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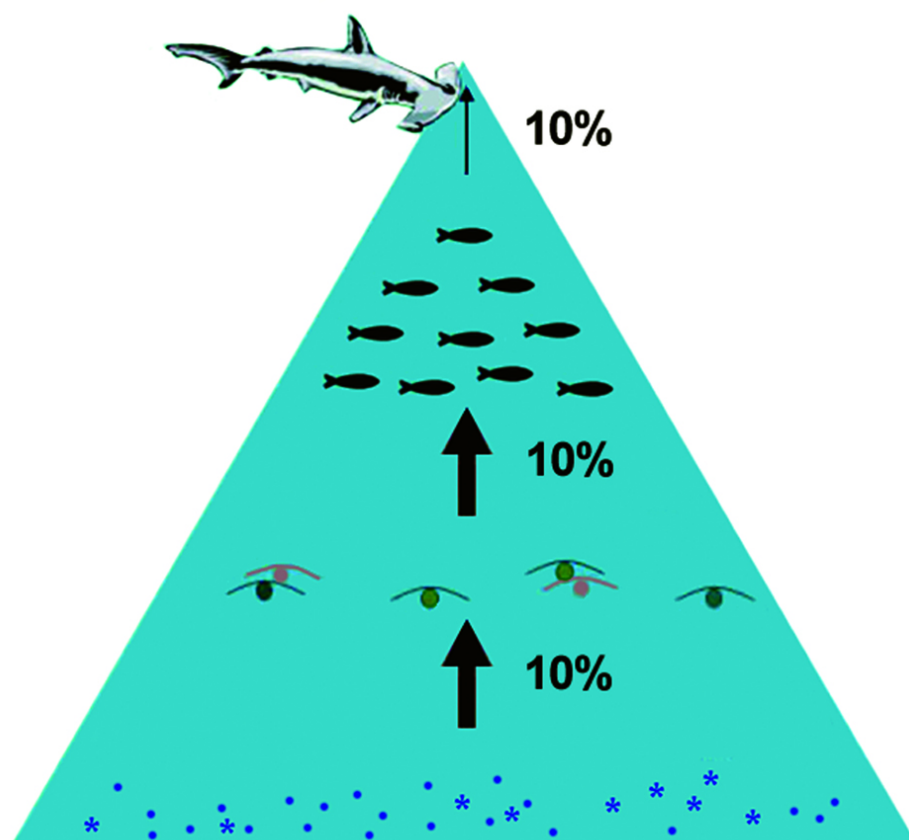
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# Lifecycle analysis model quantifies ecological footprint of salmon feed

1 January 2011

By Dr. Louise Buttle , Dr. Nathan Pelletier , Dr. Peter Tyedmers and Dr. Dave Robb

**EWOS teams with Canadian academic researchers specializing in sustainability modeling**



On average, only 10 percent of the energy is passed from lower to higher trophic levels in aquatic ecosystems. Utilizing fish species from higher trophic levels in feeds results in larger eco-footprints, as greater ecosystem resources are required to support them.

Ecological footprinting or eco-printing was introduced in the United States in the early 1990s and quickly became globally recognized as a method for measuring sustainability. An eco-footprint is a measure of the demand placed on Earth's ecosystems by specific activities. It is calculated by assessing the area of biologically productive land and marine ecosystem required to produce the resources necessary to support the activity, along with the area needed to absorb and render harmless a subset of the corresponding wastes.

EWOS Innovation has worked in cooperation with Canadian academic researchers specializing in sustainability modeling to develop a unique model to measure the eco-footprints of EWOS feeds. The EWOS group has begun to use this ecological footprint (E.F.) modeling tool to quantify the scale of ecosystem support required to sustain the production of its fish feeds and assist in the development of more sustainable feed input sourcing and product offerings at its companies in Canada, Chile, the United Kingdom and Norway.

## E.F. model

The footprint model is a sophisticated tool into which a number of different layers of data are built for each raw material. The two primary sub-components of the ecological footprint analyzed are the area of ecosystem support required to sustain the production of biotic resource inputs, whether from marine

or terrestrial origins, and to assimilate carbon equivalent to the total greenhouse gases emitted in feed production.

The quantification of supply chain greenhouse gas emissions associated with the production, processing, packaging and transport of each feed input, along with the production of salmon feeds has been undertaken using ISO-compliant lifecycle analysis methodologies.

When using the tool, it is important to realize some intrinsic differences between the raw materials used in salmon feeds. Raw materials from marine ecosystems have a higher footprint than those from terrestrial systems in general. This should not be surprising, since natural marine ecosystems – which contain a variety of species, of which only one is targeted – are much less productive per hectare than an intensively farmed, terrestrial plot of land producing a monoculture crop.

This is perhaps the largest driver in the overall feed eco-footprinting. Other important drivers include the energy used to produce, process and transport the feed inputs, along with feed milling.

## Assessing feeds

There are significant differences in the eco-footprints of feeds. Marine ingredients have by far the largest impacts on overall feed footprints. Their impacts are influenced by the quantity of marine ingredients in the dietary formulation, but even more by the trophic levels of the fish used in the production of the fishmeal and oil. Utilizing fish species from higher trophic levels results in much larger footprints, as greater total ecosystem resources are required to support these predators.

Choice of target fish species is therefore important when purchasing fishmeal and oil, as well as the total inclusion rate of marine ingredients, if the sole focus is to reduce the eco-footprint. It is worth noting that the fishing method for the target fish is also a contributory factor due to the energy consumption and associated greenhouse gas emissions.

## Plant-derived raw materials

Aside from selecting marine resources and reducing their use, E.F. magnitude can also be reduced through the careful inclusion of selected plant-derived raw materials. As noted above, intensive crop monoculture is highly productive and has much lower E.F. values than for marine resources. However, the EWOS E.F. model accounts for processing and transport to the feed mills. This makes the models sensitive to regional energy sources and transport modes, both of which influence emission intensity; as well as regional farming techniques, which influence productivity from the land area.

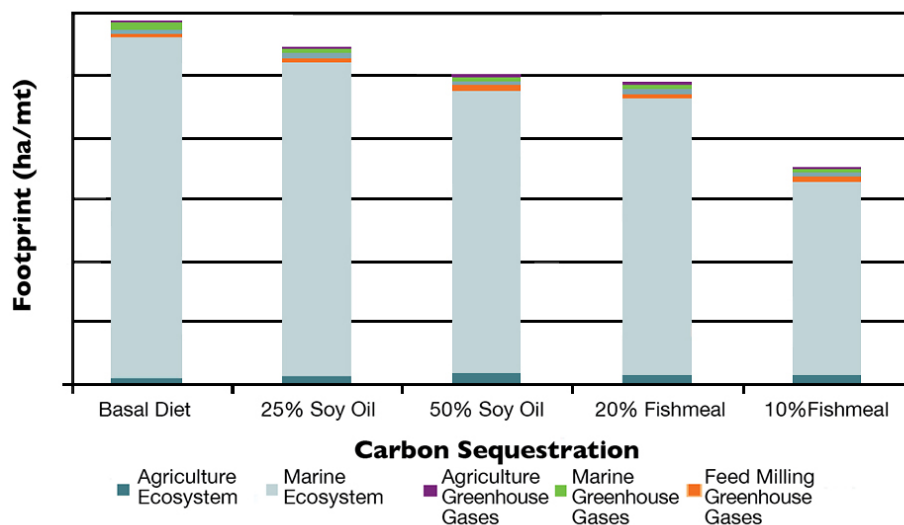
By looking at the footprint of each raw material available, scientists can compare the compositions of different feeds and formulate diets with a lower E.F. However, it is essential that the feeds also provide the nutrients required by the fish at an economically viable cost.

There has to be a balance between lowering E.F. in the feed and the overall worth of the feed nutritionally and economically. For example, if nutritional quality was compromised, the fish would require more feed to grow. So while the feed E.F. would be low, the corresponding fish E.F. would be high. Feed manufacturers are therefore seeking ways to reduce E.F. while maintaining the nutritional quality of feeds at the right price.

## Fishmeal, fish oil replacement

In general, the salmon-farming industry has gradually reduced its dependence on fishmeal and oil per unit output. However, it is still not able to completely remove these raw materials – which provide the long-chain n-3 highly unsaturated fatty acids (HUFAs) that are so beneficial to human health and currently only available in high volumes through the use of fish oil. EWOS and other manufacturers are using new technologies in instrumentation, biotechnology and trial design to get closer to “marine independence.” Fast-track innovations are achieving lower feed eco-footprints while maintaining the nutritional quality of the salmon we eat.

Running the E.F. model on new salmon feeds in which fishmeal content is reduced from 20 to 10 percent of the diet and replaced, for example, by soy meal indicates a large reduction in the total feed E.F. (Fig. 1). Similarly, replacing fish oil with soy oil also achieves a significant reduction.



Substitution for fish oil and fishmeal, and effects on total footprint.

The basal diet contains 27 percent fishmeal and 26 percent fish oil.

Carbon sequestration is the area of “global average” forest required to isolate the greenhouse gases produced during the production, processing and transport of the raw material.

## Limitation

One important limitation of the model is that it cannot yet account for the nutritional benefits of different feeds. The inclusion of n-3 HUFAs has already been mentioned as an example. Fish oil inclusion in feed secures a concentration of n-3 HUFAs in the salmon fed the diet, but also raises the E.F.

The human health benefits of n-3 HUFAs are well known and reported by doctors, scientists and governments. Failure to include these will have a much greater impact on long-term sustainability than can be measured by the E.F. alone, highlighting the complexities of sustainability issues that have to be considered by the salmon industry.

## Greenhouse gases

It is worth noting that salmon farming yields significantly lower “farm gate” greenhouse gas emissions than most other animal protein sources, mainly due to much greater efficiencies in feed conversion into meat. In an October 2009 article on life cycle assessment of salmon-farming systems in *Environmental Science and Technology*, Dr. Nathan Pelletier and fellow researchers identified greenhouse emissions for salmon of 2.15 t CO<sub>2</sub>-e/t production. The values for Swedish pork and Belgian beef were 3.3-4.4 t CO<sub>2</sub>-e/t and 14.5 t CO<sub>2</sub>-e/t, respectively.

More importantly, the potential for further improvement is significant, given the relative impact feed has upon the total environmental impact of salmon farming and the wide range of impacts characteristic of available feed inputs.

*(Editor's Note: This article was originally published in the January/February 2011 print edition of the Global Aquaculture Advocate.)*

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