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The water footprint of aquafeed production

A sustainable growth of the aquaculture sector is what we aim for. But to achieve this, freshwater consumption and pollution due to aquafeed production must be considered. The water footprint is an indicator that is used to measure this.

With the increasing importance of aquaculture in feeding the growing world population, the requirement of natural resources for producing aquafeed ingredients is intensifying. There is a growing interest in the potential to replace fish meal and fish oil with terrestrial feed ingredients. It is important to understand both the positive and negative implications of this development with regard to its claim on natural resources. While the use of feed with a large proportion of terrestrial feed may reduce the pressure on fisheries to provide feed for fish in the form of fish meal and fish oil, it may significantly increase the pressure on freshwater resources due to water consumption and pollution in crop production for aquafeed. Furthermore, the competition with feed for humans and livestock, as well as with plant material for biofuels is aggravated.

Water footprint as indicator

The commercial feed-related water consumption and pollution of fish and crustacean production in aquaculture is estimated here using the water footprint (WF). This indicator is a measure of humanity's appropriation of freshwater in volumes of water consumed and/or polluted. The water footprint is composed of three colours: green (rainwater consumption), blue (surface and groundwater consumption) and grey (water to assimilate pollutants) (Hoekstra et al., 2011). For the water footprint calculations data on aquafeed production, the feed conversion ratios for the major cultivated species groups and the percentage of those groups that is cultured using commercial feed given by Tacon et al. (2011) for the year 2008 were utilised. Global average data of the green, blue and gray water footprint of feed ingredients were selected for the current study due to lack of detailed knowledge regarding the origin of feed ingredients. Further information regarding data and methods can be found in Pahlow et al. (2015).

Impact of the major species

The total aquaculture production based on commercially manufactured feeds was 17.9 million tonnes in 2008 and the total amount of commercial aquafeed utilised was 29.7 million tonnes (Tacon et al., 2011; Ramakrishna et al., 2013). The top five species groups consuming aquafeed are carps with a share of 33% of global production of commercial aquaculture feeds, marine shrimps with 17%, tilapias with 13%, catfishes with 10% and marine fishes with 8%. In order to determine the water footprint of the commercial feed, the feed composition for 39 major species or species groups, which account for 88% of total fed production, have been compiled from the literature. It is noteworthy that soybean is the source of plant protein most often used in compound aquafeeds and the most prominent protein ingredient substitute for fish meal in aquaculture feeds (Tacon et al., 2011). For 2008 it was estimated that the aquaculture sector used 6.8 million tonnes of soybean meal, which was 23% of total commercial aquafeed. Of that,

China was using about 6 million tonnes of soybean meal within commercial aquafeed (Tacon et al., 2011). The water footprint per tonne of cultured fish and crustaceans related to the production of commercial feed for the year 2008 was calculated for the major species (Figure 1). Based on the results shown in *Figure 1* and considering the total production volume, it was found that globally the top five contributors to the total commercial feed water footprint are Nile tilapia, Grass carp, Whiteleg shrimp, Common carp and Atlantic salmon, which together account for a water footprint of 18.2 cubic kilometres of the estimated 31 - 35 cubic kilometres in 2008. In addition, the water footprint analysis was carried out with alternative research diets (to see the effects of replacing marine ingredients) for piscivorous rainbow trout, carnivorous Atlantic salmon, carnivorous Atlantic cod, carnivorous European seabass and carnivorous gilthead seabream (*Figure 2*). It was shown that replacing fish meal and fish oil in the standard diets to varying degrees with terrestrial feed ingredients in these research diets may potentially increase pressure on freshwater resources.

Sustainable choices

Each fish and crustacean has certain needs in terms of protein, fat, carbohydrates, vitamins, minerals, among others. The question is how those needs can be met in a sustainable way, thereby also considering the pressure on freshwater resources. While the selection of species is not exhaustive in the present study, the result is universal. Replacing aquafeed ingredients that stem from e.g. pelagic marine fishes that do not depend on external feed, with terrestrial feed ingredients that have a related water consumption and pollution in the production process, must lead to an increasing water footprint of the feed. Therefore it is crucial to select feed ingredients that can be sustainably produced and grow with the sector. Tacon et al. (2011) project that production and usage of commercial aquaculture feed will increase to about 71 million tonnes in 2020, which must be planned well to avoid unsustainable levels of the related water footprint. Furthermore, global production of farm-made aquafeeds, which was estimated to be between 18.7 and 30.7 million tonnes in 2006 (Tacon et al., 2011), will add to this feed water footprint and must hence be included in future studies. Efforts should focus on further improvements in feed formulation techniques and on feed ration development on the basis of individual digestible nutrient levels to ascertain growth and health of the individual species, rather than on crude gross nutrient levels, and at the same time aim to minimise the environmental and ecosystem impact of feeds and feeding regimes, thereby avoiding unsustainable appropriation of freshwater resources.

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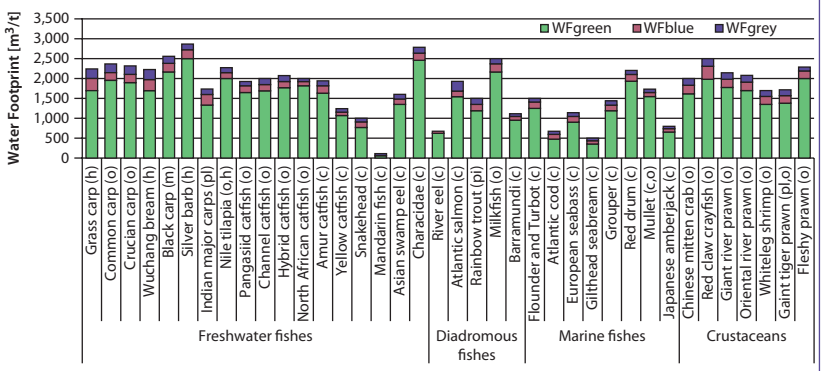
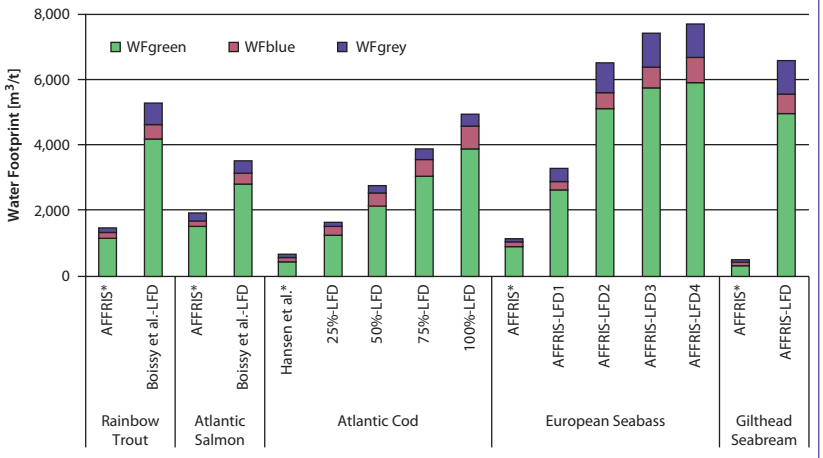
Figure 1 - Commercial feed-related green, blue and gray water footprint per tonne of fish and crustacean for the species investigated.



The dietary category for each species is also indicated: (c) carnivorous, (h) herbivorous, (pl) planktivorous, (m) molluscivorous, (pi) piscivorous and (o) omnivorous. If more than one category is shown then the species falls under different categories in different life stages.

Figure 2 - Resulting feed water footprint values of alternative research diets from the literature.



*The star * indicates the standard diet used in this study. LFD indicates research diets that are, to varying degrees, low in fishery products, i.e. in fish meal and fish oil.*