The Ecological Efficiencies of Farmed Fish

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There is a widely-promoted misconception that eating wild-caught fish is better for the oceans than eating farmed seafood. This paper refutes this notion, and estimates that on a global basis, sustainably farmed fish may represent around 60 times more efficient use of anchovy and other baitfish resources than wild fish. Farmed fish have more efficient life-cycles (by a factor of 6:1), more efficient trophic transfer (around 7.3:1), and more efficient by-catch (1.3:1). Continued careful management of baitfish resources is imperative, but fish farming is a better and higher use of these resources than reliance on commercial exploitation of wild predatory fish species.
(99 words)

Many anti-aquaculture activists would have you believe that eating wild-caught fish is better for the oceans. An examination of some fundamentals of ecological efficiencies, however, suggests that, in fact, the converse might hold true. Eating farmed fish is almost as good as eating anchovies – the lowest fish on the food chain. (Indeed, it may be better!)

Marine scientists are all of one mind: the best way to take care of our oceans is to eat at the base of the marine food chain. Our seas would be more sustainably managed if everyone ate anchovies, or similar small 'clupeiform' fishes (herrings, sardines, menhaden and the like). But part of the tragedy of the oceans is that we all (mostly) love to eat the larger fish – tunas, swordfish, cod, Chilean seabass, and the like. These are the species that we crave – because they offer big, thick fillets, and they taste great. Many of these are also, alas, the very same species that now totter on the edge of economic extinction.

We must therefore objectively examine the true environmental cost – in terms of anchovy inputs - of wild-caught fish versus sustainably farmed fish. There are three primary considerations.

Firstly, farmed fish have it easy. They don't have to hunt for food, flee for their lives, or reproduce. Farmed fish are also usually harvested at a younger age, and so most of their diet goes into fast, efficient growth. However, larger wild fish must expend energy sustaining their biomass, staying alive, and seeking a spawning-mate. A farmed fish's life cycle might therefore be between 3 and 10 times more efficient than that of a wild fish.

Secondly, we can increasingly use sustainable substitutes in farmed fish diets to lessen our reliance on marine resources. Fish feed formulations are now including more alternative proteins and oils, to where the efficiency of protein conversion can approach 1:1 (i.e. one pound of fish meal from anchovies produces one pound of sashimi-grade farmed fish, yielding no net loss of marine protein). By contrast, wild fish are subject to the laws of trophic transfer, where only 10% of their prey's food value is transferred up each step of the food chain (Pauly and Christensen, 1995). If a swordfish eats a mackerel that earlier ate an anchovy, then there are two such steps, compounding

the costs. A swordfish may therefore need to eat 100 pounds of anchovy-equivalents to increase its weight by one pound.

Finally, farmed fish don't have 'by-catch'. Farmers only harvest the fish in their pens. Anchovy fisheries also rarely have any extraneous 'take', as they target pelagic schools of one species of baitfish. Other wild fisheries, however, use trawling, dredging, or similar indiscriminate methods, which take all the fish that are caught in the net, or haul up whatever is on the hook. Unwanted fish – either unsalable, undersize, or over the quota – are usually thrown back, dead. Experts estimate that around 28% of global wild harvest is discarded as by-catch. That's a lot of wasted anchovy-equivalents.

So if a one-pound platter of sashimi is sourced from a fish farm using sustainable diets, then the environmental input required could be close to one pound of Peruvian anchovies. For a one-pound platter of wild-caught tuna, however, the cumulative cost could range from 4 pounds to 11,000 pounds of anchovies (see the table below). Sustainably-farmed fish may therefore be up to 11,000 times more ecologically efficient than wild-caught. The best estimate for a global efficiency differential between wild and farmed fish is around 60 x.

So … farmed or wild? Which is truly the wanton waste?

And if you are an ocean-conscious consumer, which should you have on your plate?

Table : Relative Ecological Efficiencies of Farmed and Wild-Caught Fish

The table shows the compounded cost in terms of anchovy-equivalents for farmed and wild-caught fish. Low-end estimates and high-end estimates are provided for each type of fish, and compared cross-ways to obtain a lowest-relative rate and highest-relative rate.

	FARMED FISH		WILD-CAUGHT FISH		GLOBAL MEAN
	Low-end estimate	High-end estimate	Low-end estimate	High-end estimate	Ratio of wild to farmed
Life-cycle efficiency[(1)]	1	1	3	10	6
Trophic transfer efficiency[(2)]	1	8	10	100	7.3[(3)]
'By-catch' efficiency	1	1	1[(4)]	11[(5)]	1.3[(4)]
Compounded "cost"	1	8	30	11,000	57

The lowest relative rate extrapolated from this table is that the least-sustainably-farmed fish are around 4 x more ecologically efficient than the most sustainably-harvested wild fish (i.e. 30 : 8). The highest relative rate is that the most sustainably-farmed fish could be 11,000 x more ecologically efficient than the least-sustainably-harvested wild fish (i.e. 11,000 : 1). The Global Mean of wild fish efficiency to farmed fish efficiency is around 57 x.

Note 1: There are no published estimates of the relative life-cycle efficiencies of farmed vs wild fish. However, fish that reach reproductive age in captivity can see Feed Conversion Ratios increase by factors or 5 or 10 over juvenile and sub-adult fish. Natural mortality and the nutritional cost of maintenance of basal metabolic processes during periods of food depravation also increase the 'Economic' Feed Conversion Ratio for wild fish populations.

Note 2: In 1997, food conversion efficiencies (FCE) for farmed marine fish and farmed salmon were around 5:1 and 3:1, respectively (Naylor, et al., 2000). By 2010, however, FCEs are projected to reach 1.5:1 for farmed marine fish, and as low as 1.2:1 for farmed salmon (Tacon, 2005). Kona Blue has been able to culture Kona Kampachi® on a diet that equates to a 1:1 ratio of wet-fish-in to wet-fish-out. However, if a less-sustainably-farmed fish is fed a pellet high in fishmeal and fish oil (say, to meet the Scottish Soils Association's Organic standards, with around 80% fishmeal and fish oil), this diet could equate to around 4 lbs of wet anchovy-equivalents for every 1 lb of dry pellet (a wet-fish to fish-meal ratio of 5:1 is considered standard). On this diet, most commercially-farmed species might have food conversion ratios of around 2:1 (dry-pellet to wet fish), implying an FCE of 8 lbs of wet-fish-in for every one pound of wet-fish-out.

Note 3: Tacon's (ibid) estimate of FCEs for farmed salmon and farmed marine fish might be conservatively pooled at, say, 1.5:1 – i.e. 1.5 pounds of anchovy-equivalents for every pound of farmed fish produced worldwide. There is a differential of around 1.1 trophic levels between global fishery landings (with a mean trophic level of around 3.3), and the Peruvian anchovetta fishery (with a trophic level of around 2.2: Pauly, et al, 1998). At a presumed 10% biomass transfer efficiency up each trophic level, this implies 11 pounds of anchovy-equivalents to produce a pound of harvested wild fish. The median ratio of wild to farmed trophic transfer efficiencies can therefore be estimated at 11:1.5, or 7.3:1 overall.

Note 4: Harrington, et al., 2005, report a "nationwide discard to landings ratio of 0.28" (i.e. for 3.7 million tons landed, some 1.06 million tons were discarded). However, for highly-selective fishing methods, such as harpooning, by-catch is effectively zero, as for farmed fish.

Note 5: "For finfish, the ratio of bycatch to target fish (in the Northern Pacific) can be as high as 11:1 because the bycatch is either too young, out of season, or the vessel has no permit to keep it." (Alverson, 1998).

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