LIKE WATER AND OIL:

OCEAN-BASED FISH FARMING AND ORGANIC DON'T MIX

CENTER FOR
FOOD SAFETY

OCTOBER 2014

ABOUT US

CENTER FOR FOOD SAFETY (CFS) is a national, non-profit, public interest membership organization founded in 1997 to protect human health and the environment by curbing the use of harmful food production technologies and by promoting organic and other forms of sustainable agriculture. Our membership has rapidly grown to include over a half million people across the country that support organic food and farming, grow organic food, and regularly purchase organic. More information can be found at www.centerforfoodsafety.org.

Organic and Beyond Campaign

Center for Food Safety works to maintain and enhance strong organic standards that live up to the quality and integrity that consumers expect from organic products through legal actions, policy comments, public testimony to government agencies and Congress, and public education. We strive to evolve the organic ethic by promoting agriculture that is local, small, medium and family-scale, biologically diverse, climate friendly, humane, and socially just. The ultimate goal of our campaign is to move beyond the industrial agriculture model to a new vision and practice of organic farming that supports and sustains the natural world for future generations.

ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

OCEAN-BASED FISH FARMING CAN NEVER BE ORGANIC

Organic aquaculture[1] has the potential to minimize the environmental and human health impacts associated with aquaculture production. It also has the potential to supply a sustainably produced source of protein for human consumption. Yet, organic systems will require more than simply replicating existing ocean-based aquaculture systems with some minor tweaks. That is because most existing conventional facilities are more akin to intensive, industrial fish factories than organic farms. Therefore, to be able to grow, label, and sell fish as "certified organic" requires the development of a holistic approach of organic systems management—from facility placement to fish harvesting.

Like Water and Oil: Ocean-Based Fish Farming and Organic Don't Mix explains why not every type of aquaculture system or fish species can be certified organic, drawing from the scientific literature and experiences and mishaps of the conventional aquaculture industry. It discusses the large number of unpreventable fish escapes documented around the world and explains how weak reporting requirements allow underreporting of the vast number and volume of escapes that occur. The Report summarizes the array of synthetic, toxic substances and radionuclides that have been regularly detected in the marine environment and how the exposure and accumulation of these substances in farmed fish cannot be avoided. Negative impacts of open-ocean fish farms on ocean ecology are examined in terms of the spread of pathogens and pollutants, the alteration of marine food webs and the behavior of wild species—sealing the case that open ocean facilities can never be organic.

We believe that allowing these practices undermines the integrity of all organic farming systems and the organic label, and they do not meet the requirements of OFPA [“Organic Aquaculture Position Statement,” with 53 endorsements, Appendix A].

Currently, the U.S. Department of Agriculture (USDA) is poised to finalize organic aquaculture production regulations, based upon recommendations from its National Organic Standards Board (NOSB) of advisors. Despite all of the well-documented problems associated with ocean-based fish farming, as discussed at length in this report, the NOSB has recommended allowing ocean-based systems to be certified organic. They have also recommended allowing wild caught fish and their by-products to be used in feed, which is not 100% certified organic. This flies in the face of the Organic Foods Production Act (OFPA)’s[2] foundational requirement that all animals are fed a 100% organic diet.

For more than a decade, Center for Food Safety and a wide range of organizations and individuals from the organic community have repeatedly argued that ocean-based aquaculture can never meet the rigorous standards required of land-based organic farms. The intent of *Like Water and Oil* is to explain in detail the many compelling reasons why that is so as well as to recommend operational criteria to guide the evaluation and regulation of potential organic, closed-looped, recirculating land-based aquaculture systems. It is our hope that USDA will seriously take into consideration this comprehensive analysis before issuing final regulations on organic aquaculture that could put the entire U.S. organic industry in jeopardy by weakening the integrity of the USDA organic label.

MAJOR REPORT FINDINGS

Open-ocean fish farms can never be organic.

Inputs and outputs to the system cannot be monitored or controlled and neither can a farmed fish’s exposure to toxic synthetic chemicals, which are prohibited under OFPA and present in the marine environment.

Farming migratory fish can never be organic.

This statement holds true regardless of the type of system in which they are reared. That is because their confinement in fish farms would curtail their biological need to swim far distances, creating stress. Some migratory species are also anadromous, such as salmon, migrating between freshwater and the ocean during various life stages, a behavior not possible while in containment.

Farmed fish fed wild fish, meal or oil can never be organic.

That is because OFPA requires that all certified organic species are fed an organic diet.[3] Feeding farmed fish wild caught fish and related by-products—fish meal and fish oil—would increase pressure on already over-exploited and recovering fisheries that form the basis of the marine food web. It would also decrease the food supply of a wide range of native, aquatic species, including seabirds and sea mammals, contravening the USDA organic biological diversity conservation requirements.

These findings are supported by 53 endorsers, which are listed in the Organic Aquaculture Position Statement in Appendix A.

All organic production systems, whether marine or terrestrial, must adhere to the principles of organic. Certified organic fish farms must support biodiversity and biological cycles within the system, prohibit and eliminate dangerous inputs and outputs, and provide nutritious, naturally-suitable, organic feed preferably from within the system itself. Organic aquaculture systems of all sizes must facilitate the natural behaviors of all farmed species, minimize negative impacts to the surrounding environment and indigenous species, and prevent escapes into neighboring water bodies. As *Like Water and Oil* demonstrates, ocean-based aquaculture facilities cannot meet these minimum requirements, and therefore can never be considered organic.

While this Report details how and why open ocean aquaculture practices contravene the spirit, intent, and letter of OFPA, it does not completely close the door on prospects of creating a land-based organic system of aquaculture. The Report concludes by recommending essential principles that must guide the creation and operation of any organic aquaculture system, leaving open the question of whether a land-based, closed-loop, recirculating *organic* system could be possible. But, given the departure from organic soil-based systems around which OFPA was created, Center for Food Safety strongly recommends mandating substantial field-testing to ensure the operational criteria for different types of land-based farms can meet the high standards demanded by OFPA.

FISH ESCAPES CANNOT BE PREVENTED

Over 24 million fish have escaped from farms worldwide in just over two decades.

Decades of experience have shown the impossibility of preventing fish escapes from aquaculture facilities located in the open ocean, regardless of system design or containment management plans. The number of fish escaped from farms is immense[4]—over 24 million worldwide in just over two decades [see the Table in Appendix B]. In the first half of 2014 alone, 13 recorded escapes occurred, releasing a combined total of nearly 700,000 fish into oceans across the globe. If this escape trend continues, the aquaculture industry will be on track for experiencing over one million unintended fish releases in 2014.

A wide range of factors can cause escapes. When sited in the ocean, facilities are highly susceptible to breakages and breaches from predator attacks, storms, and strong currents. From facilities in Norway, a series of storms resulted in approximately four million escaped fish in a single year.[5] Low oxygen levels due to natural ocean cycles killed half the fish in a Canadian sea cage. The accumulated weight of the dead fish on the bottom broke the cage, releasing the remaining fish into the ocean.[6] Vandalism, equipment failure, boat propellers tearing nets, and human error such as workers accidentally dropping fish during handling and transfer all have contributed to farmed fish releases.[7]

In the first half of 2014 alone, 13 recorded escapes occurred, releasing nearly 700,000 fish into oceans across the globe.

DATA HIGHLIGHT FREQUENCY AND MAGNITUDE OF ESCAPES

The majority of marine finfish farms operate in only a handful of countries—Scotland, Norway, Chile, and Canada, with some additional production in the U.S. and the Mediterranean. In these countries, escapes are not isolated or rare occurrences. In a given year, a single company or facility will likely experience multiple escapes. Marine Harvest, for example, has reported 46 incidents of escapes from its facilities around the world in the past 15 years, resulting in the loss of at least 821,643 fish. During that same period, Scottish Sea Farms reported 21 escape incidents, unintentionally releasing 575,509 fish into the marine environment.[8] Recognizing the regularity of fish escapes from ocean-based net pens, the U.S. Council on Environmental Quality has stated that it "must be assumed that *escapes will occur*" from net pens[9] [emphasis added]. In the United States, between 1996 and 2007, nearly 800,000 reported farmed Atlantic salmon escaped from open-ocean facilities, the majority of which occurred in the Pacific Northwest. These non-native and invasive Atlantic species survive and successfully reproduce, threatening indigenous species of endangered Pacific salmon.

Accidental releases are exceedingly difficult if not impossible to prevent or control, particularly given the wide variety of reasons why escapes occur. Despite this fact, some trade groups and local industries argue that they can eradicate accidental releases through fish farm protocol management and training. In Maine, the aquaculture industry claims zero escapes have occurred from its coastal facilities since 2003. The Maine Aquaculture Association attributes this proclaimed success to its recognition, early on, that not only can equipment fail but also that humans make mistakes. In response, they developed standard operating procedures that emphasize reducing human error.[10] The implication of this is that employee error is largely to blame for the frequent escapes of hundreds of thousands of fish annually.

When the high volume and frequency of worldwide escapes is considered, the data suggest otherwise. With respect to the 233 documented fish escapes globally that have a known cause on record since 1995, only 33 incidents (or 14 percent of the releases) listed human error as a factor. In other words, about 5 out of 6 escape events were not due to human error. Severe weather and storms caused 24 percent of the escapes, predator attacks caused 20 percent, holes found in nets with no recorded primary cause (e.g., storm, predator) caused another 18 percent, and undefined equipment failures caused 13 percent. Additionally, cases of human error typically result in fewer escaped fish than the other common causes, with an average of 3,372 fish lost per escape. Escapes caused by severe weather average 36 times as many fish lost (119,904) and those caused by net holes about 5 times as many (15,892). These data suggest that Maine's emphasis on eliminating human error does not tell the whole story. Documented escapes from the global aquaculture industry strongly suggest that Maine's escapes record is more likely attributable to how escapes are monitored and reported to the authorities there than zero actual escapes.

INADEQUATE REPORTING MASKS THE MAGNITUDE OF ESCAPES

Ocean-based aquaculture regulation in the U.S. varies greatly from state to state and is largely self-regulated by the industry, especially regarding escape prevention and response measures. The industry primarily has been developed in Washington State and Maine. Only Maine has created a baseline for minimizing escapes, called the Containment Management System (CMS). Nonetheless, CMS is a set of minimum standards, and each fish farm creates its own escape prevention plans and response procedures.[11] The plans are audited by a third party annually or within 30 days of a reportable escape. In Washington State, ocean-based aquaculture facilities are required to outline best management practices for minimizing escapes in the permit application. The state's regulations allow individual facilities to develop their own procedures for determining what constitutes a reportable fish escape.[12] All of Washington's current offshore facilities are operated by a single company, Icicle Seafoods.

Compounding problems inherent in self-regulation and the inconsistencies in escape reporting requirements is the inadequacy of industry definitions of "reportable escapes." In the U.S., the number or volume of escapes permitted before an individual facility must report them to government officials varies greatly. In Maine, for example, a reportable escape consists of "25% or more of a cage population and/or more than 50 fish with an average weight of two kg (2.2 pounds) each."[13] This means that an escape of 49 large fish does not merit filing a report with officials, nor would an escape of 24 percent of the caged population if the fish were small, even despite the fact that a single cage can hold over 100,000 fish.[14] In Washington State, the government permits similar "biomass thresholds" before requiring government notification.[15] Allowing for self-reporting and acceptable release thresholds means that escapes consistently go undocumented.

Canada similarly allows for industry self-regulation. In October 2013, over 70 farmed salmon were found in rivers over the course of a few weeks. Based upon figures and dispersion/escape patterns from previous escapes, the Atlantic Salmon Federation estimated that these fish were part of a large escape comprised of over 50,000 fish. Even so, no corresponding escapes of that size had been reported.[16]

Norway, in contrast, is more heavily regulated, and their law requires licensed fish farmers to report any detected or suspected escapes to the Directorate of Fisheries. Even so, Norwegian officials have acknowledged that the fish farm industry has experienced numerous unreported escapes and that actual escape numbers are higher than the official statistics.[17] The law in Norway also allows the government to fine companies when fish escape their facilities in order to incentivize best practices in escape prevention.[18] Rather than encourage prevention measures, local NGOs (non-government organizations) argue that the fine has encouraged companies to fail to report escapes.[19]

> Restructuring of food webs from the introduction of non-native species can directly affect the food webs of surrounding forests due to the interconnectivity of forest and stream ecosystems.

ESCAPEES THREATEN WILD SPECIES AND ECOSYSTEMS

Frequent farmed fish escapes have negatively impacted wild fish populations by decreasing species diversity. During the listing of Atlantic salmon as an endangered species, the National Marine Fisheries Service/Fish and Wildlife Service (FWS) identified Atlantic salmon aquaculture facilities as one of the reasons for the decline in the wild species.[20] Farmed fish tend to be genetically homogeneous, with 70 percent of the eggs used in Atlantic salmon farming originating from just 40 breeding stocks.[21] They are also bred to be larger, with smaller fins, and to be more aggressive than wild fish. Although breeding performance of farmed salmon has been shown to be inferior to that of wild salmon, farm escapees have still successfully bred with wild salmon.[22]

Escapees may also swim through and inhabit areas in which they were previously absent. In the case of stream environments, the resultant restructuring of food webs from the introduction of non-native species can directly affect the food webs of surrounding forests due to the interconnectivity of forest and stream ecosystems.[23] A study of the effects of invading farmed trout on streams and surrounding riparian ecosystems found that the introduction of non-native rainbow trout altered the feeding behavior of native fish species. The alteration of feeding interactions caused a reduction in the emergence of adult aquatic insects, which in turn affected populations of forest spiders. Researchers referred to this food web impact as a "trophic cascade" and predict that reduced density of spiders and other small forest consumers would subsequently impact larger forest species.[24]

Escaped fish in the open ocean can also carry diseases and pathogens well beyond the facility from which they were reared, infecting other species with whom they come into contact. Infectious Salmon Anemia (ISA), for example, is a viral infection that originates in fish farms and typically only develops in marine environments. Farmed fish escapees in Canada have been documented to carry the disease to nearby rivers, transmitting it to wild salmon populations living in freshwater where the disease would otherwise have not been found.[25] Similarly, the Scottish government has reported that three out of four salmon escapes occurred from farms affected by Infectious Pancreatic Necrosis,[26] a highly contagious viral infection attributed to young *Salmonid* species held under intensively farmed conditions.[27] In yet another example, the furunculosis disease[28] spread quickly to roughly 70 percent of Norwegian farms after the industry received infected juveniles from Scotland.[29] Escapees from infected Norwegian farms were found in nearby rivers, and they are the suspected cause of a furunculosis epidemic among wild populations.[30]

Studies have shown that when farmed and wild fish interbreed their offspring have diminished survival skills, reduced fitness, and potentially altered life-history characteristics such as altered timing of development events.[31] However, this decreased fitness and survivability is primarily in the early development stages. Overall, farmed salmon escapees and "hybrid" salmon (offspring of farmed and wild fish) are less likely to survive past juvenile stages than wild salmon. However, due to the genetic selection in farmed fish for increased growth rate and larger size, those that do survive are soon able to out-compete wild salmon for resources.[32] This may be especially true when aggressive adult farmed fish return to spawning grounds where wild juveniles are developing.[33]

Researchers in Ireland have found that the interactions of farm escapees and wild salmon reduced the overall fitness of wild species. They concluded that continued escapes of farmed salmon could lead to the extinction of wild populations.[34] Pacific commercial fishers regularly catch Atlantic salmon that have escaped from aquaculture operations in Washington State and British Columbia. Atlantic salmon compete with wild Pacific stocks for food, habitat, and spawning grounds, and increasing numbers of Atlantic salmon have been observed returning to rivers on the West Coast.[35] Even in the Atlantic region, the U.S. Fish and Wildlife Service (FWS) concurs that "Atlantic salmon that escape from farms and hatcheries pose a threat to native Atlantic salmon populations."[36] They also predict that "escapement and resultant interactions with native stocks are expected to increase given the continued operation of farms and growth of the industry under current practices."[37]

CLOSED-CONTAINMENT OCEAN SYSTEMS NOT IMPENETRABLE

The ocean-based aquaculture industry has proposed and developed designs for closed-containment facilities—also called ocean-based solid wall systems—in attempt to address the problems associated with net-pen escapes. These facilities are still sited offshore in the open water and do not adequately address or mitigate the detrimental impacts of open-ocean aquaculture. Composed of either a flexible, bladder-like material or rigid metal, the farmed fish are not in direct contact with the marine ecosystem in which the facility rests. However, these "closed-containment facilities" are not completely closed because they take in water pumped in from the surrounding environment, which is not treated before entering the tank or when it is released back into the ocean.[38] Therefore, pathogens, diseases, and/or uneaten feed present in the system are flushed out into the ocean with the outtake water. Similarly, any contaminants present in the ocean freely flow into the aquaculture system, untreated, via the ambient sea water.

AgriMarine Industries, producers of "closed containment systems" claims that, "[W]ith solid-wall containment there's no possibility of interaction between farmed and wild fish, no fish escapes, and no predator interactions."[39] Yet, the potential hazards present in marine ecosystems—such as severe storms, strong currents, and large predators—make the promise of zero breaches unrealistic. In fact, in 2012 an extreme storm damaged AgriMarine's "solid-wall" demonstration farm in British Columbia, Canada, releasing nearly 2,800 salmon from the facility that was touted as the "leader in floating solid-wall containment technology."[40]

When Operations Manager at Creative Salmon Company was asked about whether the systems are escape-proof, he responded: "Typically, big escapes have been the result of serious events like major storms or equipment failures. But many minor escapes happen due to human error, harvesting, and that sort of thing. I don't think you can get around those sorts of human errors on a small scale."[41] Clearly this so-called "containment system" is a misnomer because it does not contain inputs or outputs to the system, and it does not prevent fish escapes.

CONSUMERS DEMAND THAT ORGANIC AQUACULTURE DOES NOT POLLUTE

In 2007 and 2008, Consumers Union (CU), the policy arm of Consumer Reports, conducted surveys of the American public regarding their concerns and perceptions of various aspects of the food industry. Poll results[42] showed that:

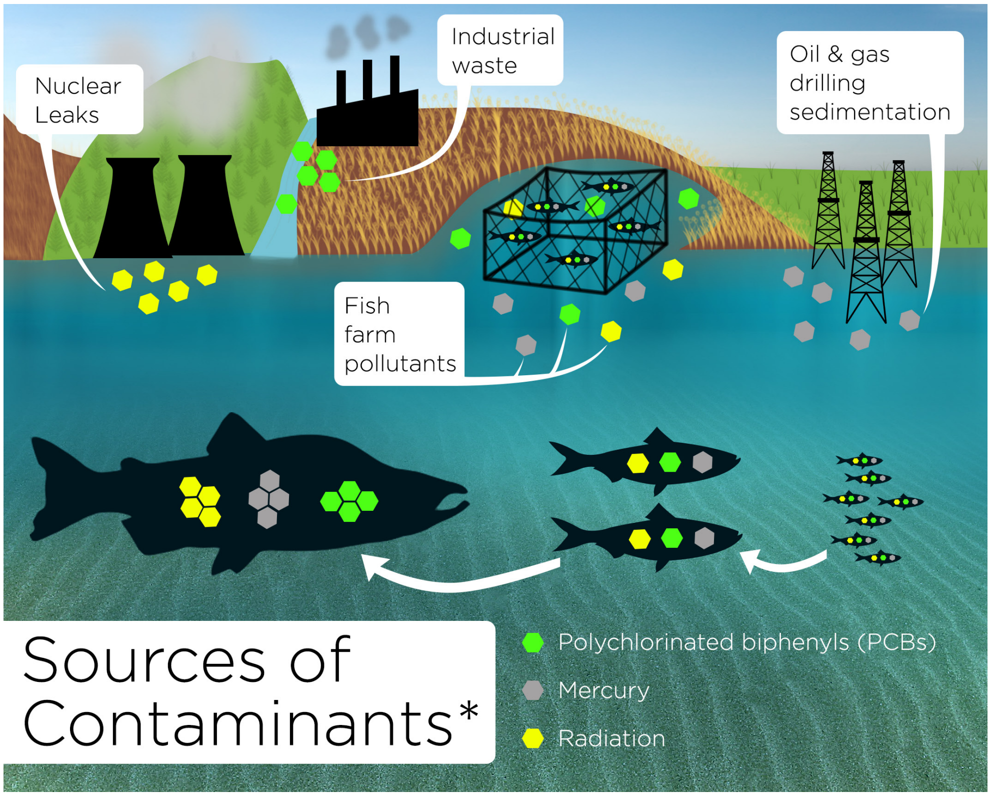
- **90%** of Americans agree that "organic" fish should be produced without environmental pollution and be free-of or low-in contaminants like mercury and polychlorinated biphenyls (PCBs).
- **93%** of Americans agree that organic fish should be produced with 100% organic feed like all other [certified organic] animals.
- **91%** of Americans agree that organic fish farms should be required to recover waste and not pollute the environment.
- **57%** of Americans registered concern about ocean pollution caused by "organic" fish farms.

In 2014, CU conducted another survey[43] of the American public related to perceptions of organic food, and found that:

- **84%** of consumers feel that organic standards for fish should require 100% organic feed.
- **67%** of consumers feel that organic standards for fish should not allow net pens in the ocean.

OCEANS EXPOSE FISH TO TOXINS AND RADIOACTIVITY

Organic plants and animals must be produced under conditions that can be monitored and controlled, for the most part. That simply cannot be the case with fish grown in the open ocean where they can ingest or absorb industrial and agricultural toxins and radioactivity. These hazardous materials can be found in the water column, sediment, or the fish, plants, and plankton upon which the fish feed. There is no way to know which pollutants farmed fish are exposed to, for how long, or in what combination or quantities. Wild forage fish used for feed in aquaculture facilities are similarly exposed to marine toxins in the ocean environment, which cannot be controlled.



*These are among the many toxic contaminants that persist in the ocean and bioaccumulate in fish.

PCBs BIOACCUMULATE AND BIOMAGNIFY IN FISH

PCBs persist in the environment indefinitely and have been documented to reach locations as far as Antarctica.

Polychlorinated biphenyls (PCBs) are mixtures of synthetic and organic chemicals that were developed to take advantage of their capacity to burn only at very high temperatures. Common uses include fire retardants, insulators, and plasticizers in electrical devises and electricity conductors.[44] PCBs are most often released into the environment from leaking transformers, capacitors, and other electrical equipment, illegal dumping, and leaching hazardous waste landfills where they contaminate soils, run off into nearby surface and ground water, and accumulate in ocean sediment.[45] Since PCBs persist in the environment indefinitely, they have been documented to travel to long distances well-beyond where they were first released—in locations as far away as Antarctica.[46]

The U.S. Environmental Protection Agency (EPA) categorizes PCBs as a "probable human carcinogen," especially of the liver.[47] In 1976, Congress passed the Toxic Substances Control Act (TSCA), which banned the production of PCBs, but since they are long-lasting pollutants that cycle through ecosystems they still persist in the environment today.[48] Human health studies have linked PCB exposure to reproductive disruption, neurobehavioral and developmental deficits in children, and increased risk of cancers such as non-Hodgkin's lymphoma.[49]

PCBs are lipophilic, meaning they bond to fatty tissue. In the marine environment, they accumulate in the fatty tissue of fish, which are exposed from both the surrounding water and from contaminated food sources.[50] Large marine species are especially vulnerable to accumulating high levels of PCBs in their fatty tissue. These highly toxic and persistent chemicals biomagnify as they pass through the food web and larger fish receive their own doses of contaminants plus those of the smaller fish they eat. Salmon are a particularly fatty species of fish,[51] and thus susceptible to accumulating and storing lipophilic contaminants. Wild salmon, which typically live for only 2 to 8 years, are not exposed to contaminants for the same duration as other large, predatory fish species. They therefore do not bioaccumulate as many toxins in their tissues. Tuna, for example, can live up to 32 years in the wild and samples showed higher concentrations per gram of PCBs and polychlorinated dibenzo-*p*-dioxins (PCDDs) than salmon samples.[52]

Studies from around the world have consistently demonstrated that farmed salmon have higher levels of PCBs in their tissues than their wild counterparts,[53] and researchers have attributed this to the presence of contaminants in feed composed of wild-caught fishmeal and oils.[54] A study by researchers at the University of Albany tested farmed salmon tissue samples from Maine, Canada, and Norway, as well as wild salmon tissue samples from Alaska. The researchers found concentrations of PCBs ranging from about 14 to nearly 30 parts per

PCB levels have been found in farmed Atlantic salmon three to six time higher than the tolerable daily intake levels set by the World Health Organization.

billion (ppb) in farmed samples compared with only 5 ppb in wild.[55] Canadian researchers in British Columbia have found PCB levels in farmed Atlantic salmon three to six times higher than the tolerable daily intake levels set by the World Health Organization (WHO).[56] Similar testing conducted in Europe has found PCBs in farmed salmon samples at levels that pose health risks to consumers, especially young children.[57] In addition, a technical review by the European Commission found that animal feed made of fish meal contained the highest levels of PCBs of all feed sampled.[58]

MERCURY BIOACCUMULATES AND BIOMAGNIFIES IN FISH

Mercury is a dangerous neurotoxin that can adversely affect the brain, heart, and immune system, especially those of children and developing fetuses. Chronic exposure to mercury can cause problems such as learning disabilities and developmental delays.[59] EPA acknowledges that fish consumption dominates all other pathways for human exposure to mercury,[60] and the U.S. Food and Drug Administration (FDA) has indicated that fish and shellfish are almost *exclusively* the source of mercury in U.S. diets.[61] An EPA study of over 1,700 women found that mercury concentrations in the blood were seven times higher for those who reported eating fish and/or shellfish meals nine or more times within the past 30 days than for those who reported eating none.[62]

Mercury has historically been used in a variety of industrial processes and it continues to enter the environment regularly as a result of the combustion of mercury-containing fuels or waste.[63] Once deposited, it may be remobilized later.[64] Mercury may enter waterways directly or ultimately reach waterways when atmospheric mercury is deposited on land and washed into streams.[65] Mercury is converted to a highly toxic form called methylmercury in the environment and research suggests that aquatic sediments are where this conversion most commonly occurs.[66]

Recent reports have demonstrated a connection between oil and gas rigs and elevated mercury levels found in sediment and wild-caught fish. Scientists attribute the contamination in and around the rigs to drilling muds[67]—a mercury-rich mixture of sediment and materials used to cool and lubricate drill bits that bore into the ocean.[68] The U.S. government estimates that 0.8 metric tons (1,600 pounds) of mercury is released into the Gulf of Mexico from offshore oil and gas drilling per year.[69] Researchers from Texas A&M University studied benthic systems near three rigs in the Gulf of Mexico and found that sediments within a few hundred feet of two rigs had mercury levels many times higher than base levels in Gulf of Mexico sediments.[70] Data also indicated that shrimp and fish caught beneath the rig where the most contaminated sediments lie had average mercury levels two to five times higher than those caught around the least contaminated rigs.[71] High levels of mercury have been documented in sediments 12 years after drilling has stopped.[72]

Fish can absorb mercury as contaminated water passes over their gills, as well as by consuming other contaminated species.[73] Mercury is most readily absorbed by lower-trophic species such as algae and plankton and biomagnifies in the food chain so that larger fish species accumulate higher doses of mercury.[74] In addition, Canadian researchers have demonstrated that the presence of fish farms depletes the oxygen in the sediments beneath, creating conditions that convert deposited mercury to a form that is accessible to marine organisms and thus enters the food web.[75]

Persistence of mercury in ocean sediments and its mobilization from fish farm activity make exposure to mercury by farmed fish impossible to prevent.

In response to concerns from indigenous communities in British Columbia, Canada, researchers tested culturally-important fish species in traditional harvesting waters of three First Nations' territories: the Ahousaht, the Kitasoo/Xaixais, and the member nations of the Musgumagw Tsawataineuk Tribal Council. Samples of two species of rockfish taken down-current from active salmon farms had higher concentrations of mercury than those taken from sites not directly down-current.[76] Researchers attributed this to the fact that the rockfish consumed smaller species that had previously fed on the fish waste and uneaten feed (fish meal/oil) from the salmon farms, thus biomagnifying the mercury levels in the rockfish. The persistence of mercury in ocean sediments, combined with the likelihood of it being mobilized from fish farm activity makes exposure to mercury by farmed fish impossible to prevent.

RADIATION BIOACCUMULATES AND BIOMAGNIFIES IN FISH

Exposure of farmed fish to radioactive contamination from the Fukushima, Japan, nuclear power plant and other past or future leaks of radioactive material represents an issue of considerable concern. Ocean-based radiation from Fukushima is expected to reach as far as the U.S. West Coast[77] and mix to depths of 1500 meters.[78]

Cesium-134, cesium-137,[79] and cobalt-60[80] from Fukushima have been detected in fish, soil, and marine plant samples from Japan.[81] Tritium[82] and strontium-90[83] have leaked into the ocean in the magnitude of Terabecquerels (10^{12}) and Petabecquerels (10^{15}), respectively. These radionuclides will be present in the Pacific for decades to come.[84]

Sediments, seaweeds, plankton, and fish can absorb radionuclides from both the surrounding water and contaminated food sources. Concentrations of radioactivity increases in larger fish species as they bioaccumulate and biomagnify in the food web.[85] Farmed fish in the open ocean are particularly susceptible to contamination because they are fed diets consisting of highly-concentrated wild-caught species. Thus, they receive their own exposure as well as exposure to more contaminants through the fish meal and fish oils they eat. Some predatory fish species living near Japan continued to contain cesium levels that exceed regulatory limits more than one year after the Fukushima meltdown.[86] Studies have also concluded that it is possible for concentrations in fish tissue to exceed that of the ambient water as radiation bioaccumulates and biomagnifies in the food web.[87] Also, contaminants may remain in the feces or other detrital particles that settle to the seafloor, again accumulating in sediments and potentially reentering the food chain via bottom dwellers or other sediment disturbances,[88] such as dredging.

Although radionuclides are excreted from fish rapidly at first, a significant percentage may persist in tissues for much longer.[89] Concentrations of Fukushima-derived radioactivity have persisted longer than researchers initially predicted, even in fish that migrated away from Japanese waters. For example, despite having traveled the length of the Pacific, some bluefin tuna caught near California still contained low levels of cesium in their muscle tissue[90]—roughly 6%[91] of their estimated concentration upon leaving Japan. Other large, carnivorous, and migratory fish species will likely have similar difficulties completely excreting Fukushima radioisotopes, especially as the marine food web and ambient water continue to be sources of regular contamination.

The presence in the marine environment of these artificial radioisotopes—by-products of human-made nuclear reactions—means that farmed fish in open-ocean facilities, and those fed wild fish meal and oil, may concentrate low levels of radiation in their bone, blood, organs, muscle, and other tissue. This further compounds the difficulties of strictly regulating open ocean organic aquaculture systems. It would also make it impossible to differentiate organically farmed fish from their conventional counterpart in the marketplace.

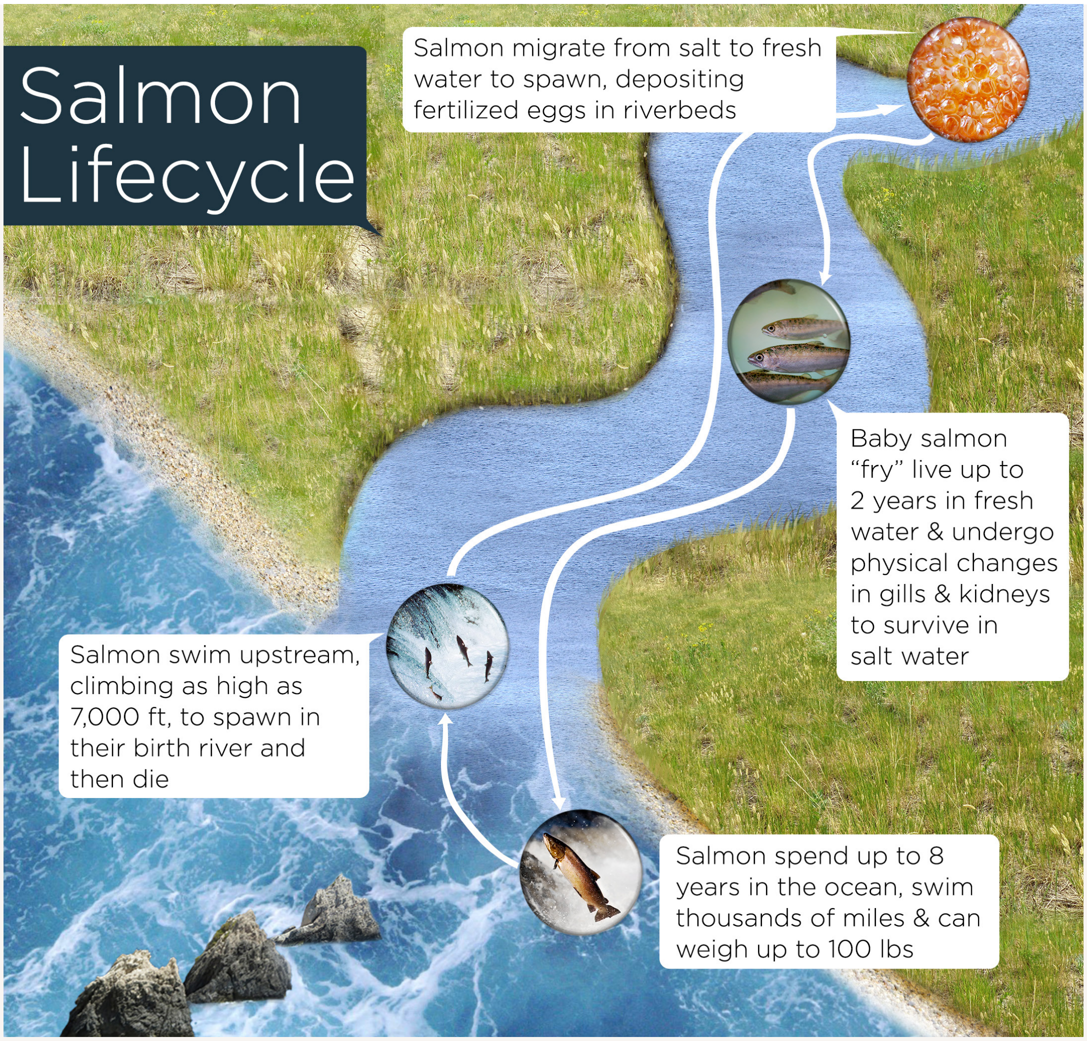
MARINE ECOLOGY IS NEGATIVELY IMPACTED

Organic production systems must be designed to promote and enhance biological diversity of both the production system itself and its surrounding environment, in accordance with organic regulations.[92] The use of minimal off-farm inputs is expected as well as management practices that restore, maintain, and enhance ecological harmony.[93] Yet that has not been the practice of open-ocean fish farms. On the contrary, ocean-based aquaculture poses a significant threat to wild marine species and ecosystems through the alteration of wild fish diets and behavior, the overexploitation of fisheries for feed stocks, the spread of pathogens, the accumulation of pollutants, and harm caused to large marine predators in the vicinity of fish farms.

OCEAN-BASED FISH FARMS ALTER WILD SPECIES' BEHAVIOR AND PHYSIOLOGY

The mere presence of fish farms negatively impacts wild marine life that congregate around cages, as they are subject to ecological processes which differ greatly from natural marine habitats.[94] Marine aquaculture cages have been referred to as fish aggregation devices (FADs) because of the large numbers of wild fish attracted to the structures.[95] Unlike other objects that serve as aggregation devices—which can be naturally occurring, like logs, or artificial, such as docks and oil platforms—fish farms function as "enhanced aggregating devices" due to the availability of food.[96] Uneaten feed pellets and fish wastes empty from cages directly into the ocean environment, changing diet and feeding behavior[97] and substituting large portions of the natural diets of wild fish with manufactured food pellets.[98]

Changes in the diets of wild fish that linger near fish farms in turn alters fish's physiological condition by changing the fat content and fatty acid composition in their tissues. These modified fat levels have been documented to interfere with reproduction and adversely affect egg quality.[99] A study from the University of Alicante in Spain found significant morphological changes in farm-associated wild fish, visible to the naked eye, including an apparently arched spine, abnormal pelvic and caudal fins, and distinct liver size, compared with wild fish of the same species in areas distant from farms.[100] Wild pollock captured near Mediterranean



Salmon Lifecycle

Salmon migrate from salt to fresh water to spawn, depositing fertilized eggs in riverbeds

Baby salmon "fry" live up to 2 years in fresh water & undergo physical changes in gills & kidneys to survive in salt water

Salmon swim upstream, climbing as high as 7,000 ft, to spawn in their birth river and then die

Salmon spend up to 8 years in the ocean, swim thousands of miles & can weigh up to 100 lbs

sea cages also had markedly different body form and liver size than those caught in distant areas.[101]

To protect against these well-known health impacts on wild salmon in particular, the State of Alaska passed legislation to prohibit open-ocean fish farming in 1990. The legislature took a stand against open ocean fish farming to avert "persistent risks to the health of the marine resources of Alaska."[102]

FISHMEAL AND FISH OIL THREATEN WILD FISH STOCKS

When the Organic Foods Production Act (OFPA) was passed in 1990, Congress intended for fish farming to adhere to the same rules as all other organic systems of production. Under the law, all "organic production" systems must comply with general management criteria to foster the cycling of resources, promote ecological balance and conserve biodiversity.[103]

SALMON'S DEVELOPMENTAL AND MIGRATION PATTERNS DEFY CONFINEMENT

Raising salmon in a confined fish farm interferes with the fish's natural behavior, which runs contrary to organic animal rearing practices. The life history of all salmon is complex, highly variant, and involves an incredibly long migration of thousands of miles between fresh and salt water. While there is only one salmon species native to the Atlantic Ocean, Atlantic salmon, the Pacific Ocean is home to five distinct species: coho, chinook, sockeye, pink, and chum.[104]

Salmon hatch in the spring in either lakes or rivers and subsist on their egg yolk sac until they can swim to the surface. Pink and chum salmon head directly to sea, while the others remain in freshwater for periods of 5 months up to several years.[105] Environmental cues which are not fully understood cause Pacific salmon fry (babies) to migrate downstream. During their migration, the salmon go through physiological changes called smolting to physically prepare to live in sea water. Atlantic salmon smolt while still living in their spawning grounds, and may spend up to 8 years in freshwater before migrating.[106]

Some species may spend 7 to 8 years at sea while others, like the Pink salmon, spend 18 months before returning to their spawning grounds.[107] It is not fully understood how salmon detect their birth streams—through smell, pheromones or the earth's magnetic field—but they possess a remarkable "homing instinct" that drives them to swim thousands of miles upstream to spawn where they were born.[108] Most salmon spawn only once or twice in their lifetime, but some Atlantic salmon can spawn up to seven times.[109]

Given the complex nature of salmon's lifecycle, which is dependent upon its ability not only to migrate long distances but also to swim between fresh and salt waters, salmon aquaculture can never be organic. Such confined systems of production would interfere with salmon's natural behavior and, therefore, not comply with organic standards of animal production.

For wild caught fish and its by-products used in fish farm feed to meet even these general criteria of organic is simply not possible. On the contrary, the exploitation of fish in the service of fishmeal and fish oil production actually harms the ecological balance of marine ecosystems. Moreover, it has been well-documented that fisheries that provide fish for the production of fishmeal and oil have harvested at rates that have reached or exceeded the rates at which the stocks can naturally replenish.[110] According to the Food and Agriculture Organization's (FAO) *State of the World's Fisheries and Aquaculture*, the primary stocks of Peruvian anchoveta, Japanese anchovy, and Atlantic herring—the most common pelagic species harvested for fishmeal and fish oil—are either fully exploited or depleted.[111]

OFPA requires organic farmers to produce a written Organic System Plan (OSP) to document all aspects of production including inputs and outputs.[112] This type of documentation is not possible when fish farms are located in the ocean where water freely flows in and out of the system carrying a wide variety of substances.

Primary stocks of the most common species harvested for fishmeal and oil are either fully exploited or depleted, according to the Food and Agriculture Organization of the United Nations.

In addition, the law requires that organic products are produced and handled without the use of synthetic chemicals, with the exception of those allowed on the National List.[113] As this Report has already addressed, prohibited synthetic toxic chemicals such as PCBs, mercury, and even radionuclides circulate within ocean ecosystems, making the bioaccumulation and biomagnification of these substances in wild fish inevitable.

The aquaculture industry is by far the largest consumer of fishmeal and fish oil, using about 46 percent of the global fishmeal supply and 81 percent of the global fish oil supply.[114] Studies estimate that it can take between 1 and 6 pounds of wild fish to produce 1 pound of farmed fish, depending upon the species.[115] The U.S. National Marine Fisheries Service estimates that producing 1 pound of farmed salmon can use the oil of approximately 5 pounds of wild fish.[116] The International Fishmeal and Fishoil Organization (IFFO) estimates that aquaculture of all *Salmonid* species, which includes trout, requires 1.4 pounds of wild fish to produce 1 pound of farmed fish.[117] This practice is unsustainable and damaging to marine ecosystems, and therefore would not qualify as certified organic given organic's requirements to conserve biodiversity and promote ecological balance.

OCEAN-BASED FISH FARMS SPREAD DISEASE AND PATHOGENS

When packed densely together in aquaculture operations, fish are exposed to pathogens in the marine environment.[118] Fish farms also alter the surrounding ecology to such an extent that they actually foster the proliferation of pathogens. A 23-year study in Finland found that not only do the high stocking densities of homogenous fish enhance transmission opportunities of common pathogens, but fish farms also promote the evolution of more virulent strains.[119] The now defunct Kona Blue Water Farms in Hawaii encountered problems with skin flukes, a parasitic flat worm that attaches to fish to eat their skin and suck their blood.[120] That company also experienced outbreaks of streptococcus infections.[121]

In the case of salmon, the U.S. Fish and Wildlife Service (FWS) has observed that while fish diseases have always affected wild Atlantic salmon, "the threats of major loss due to disease are generally associated with salmon aquaculture."[122] Sea lice is one of the most notorious pathogens associated with aquaculture facilities. Salmon farms have exposed wild pink salmon to lice infestations in British Columbia's Broughton Archipelago, resulting in a "sharp decline" in wild population.[123]

Infectious salmon anemia (ISA) also has been a major problem for salmon farms in several countries. ISA is a viral infection that has no treatment. It is characterized by fluid accumulation in the body cavity and hemorrhaging of internal organs.[124]

Norway first reported the disease in 1984, and it later spread to Canada, Scotland, the Faroe Islands, and the U.S.[125] From 2007 to 2009, the virus wreaked havoc on the salmon industry in Chile, killing off approximately 50 percent of the farmed salmon population and putting at least 7,000 people out of work.[126]

Infectious salmon anemia had never been seen in wild salmon until 1999, when it was found in wild Atlantic salmon in New Brunswick, Canada, and Scotland.[127] The FWS and National Oceanic and Atmospheric Administration (NOAA) have identified aquaculture as the specific origin and route of ISA infection to wild populations. They specifically concluded that ISA was known to cause disease only in "artificially confined" fish and that it was not observed "in free ranging salmon or other species until very recently."[128] Now, the virus has not only infected wild and farmed salmon, but farmed rainbow trout, wild sea trout, and eels.[129]

Scotland's 350 marine salmon farms generated more sewage waste (measured in terms of nitrogen and phosphorous) than the country's human population.

FISH FARM WASTE POLLUTES OCEANS AND ALTERS FOOD WEBS

Fish farms can be an enormous source of toxic pollution as well as untreated fish waste, uneaten feed, and dead fish which empties directly into the ocean without filtering. This waste has been shown to alter fragile marine habitats.[130] A study commissioned by the World Wildlife Fund found that Scotland's 350 marine salmon farms generated more sewage waste (measured in terms of nitrogen and phosphorous) than the country's human population.[131] Researchers in Italy found that aquaculture facilities were responsible for an increase of nutrients (or pollutants) in a gulf off the Italian coast and concluded that, "off-shore aquaculture may affect the marine ecosystem well beyond the local scale."[132]

Effluent from offshore facilities has such a high nutrient content that it contributes to toxic algal blooms and hypoxic zones.[133] This fish waste sometimes creates a visible "plume" on the surface of the waters surrounding the cages.[134] Recent studies have observed shifts in the behavior and interactions of marine communities surrounding fish farms, which they attribute to the nutrient buildup that occurs as fish waste and uneaten feed drift outside the permeable confines of open ocean facilities. In several cases, this build-up created shifts in the way organisms in the ocean environment obtain and process food.[135] The long-term implications of this shift may mean changes to regional food webs where ocean-based fish farms are located.[136]

In the mouth of the Gulf of Northern Italy, the presence of aquaculture facilities has had a measurable impact on the waters within a ten-mile radius.[137] A study, which is the first of its kind in terms of the scale of impacts considered, found overall increased levels of chlorophyll-a throughout the entire gulf. Researchers concluded that this was "mostly as the result of the chronic release of nutrient

Seal Protection Action Group in Scotland revealed that as many as 5,000 seals are being shot annually by Scottish fish farmers, in what amounts to a "secret slaughter."

waste produced by local aquaculture…[observable] at a spatial scale never considered before."[138] Chlorophyll-a concentrations are correlated with the derivatives of nutrients such as nitrogen and phosphorous, both of which are typically excreted at high concentrations from fish farms.

Exacerbating this issue is the fact that wild fish tend to aggregate in large numbers in the vicinity of fish farms. One study observed as many as 30 unique species surrounding fish farms. Researchers have estimated that aggregate biomass of fish around certain Mediterranean net pens reached 40 tons per site.[139] This high concentration of fish found in the immediate vicinity of net pens can be 20 times higher compared to wild areas 200 meters away.[140] It stands to reason that this aggregation of wild fish in the vicinity of fish farms further increases waste pollution in the surrounding waters and benthic environment.

OCEAN-BASED FISH FARMS POSE RISKS TO LARGE MARINE PREDATORS

In April of 2007, 51 California sea lions died in a mass drowning after they were caught in the nets of a fish farm near Vancouver Island.[141] It is likely the harem of sea lions, naturally attracted to the captive fish, was attempting to eat fish in the nets and got tangled in the process.

Anecdotal evidence also suggests that fish farming may negatively affect endangered great white sharks. Great whites have been observed visiting tuna farms off the coast of Mexico and southern Australia, and several have been killed because they threatened the valuable tuna fish farms.[142] A similar incident occurred at the Hawaiian aquaculture facility, Kona Blue Water Farms, when a 16-foot tiger shark (considered a sacred animal to native Hawaiians) was killed after spending too much time around the farm and one of the company's divers.[143]

In the most horrific and ongoing example, campaigners for the Seal Protection Action Group (SPAG) in Scotland revealed that as many as 5,000 seals are being shot annually by Scottish fish farmers, in what amounts to a "secret slaughter."[144] The group has witnessed the shooting near fish farms, and its members have come across seals washed up on shore with bullet holes in their heads. According to a representative of SPAG, "The seal shooting takes place in very remote locations in sea lochs around Scotland and there are no witnesses, and under the law the industry doesn't even need to release the figures of the numbers they have killed." The farming industry argues that the killings are necessary to protect their investment, and alleges the number is closer to 500. This is still a high number considering that there has been a decline in seal populations, especially around fish farms.[145]

SOY-BASED FEED UNSUITABLE FOR FISH AND NEGATIVELY IMPACTS OCEAN ECOLOGY[146]

In response to criticisms that ocean aquaculture depletes and threatens wild marine species because they use fishmeal and oil in feeds, the soy industry seized the opportunity to create a soy-based fish feed. However, soy is an unsuitable fish feed and an unnatural component of marine ecosystems. It is not easily digestible for fish and it can lead to reduced growth rates and inefficient feed use.[147] Soybeans contain lower levels of essential nutrients that fish need to survive—lower than fishmeal in 9 of the 10 essential amino acids.[148] They contain high levels of carbohydrates, including two types that are indigestible for fish.[149] One carbohydrate, non-starch polysaccharides (NSPs), interferes with the ability of fish to digest feed, thus making it difficult for the fish to obtain the energy they need.[150]

Soybeans also contain protease inhibitors that damage the enzyme balance in fish digestive tracts, impeding their ability to digest and utilize soy.[151] These limits of soy feed have led the America Soybean Association to conclude that "despite years of research funded both by government and industry, there are still unidentified factors in plant feedstuffs that limit its use in diets for carnivorous species, including most marine species of commercial importance, as well as salmon and trout."[152]

Soy also can be toxic to fish in the wrong quantities. When the fraction of soybeans in fish feed is too high, fish may develop an inflammation of the lower intestine called enteritis.[153] This inflammation may be sparked by immunological food intolerance.[154] Trout and salmon that are fed soy, for example, sometimes mimic the human allergic reaction, suffering skin lesions, alterations of the digestive tract, and excessive mucus in the feces.[155]

Moreover, soy fed to farmed fish is also detrimental to marine ecosystems. Because soy is difficult for fish to digest, feeding fish soy and other plant-based feeds causes them to produce higher levels of excrement.[156] Soybeans also contain phytoestrogen, an estrogen-like chemical produced by plants, the impacts of which are deeply concerning but far from understood. Research has confirmed that the phytoestrogens in soybeans stimulate changes in the reproductive organs of female fish during the oestrous cycle and promote the development of female secondary sexual characteristics.[157] When eels were fed isolated phytoestrogens that are present in soy, researchers found that 11 times more eels became females than in the control group.[158]

Insufficient research exists to know at what levels soy feed in the aquatic environment could harm reproduction of native fish species in the surrounding areas, but this lack of understanding is reason enough to not allow soy-based diets, even if they are certified organic, to be fed to farmed fish in the open ocean.

CONCLUSION

OCEAN-BASED FISH FARMING CAN NEVER BE ORGANIC

Center for Food Safety and 52 additional endorsers (see Appendix A) categorically oppose industry and government efforts to allow the following aquaculture practices to be certified as organic:

- *Open-ocean fish aquaculture systems of any type*
- *Farming of migratory fish*
- *Wild caught fish and fish meal and/or fish oil from wild fish used as feed*

We believe that allowing these practices undermines the integrity of all organic farming systems and the organic label.

INLAND, CLOSED-LOOP, RECIRCULATING SYSTEMS: CAN THEY BE ORGANIC?

Like Water and Oil: Ocean-Based Fish Farming and Organic Don't Mix details how and why open ocean aquaculture practices contravene the spirit, intent, and letter of OFPA. However, it does not completely close the door on prospects of creating land-based systems of organic aquaculture. Center for Food Safety believes that land-based, closed-loop, recirculating systems have the potential to meet OFPA criteria and become certified organic, but operational criteria for those types of systems have yet to be developed and put to the test.

Given the departure of aquaculture systems from the soil-based systems around which OFPA was created, specific land-based fish farm regulations must be developed. That is why Center for Food Safety strongly recommends mandating substantial field-testing to ensure that operational criteria for different types of land-based fish farms can meet OFPA's high bar for organic integrity. Such systems must be evaluated and approved by the USDA's National Organic Program, at first on a case-by-case basis, in consultation with the National Organic Standards Board (NOSB) and with public input, before they are allowed to carry the USDA organic seal. This would allow for the highest level of scientific and policy-making expertise to be brought to bear on the development of this novel, organic, industrial sector before it is fully commercialized.

All organic systems must ultimately confront the limitations of scale. Certainly, from an organic systems perspective, the issue of scale necessitates that the government carefully assess the point at which synthetic inputs are used to prop-up and maintain the system—such as to prevent the spread of disease and fish deaths—rather than used as an occasional additive. It is critical that checks and balances are established within the organic aquaculture regulations to ensure that large-scale, industrialized, ocean-based fish farms, akin to concentrated animal feeding operations (CAFOs) on land, are never permitted to be certified as organic.

Whether marine or terrestrial, all organic systems must adhere to the NOSB principles of organic[159] as well as OFPA and its supporting standards. Certified organic fish farms must enhance biodiversity and biological cycles, prohibit and eliminate dangerous inputs and outputs, and provide nutritious, naturally-suitable, organic feed, preferably from within the system itself. Organic aquaculture systems of all sizes must be able to facilitate the natural behaviors of farmed species within the system, minimize negative impacts to the surrounding environment and indigenous species, and prevent escapes into neighboring water bodies. **As this Report has demonstrated, ocean-based aquaculture facilities cannot meet these minimum requirements and, therefore, can never be considered organic.**

We recommend that the NOSB principles of organic[160] guide the creation and operation of any potential land-based, closed-loop, recirculating organic aquaculture system. In this vein, we urge that the following operational criteria provide the foundation for the development and regulation of organic aquaculture systems:

✓ Enhance the biodiversity and aquatic ecology within the system to minimize external inputs. This includes growing plants, bivalves, other shell fish and bottom feeders within the system to filter waste, supply nutrients, and provide habitat and shelter.

✓ Prohibit dangerous inputs and outputs. This includes materials already prohibited in organic such as: antibiotics, genetically engineered organisms (GMOs), hormones, growth regulators, synthetic pesticides and fertilizers, synthetic dyes and colorants, and all other substances incompatible with organic such as nanomaterials.

✓ Use nutritious, 100% certified organic feed, as is required for all organic livestock and poultry producers under OFPA. The use of wild or non-organic farmed fish meal and fish oil in feed must be strictly prohibited.

- ✓ Synthetic materials of any type must not be used to fulfill system functions such as feeding and filtering, and they must not be used as a crutch to prop up overcrowded or poorly designed systems. The limited synthetics that are permitted must be thoroughly vetted through a newly established materials review process specifically tailored for aquaculture systems. Synthetic materials already on the National List cannot automatically be allowed in organic aquaculture systems, due to the different ways in which materials react, persist, dissolve, settle, and disperse in water versus soil environments.

- ✓ Stocking rates and the living environment of the system must promote and maintain the health and welfare of fish and other living organisms in a harmonious manner and non-stressful environment that is appropriate to the species and their reproductive needs.

- ✓ An Organic System Plan[161] must be required, complete with records and audit trails, to allow certifiers to verify inputs, outputs, and biodiversity conservation and to track fish products from the aquaculture facility to the point of purchase.

ENDNOTES

[1] In this document, the terms "aquaculture" and "fish farms" are used interchangeably.

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[8] Based on data compiled by CFS available in Appendix B, it is worth noting that these are the *reported* escapes; however, due to weak reporting requirements an untold number of unreported escapes occur annually, as described in detail in this section.

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[161] An Organic System Plan (OSP) is required by all organic growers and it is open to inspection by the USDA-deputized, third-party, organic certification agency. It describes in detail the inputs, outputs and management system used to grow certified organic crops and livestock.

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p. 5 70M1085-01 - Southern Bluefin Tuna (Thunnus maccoyii), caught in the netting of a fish net holding pen, at a fish farm off Port Lincoln, South Australia. Photo Copyright: © David Fleetham/OceanwideImages.com

APPENDIX A

ORGANIC AQUACULTURE POSITION STATEMENT

We, the undersigned, stand united in our opposition to allowing the following aquaculture practices to be certified organic:

- **Open-ocean aquaculture systems of any type.** *Open-ocean fish farms can never be organic* because inputs and outputs to the system cannot be monitored or controlled and neither can a farmed fish's exposure to synthetic, toxic chemicals present in the marine environment, most of which are prohibited by law.

- **Migratory fish production.** *Farming migratory fish can never be organic, regardless of the type of system in which they are reared* because their confinement in fish farms would curtail their biological need to swim far distances, creating stress. Some migratory species are also anadromous, such as salmon, migrating between freshwater and ocean environments, a behavior not possible while in containment.

- **Wild caught fish, fish meal and/or fish oil used as feed.** *Farmed fish that have been fed wild caught fish, or fish meal or oil from wild fish can never be organic* because OFPA requires that all certified organic species are fed a certified organic diet. Feeding farmed fish wild caught fish and related products—fish meal and fish oil—would increase pressure on already over-exploited or recovering fisheries that form the basis of the marine food web. It would also decrease the food supply for a wide range of native, aquatic species, including seabirds and sea mammals, contravening the USDA organic biological diversity conservation requirements.

We believe that allowing these practices undermines the integrity of all organic farming systems and the organic label, and they do not meet the requirements of OFPA. Such practices compete with wild fisheries and other marine life by reducing their opportunities for food. They also threaten marine ecosystems with the spread of disease and parasites.

Path to Certified Organic Aquaculture Systems:

Land-based, closed-loop, recirculating aquaculture systems have the potential to meet the spirit, intent, and letter of the Organic Foods Production Act (OFPA). But operational criteria for organic aquaculture systems have yet to be developed and tested. To be certified organic, a land-based aquaculture facility must promote biodiversity and ecological harmony and rely upon the system's underlying ecology to feed plants and animals. Synthetic materials must not be routinely used to fulfill or prop-up system functions.

Given the departure of aquaculture systems from the soil-based systems around which OFPA was created, specific land-based fish farm regulations must be developed. We strongly recommend mandating substantial field-testing to ensure that operational criteria for different types of land-based fish farms can meet OFPA's high bar for organic integrity. Such systems must be evaluated and approved by the USDA's National Organic Program, at first on a case-by-case basis, in consultation with the National Organic Standards Board and with public input. This would allow for the highest level of scientific and policy-making expertise to be brought to bear on the development of this novel, organic, industrial sector before it is fully commercialized.

ORGANIC AQUACULTURE POSITION STATEMENT ENDORSEMENTS

Alaska Marine Conservation Council
Animal Legal Defense Fund
Beyond Pesticides
Bristol Bay Regional Seafood Development Association
Center for Biological Diversity
Center for Environmental Health
Center for Food Safety
Center for a Livable Future
Coastal Trollers Association
Colorado Ocean Coalition
Consumers Union
Equal Exchange
Farm Forward
Farm Sanctuary
Fearless Fund
Food & Water Watch
Friends of Clayoquot Sound
Global Alliance Against Industrial Aquaculture
Go Wild Campaign
Gulf Restoration Network
Hawaiian Learning Center
Hui o Kuapa
Independent Shellfish Growers of Wa. State
La Montanita Coop, NM
Living Oceans Society
Maine Organic Farmers and Gardeners Association
Mangrove Action Project
MAP Question Your Shrimp
Mari's Garden, HI
Midwest Organic & Sustainable Education Service
Moby Dick Hotel and Oyster Farm, WA
National Cooperative Grocers Association
National Organic Coalition
New Natives, CA
Northeast Organic Farming Association – Interstate Council
Northeast Organic Farming Association: Massachusetts
Northeast Organic Farming Association of New Jersey
Northeast Organic Dairy Producers Alliance
NorthWest Atlantic Marine Alliance
Northwest Center for Alternatives to Pesticides
Ohio Ecological Food and Farm Association
Organic Consumers Association
Organic Seed Alliance
PCC Natural Markets, WA
Public Employees for Environmental Responsibility
Rural Advancement Foundation International-USA
Raincoast Conservation Foundation
Rivers Without Borders
Save Our Wild Salmon
Seafood Producers Cooperative
Washington Trollers Association
Wild Farm Alliance
Wild Oceans

APPENDIX B

TABLE: ANNUAL FISH FARM ESCAPES BY SPECIES AND COUNTRY*

*Data compiled by Center for Food Safety based on available public records. Actual figures are likely to be higher as fish escapes may go unreported for various reasons, including: threshold requirements for reporting, reports of holes found in nets with escapes unknown, leakages of small numbers of small fish, severe weather conditions, etc.

YEAR	COUNTRY	SPECIES	# ESCAPED	CAUSE	OPERATOR/ LOCATION
2014			**696,205**		
	Norway[1]	Atlantic Salmon	120,000	Fire	Firda Sjofarmer
		Atlantic Salmon	47,000	--	Alsaker Fjordbruk
		Atlantic Salmon	103,000	Hole in net	Rogaland
	Scotland[2]	Atlantic Salmon	154,569	Severe storm	Meridian Salmon
		Atlantic Salmon	2,500	Predator	Balta Island
		Atlantic Salmon	35	--	Scottish Salmon Co
		Atlantic Salmon	150	Predator	Balta Island
		Atlantic Salmon	1	Human Error	Scottish Sea Farms
		Atlantic Salmon	25,259	Hole in net	Hjaltland
		Rainbow Trout	4	Vandalism	Dawnfresh
	Ireland[3]	Atlantic Salmon	230,000	Storm	Bantry Bay
	Canada[4]	Rainbow Trout	Unknown	Storm	Ocean Trout Farms
		Rainbow Trout	13,687	Boat propeller → Hole in net	West Coast Fish
2013			**386,054**		
	Scotland[5]	Rainbow Trout	7,172	Weather → Equipment failure	Dawnfresh
		Rainbow Trout	270	Predator → Hole in net	Kames
		Atlantic Salmon	10	Hole in net	Marine Harvest
		Atlantic Salmon	16,446	Human error → Equipment failure	Migdale Transport
		Atlantic Salmon	1	Human error	Scottish Sea Farms
		Atlantic Salmon	200	Human error	Marine Harvest
		Atlantic Salmon	823	Predator → Hole in net	Scottish Sea Farms
		Atlantic Salmon	8,875	Equipment failure	Scottish Salmon
		Halibut	6,957	Predator → Hole in net	Kames
	Norway[6]	Atlantic Salmon	127,000	Storm → Hole in net	Marine Harvest
		Atlantic Salmon	4,000	Annual figure	Finnmark
		Atlantic Salmon	85,000	Annual figure	Nord-Trondelag
		Atlantic Salmon	30,000	Annual figure	Sor-Trondelag
		Atlantic Salmon	9,000	Annual figure	Sogn og Fjordane
		Atlantic Salmon	70,000	Annual figure	Hordaland
	Canada[7]	Atlantic Salmon	20,000	Strong currents	Cooke Aquaculture
		Coho Salmon	300	Overflow during transport	Grieg Seafoods
2012			**343,740**		
	Canada[8]	Chinook Salmon	2,745	Severe storm	AgriMarine
		Atlantic Salmon	1	Escaped during transfer	Mainstream
		Chinook Salmon	1	Escaped during transfer	Creative Salmon
		Atlantic Salmon	7	Escaped during transfer	Marine Harvest
		Atlantic Salmon	100+	Hole in net	Seeley's Cove
		Atlantic Salmon	Unknown	Net failure	Seeley's Cove
		Atlantic Salmon	Unknown	Predator → Hole in net	Maces Bay
		Atlantic Salmon	Unknown	Predator → Hole in net	Beaver Harbour
		Atlantic Salmon	<20	Net damage	
	Scotland[9]	Atlantic Salmon	25,623	Extreme weather → Mooring failure	Meridian Salmon
		Atlantic Salmon	8,700	Predator → Hole in net	Loch Duart
		Atlantic Salmon	3,180	Weather → Hole in net	Scottish Salmon Co

		Atlantic Salmon	20	Equipment failure → Hole in net	Loch Duart
		Rainbow Trout	3,056	Human error → Equipment failure	Dawnfresh
		Rainbow Trout	378	Weather → Hole in net	Kames
	Chile[10]	Atlantic Salmon	70,900	Annual figure	Various
	Norway[11]	Atlantic Salmon	9,000	Annual figure	Troms
		Atlantic Salmon	27,000	Annual figure	Nordland
		Atlantic Salmon	3,000	Annual figure	Rogaland
		Rainbow Trout	123,000	Annual figure	Sogn og Fjordane
		Rainbow Trout	10,000	Annual figure	Hordaland
		Cod	57,000	Annual figure	More og Romsdal
2011			**860,348**		
	Canada[12]	Steelhead Trout	12,382	Storm	Hardy Cove
		Atlantic Salmon	12	Escaped during transfer	Grieg Seafood
		Atlantic Salmon	Unknown	Storm → Hole in net	Grand Manan
		Atlantic Salmon	Unknown	Storm → Hole in net	Maces Bay
	Scotland[13]	Rainbow Trout	3,810	Predator	Torhouse
		Rainbow Trout	1,439	Predator	Dawnfresh
		Rainbow Trout	200	Equipment failure	Dawnfresh
		Rainbow Trout	7,371	Vandalism	Dawnfresh
		Atlantic Salmon	1,500	Human error	Kames
		Atlantic Salmon	6,000	Predator	Balta Island
		Atlantic Salmon	40	Predator	Loch Duart
		Atlantic Salmon	15,000	Predator	Balta Island
		Atlantic Salmon	20	Human error	Scottish Salmon Co
		Atlantic Salmon	2,500	Human error	Scottish Salmon Co
		Atlantic Salmon	50	Weather	Marine Scotland
		Atlantic Salmon	8,299	Weather	Scottish Sea Farms
		Atlantic Salmon	336,470	Weather	Lakeland Unst
		Atlantic Salmon	33,755	Weather	Scottish Sea Farms
	Chile[14]	Atlantic Salmon	15,500	Annual figure	Various
	Norway[15]	Atlantic Salmon	360,000	Annual figure	Sor-Trondelag
		Atlantic Salmon	10,000	Annual figure	Sogn og Fjordane
		Atlantic Salmon	3,000	Annual figure	Hordaland
		Atlantic Salmon	30,000	Annual figure	Rogaland
		Atlantic Salmon	2,000	Annual figure	Troms
		Rainbow Trout	4,000	Annual figure	Hordaland
		Cod	7,000	Annual figure	Nordland
2010			**938,956**		
	Scotland[16]	Rainbow Trout	19,879	Severe ice	College Mill
		Rainbow Trout	40	Equipment failure	Dawnfresh
		Rainbow Trout	57	Human error	Dawnfresh
		Atlantic Salmon	10,775	Human error	Marine Harvest
		Atlantic Salmon	110	Human error	Scottish Sea Farms
		Atlantic Salmon	200	Human error	Marine Harvest
		Atlantic Salmon	100	Equipment	Marine Harvest
		Atlantic Salmon	4,000	Hole in net	Loch Duart
		Atlantic Salmon	2,766	Hole in net	Scottish Salmon Co
		Atlantic Salmon	36	Equipment	Marine Harvest
		Salmon	100,000	Hole in net	Marine Harvest
	Canada[17]	Atlantic Salmon	13,000	Predator → Hole in net	Western Passage
		Atlantic Salmon	138,000	Weather → Net failure	Grand Manan
		Atlantic Salmon	33,000	Hole in net	Grand Manan
		Arctic Charr	15,000	Vandalism	Bay d’Espoir
		Arctic Charr	55,000	Vandalism	Bay d’Espoir
		Atlantic Salmon	150	Harvesting spill	Fortune Bay

		Steelhead Trout	11,643	Storm damage	Bay d'Espoir
		Steelhead Trout	20,800	Hole in net	Bay d'Espoir
	Norway[18]	Salmon	76,000	Escape during harvesting	SJotroll Havruk
		Atlantic Salmon	182,000	Annual figure	Various
		Rainbow Trout	6,000	Annual figure	Sogn og Fjordane
		Rainbow Trout	1,000	Annual figure	Finnmark
		Cod	121,000	Annual figure	Nordland
		Cod	15,000	Annual figure	More og Romsdal
		Cod	30,000	Annual figure	Sogn og Fjordane
	Ireland[19]	Atlantic Salmon	83,000	Equipment failure	Inver Bay
	Chile[20]	Coho Salmon	400	Annual figure	Various
2009			**1,570,307**		
	USA[21]	Yellowtail	Unknown	Shark attack	Hawai'i
	Canada[22]	Atlantic Salmon	48,822	Hole in net	Marine Harvest
		Atlantic Salmon	35	Annual figure	Various
		Chinook Salmon	23,888	Annual figure	Various
	Scotland[23]	Rainbow Trout	4,671	Predator → Hole in net	Dawnfresh
		Rainbow Trout	2,500	Equipment failure	Dawnfresh
		Rainbow Trout	700	Human error	Dawnfresh
		Rainbow Trout	523	Hole in net	Dawnfresh
		Rainbow Trout	197	Hole in net	Dawnfresh
		Atlantic Salmon	17,766	Hole in net	Lighthouse
		Atlantic Salmon	1	Human error	Marine Harvest
		Atlantic Salmon	10,534	Human error	Marine Harvest
		Atlantic Salmon	315	Equipment failure	Marine Harvest
		Atlantic Salmon	621	Equipment failure	Marine Harvest
		Atlantic Salmon	34,227	Predator → Hole in net	Scottish Sea Farms
		Atlantic Salmon	9,700	Predator → Hole in net	Howietown
		Atlantic Salmon	58,800	Hole in net	Lighthouse
		Atlantic Salmon	7	Human error	Marine Harvest
	Norway[24]	Atlantic Salmon	118,000	Annual figure	Nordland
		Atlantic Salmon	11,000	Annual figure	Nord-Trondelag
		Atlantic Salmon	31,000	Annual figure	More og Romsdal
		Atlantic Salmon	30,000	Annual figure	Hordaland
		Atlantic Salmon	3,000	Annual figure	Ovrige fylker
		Rainbow Trout	133,000	Annual figure	Finnmark
		Cod	32,000	Annual figure	Finnmark og Troms
		Cod	68,000	Annual figure	Nordland
		Cod	42,000	Annual figure	Trondelag
		Cod	33,000	Annual figure	More og Romsdal
		Cod	37,000	Annual figure	Rogaland
	Chile[25]	Atlantic Salmon	312,000	Annual figure	Various
		Coho Salmon	22,300	Annual figure	Various
		Rainbow Trout	484,700	Annual figure	Various
2008			**2,159,200**		
	Chile[26]	Atlantic Salmon	447,400	Severe weather	Multiple farms
		Coho Salmon	12,900	Severe weather	Multiple farms
		Rainbow Trout	1,137,100	Severe weather	Multiple farms
	Canada[27]	Atlantic Salmon	30,000	Strong currents → Equipment failure	Marine Harvest
		Atlantic Salmon	81,769	--	--
	Norway[28]	Atlantic Salmon	2,000	Annual figure	Troms
		Atlantic Salmon	24,000	Annual figure	Nordland
		Atlantic Salmon	2,000	Annual figure	Sor-Trondelag
		Atlantic Salmon	44,000	Annual figure	More og Romsdal
		Rainbow Trout	1,000	Annual figure	Sogn og Fjordane

		Rainbow Trout	1,000	Annual figure	Hordaland
		Cod	103,000	Annual figure	Finnmark og Troms
		Cod	5,000	Annual figure	Nordland
		Cod	1,000	Annual figure	Trondelag
		Cod	193,000	Annual figure	More og Romsdal
		Cod	1,000	Annual figure	Sogn og Fjordane
	Scotland[29]	Atlantic Salmon	10,000	Weather	Balta Island
		Atlantic Salmon	20,000	Weather	Balta Island
		Atlantic Salmon	20	--	Marine Harvest
		Atlantic Salmon	1,700	--	Kames
		Atlantic Salmon	5,500	Hole in net	Lighthouse
		Atlantic Salmon	7,437	Hole in net	Lighthouse
		Atlantic Salmon	7,424	Hole in net	Marine Harvest
		Atlantic Salmon	6,560	Predator → Hole in net	Loch Duart
		Rainbow Trout	4,047	Weather	Scot Trout
		Rainbow Trout	126	--	Kames
		Rainbow Trout	200	--	Scot Trout
		Rainbow Trout	381	Vandalism	Scot Trout
		Rainbow Trout	1,254	Hole in net	Dawnfresh
		Rainbow Trout	1,062	Predator	Dawnfresh
		Rainbow Trout	3,620	--	Dawnfresh
		Halibut	3,700	--	Shetland Halibut
2007			**2,615,489**		
	USA[30]	Yellowtail	1,500	Human error	Hawai'i
	Norway[31]	Atlantic Salmon	290,000	Annual figure	Various
		Rainbow Trout	300,000+	Annual figure	Various
		Cod	75,000	Annual figure	Various
	Scotland[32]	Atlantic Salmon	8,213	Hole in net	Lakeland Unst
		Atlantic Salmon	4,000	Weather	Balta Island
		Atlantic Salmon	18,500	Hole in net	Marine Harvest
		Atlantic Salmon	52,353	--	Marine Harvest
		Atlantic Salmon	16,989	Hole in net	Scottish Sea Farms
		Atlantic Salmon	1,000	Hole in net	Fjord Seafood
		Atlantic Salmon	2,500	Human error	Landcatch
		Atlantic Salmon	1,629	Predator	Fjord Seafood
		Atlantic Salmon	15,075	--	Marine Harvest
		Atlantic Salmon	10,400	Weather	Loch Duart
		Atlantic Salmon	23,805	--	Marine Harvest
		Atlantic Salmon	2	Human error	Lakeland Unst
		Rainbow Trout	5,727	Hole in net	Mainstream
		Rainbow Trout	5,900	Predator	Scottrout
		Rainbow Trout	1,000	Escape during transfer	Scottrout
		Rainbow Trout	12	Equipment failure	Invicta
		Rainbow Trout	570	Predator	Kames
		Rainbow Trout	28,500	Predator	Drummond
		Rainbow Trout	14,442	Hole in net	Caledonian
		Cod	1	--	Weddell
		Arctic Charr	25	--	John Eccles
	Canada[33]	Atlantic Salmon	19,223	Annual figure	Various
		Chinook Salmon	11	Annual figure	Various
		Coho Salmon	12	Annual figure	Various
	Chile[34]	Atlantic Salmon	1,119,200	Annual figure	Various
		Coho Salmon	26,300	Annual figure	Various
		Rainbow Trout	573,600	Annual figure	Various

2006			**1,705,636**		
	Norway[35]	Atlantic Salmon	921,000	Annual figure	Various
		Rainbow Trout	15,000	Annual figure	Various
		Cod	300,000	Annual figure	Various
	Scotland[36]	Atlantic Salmon	3,900	--	Fjord Seafood
		Atlantic Salmon	25,108	Predator → Hole in net	Mainstream
		Atlantic Salmon	1,293	Human error	Marine Harvest
		Atlantic Salmon	12,280	Predator	Marine Harvest
		Atlantic Salmon	2,019	Predator → Hole in net	Mainstream
		Atlantic Salmon	223	Predator → Hole in net	Marine Harvest
		Atlantic Salmon	16,000	Hole in net	Murray Seafoods
		Atlantic Salmon	2,500	--	Fjord Seafood
		Atlantic Salmon	5,500	Hole in net	Pan Fish
		Atlantic Salmon	490	Equipment failure	Landcatch
		Atlantic Salmon	4,193	Escaped during transfer	Landcatch
		Atlantic Salmon	34,500	--	Mainstream
		Atlantic Salmon	1,950	Hole in net	Marine Harvest
		Atlantic Salmon	2,981	Human error	Murray Seafoods
		Atlantic Salmon	8,838	Human error	Murray Seafoods
		Atlantic Salmon	100	Predator → Hole in net	Fjord Seafood
		Atlantic Salmon	10	Human error	Wester Ross
		Atlantic Salmon	5,000	Equipment damage	Hebridean Smolts
		Atlantic Salmon	11,900	Hole in net	Marine Harvest
		Atlantic Salmon	16,868	Predator → Hole in net	Pan Fish
		Rainbow Trout	27	Hole in net	Kames
		Rainbow Trout	8,859	Predator	Kames
		Rainbow Trout	200	--	Invicta
		Rainbow Trout	27,767	Flooding	David M Brien
		Halibut	12,230	Vandalism	Kames
	Chile[37]	Atlantic Salmon	95,800	Annual figure	Various
		Coho Salmon	80,000	Annual figure	Various
		Rainbow Trout	89,100	Annual figure	Various
2005			**2,244,853**		
	Scotland[38]	Atlantic Salmon	3,000	Hole in net	Loch Duart
		Atlantic Salmon	8,500	--	Fjord Seafood
		Atlantic Salmon	7,000	Weather	Marine Harvest
		Atlantic Salmon	5	--	Marine Harvest
		Atlantic Salmon	3,608	Escaped during transfer	Landcatch
		Atlantic Salmon	22,500	Hole in net	Murray Seafoods
		Atlantic Salmon	12,000	Weather	Fjord Seafood
		Atlantic Salmon	321,000	--	Stolt Sea Farm
		Atlantic Salmon	80,000	Weather	Pan Fish
		Atlantic Salmon	80,513	--	Fjord Seafood
		Atlantic Salmon	1,998	Weather	Mainstream
		Atlantic Salmon	20,928	Weather	Marine Harvest
		Atlantic Salmon	43,453	Weather	Scottish Sea Farms
		Atlantic Salmon	169,435	Weather	North Uist
		Atlantic Salmon	51,000	--	Marine Harvest
		Atlantic Salmon	12,943	Weather	Marine Harvest
		Atlantic Salmon	40,000	Weather	Pan Fish
		Atlantic Salmon	194,000	Weather	Marine Harvest
		Rainbow Trout	4,500	Predator	Torhouse
		Rainbow Trout	2,203	Hole in net	Mainstream
		Rainbow Trout	1,267	--	Mainstream

		Cod	15,800	Predator	Papil Salmon
	USA[39]	Atlantic Salmon	2,500	--	Washington
	Norway[40]	Atlantic Salmon	700,000+	Annual figure	Various
		Cod	200,000+	Annual figure	Various
	Chile[41]	Atlantic Salmon	190,300	Annual figure	Various
		Coho Salmon	31,400	Annual figure	Various
	Australia[42]	Salmon & Trout	25,000	--	Macquarie Harbor
2004			**2,698,615**		
	USA[43]	Atlantic Salmon	24,552	Annual figure	Washington
	Canada[44]	Atlantic Salmon	43,969	Annual figure	British Columbia
	Chile[45]	Salmon	1,000,000	Severe storm	Salmones Antartica
		Rainbow Trout	949,500	Severe storm	Various
	Scotland[46]	Atlantic Salmon	1	Predator	Lakeland Marine
		Atlantic Salmon	3,000	Predator	Marine Harvest
		Atlantic Salmon	200	Human error	Scottish Sea Farms
		Atlantic Salmon	15,946	--	Stolt Sea Farms
		Atlantic Salmon	320	Equipment damage	Marine Harvest
		Atlantic Salmon	10,000	Equipment damage	Lewis Salmon
		Atlantic Salmon	400	Predator	Balta Island
		Atlantic Salmon	200	Hole in net	Loch Duart
		Atlantic Salmon	4,227	Equipment damage	Lewis Salmon
		Atlantic Salmon	11,300	Predator	Balta Island
		Atlantic Salmon	45,000	Weather	Scottish Sea Farms
		Sea Trout	10,000	Weather	Balta Island
	Norway[47]	Atlantic Salmon	550,000+	Annual figure	Various
		Rainbow Trout	10,000	Annual figure	Various
		Cod	20,000+	Annual figure	Various
2003			**713,438**		
	USA[48]	Atlantic Salmon	2,000	--	Birch Point
	Scotland[49]	Atlantic Salmon	47,176	Weather	North Uist
		Atlantic Salmon	2,000	--	Hunter Salmon
		Atlantic Salmon	11,476	Hole in net	Marine Harvest
		Atlantic Salmon	50	Hole in net	Marine Harvest
		Atlantic Salmon	5,000	--	Kilean Salmon
		Atlantic Salmon	16,000	Equipment damage	Marine Harvest
		Atlantic Salmon	18,416	Hole in net	Loch Duart
		Atlantic Salmon	50,983	Predator	Orkney Sea Farms
		Atlantic Salmon	50	Net failure (no hole)	Scottish Sea Farms
		Atlantic Salmon	500	Equipment damage	Stolt Sea Farms
		Atlantic Salmon	1	Human error	Scottish Sea Farms
		Atlantic Salmon	1	Human error	Marine Harvest
		Atlantic Salmon	200	Weather	Ardvar Salmon
		Rainbow Trout	1,560	Vandalism	Kames
		Sea Trout	5,000	Hole in net	Balta Island
		Halibut	3,025	--	Bressay Salmon
	Norway[50]	Atlantic Salmon	400,000	Annual figure	Various
		Rainbow Trout	150,000	Annual figure	Various
2002			**1,088,403**		
	Scotland[51]	Atlantic Salmon	35,335	Weather	Hascosay Salmon
		Atlantic Salmon	8,147	Equipment failure	Loch Duart
		Atlantic Salmon	36	Hole in net	Finfish Ltd
		Atlantic Salmon	58	--	Marine Harvest
		Atlantic Salmon	500	Human error	Fjord Seafood
		Atlantic Salmon	13,500	Weather	Balta Island
		Atlantic Salmon	238,420	Weather	Cro Lax

		Atlantic Salmon	14,000	Weather	Balta Island
		Atlantic Salmon	19,750	Human error → Equipment failure	Scottish Salmon
		Atlantic Salmon	20,000	Equipment damage	Scottish Sea Farms
		Atlantic Salmon	3,000	Predator	Loch Duart
		Atlantic Salmon	2,400	Vandalism	Marine Harvest
		Atlantic Salmon	12,000	Human error	Meridian Salmon
		Rainbow Trout	80,000	Flooding	Abbey St Bathans
	Norway[52]	Atlantic Salmon	53,000	Annual figure	Finnmark
		Atlantic Salmon	89,000	Annual figure	Troms
		Atlantic Salmon	78,000	Annual figure	Nordland
		Atlantic Salmon	46,000	Annual figure	Nord-Trondelag
		Atlantic Salmon	50,000	Annual figure	Sor-Trondelag
		Atlantic Salmon	25,000	Annual figure	More og Romsdal
		Atlantic Salmon	23,000	Annual figure	Sogn og Fjordane
		Atlantic Salmon	100,000	Annual figure	Hordaland
		Atlantic Salmon	11,000	Annual figure	Rrogaland
		Trout	105,000	Annual figure	Nordland
		Trout	3,000	Annual figure	Sor-Trondelag
		Trout	2,000	Annual figure	More og Romsdal
		Trout	36,000	Annual figure	Sogn og Fjordane
		Trout	8,000	Annual figure	Hordaland
		Trout	1,000	Annual figure	Ovrige fylker
	Canada[53]	Atlantic Salmon	11,257	Annual figure	British Columbia
2001			**452,414**		
	Canada[54]	Atlantic Salmon	55,414	Annual figure	Washington
	Norway[55]	Atlantic Salmon	250,000+	Annual figure	Various
		Rainbow Trout	100,000	Annual figure	Various
	Scotland[56]	Brown Trout	3,500	Predator	Balta Island
		Atlantic Salmon	9,000	Weather	Scottish Sea Farms
		Atlantic Salmon	4,500	Human error	Scottish Sea Farms
		Atlantic Salmon	Unknown	Predator	Scottish Sea Farms
		Atlantic Salmon	10,000	Predator	Meridian Salmon
		Atlantic Salmon	7,000	Predator	Scottish Salmon Co
		Atlantic Salmon	3,000	Predator	Marine Harvest
		Atlantic Salmon	10,000	Equipment damage	Meridian Salmon
2000			**817,203**		
	Canada[57]	Atlantic Salmon	31,855	Annual figure	British Columbia
	USA[58]	Atlantic Salmon	170,000	--	Stone Island
	Scotland[59]	Atlantic Salmon	235	Equipment failure	Marine Harvest
		Atlantic Salmon	20,000	Equipment damage	Meridian Salmon
		Atlantic Salmon	3,000	Equipment damage	Meridian Salmon
		Atlantic Salmon	5,776	Predator	Marine Harvest
		Atlantic Salmon	6,000	Equipment failure	Hjaltland
		Atlantic Salmon	1,000	Human error	Scottish Sea Farms
		Atlantic Salmon	Unknown	Hole in net	Marine Harvest
		Atlantic Salmon	230,000	Weather	Finfish Ltd
		Atlantic Salmon	62,000	Weather	Meridian Salmon
		Atlantic Salmon	258,000	Weather	Scottish Sea Farms
		Atlantic Salmon	11,237	Weather	Loch Duart
		Atlantic Salmon	100	Human error	Scottish Sea Farms
		Brown Trout	18,000	Equipment damage	QA Fish
1999			**347,854**		
	Canada[60]	Atlantic Salmon	35,954	Annual figure	British Columbia
	USA[61]	Atlantic Salmon	115,000	--	Washington
	Scotland[62]	Atlantic Salmon	4,000	Hole in net	Meridian Salmon

		Atlantic Salmon	10,000	Weather	Hjaltland
		Atlantic Salmon	6,900	Predator	Meridian Salmon
		Atlantic Salmon	50,000	Predator	Meridian Salmon
		Atlantic Salmon	6,000	--	Hjaltland
		Atlantic Salmon	100,000	Weather	Scottish Sea Farms
		Atlantic Salmon	20,000	Hole in net	Marine Harvest
1998			**147,975**		
	Canada[63]	Atlantic Salmon	80,975	Annual figure	British Columbia
	Scotland[64]	Atlantic Salmon	10,000	Equipment damage	Scottish Salmon Co
		Atlantic Salmon	17,000	Equipment failure	Scottish Salmon Co
		Atlantic Salmon	10,000	Human error	Scottish Salmon Co
		Atlantic Salmon	30,000	Hole in net	Scottish Salmon Co
1997			**419,000**		
	USA[65]	Atlantic Salmon	369,000	--	Washington
	Scotland[66]	Atlantic Salmon	50,000	Vandalism	Scottish Salmon Co
1996			**498,737**		
	USA[67]	Atlantic Salmon	107,000	--	Washington
	Chile[68]	Atlantic Salmon	21,900	Annual figure	Various
		Coho Salmon	324,900	Annual figure	Various
		Rainbow Trout	31,800	Annual figure	Various
	Canada[69]	Atlantic Salmon	13,137	Annual figure	British Columbia
1995			**659,883**		
	Canada[70]	Atlantic Salmon	51,883	Annual figure	British Columbia
	Chile[71]	Atlantic Salmon	27,400	Annual figure	Various
		Coho Salmon	392,100	Annual figure	Various
		Rainbow Trout	168,500	Annual figure	Various
	Scotland[72]	Atlantic Salmon	20,000	Weather	Scottish Sea Farms
1994			**3,021,109**		
	Canada[73]	Atlantic Salmon	62,809	Annual figure	British Columbia
	Chile[74]	Atlantic Salmon	1,023,100	Annual figure	Various
		Coho Salmon	1,288,800	Annual figure	Various
		Rainbow Trout	646,400	Annual figure	Various
1993			**477,800**		
	Canada[75]	Atlantic Salmon	9,000	Annual figure	British Columbia
	Chile[76]	Atlantic Salmon	425,000	Annual figure	Various
		Coho Salmon	43,800	Annual figure	Various
1993-2014	**WORLD**		**>24,863,219**		

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