

FISH, FEED & NUTRITION
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Urban Legends and Fish Nutrition

We all know about urban legends, those implausible stories that circulate with increasing frequency, now via the Internet. They play on our fears, prejudices, and uncertainties, and although they are farfetched, sometimes they seem to resonate with us just enough to make us wonder if maybe, just maybe, they are true. Take, for example, the story about the man who is in Dallas on business, and is invited to the home of a woman he meets somewhere. They have a drink, and then he wakes up in the bathtub full of ice. He finds a cell-phone next to him, and sees a message on the wall that says, "Don't move, and call 911." He makes the call, and medics arrive to find that his kidneys have been removed, presumably to be sold in the black market for transplantation. Could this happen? What does it have to do with fish nutrition? The connection is that similar legends concerning aquaculture are making the rounds in various media outlets, and some of these legends concern fish nutrition. In an election year, especially, various organizations publicizing their causes and "informing" their constituents step up their rhetoric against aquaculture, employing their versions of the urban legend. Bogus scientific claims that purport to irrefutably demonstrate that aquaculture is an undesirable practice include the following: farmed fish are full of antibiotics; farmed fish give diseases to wild fish; escaped fish from farms are genetically inferior to wild fish and will destroy the genetic integrity of wild fish (read salmon); fish farming is unsustainable because of its dependence on fish meal as a dietary component; and pollution from one salmon farm dumps as much sewage as 1.5 million people. The last assertion is an attention-getter, and any sensible citizen would be stunned by this comparison, and swayed by the apparent environmental cost of salmon farming. But, is it true?

Most recent source of an *Aquaculture Urban Legend*: The Sierra Club

In their September/October 2000 publication, which is devoted to the subject of "Why vote?" there is a section entitled "To Save Wild Salmon." The section features a 48-year old fisherman, Peter Knutsen, posed in front of fishing boats, presumably at Fisherman's Terminal in Seattle. Mr.

Knutsen is quoted as saying that the fishing community has been devastated by the drastic reduction in fishing days, which are now 4-5 days per year, compared to 5-6 months of fishing twenty or thirty years ago. There is no mention of the fact that commercial fishermen have overfished the resource, aided and abetted by the Washington Department of Fisheries, who set salmon escapement goals much too low for the salmon populations around Puget Sound to be self-sustaining. In any event, Mr. Knutsen is quoted further as saying that one of the things that has hit the fishing industry hard is fish farms, which “are subsidized by the destruction of wild ecosystems.” No mention about ecosystem destruction caused by over-harvesting of salmon and other fish, bottom trawling which has destroyed eel grass habitat used by so many fish species as spawning and nursery grounds, and the non-discriminate harvesting of threatened salmon populations along with robust populations. Then, Mr. Knutsen gets to an urban legend. He says “One farm in Puget Sound dumps as much sewage as a million and a half people.” This means, in effect, that a regular salmon farm, producing 1,000 mt of salmon per year, raises 200,000 salmon to 5 kg average weight. Standing crop (the biomass of fish at any given period) is usually about 70% of annual production, but to keep things simple, let’s assume that standing crop is equal to annual production. A salmon farm like this is (200,000 fish) said to produce the same amount of sewage, meaning nitrogen, phosphorus, and biological oxygen demand, as 7.5 times as many humans. Is this plausible? Let’s look at the numbers, with the fish calculations first.

Nitrogen:

A farm of 200,000 fish, averaging 5 kg per fish, would consume 10,000 kg of feed per day, averaged throughout the year (winter and summer). This feed contain 45% protein, of which 45% would be retained by the fish, and 55% would not be retained (nitrogen balance). So, 10,000 kg of feed would be fed per day, containing 4500 kg of protein, of which 2475 kg would not be retained. Protein contains an average of 16% nitrogen, on a molecular weight basis, so the 2475 kg of protein that is not retained by the fish (e.g., protein that is de-aminated, with the carbon skeletons used to provide metabolic energy, and the amine group containing nitrogen excreted as ammonia via the gills) would result in 396 kg of nitrogen per day being discharged into the environment. This is a relatively generous calculation; the actual figure could be much less at times during the production cycle. How does nitrogen excretion from humans compare? According to Samson Wright’s Applied Physiology, an average human consuming a normal diet excreted 16.8 g of nitrogen in the urine per day. All of the protein ingested during a day is not absorbed, so let’s increase the nitrogen

output per person per day to 20 g total, or 0.020 kg per day. Now, how many people does it take to equal 396 kg of nitrogen excretion? My calculator says 19,800 people. We are ignoring other sources of nitrogen that end up in sewers from fertilized lawns, food scraps sent down garbage disposals, etc., which would reduce the number of people it takes to equal the nitrogen output from a reasonably sized salmon farm, but it would not be unreasonable to say that our 1,000 mt salmon farm puts out the same amount of nitrogen as 15,000 people, or about 1% of the number of people that urban legends assert. In the process of doing so, our salmon farm provides 1,000,000 kg of salmon for human consumption, of which 60% is edible fillets. This yields 600,000 kg of salmon, or 2,640,000 8-ounce servings of high quality, high omega-3 fatty acid salmon. The American Heart Association advises that people eat fish twice a week, especially salmon or tuna because of their high levels of omega-3 fatty acids (CNN web site, October 5, 2000)

Where did the bogus number upon which our urban legend is based come from in the first place? I found a reference to this in the publication "Murky Waters" put out by the Environmental Defense Fund. However, this citation is not a peer-reviewed publication, but rather a report from the David Suzuki Foundation by D.W. Ellis and Associates, entitled "Net loss: the salmon netcage industry in British Columbia." The Suzuki Foundation is a prominent critic of the salmon farming industry in BC. How D.W. Ellis and Associates came up with their number is not clear, but one thing is clear. The conclusion that salmon farming dumps a quantity of waste equivalent to a city of 1.5 million people has never been subject to review, the final, essential step in the scientific process, and is certainly not true for nitrogen.

Phosphorus:

What about phosphorus, the other nutrient of concern in fish farm effluents? Salmon and trout require about 0.5-0.7% available phosphorus in their diet, the exact amount depending upon fish size, energy density of the diet, and what criteria is used to estimate the requirement. Catfish, like other scale-less fish, have a lower dietary requirement. It is virtually impossible to formulate a feed in which all phosphorus is available. Antagonistic interactions with dietary calcium, which causes phosphorus to precipitate in the intestine and the presence of phytate, the storage form of phosphorus in grains and oilseeds, results in some loss of phosphorus in the feces. It is possible, however, to formulate feeds that meet the phosphorus needs of salmon and trout that contain about 1% total phosphorus. This means that about 0.4% of the total phosphorus in the diet is not retained

by the fish, being lost in the feces. From this information, one can calculate the daily phosphorus loss from our 1,000 mt salmon farm as being 40 kg per day. Humans excrete 0.6 g of phosphorus per day in urine, plus whatever is lost in feces, which is likely much more than that lost in urine. Assuming that each person excretes 1.5 g phosphorus per day, 26, 667 people would produce 40 kg of phosphorus per day, equivalent to our salmon farm containing 200,000 fish. This ignores other human-generated sources of phosphorus, like fertilizers, detergents, and so on. So, based upon phosphorus in salmon and human waste, there is no way that a salmon farm produces the same amount as 1.5 million people.

Biological Oxygen Demand (BOD):

Finally, what about BOD? BOD is defined as the weight of dissolved oxygen taken up by organic material as it decomposes. Comparing humans and salmon is not as easy as for nitrogen and phosphorus, but a rough comparison can be made on the basis of fecal output. The logic behind this comparison is that BOD is associated with the organic components of feces, and thus comparisons can be made between humans and salmon based upon fecal output. Humans excrete 30-50 g of feces (dry weight basis) per day, so using an average of 40 g, a city of 1.5 million people would produce 60,000 kg. Our salmon farm contains 200,000 fish, averaging 5 kg in weight. Each fish consumes 1% of body weight per day, or 50 g of feed, and today's high-energy feeds yield dry matter digestibility values of 75-80%. Using the lower number, each fish therefore excretes 12.5 g of dry matter, and the entire farm produces 2500 kg of dried feces, at most. This material is mostly starch and fiber; the lipid fraction is >95% digestible, and the protein fraction is >90% digestible. So, our fish farm produces slightly over 4% of the city of 1.5 million people. Put another way, our salmon farm of 200,000 fish produces about the same amount of fecal solids as 62, 505 people, a far cry from the urban legend of 1.5 million people that is quoted far and wide by critics of aquaculture.

Addendum: Now the Monterey Bay Aquarium, apparently following the same flawed logic and bogus mathematics as the Sierra Club, the Environmental Defense Fund, and others has decreed that we should not eat farmed salmon because of "conservation concerns." Which urban legend are they perpetuating and how can they reconcile this advice in light of the recommendations of the American Heart Association, and the increasing pressure on wild stocks of Pacific salmon that are consumed as fillets, rather than as canned product which are low in omega-3 fatty acids?

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Table 1. Estimates of nitrogen, phosphorus, and fecal excretion from a 1,000 mt salmon farm and a city of 1.5 million people*.

<u>Excretory product</u>	<u>Nitrogen</u>	<u>Phosphorus</u>	<u>Fecal solids</u>
Salmon farm	396 kg/day	40 kg/day	2,500 kg/day
1.5 million people	30,000 kg/day	2,250 kg/day	60,000 kg/day
<u>Salmon farm equivalent</u>	<u>19,800 people</u>	<u>26, 667 people</u>	<u>62, 505 people</u>

*estimate ignores other sources of N, P, and solids from humans than end up in sewers, such as food scraps, paper products flushed down toilets, and so on.