.pdf?null accessed January 14, 2021).

[46] 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).

[47] Ibid.

[48] Reverter, M., S. Sarter, D. Caruso, J-C. Avarre, M. Combe, E. Pepey, L. Pouyard, S. Vega-Heredia, H. de Verdal and R.E. Gozlan. 2020. Aquaculture at the crossroads of global warming and antimicrobial resistance. Nature Communications. 11:1870. https://doi.org/10.1038/s41467-020-15735-6.

[49] Adams, C.M., S.E. Shumway, R.B. Whitlatch and T. Getchis. 2011. Biofouling in marine molluscan shellfish aquaculture. A survey assessing the business and economic implications of mitigation. Journal of the World Aquaculture Society 42(2): 242-252.

Belle and Nash (2008) at 294.

Fitridge, I. T. Dempster, J. Guenther and R. de Nys. 2012. The impact and control of biofouling in marine aquaculture: a review. Biofouling 28(7):649-669.

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 net exchange and the use of antifoulants on nets and are using mechanical robotic net cleaners or copper-alloy metal mesh.

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.

A recent study conducted by the Naval Information Warfare Center Pacific by Earley et al. (2020)[50] examined metal leaching rates for four copper alloy materials and one traditional coated-nylon net material during a 365 day field test in San Diego Bay, California and modeled the theoretical deployments of 50 copper-alloy mesh aquaculture pens in San Diego Bay CA (an arid, Mediterranean bay with a low flushing regime) and Sinclair Inlet, WA (a cold water, high flushing regime environment) to assess overall environmental loading in these representative scenarios. The authors concluded (internal citation omitted):

> "The results from the current study indicate that environmental loading of metals from copper alloy materials is higher than from antifoulant-treated nets. However, using the weight of evidence approach presented here, the overall effect of this metal input is not interpreted to be environmentally detrimental. This difference (in metal release rates) is important for farming pen maintenance purposes, including factors such as control of water flow obstruction, steady oxygen availability, decrease in the probability for establishment of pathogen vectors and control on the total weight of the pen structure (page 289)."

Myth: Offshore farms entangle marine animals.

The federal permitting process for offshore farms requires interagency consultations, as authorized by the National Environmental Policy Act, to enforce the provisions of the Endangered Species Act, Marine Mammal Protection Act, Migratory Bird Treaty Act and Magnuson-Stevens Fishery Conservation and Management Act to prevent injury or death to

---

Bannister, J. M. Sievers, F. Bush and N. Bloecher. 2019. Biofouling in marine aquaculture: a review of recent research and developments. Biofouling 35(5):631-648.

[50] Earley, P.J., B.L. Swope, M.A. Colvin, G. Rosen, P-F. Wang, J. Carilli and I. Rivera-Duarte. 2020. Estimates of environmental loading from copper alloy materials. Biofouling, 36(3): 276-291 (https://www.tandfonline.com/doi/full/10.1080/08927014.2020.1756267 accessed November 18, 2020).

listed species, marine mammals and birds and to prohibit unpermitted fishery harvest, possession or sale. Price and Morris (2013) evaluated entanglements across the globe and summarized:

> "At modern fish farms, impacts to predatory sharks and marine mammals are being minimized with improved net technologies and removal of dead fish from cages to prevent predation on cultured fish. Siting away from known aggregation sites and installing rigid predator exclusion nets are effective at preventing negative impacts to cultured fish, farm structures and marine predators. Acoustic deterrent devices are not consistently useful against sea lions and seals and may have deleterious impacts to non-target marine mammals. In the U.S., nonlethal interventions to prevent marine mammal predation are preferred.[51] At marine fish farms, entanglement in the farm structures may pose a slight threat to sea turtles, dolphins, whales and seabirds. Keeping lines taut and the water free of debris are effective at minimizing or eliminating conflict with marine mammals and turtles (page iv)."[52]

Unlike fishing gear that is designed to intentionally "catch" animals, aquaculture gear is designed to contain animals being cultured without hurting them or any wild animals that may occur around farms. A second in-depth analysis summarized interactions by at-risk sea turtles, sea birds, sharks and marine mammals with aquaculture production gear to inform the federal permitting process. The goal of the assessment was to strengthen the ability of the National Oceanic and Atmospheric Administration and other regulatory agencies to make science-based decisions and recommendations as part of the review and consultation process required by the National Environmental Policy Act to permit nearshore and offshore aquaculture operations. [53]

The authors found few at-risk species and aquaculture production gear interactions. As a surrogate they examined analogous fishery gear and then suggested preventative measures to include farm siting to avoid migration routes and resting, feeding and breeding habitats; farm worker training to avoid feeding or harassing visiting animals; properly tensioned lines; installation and maintenance of predation prevention nets; and similar commonsense practices (pages 57-58).

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

Belle and Nash (2008) noted that escaping fish may pose a variety of environmental risks including pathogen transmission, interbreeding with wild conspecific to introduce new genetics, competition for resources, predation, colonization or disruption or damage to existing commercial or recreational fishing. The authors concluded:

---

[51] The authors should have clarified non-lethal methods are required in the United States as authorized for all marine mammals and birds by the Marine Mammal Protection Act and the Migratory Bird Protection Act, respectively, and specific marine mammals and birds when listed under the authority of the Endangered Species Act.

[52] Price, C.S. and J.A. Morris, Jr. 2013. Marine Cage Culture and the Environment: Twenty-first Century Science Informing a Sustainable Industry. NOAA Technical Memorandum NOS NCCOS 164. (https://www.noaa.gov/stories2013/pdfs/2013_PriceandMorris_MarineCageCultureandTheEnvironment(5).pdf accessed January 8, 2020)

[53] Price, C.S., E. Keane, D. Morin, C. Vaccaro, D. Bean, and J.A. Morris, Jr. 2017. Protected Species & Marine Aquaculture Interactions. NOAA Technical Memorandum NOS NCCOS 211. (https://repository.library.noaa.gov/view/noaa/16942 accessed January 16, 2020).

"For most of the aquatic species commercially cultured in the United States, these outcomes have neither occurred nor are anticipated to occur because:

- Producers have a strong economic incentive to prevent escape of cultured animals and to recover animals that do escape;
- Most pathogens are naturally occurring and ubiquitous;
- Most species are cultured in their native range;
- Successful introduction and spread of a nonnative species often meet strong biological resistance; and
- Federal and state agencies have implemented a variety of invasive-species regulations to prevent, control, manage, or mitigate potential impacts."[54]

This non-regulatory and regulatory framework has been effective for the United States. 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 Hawaii, Maine and Washington. A 2014 analysis led by National Oceanic and Atmospheric Administration 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)." [55]

Two studies examined whether farm escapes had any measurable genetic impacts on wild Atlantic Salmon populations in Maine. Both studies concluded that although there had been escapes from Maine salmon farms in the early days of their operation no evidence of any genetic impacts could be detected in local wild Atlantic Salmon populations.[56] 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.[57] The authors reported:

---

[54] Belle and Nash (2008) at 297-298.

[55] 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.

[56] King, T.L., W.B. Schill, B.A. Lubinski, M.C. Smith, M.S. Eackles, and R. Coleman. 1999. Microsatellite and Mitochondrial DNA Diversity in Atlantic Salmon with Emphasis on Small Coastal Drainages of the Downeast and Midcoast Regions of Maine. A report of Region 5, USFWS, Hadley MA, by USGS-BRD-Leetown Science Center, Kearneysville, WV.

National Research Council of the National Academy of Sciences, Committee on Atlantic Salmon in Maine. 2003. Atlantic Salmon in Maine. National Academies Press, Washington, D.C. (https://www.nap.edu/catalog/10892/atlantic-salmon-in-maine accessed January 26, 2020)

[57] 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).

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

A highly publicized net pen collapse and escape of farm-raised Atlantic salmon in Puget Sound during 2017 resulted in state legislation phasing out nonnative fish culture when existing permits expire; however, "The new law, with bipartisan support, and the clear and explicit backing from many tribes and environmental NGOs *unambiguously allows for the continued operation of commercial net-pen aquaculture in Puget Sound, including in areas where current operations currently exist* (page 2)."[58]

An initial analysis of the collapse by the Washington Department of Natural Resources concluded:[59]

> "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.

[58] Washington Department of Fish and Wildlife. 2020. Justification for the Mitigated Determination of Non-Significance (MDNS) for Washington Department of Fish and Wildlife SEPA 19-056 and for the Approval of Cooke Aquaculture Pacific's Marine Aquaculture Permit Application (https://wdfw.wa.gov/sites/default/files/2020-01/marine_aquaculture_permit_justification.pdf accessed January 26, 2020).

[59] 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).

2. Over time, the [escaped] 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)."

In the Washington case, 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."[60]

And state agency analysis of public comments further rebutted concerns that a unique pathogen or disease had been introduced.[61]

Relative to the Puget Sound fish farm that experienced a 2017 net pen system collapse. After a several year process that included public comment and litigation, the Washington Department of Fish and Wildlife analyzed more than 150 studies on marine aquaculture to conclude that farming of sterile, all-female steelhead posed no significant risk to the marine environment[62] and the State of Washington Department of Ecology approved Clean Water Act authorized National

---

[60] 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).

[61] 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).

[62] Washington Department of Fish and Wildlife news release: WDFW approves permit to farm sterile rainbow trout/steelhead in Washington waters, January 22, 2020. (https://wdfw.wa.gov/news/wdfw-approves-permit-farm-sterile-rainbow-troutsteelhead-washington-waters accessed January 12, 2021).

Pollution Discharge Elimination System permit modifications to allow the farming of the steelheads at four sites previously used to raise Atlantic salmon.[63]

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.[64] Containment management is based upon a hazard analysis critical control point program and has resulted in no escapes since 2003.[65]

The National Oceanic and Atmospheric Administration has developed a scientific decision-support tool called the Offshore Mariculture Escapes Genetics Assessment (OMEGA) model to better understand genetic effects should farmed fish escape and encounter wild stocks and aid in the design of management strategies to address the potential risks to marine resources.[66]

OMEGA is a mathematical model with inputs that include the size and growth characteristics of the cultured fish, the frequency and magnitude of escape events, survival rates of escapees in the wild, probability of escaped fish encountering wild counterparts and interbreeding, and the dynamics of the wild population. Outputs from OMEGA describe the influence these aquaculture escapees may have on the survival and fitness of the mixed population over time. NOAA Fisheries is using the OMEGA model to identify and evaluate the genetic risks associated with marine aquaculture operations, recommend management practices for responsible and sustainable aquaculture programs, explore the effects of regulatory and technical advances, and identify research priorities.[67]

Aquaculture critics focus upon perceived escape risks while rarely acknowledging national efforts to maintain recreational fishing opportunities or rebuilding at-risk aquatic species through purposeful release of cultured animals to enhance or recover federal or state listed species. Nationally, 809 hatcheries (85 federal, 435 state, 29 nongovernmental organization, 96 tribal/First Nation, and 164 other facilities) stock approximately 2.6 billion fish annually to enhance recreational fishing or recover at-risk species.[68] Trushenski et al. 2018 concluded that hatchery efforts:

---

[63] Department of Ecology news release, Ecology revises Puget Sound net pen permits for steelhead, January 6, 2020 (https://ecology.wa.gov/About-us/Get-to-know-us/News/2021/Ecology-revises-Puget-Sound-net-pen-permits-for-st accessed January 12, 2021).

[64] Goode, A. and F. Whoriskey. 2003. Chapter 13: Finding resolution to farmed salmon issues in eastern North America *in* Mills (ed) Salmon on the Edge. Blackwell Science, Oxford United Kingdom.

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

[66] Potential Risks of Aquaculture Escapes. NOAA Fisheries (https://media.fisheries.noaa.gov/2021-01/Fact-Sheet-Potential-Risks-of-Aquaculture-Escapes.pdf?null accessed January 14, 2021).

[67] Webpage describing and providing access to the Offshore Mariculture Escapes Genetics Assessment (OMEGA) model (https://www.fisheries.noaa.gov/offshore-aquaculture-escapes-genetics-assessment-omega-model accessed January 16, 2020).

[68] Trushenski, J.T., G.E. Whelan and J.D. Bowker. 2018. Why keep hatcheries? Weighing the economic cost and value of fish production for public use and public trust purposes. Fisheries. 43(6): 284-293.

- Strengthen food security and directly or indirectly employ hundreds of thousands of Americans, helping to drive the U.S. economy.
- Provide fishing opportunities and help to bring imperiled species back from the brink of extinction, protecting the cultural and ecological legacies that will be passed on to future generations.
- Are the "storefronts" of aquatic resource management and conservation, helping the public to learn about and appreciate fish, whether for their instrumental or intrinsic value.[69]

Marine aquaculture can and has contributed to improving climate change resilience in stocks, ecosystems, and communities by using different marine aquaculture tools and techniques. Aquaculture provides an alternative and augmentation to traditional wild-capture fishing, which can enhance the recovery of stocks under stress as well as provide economic benefit to fishing communities. Communities under stress can implement aquaculture as an adjunct, or even a replacement, for participation in wild-capture fisheries. In addition, aquaculture can propagate specific species under stress to augment the natural ecosystem. Aquaculture also has the potential to reduce the impacts of ocean acidification by culturing and augmentation of natural aquatic plants that reduce the levels of acidic components of seawater. Finally, culturing and propagation of specific species that are resistant to more acidic seawater can improve the ecological resilience of the ecosystems in which they are used as an augmentation.[70]

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

In 2018, about 88 percent (or over 172 million tons) of the 197 million tons of total global fish production was utilized for direct human consumption, while the remaining 12 percent (or about 24 million tons) was used for non-food purposes. Of the latter, 80 percent (about 20 million tons) was reduced to fishmeal and fish oil, while the rest (4 million tons) was largely utilized as ornamental fish, for culture (e.g. fry, fingerlings or small adults for on growing), as bait, in pharmaceutical uses, for pet food, or as raw material for direct feeding in aquaculture and for the raising of livestock and fur animals. Fish meal, fish oil and fishery by-products (skin, bone, and offal) are used in the production of terrestrial and aquatic animal feeds, biofuel and biogas, dietetic products (chitosan), pharmaceuticals (omega-3 oils), natural pigments, cosmetics, alternatives to plastic, and constituents in other industrial processes. A significant but declining proportion of world fisheries production is processed into fishmeal and fish oil because of increasing use of fishery by-products to produce fish meal and fish oil and the use of substitutes such as plant, insect, algae and microbial produced proteins and oils.

---

[69] Ibid at page 291.

[70] Corbin, J., J. Forster, J. Parsons, R. Rheault, G.K. Vick, D. Wallace and P. Zajicek. 2016. Appendix B: Aquaculture-based tools to enhance fisheries resiliency during climate change *in* Report of the MAFAC Coastal Resilience Working Group. National Atmospheric and Oceanic Administration, Marine Fisheries Advisory Committee (MAFAC), Washington DC. (https://www.fisheries.noaa.gov/national/partners/report-mafac-coastal-resilience-working-group accessed January 8, 2020).

Climate Resilience and Aquaculture. NOAA Fisheries (https://media.fisheries.noaa.gov/2021-01/Fact-Sheet-Climate-Resilience-Aquaculture-010621.pdf?null January 14, 2021).

Fishmeal and fish oil are still considered the most nutritious and most digestible ingredients for farmed fish, as well as the major source of omega-3 fatty acids (eicosapentaenoic acid [EPA] and docosahexaenoic acid [DHA]). However, their inclusion rates in compound feeds for aquaculture have shown a clear downward trend, largely as a result of supply and price variation coupled with continuously increasing demand from the aquafeed industry. They are increasingly used selectively at specific stages of production, such as for hatchery, broodstock and finishing diets. The incorporation of fishmeal and fish oil in grower diets is decreasing. For example, their share in grower diets for farmed Atlantic salmon is now often less than 10 percent. (FAO 2020: pages 60-64).[71]

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.[72] The National Oceanic and Atmospheric Administration and U.S. Department of Agriculture[73] support a research initiative to:

> "…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. (2019)[74] 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

[71] FAO. 2020. The State of World Fisheries and Aquaculture 2020. Sustainability in action. Rome. (https://doi.org/10.4060/ca9229en accessed October 14, 2020).

[72] Sustainable Aquaculture Feeds and Nutrition. NOAA Fisheries (https://media.fisheries.noaa.gov/2021-01/Fact-Sheet-Sustainable-Aquafeeds-Fish-Nutrition.pdf?null accessed January 14, 2021).

[73] 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).

[74] 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.

> 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)."

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)."

A paper by Kok et. al. (2020)[75] reexamined fish meal and fish efficiency assessments in light of progress to incorporate plant derived protein and lipids into fish feeds, insect meals, algae oils and fish processing by-products. The authors focused on a commonly used metric, Fish In : Fish Out ratio, meaning the amount of fish required in compounded fish feeds to produce an amount of farm-raised fish, and concluded:

> "Efforts to reduce the dependency of aquaculture on marine resources by alternate feed ingredients have significantly reduced the amount of fishmeal and fish oil in aquafeed formulations for most farmed fish species. Results show that most aquaculture species groups assessed in this study are net producers of fish, while farm raised salmon and trout are net neutral, producing as much fish biomass as is consumed. Of the species groups analysed in this research, only the production of eel is a net consumer of fish. However, it is important to note that FIFO could vary within species and between production systems. Overall, global fed-aquaculture as a whole, currently produces three to four times as much fish as it consumes (page 8)."

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 and that advances in the formulation of compounded feeds is advancing at a rapid and sustainable rate.

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, business regulations and permits and mandated minimum wage.

---

[75] Kok, B., W. Malcorps, M.F. Tlusty, M.M. Ethouth, N.A. Auchterlonie, D.C. Little, R. Harmsen, R.W. Newton and S.J. Davies. 2020. Fish as feed: Using economic allocation to quantify the Fish In : Fish Out ratio of major fed aquaculture species. Aquaculture Vol. 528 (https://doi.org/10.1016/j.aquaculture.2020.735474 accessed June 12, 2020).

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 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.[76] 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.
>
> 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)."

---

[76] 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).

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:

> "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)."[77]

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 counterintuitive given the 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)."[78]

---

[77] 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.

[78] 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 a discussion of the major factors which might affect the costs, prices, profitability, and competitiveness.[79] 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:
>
> - 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

[79] 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.

commitment. Numerous federal and state agencies are involved with maintaining the wholesome attributes of farm-raised seafood.

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.[80]

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.[81]

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.[82] 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.[83]

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 National Aquaculture Association has been working to develop markets that appreciate locally grown and high-quality fish, shellfish and seaweed products. And we are 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.

---

[80] Please visit https://www.fda.gov/Food/PopularTopics/ucm341987.htm.
[81] Please visit http://www.issc.org/.
[82] Please visit https://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/Seafood/ucm176892.htm.
[83] Please visit https://www.fda.gov/food/guidanceregulation/fsma/.