Lack of suitable raw materials for fish feed — could we use plankton?

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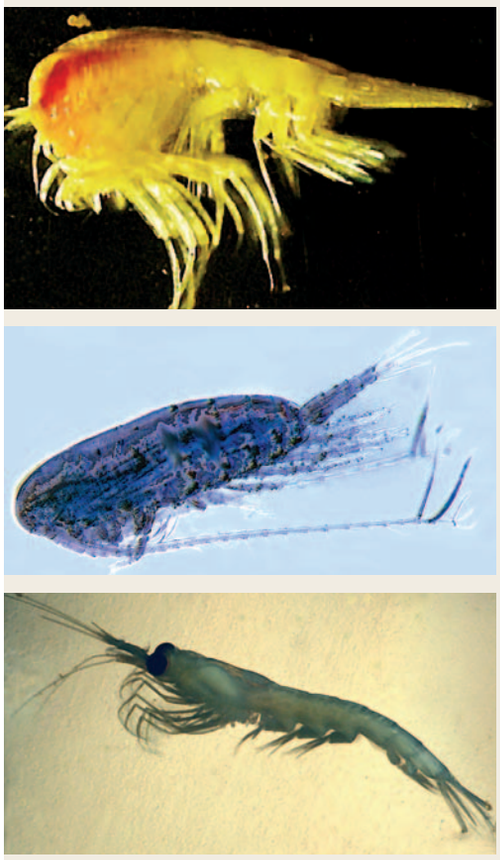
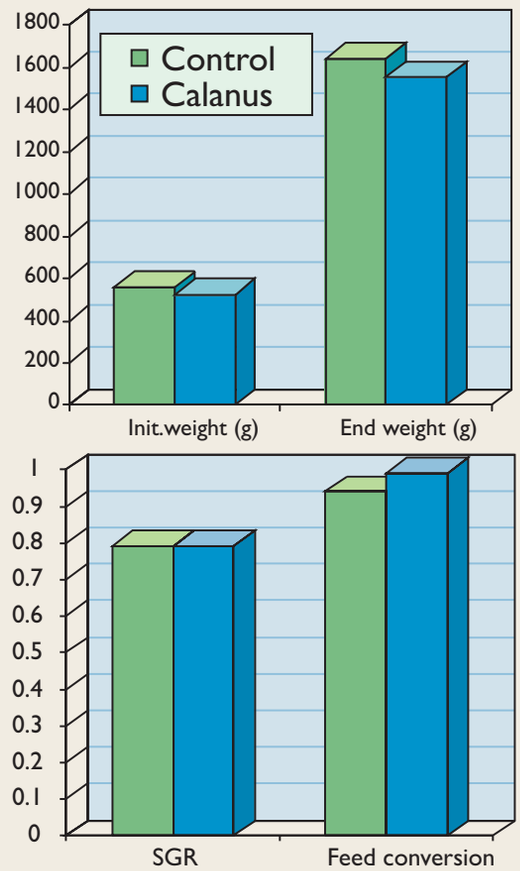
The volume of carnivorous aquaculture production has increased significantly over the past few decades. If the tendency continues, we will soon be faced with shortages of the raw materials traditionally used in aquaculture feedstuffs, fishmeal and oil. Furthermore, overfishing and low stocks of wild fish mean that there is no prospect of increasing the amount of fish we can harvest from the oceans. In order to support further growth of the aquaculture industry, there is an absolute requirement for alternative feed sources. One possibility is to harvest from lower tropic levels of the marine community, utilizing species like krill, amphipods and copepods. They are available in ample amounts and are good sources of fats and proteins.

Norwegian fish farming is based on raising carnivorous species of fish such as salmon, trout and cod. To present date, most of the feed that we give these species are based on fishmeal and oil. According to the UN's Food and Agriculture Organisation (FAO 1997), 70 % of the world's stocks of fish are either overfished or wholly depleted, and it will be impossible to increase the volume of catches in the foreseeable future. At the same time, there is a growing global need for raw materials for the rapidly increasing production volumes of carnivorous fish species.

This means that it is essential to seek out new alternative feed resources. Significant research has been put into the possibility to used plant-based raw materials. However, carnivorous fish are not well adapted to plant-based feeds, and anomalities may occur if large amounts are included into the diets. Furhtermore, using vegetable oils will produce flesh in salmon that is low in the long chain "marine" polyunsaturated fatty acids being benificial for



Amphipod, copepod and krill.



Growth, specific growth rate and food coversion in salmon fed copepod oil (*Calanus finmarchicus*) instead of fish oil. The fat content of the feed was 30 %.

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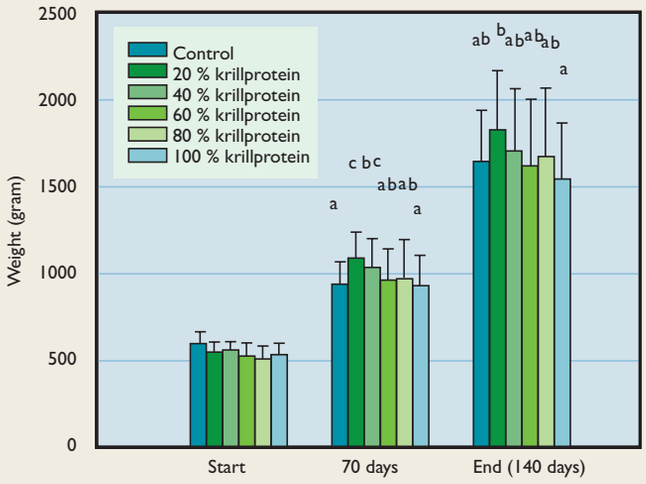
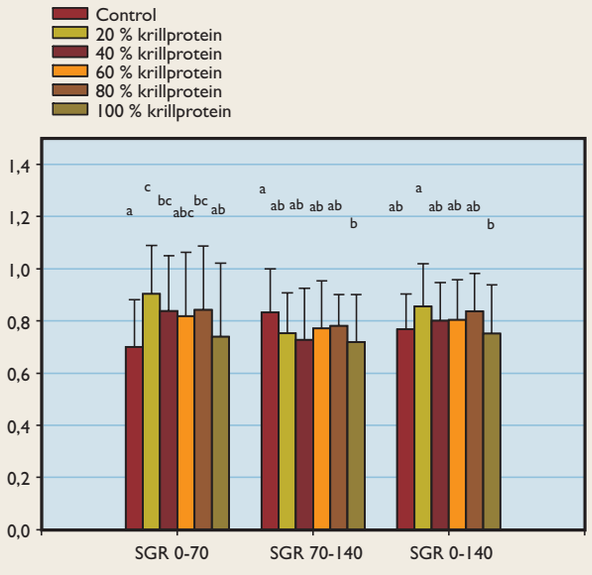


Weight in the groups



Days of feeding

Specific growth rate and weight of salmon fed Antarctic krill (*Euphausia superba*). From zero to 100 % of the fish protein in the feed was replaced by krill protein.

causing problems with traditional fish-based raw materials and more so for birds and mammals that are even higher in the food chain.

In northern waters there are several species that could be used as raw materials for aquaculture feeds. Copepods are zooplankton species that reproduce in quantities of several hundred million tonnes a year. Harvesting only a few percent of this production would easily produce enough raw materials to keep the aquaculture industry supplied for many years to come. However, because of the small dimensions of copepods, it will probably be necessary to develop new, improved fishing gear to catch these species efficiently and profitably. Northern species of krill such as *Meganyctiphanes norvegica* are larger, which means that they can be caught with modified trawl nets. Here too, annual production is probably more than 100 million tonnes.

The Institute of Marine Research has carried out several growth studies on salmon, halibut and cod fed krill and copepods, in collaboration with the National Institute of Nutrition and Seafood Research (NIFES) and the Norwegian Institute of Fisheries and Aquaculture Research. In virtually all cases, growth rates and feed utilisation have been similar or even better when compared to first-class fishmeal or oil based feeds.

human health. The alternative is to exploit resources at lower throphic levels. Here we can find considerable quantities of zooplankton, amphipods and krill. Because these exist in huge quantities (several hundred million tonnes) it seems likely that moderate harvesting would not significantly affect the amount of food available to fish and marine mammals. However, a moderate outtake could supply the aquaculture industry with raw materials far into this century. Another advantage is that these raw materials contain lower amounts of environmental toxins than organisms higher up the food chain. This because environmental toxins accumulate as they move up the food chain, eventually

Before we can start catching these species commercially, however, it is essential to chart their distribution and production accurately, so that we have the best possible basis for recommending how much that can be harvested. It is important not to remove the food from the fish in the sea. The Institute of Marine Research is currently doing a great deal of work in this field, both in the development of biomass measurement methods and mapping zooplankton. We are also developing ecological management models based on studies of the ecological consequences of harvesting lower trophic levels.

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