Creating value for the cod industry - Feed development for an emerging aquaculture species

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Atlantic cod – a culture defining species and geopolitical resource

Late August 1973, Halldór Hallfreðsson, an engineer on the Icelandic Coast Guard Vessel *ICGV Ægir* tries to repair the hull of the ship after a collision with the British frigate *HMS Apollo*. During a manoeuvre to avoid another clash with the British tug *Statesman*, Hallfreðsson was surprised by sea water flooding the compartment he was working in, leading to a fatal electrocution caused by his welding equipment. This accident happened during a series of militarized interstate disputes between the UK (and Western-Germany) on the one and Iceland on the other hand, referred to as the "***Cod Wars***". The conflict started in the early 1950's and continued to the mid 1970's, including several ramming attacks, cutting off trawls, economic sanctions, and Iceland's threat to leave NATO in the middle of the cold war. Finally, a United Nations agreement of increasing the size of the exclusive economic zones to 200 nautical miles ended the dispute, protecting one of Iceland's most important export commodities, the Atlantic cod. This brief historic summary, alongside plenty of cultural references such as the motif on the Norwegian 200 NOK bill (figure 1) or the "Sacred Cod", a wooden effigy in the Massachusetts State House originating from the 18th century, underlines the enormous economic and cultural importance of the Atlantic cod.

Figure 1

Rise and fall of a promising industry

Gadus morhua is a benthopelagic, marine fish that can reach an individual weight of more than 50kg and its habitat covers the Northern Atlantic shorelines from the United States' East coast to the Baltic Sea, where it lives in depths up to 1000m. Despite its relatively wide tolerance to

temperature (0°C – 20°C) and salinity (10PPT – 35 PPT), the species saw a rapid decline in numbers mainly due to overfishing, resulting in the collapse of several Atlantic cod stocks and the ban of cod-fisheries in Canada in 1992. Fuelled by the success and growth of some aquacultural industries such as Atlantic salmon in the North Sea or sea bass and sea bream in the Mediterranean, as well as the ongoing decline of Atlantic cod stocks and the listing of the species on the 1996 IUCN Red List of Threatened Animals, aquacultural entrepreneurs and investors draw their attention to the Atlantic cod in the late 1990's. The decrease in wild cod landings at that time, historically high prices, and the outlook to supply the seafood market with all-year fresh cod sparked an aquacultural boom at the beginning of the new millennium with hundreds of hatcheries and grow-out facilities started operating *Gadus morhua*. Ten years later, the cod-farming industry had experienced all facets of the harsh reality. The high Atlantic cod prices created room for other species such as the Pacific cod, Alaska pollock or even pangasius to enter and take over market shares, wild Atlantic cod stocks partially recovered and landings started increasing again, the world-wide economic and financial crisis kicked in, and most importantly plenty of technical and biological problems such as deformities led to a much lower product quality than the businesses could possibly handle. As a result, the complete industry collapsed.

The situation today

To our knowledge, there is only one private company in Norway that held on to their Atlantic cod brood stock after the collapse and kept working on some of the most important issues like deformities, slow growth rates or early maturation: Havlandet Marin Yngel Torsk A/S. The company based in Florø, Norway, established its own breeding programme in 2003 and since then constantly boosts the performance by a careful selection of brood stock fish. Additionally, their on-site production of live feed enables them to test out different strains of rotifers and artemia, thus providing the freshly hatched fish an optimal nutrition during the crucial first weeks of feeding. During the last 20 years, the people of Havlandet Marin Yngel Torsk A/S accomplished many significant improvements including higher larvae survival rates, far less deformities, faster growth, and controlling sexual maturation by manipulating light periods. Today, Havlandet´s facility has a capacity of approximately 50 million dry feed adapted cod fry with an average weight of 2-3g per year.

Given those fish are fed with high quality grower feeds, they can reach the preferred market size of 3.5kg to 4.0kg within two years. Those improvements sparked our interest. At Aller Aqua, we are

very aware that exchanging knowledge is an important component to an organic and healthy development of the industry, as working and growing together are the key principles of our core philosophy. Therefore, meeting up with Halvard Hovland, CEO of Havlandet, and discussing the state of Atlantic cod aquaculture with him was a great opportunity to start cooperating and sharing our experiences and perspectives on the once again emerging market of Atlantic cod farming.

The Atlantic cod market

In the year 2019, Atlantic cod was the third most consumed fish species in the EU, ranking just behind Tuna and Atlantic salmon (figure 2). Its low-fat white muscle flesh is the base for a lot of classical dishes in Northern Europe such as stockfish or the British "Fish 'n' Chips" but has also

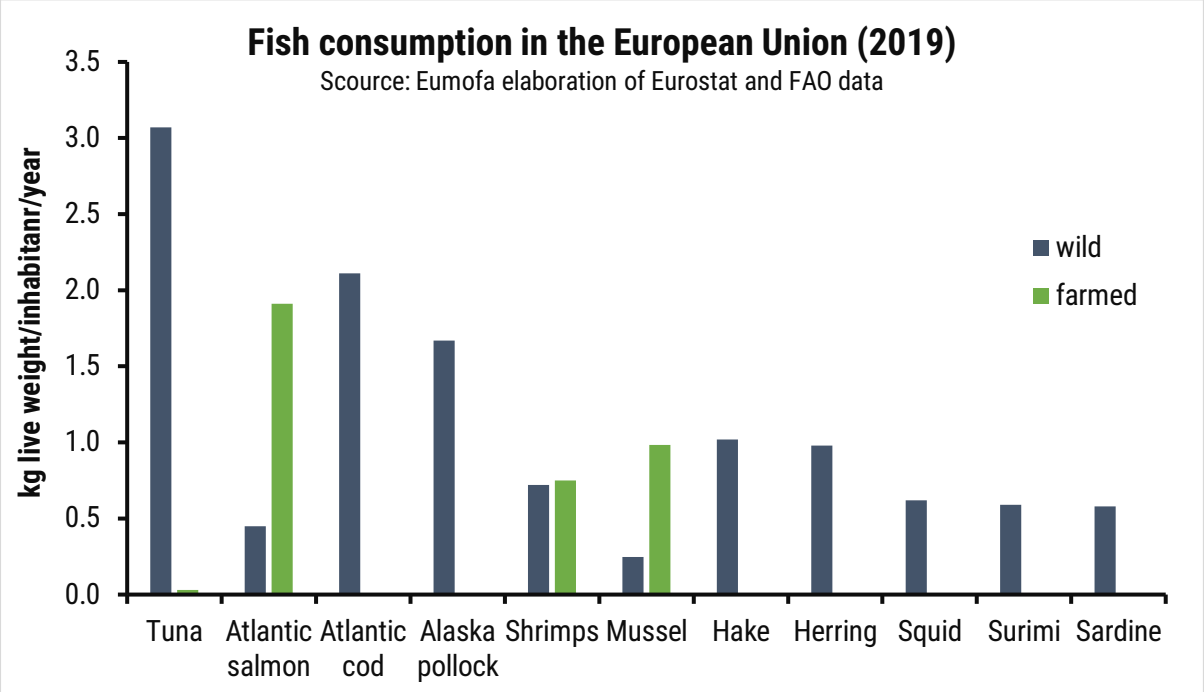

Figure 2

found entry to the haute cuisine in the past decades. Whereas most of the Atlantic salmon originate from the aquaculture industry, Atlantic cod is almost exclusively produced by fisheries. Taking climate change, reduced fishing quotas and regional environmental problems as well as the recent breeding successes into consideration, the potential for a constantly maturing cod-farming industry is obvious. Despite the popularity of Atlantic cod and the promising market situation of cod-farming, comparatively low efforts have been made to investigate the species scientifically, especially when it comes to aquacultural traits (figure 3). Therefore, conducting a comprehensive trial series was the logical next step of the cooperation between Havlandet and Aller Aqua.

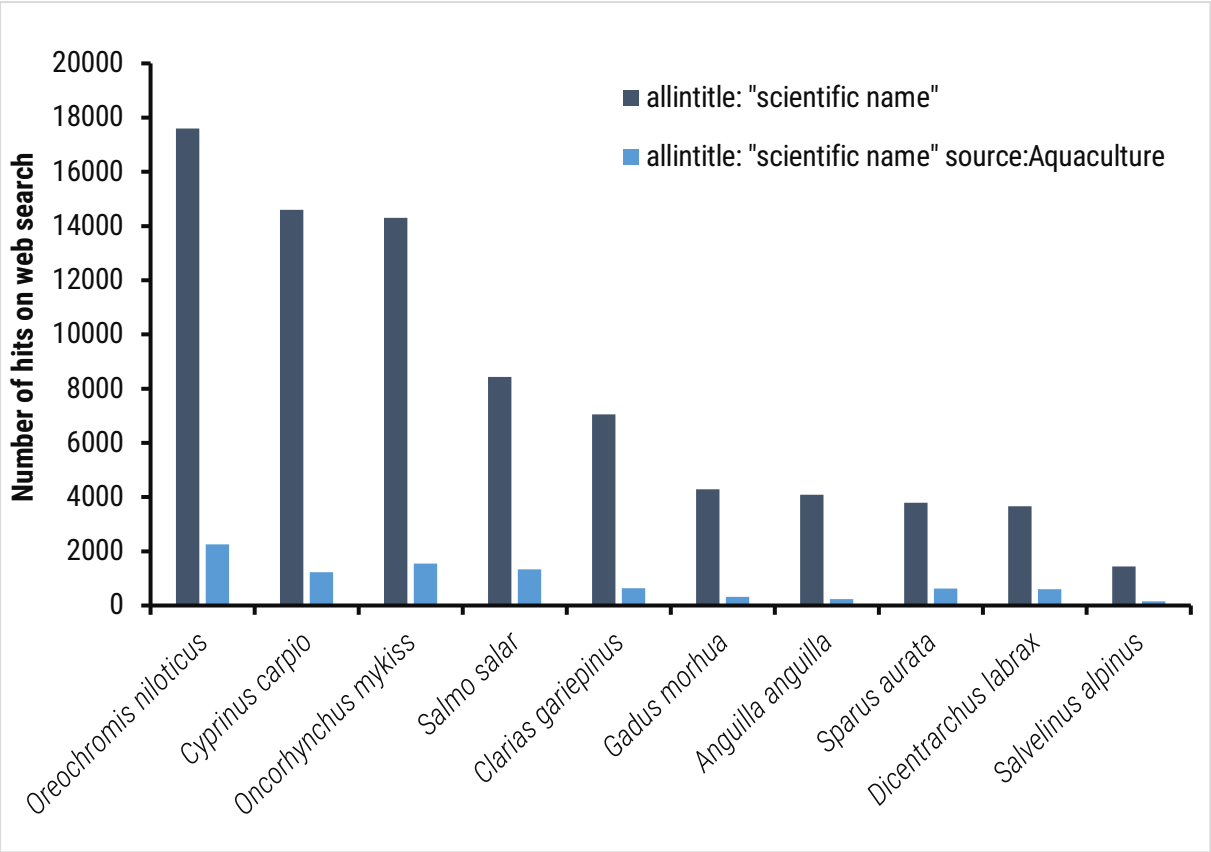

Figure 3

Benchmarking

From a fish feed producer's perspective, benchmarking is a great tool to obtain a detailed overview of the status quo as it sheds light on the most urgent questions: Which products are farmers using right now? Which products yield the highest economic benefits? Is there a causal link between potential health issues and feeds? How big is the room for dietary improvements? How widespread are different farming techniques and is it efficient or even necessary to develop tailor-made products for those particular niches?

As the cod-farming industry is still in a "juvenile state", the amount of serious competition is low. Most products on the market are not tailored towards the needs of Atlantic cod specifically, but are made for marine species in general, reflecting a compromise that is understandable from a commercial point of view but could inhibit the growth potential of the industry due to a lack of specialisation. When the Norwegian Norcod A/S "re-pioneered" the commercial Atlantic cod production in 2018, Aller Aqua took the chance to accompany their journey with the development of a cod-specific feed programme centred around the ALLER OCEAN QUANTUM EX feed. While this development marked a milestone for Aller Aqua and the cod-farming industry, it was evident from

the very beginning that with the on-going breeding success and upscaling of production, revisiting the feed programme to balance out nutritional profiles and adjust formulations was necessary to keep track with the maturing industry. Cooperating with Havlandet and getting access to the newest generation of Atlantic cod fry, represented a great opportunity to start a benchmark trial series and investigate the growth performance, health status and product quality of Atlantic cod reared under standardised, optimal environmental conditions in our own RAS-facility (figure 4).

Figure 4

Impressive growth rates

After the arrival of the Atlantic cod fry and adaption to the system, we split the stock into two lines being fed with either Aller Aqua's feed programme or competitor's feed. The trial series started with fish of 0.5g individual weight and feeding was done via belt feeders. Twice a day, all uneaten pellets were removed from each of the tanks and counted. Based on the amount of uneaten feed, the feeding ratio for the next day was adjusted in a way that the fish were not able to consume all feed. Thereby, we made sure that the fish had constant feed supply and were fed to satiation, lowering the risk of aggressive or cannibalistic behaviour, and ensuring that we achieve maximum growth rates and an equal management for all treatments during the trial series. During the first two weeks of feeding, the fish grew with impressive growth rates of approximately 8% of bodyweight per day and after two months the fish reached the 25g mark, while showing high survival rates and a good feed conversion (figure 5). Those results already indicated the progression of Atlantic cod breeding during the last two decades and this trend was only confirmed after switching to grower feeds (figure 6). After 6 months, fish fed Aller Aqua's cod feed had an average individual weight of 300g

and by the time writing this article (9 months into the trial series) the cods are advancing towards the 1kg line, proving the claim that the fish can reach market size within two years.

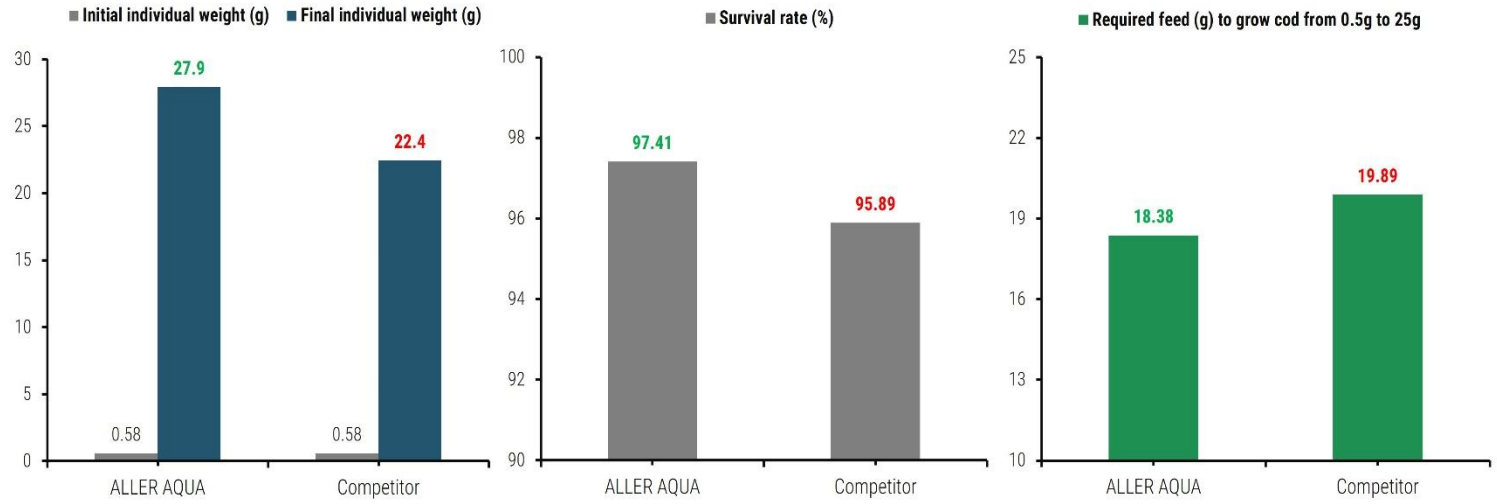

Figure 5

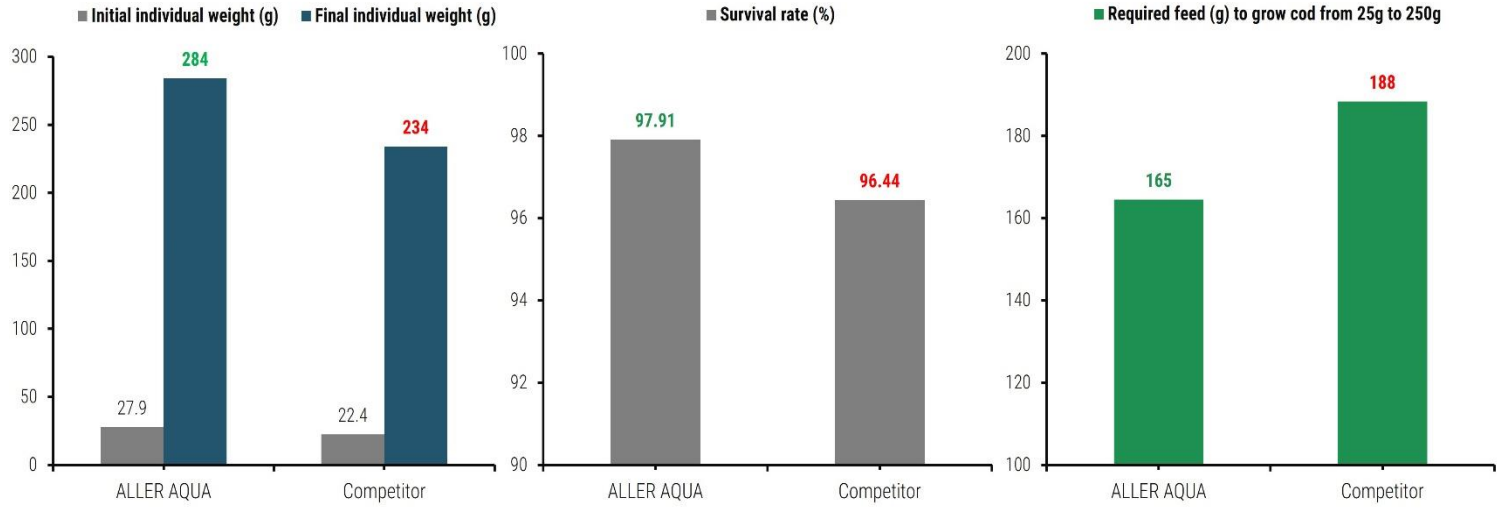

Figure 6

Would cats eat aquaculture cod?

Due to license issues and limited knowledge, farmed Atlantic cod during the 2000's showed high prevalence of bone deformities and some media in Norway started calling them "monster cod", resulting in negative press for the producers and culminating in the claim of fishermen, that caught net-cage escapes, "that not even the cat would eat them" (source: Atlantic cod aquaculture: Boom, bust, and rebirth? Nardi et al., 2021). In fact, the level of deformities of farmed cod has already been significantly improved prior to the collapse of the industry in the late 2000's. The introduction of functional vaccines lowered the amount of jaw deformities and spinal deformities are mostly avoidable by optimal nutrition, careful handling, and stable environmental conditions. Additionally,

grading of fish stocks in the earlier stages of development will drastically reduce the economic losses due to deformities. Obviously, it is not possible to lower the number of deformed fish to zero, but our trial results show that the times of “monster cod” are long gone. Even in our ungraded cod stocks, the quantity of fish showing severe deformities are close to being comparable with long-time established aquacultural species such as rainbow trout or Atlantic salmon, independently from the feed that they received during the trial series (figure 7).

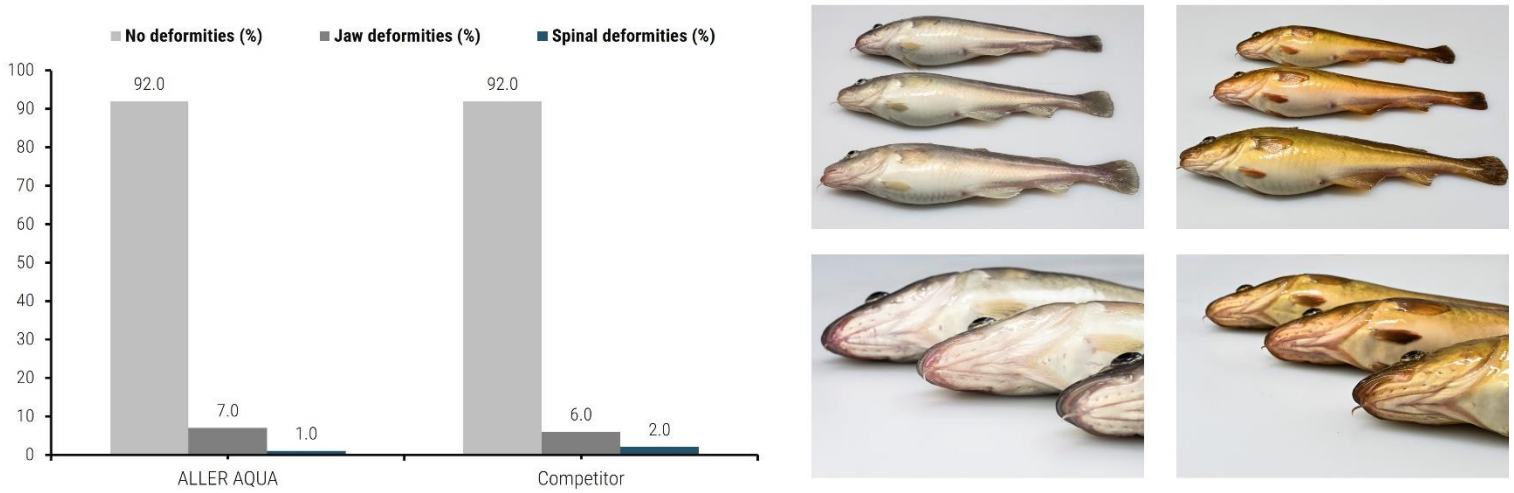

Figure 7

Intestinal health and liver size

If you ask the experts from Havlandet or Norcod, the biggest remaining issue of cod-farming is the intestinal health. So called “intestinal loops”, “gut knots” or “gut wrenching” are a severe problem that cause a blockage of the gut while showing heavily inflamed tissue, especially in the mid-gut, finally leading to the death of fish. As this malfunction is not visible from the outside and affects mainly larger fish, grading is not an option to reduce the economic losses. As farmers are responsible for the well-being of their fish and losses due to mortality significantly lower the revenue of the industry, broader attention has been drawn to this issue in recent months. One of the current theories is related to the length of the mid-gut, as an extended mid-gut might have been one of the outcomes from the breeding selection, that initially led to the improved growth rates of farmed Atlantic cod. A team of researchers from the Norwegian University of Life Sciences (NMBU) began a project (FORCOD) in early 2023 to investigate the problem and comparing the intestines of farmed cod with those of their counterparts from wild populations. At Aller Aqua, we are paying close attention to this issue as well but have not yet seen any signs of the extensive problem that has been reported by our Norwegian colleagues. So far, the intestinal health appears to be intact

(figure 8), and we can currently only speculate whether this is due to the constant conditions of the RAS, the early adaption of the fry to our system or other aspects like ozonisation or the absence of parasites.

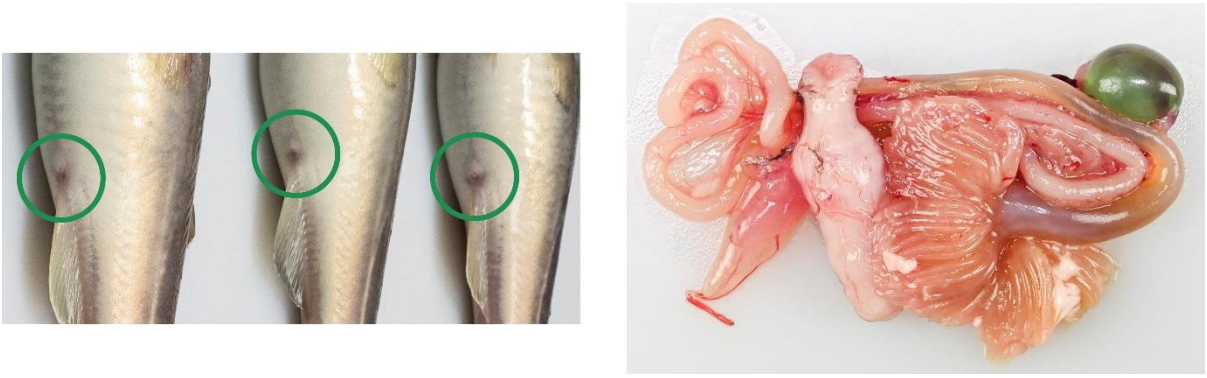

Figure 8

Another hot topic is the size of the liver. One of the main differences between salmonids and the Atlantic cod is the storage of excessive energy. While salmonids can store fat in their muscle tissue, Atlantic cod store it in the liver and thus the Hepatosomatic index, the relation of liver size to total weight, can reach values of more than 15%. It is therefore important to not only take the feed conversion into account when it comes to calculating the economic benefits of a given feed, but to look at the head-on-gutted-weight (HOG) as well. Our trial results so far not only suggest that feeds with a higher digestible energy significantly outperform lower energy diets in terms of growth and feed conversion, but also that the slightly reduced slaughter yield does not justify the usage of lower energy feeds. As liver size might play a role in the prevalence of intestinal inflammation of Atlantic cod and could be an indicator for reaching the ceiling of growth potential, we are constantly working on finding the optimal nutritional balance in accordance with the preferred feeding strategies of the cod-farmers.

Conclusion and outlook

Unlike the last “cod adventure” the (re-)entering of Atlantic cod into the world of aquaculture happens in a more even-tempered manner, although the circumstances, for example improved cod strains and farming techniques, far less deformities, higher larval survival rates and the availability of feeds tailored to the specific needs of the species seem to be just as promising. We are convinced that this approach, without rapid decision making and overheated financial reactions, can only benefit the organic growth of the cod-farming industry, and will help earning the trust of consumers. The progress of the last 10 to 15 years is truly astonishing, and we are eager to keep

supporting the industry by sharing our knowledge and providing high quality feeds that fulfil the needs of cod-farmers.

If you are interested in learning more about the cod production of Norcod, the breeding success and cod fry of Havlandet or the feeds of Aller Aqua, please feel free to visit the respective websites:

https://norcod.com/

https://havland.no/torsk/

https://www.aller-aqua.com/